Climate Change and Energy in the Mediterranean

Plan Bleu
Regional Activity Center

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CONTENT

Climate Change and Energy in the Mediterranean

EXECUTIVE SUMMARY

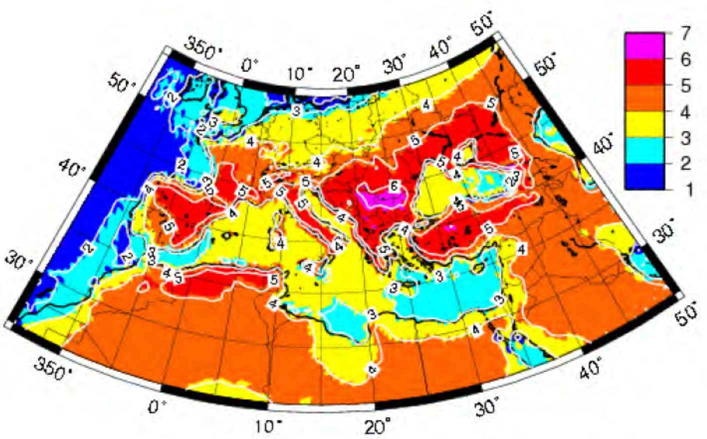
The Mediterranean: A "hot spot" of climate change

Since 1970, South-Western Europe (Iberian peninsula, southern France) has reported a temperature rise of about 2°C (IPCC 2007). This warming is also felt in North Africa, though it is more difficult to quantify due to an incomplete observation network.

For the Mediterranean region, climate experts anticipate during the 21st century:

- An increase in air temperature in the range of 2.2 C° to 5.1 C° for the countries of Southern Europe and the Mediterranean region over the period 2080 – 2099 with respect to the period 1980 – 1999 (IPCC 2007, scenario A1B);
- A significant decrease in rainfall, ranging between -4 and -27 % for the countries of Southern Europe and the Mediterranean region (while the countries of Northern Europe will report a rise between 0 and 16 %) (IPCC 2007, scenario A1B);
- Increase in drought periods manifested by a high frequency of days during which the temperature would exceed 30 °C (Giannakopoulos et al. 2005). Extreme events, such as heat waves, droughts or floods, are likely to be more frequent and violent.
- An increase of the sea level which, according to some specific studies, could be around 35 cm up to the end of the century.

Annual mean variation of air temperatures in summer (°C) – 2070-2099 vs 1961-1990



Source : Somot and al. 2007

The impacts of climate change on the Mediterranean environment will relate particularly to:

- Water, via a change of its cycle due to a rise in evaporation and a decrease in rainfall. This water problem will be of crucial importance with regard to the issue of sustainable development in the region;
- Soil, via the acceleration of already existing desertification phenomena;
- Land and marine biological diversity (animal and plant), via a displacement northwards and in altitude of certain species, extinction of less mobile or more climate sensitive species, and emergence of new species;
- Forests, via a rise in fire hazards and parasite risks.

These impacts will exacerbate already existing pressures on the natural environment connected with anthropogenic activities.

Climate change will have impacts particularly on: agriculture and fishery (reduction of yields), tourism attractiveness (heat waves, water scarcity), coastal areas and infrastructures (significant exposure to the action of waves, coastal storms and other extreme weather events, rise in sea level), human health (heat waves), the energy sector (water needs for power plants, hydropower and increased consumption).

The more vulnerable Mediterranean areas will be those of North Africa adjacent to desert areas, the major deltas (those of the Nile, the Po and the Rhone, for instance), the coastal areas (Northern rim and Southern rim of the Mediterranean basin), as well as the high-demographic growth and socially-vulnerable areas (Southern and Eastern rim, densely populated cities and suburbs).

The Southern and Eastern Mediterranean Countries (SEMCs) appear to be more vulnerable to climate change than the Northern Mediterranean Countries (NMCs). Indeed, they are, on the one hand, more exposed to accelerated desertification, soil aridity and water scarcity and, on the other hand, presenting economic structures that are more strongly dependent on natural resources, as well as technical and financial capacities that are too limited to help implement large-scale adaptation options.

Nile Delta, potential impact of sea level rise

Source: UNEP/GRID – Arendal Maps and Graphics Library.

CO_2 emissions not under control and a risk-ridden energy scenario

In 2000, seventy two per cent (72%) of the Mediterranean green house gas (GHG) emissions were due to CO_2 connected with energy use (77% in the NMCs and 64% in the SEMCs).

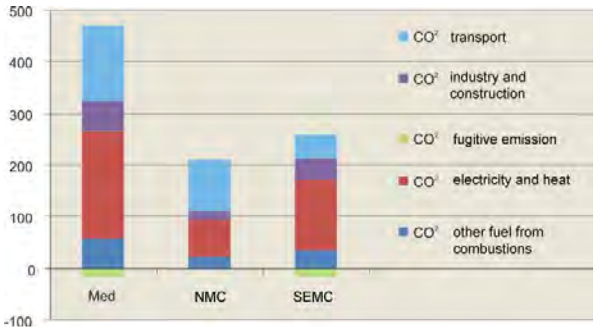
In 2025, the CO_2 emissions due to energy use will be twice as high as they were in 1990 (OME/ MEO).

The share of the SEMCs in the total emissions generated in the Mediterranean would be of about 50% in 2025. In 2006, the NMCs accounted for about 2/3 (two thirds) of the CO_2 emissions due to energy use of the whole Mediterranean basin (OME/ MEO).

However, the growth of CO_2 emissions seems to be far more rapid in the SEMCs than in the NMCs. Indeed, while the NMCs reported an increase by 18% between 1990 and 2004, the emissions of the SEMCs increased by 58% over the same period. This growth rate is twenty points higher than the world rate (WRI).

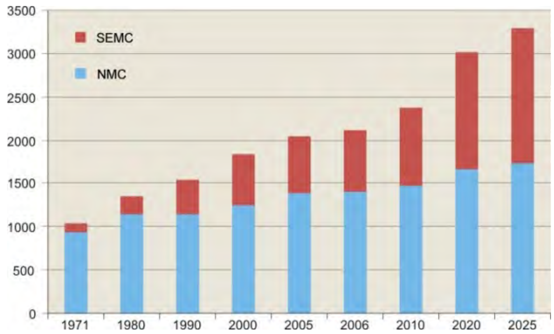
Electricity and heating are the main contributor to the rise in emissions between 1990 and 2004 in the SEMCs. In the NMCs, the chief contributor is the transport sector.

CO2 emission from energy use: variation by sector between 1990 and 2004, Mio t. CO2



Source: computed by Plan Bleu from WRI data.

CO2 emission from energy use, Mio. T. CO2, 1971-2025, trend scenario



Source : OME.

The updated energy trend scenario of the Observatoire Méditerranéen de l'Energie (2007), based on the aggregate of the evolutions estimated by the countries and by the major energy companies, reveals the following:

- In 2006, fossil energies (oil, gas, coal) dominated the energy supply, accounting for as much as 80% for the whole Mediterranean countries, and for as much as 94% for the SEMCs alone (75% for the NMCs). The primary energy consumption per capita is 3.3 times lower in the SEMCs than in the NMCs;

- By 2025, the weight of fossil energies is likely to stabilize at equivalent levels. The share of coal (high CO_2 emitter) persists in the energy mix due to its envisaged use for power production;

- The primary energy demand in the Mediterranean basin is likely to multiply by 1.5 between 2006 and 2025 and by 2.2 in the fast-developing SEMCs and whose population is markedly on the increase;

- The energy demand is characterized by a rise in demand on electricity that is much more rapid than the growth of demand on primary energy or population growth. It is likely to be multiplied by 2.6 between 2006 and 2025 in the SEMCs, due in particular to a tripling of consumption in Turkey, Tunisia and Algeria and a doubling in Egypt and Morocco.

Irrespective of the evolutions on global level, in the Mediterranean, the tensions already prevalent in matter of energy are likely to become significantly more acute if the trend scenario obtains, particularly through the following developments:

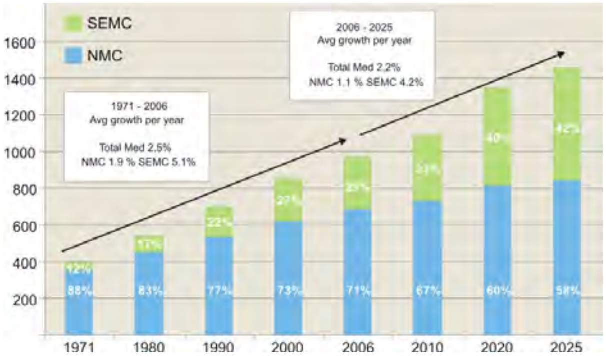
- Increase in CO_2 emissions and an exacerbation of local atmospheric pollutions;

- Greater energy dependence of importing countries, more felt by importing SEMCs (passing from 77% in 2006 to 88% in 2025) than by importing NMCs (passing from 68% to73%, over the same period);

- Social and economic risks connected with the rise in supply costs and its incidence on the energy bill of the countries, households and enterprises;

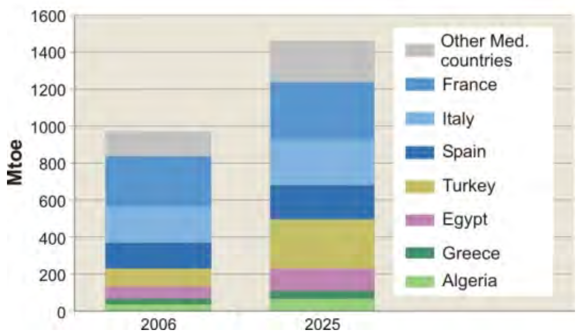
- Impacts of climate change on the energy system: via, on the one hand, the power production and infrastructures and, on the other hand, the growth in energy demand.

Primary energy demand : baseline scenario up to 2025



Source: OME.

The seven main energy consumer in the Mediterranean



Investing today in energy efficiency (EE) and in renewable energies (RE) presents real economic advantages for the time frame 2015

The economic simulations conducted reveal that a high potential of economic return lies on the demand side (simulation for an improvement of energy intensity by 10% within 10 years), based on energy efficiency actions, and that a rather modest effort in terms of RE (putting up the share of the solar, wind and geothermal to slightly over 1.1% of primary energy), allows a non negligible gain.

An extrapolation to the MEDA countries of the aggregate results obtained for 3 countries (Morocco, Tunisia, Egypt) reveals that aggregate actions would allow as from 2015 an annual gain on actions of about 30 billion dollars with a barrel at 120$ with respect to a situation where the current trend persists (to 43 to 49 billion USD with a barrel at 175 USD) . About 36 million tonne oil equivalent (TOE) would be saved, and a drop by 130 million tons of CO_2 emissions would be observed.

This "cost of non action" is equivalent to the GDP 2005 of Tunisia which amounted to 28.7 billion dollars. During this same year, CO_2 emissions due to energy use were about 20 million tons in the latter country.

This "cost of non action" remains to be compared with the costs of the actions that need to be conducted in order to achieve the objectives of improvement of energy intensity and promotion of RE.

The national analyses (Egypt and Tunisia) conducted within the framework of this report reveal that:

- In Tunisia, the cost of saving the equivalent of one TOE thanks to energy management actions is about 40 euros ;
- In Egypt, the cost of saving one TOE based on renewable energies (wind energy) is estimated as 50 euros; to save one TOE based on energy efficiency actions, the cost is estimated as between 20 and 30 euros;
- The investments necessary to step up the contribution of RE and EE are likely to amount, for the periods analysed (2008-2011 for Tunisia, 2008-2015 for Egypt) to 10 and 13%, respectively, of the amounts of investment envisaged in the energy sector over the same period and would need to be outlaid in addition to the latter.

To the purely economic and financial advantages, there must be added potential fringe benefits in terms of employment and development (industry and services), which have already been observed in countries that have set up dedicated vocational training schemes (Tunisia, Morocco), and for the health of local population. Further, there must also be added the potential financial gain that would be possible within the framework of the Clean Development Mechanism.

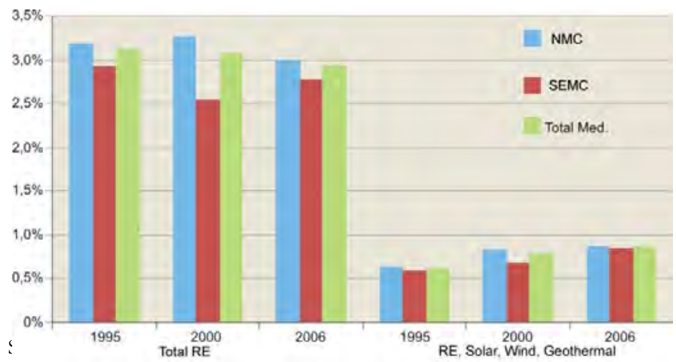
Awareness is on the increase, but progress in terms of EE and RE remains limited

Awareness about the importance of easing the energy constraints and the obviousness of the link between environment and development in the Mediterranean is on the increase.

On the Northern rim, in the European Union, the adoption of drastic measures for the development of energy efficiency, promotion of renewable energies and reduction of GHG emissions attest to this awareness. On national level, several SEMCs are also geared up for a greater energy sobriety.

Basin-wide, and on the political level, the adoption in November 2005 of the "Mediterranean Strategy for Sustainable Development" (MSSD) by the contracting parties to the the Barcelona Convention is a real signal. It proposes, on the one hand, improving energy intensity by 1 to 2% per year and, on the other hand, reaching a rate of 7% for RE in the total primary energy demand by 2015.

Share of RE in the primary energy consumption (%)



With reference to the objectives of RE and EE of the MSSD and to the Plan Bleu Report of 2005, one observes the following:

- In the SEMCs, with very few exceptions, concrete applications of RE are on the increase, but remain limited. The share of RE (hydropower, wind, solar, geothermal) in the consumption of primary energy passed from 2.5% in 2000 to 2.8% in 2006, which remains in line with the MSSD objective of 7% by 2015;
- Energy intensity in the Mediterranean countries as a whole was up by 0.3% per year between 1992 and 2003, which is far short of the 1 to 2% growth rate put forward by the MSSD. Besides, the tapping of the EE potential seems to be "neglected" by comparison with the development of RE.

An institutional and legal framework to be finalised and economic and financial impediments to be lifted

Energy efficiency options seem, therefore, to be still under-tapped. Yet, the several projects implemented and the experiences of a few countries in certain dedicated sectors (Tunisia, Morocco, Egypt, Israel, for instance), prove that RE and EE are proven, appropriate and advantageous options.

The challenge for the region remains a massive generalisation of success stories, the creation of a Mediterranean RE and EE market, and a focus of investments on RE and EE.

The obstacles on national level, as identified in this report, relate to:

- The institutional and legal frameworks necessary for the development of a real energy efficiency market which, despite the progress made, are still often incomplete, little visible and—at times—instable;
- Lack of information on the importance of the economic and financial gains for both investors and consumers of energy efficiency actions;
- Economic impediments: subsidies for fossil energies in several SEMCs lead to fairly low end-user price; besides, a low efficiency of the economic and financial incentives for RE and EE is sometimes observed.

A strong political will on national level is indispensable to overcome these impediments.

Regional and international cooperation has no doubt a significant role to play, especially by acting as a lever and facilitating transfer of technology and know-how between the Northern rim, where technologies are available—for RE, for instance—, and the Southern rim where natural conditions are more favourable and energy efficiency potentials more important. In future—subject to convergence of the legal frameworks between the countries of the region—export of "green" electricity from the Southern rim to the Northern rim, and the European Union, as a whole, could become a reality, especially via the development of the solar sector. The Clean Development Mechanism (CDM) is also an instrument that needs to be better tapped in the region.

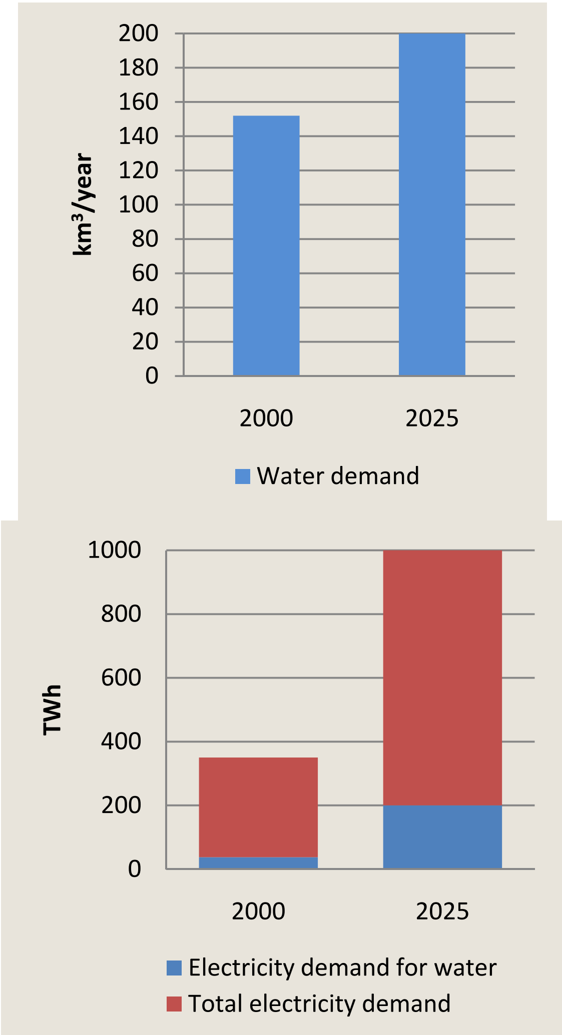
It is no longer possible to consider the development of the energy system independently from the other sectors

In order to yield significant effects, the measures outlined above must be accompanied by evolutions in several strategic sectors for which energy efficiency and renewable energies can be considered, not only as measures of reduction of CO_2 emissions, but also as measures of adaptation to climate change.

The report analyses the implications of climate change for the linkages between energy and water, woodlands, tourism and urban areas.

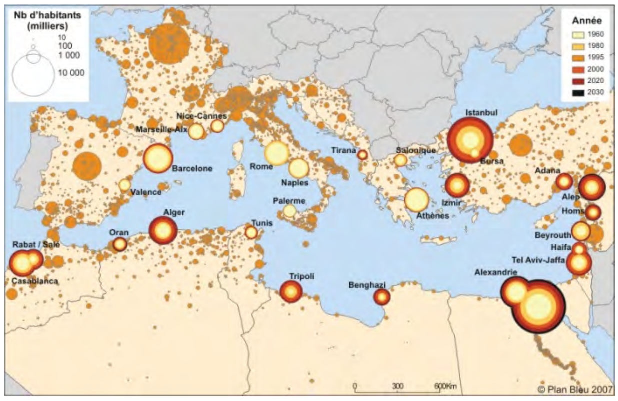
Thus, electricity needs for water production and mobilisation, which currently account for about 10% of the power demand of the SEMCs, is likely to account for 20% of it for the time-frame 2025. This trend could be curbed, firstly, by the implementation of policies of rational water use and, secondly, by the use of RE and most energy-efficient technologies for the mobilisation of non conventional water.

Water and electricity demand in the SEMC, trend scenario up to 2025



Source : OME, Plan Bleu.

Cities of Mediterranean countries up to 2030



Source : Plan Bleu d'après Géopolis 1998, ONU, World Urbanization Prospects : The 2005 revision.

GENERAL CONCLUSION

The Mediterranean, and more especially the Southern and Eastern rim, is and will be more affected by climate change than most other regions of the world in the course of the 21st century.

The impacts of the rise in temperatures, the decrease in rainfall, the multiplication of the number and intensity of extreme events and the possible rise in sea level overlap and amplify the already existing pressures of anthropogenic origin on the natural environment.

Through the crucial issue of scarcity of water resources, their impacts are fraught with consequences in the 21st century for human activities, in particular agriculture, fishery, tourism, infrastructures, urbanised coastal areas and hydropower production. In order to minimize as much as possible the economic losses and damages, several adaptation options must be thought out and implemented.

Energy lies at the heart of the climate change issue. On the one hand, it is the main GHG emitting sector, and CO2 emissions in the future are likely to increase much more rapidly than the global average. On the other hand, hydropower production—relatively significant in certain countries (13% of power production in the SEMCs)—is affected by the climate as well as by the plant cooling constraints. Lastly, the energy demand (in particular, electricity) which is growing at a very high pace in the region, is likely to be further accelerated by the additional demand necessary to lessen the impacts of climate change (water desalination, air-conditioning of buildings, . . . etc).

Developing renewable energies on a large scale, granting priority order to energy efficiency in order to gain control over demand and CO2 emissions, and easing energy constraints, all constitute today an economic opportunity for the SEMCs. The costs of non action show that, investing today in this field can generate economic benefits of about 30 billion $ within the fairly close time frame of 2015 (with a barrel at 120 USD). Besides, saving one TOE costs 4 to 5 times less than mobilizing one additional TOE of fossil energy.

In the SEMCs—now in fast development—, several anticipation possibilities exist for the 7 to 10 coming years in order to gain control both on rising consumption and increasing CO2 emissions, and to mitigate the vulnerability of the energy sector.

The energy efficiency (EE) option is possible at once and presents the highest cost/effectiveness ratio, particularly in the building sector (solar water heating, low consumption lighting, insulation of buildings), but also in the industry and the transport sectors.

The renewable energies (RE) option is also possible at once, concurrently with other sectors. The solar sector is particularly interesting, not only on national level, but also for the development of a Euro-Mediterranean renewable electricity market.

Accelerated penetration of natural gas and/or the rehabilitation of older plants are also solutions to reduce CO2 emissions. Other options, such as that of the capture and storage of carbon to mitigate the emissions due to the use of coal for power production, seem to be still quite costly and uncertain, and are unlikely to report a large-scale development in the SEMCs within the time frame 2020-2025.

Lastly, the options taken—particularly in the sectors of “water”, urbanisation and tourism (transport, land use planning, buildings)—will determine the future growth of energy consumption and the vulnerability of the region vis-à-vis climate change. They can no longer be addressed independently from energy issues.

To date, given the constraints and uncertainties—both climate and energy related—and the growth of energy demand in the SEMCs, stepping up the role of RE and EE in all sectors becomes more a necessity than a choice.

GENERAL INTRODUCTION

Context

The Intergovernmental Panel on Climate Change (IPCC) has confirmed in its Report 4 (AR4, 2007) that the rise in greenhouse gas (GHG) concentration in the atmosphere was due to anthropogenic activity—in particular energy consumption and production—and that, consequently, temperatures are likely to significantly rise in the coming years.

The Mediterranean—especially its Southern and Eastern rims—is likely to be more affected by climate change than most other regions of the globe in the 21st century.

The impacts of the rise in temperature, drop in rainfall, increase in number and intensity of extreme events, as well as of a possible rise in sea level, could thus overlap and exacerbate the pressures due to anthropogenic activities that are already exerted on the natural environment.

Manifested above all in the central issue of water resources scarcity, the impacts should be particularly strong on agriculture, fishery, tourism, infrastructures, urbanised coastal zones and hydropower production. In order to minimise as much as possible the ensuing economic damage and losses, several adaptation options must be identified and implemented.

Energy lies at the heart of the climate change issue. Indeed, the energy sector is the main GHG emitter—with CO_2 emissions increasing more rapidly in the Mediterranean than on global level, on average—and climate change directly influences energy production and consumption (especially electricity). Accordingly, in the face of climate change and its unquestionable reality, the region must, on the one hand, adapt its energy system and, on the other hand, opt for low-CO_2 emissions energy solutions in order to participate in the climate change mitigation efforts.

In view of the above, Plan Bleu and the European Investment Bank (EIB) have cooperated to produce a Report on "Climate Change and Energy in the Mediterranean".

Drafting of the Report

In order to draft this Report, Plan Bleu has enlisted the contribution of regional institutions and national experts knowledgeable in the field of climate change and energy (MEDIAS, the Mediterranean Energy Observatory (OME), the French Environment and Energy Management Agency (ADEME), the Tunisian National Agency for Energy Management (ANME), FEMISE/ Mediterranean Institute. In total, twenty five contributors have been directly involved in drafting the Report, of whom an International Steering Committee—composed of IPCC, OME, ENDA NGO and national government experts—has supervised and directed the works.

This Report follows upon the previous works of Plan Bleu on energy, sustainable development and climate change. In particular, it draws upon the Plan Bleu Report entitled "The Mediterranean: Plan Bleu Environment and Development Outlook" (2005), as well as upon the activities conducted in 2006-2007, as part of the follow-up on the Chapters entitled "Energy and Climate Change" and "Water", of the Mediterranean Strategy on Sustainable Development (MSSD).

Besides the mining of regional data bases (EUROSTAT/MEDSTAT, MEO (OME), Plan Bleu, FEMISE) and international data bases (World Bank, World Resource Institute, UNO, IMF), several sets of information and case studies have been conducted or compiled during expert workshops (particularly in partnership with MEDITEP and ENERGAÏA).

The Report comprises 11 chapters. Each of them can be read separately from the others, though the set of chapters does constitute a consistent and cohesive whole. The Report brings into play a variety of methodological approaches: climate models, economic models and simulations, and prospective and systemic energy projections (sector-system interactions) and endeavours to quantify the energy (and related emissions) trends, thus providing detailed quantification of the region's past trends (over the last 35 years) and future prospects (up to 2025).

Report objectives and contents

The Report covers the 21 Mediterranean riparian countries, though with a special focus on the Southern and Eastern rims of the Mediterranean basin.[1]

It is divided into three parts.

Part I provides a summary overview of the scientific results related to the possible climate evolution in the Mediterranean in the 21st century. The impacts associated with the possible evolutions are analysed. Their expected effects in economic terms are addressed via a review of the economic literature on the costs of climate change. Lastly, this Part provides both a comprehensive and detailed picture of the past and future trends of GHG and CO_2 emissions due to energy use.

Parts II and III are dedicated to energy issues.

Thus, Part II examines the possible options offered to the region, as of now, to gain control over the growth of CO_2 emissions due to energy use. Economic costs-advantages simulations and quantifications are conducted for various options and alternative scenarios for the time frame 2015 for the whole region. Besides, two case studies (one for Tunisia, the other for Egypt) help refine the analysis of alternative scenarios and their costs on country level.

Part III highlights the impacts and the vulnerability of the Mediterranean energy system (production, distribution, consumption) in the face of the inevitable climate change in the region. Drawing upon case studies, this Part underscores the fact that the power production sector is itself disrupted by climate change. It also shows how development options in key sectors/resources (forestry, water, building, tourism, city) in a climate change context can in the long run strongly impact energy demand.

[1] Mediterranean riparian countries: Southern and Eastern Mediterranean Countries (SEMCs): Algeria, Egypt, Israel, Lebanon, Libya, Morocco, Syria, Palestinian Territories, Tunisia, and Turkey. Northern Mediterranean Countries (NMCs): Bosnia-Herzegovena, Cyprus, Croatia, Spain, France, Italy, Greece, Malta, Monaco, and Slovenia. This Report also includes information on Jordan, a non Mediterranean riparian country but participating in the Euro-Mediterranean partnership.

PART 1

Climate change in the Mediterranean: scientific knowledge, impacts and green house gas emissions

CHAPTER 1

Mediterranean Basin: Climate change and impacts during the 21st Century

CHAPTER 2

Review of the Economic Literature on Impacts of Climate Change in the Southern and Eastern Mediterranean Countries

CHAPTER 3

Carbon Dioxide emissions from energy use in the Mediterranean economies: trends and patterns

INTRODUCTION

Part I objective is to assess climate change in the Mediterranean, its physical and economic impacts and also to consider the region's contribution to this global phenomenon.

Chapter 1 analyses scientific results form climate models, the impacts on the natural environment of possible changes and their physical effects on human activities.

Chapter 2 studies the economic impact of climate change in the Mediterranean. From a review of the existing literature, it highlights cost of climate change, as computed by economists.

Chapter 3 depicts the contribution of the region to global climate change through a detailed analysis of greenhouse gas and CO_2 emissions.

CHAPTER 1

Mediterranean Basin: Climate Change and Impacts during the 21st Century

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KEY MESSAGES

Changed in the far distant past and in recent period:

In the Mediterranean, the far distant past has witnessed some major climatic changes (with temperatures which could on average be 8°C below current ones (20, 000 years ago) or 1 - 3°C higher (6,000 years ago). Landscape, fauna and flora and coastal layout were very different depending on the period (due to variations in sea level of several tens of metres). These developments took hundreds if not thousands of years.

The current situation, however, and the one expected to prevail over coming years is marked by the speed of the changes coming about. This factor amplifies the expected impact since relatively rapid developments give ecosystems or societies no chance to acclimatise and gradually adapt. Moreover, we are witnessing meteorological events on an unprecedented scale. In June and July 2007, for example, two extreme heat-waves struck south-eastern Europe, with daily highs of over 40°C/104°F even climbing to 45°C/113°F in Bulgaria.

During the 20th century, air temperature in the Mediterranean basin was observed to have risen by 1.5-4°C depending on the sub-region. Over the same period and with clear acceleration since 1970, temperatures in south-western Europe (Iberian peninsula, south of France) rose by almost 2°C. The same warming effect can also be seen in North Africa, albeit more difficult to quantify given the more patchy nature of the observation system.

Some uncertainties but a set of consensus making the Mediterranean a climate change “hot spot” for the 21 century:

Uncertainty about regional climate forecasts in the Mediterranean basin for the 21st century can largely be attributed to the fact that numerical methods and disaggregation techniques differ from one regional model to the next. Similarly, uncertainty regarding the multiplicity of areas affected is due to the fact that interaction and retroaction between the ‘sphere’ components (physical systems) comprising the climate (including the biosphere) are highly complex.

The conclusions drawn by climate specialists converge, however, on several points of general consensus:

- Even if the European Union’s objective of not exceeding a global average temperature increase of 2°C is met, temperature increases in the Mediterranean are likely to be above 2°C and, because of the ecological and socio-economic characteristics of the areas, the impact will be more marked than in many other regions of the world; The Mediterranean has thus been qualified as the « hot spot for climate change» (Giorgi, 2007).
- A general decrease in average rainfall is expected throughout the Mediterranean basin.
- The most vulnerable areas of the Mediterranean are the north African ones bordering on the desert areas, the major deltas (Nile, Po and Rhone, for example), the coastal zones (both Northern and Southern shores) as well as socially vulnerable areas and those with rapid demographic growth (southern and eastern banks, dense towns and suburbs) (IPCC AR4, 2007).
- The impact of climate change on the environment is already noticeable in the Mediterranean, and is already producing observable effects on human activity.
- Given the uncertainty previously referred to, more optimistic or more pessimistic scenarios (breakdown scenarios with abrupt and rapid change) around the central ones presented here are not to be ruled out.

Thus a consensus has been reached on temperature increase and precipitation decrease in the MB as a whole.

- According the 4th IPCC Report under the scenario A1B, air temperature will increase between 2.2°C and 5.1°C in the Southern Europe and Mediterranean region if the 2080-2099 period is compared to that of 1980-1999 (with some sub-regions differences).
- The same projections assume a decrease for the precipitations between 4 and 27% in the Southern Europe and Mediterranean region (while the Northern Europe region will record an increase between 0 and 16%). An increase of drought periods (associated to land degradation) being declined by an high number of days recording more than 30°C is also expected (Giannakopoulos and al. 2005).
- Extreme event such as heat wawes, drought or floods could be more frequent and stronger.
- As for the sea level trend/change there is still a need for longer time-series from satellite altimetry and for an improved in-situ tide-gauge network to attain robust conclusions. Only a few climatological studies estimate that a mean 35 cm sea level increase could occur during the 21st century.

Water at the heart of the main expected impacts of climate change on the natural environment in the Mediterranean, which are:

- Water: A rapid change in the water cycle due to increased evaporation and less rainfall;
- Soil: A drop in water storage capacity (because of changes in porosity as a result of temperature change, making it drier), accelerated desertification which is already underway (soil over-use and depletion);
- Land and marine biodiversity (animal and plant): A northwards and altitude shift of certain species, extinction of the most climate-sensitive or less mobile species and the appearance of new ones;

- Forests: increased fire hazard and risk of parasites;
- Living beings: animal and human health issues due to repeated thermal stress (heat-waves) and the possible appearance of infectious and parasitic disease in areas not usually affected to date.

Impacts with major direct physical consequences for human activity

Since these impacts add to and intensify the pressures which already exist on the natural environment, their effects are therefore expected to become even more marked over the 21st century which will have major direct physical consequences for human activity.

The water issue, already central to sustainable development concerns in the Mediterranean (particularly to the South) because it is so scarce, will be a key factor through which the effects of climate change on human activity are expected to spread.

The main human activities and areas directly affected by the effects of climate change in the Mediterranean are:

- **Agriculture and fisheries:** Agricultural and fishing yields are expected to drop (as a result of the accumulated conditions related to temperature, rainfall, the state of the soil and the behaviour of animal and plant species). In Morocco, for example, the Cropwat model (FAO, 2001) applied to winter cereal crops under 3rd IPCC report scenarios show yield decreases by 2020 in the order of 10% for a normal year and 50% for a dry one and a 30% drop in national production. In a drier, hotter climate, crops will require more water. It can also be presumed that if fish populations change (through species migration and/or changes to the food chain) to the benefit of species of sub-tropical origin, this will in turn profoundly affect catch value and quantity.
- **Tourism**: The climate is an essential component in the choice of tourist destination. If heat-waves and summer temperatures increase, creating problems with water resources, the Mediterranean regions could end up becoming less attractive than more northern climes. Some estimates suggest that 1°C of warming by 2050 could drive tourist numbers on the southern shores down by 10%.
- **The coastal zones:** Greater exposure of infrastructure to wave action and coastal storms could be cited as one of the most serious effects. The same problems will be faced by port installations (Alexandria, La Golette), lagoon areas (Venice), and deltas (Nile, Rhone). The costliest effects for infrastructure will be the ones related to extreme, intense but short-lived events.
- **Energy:** The energy production sector is the industrial activity most physically affected by the effects of climate change. One consequence of increased hydric stress coupled with the increased frequency of extreme climatic events would be a drop in hydro-electric potential and the cooling potential of thermal plants (reduced yield). The probable increase in the number of extreme events would entail re-scaling or modification (e.g.: dams designed for much higher peak flows than is currently the case …).

The Mediterranean basin can thus be seen as a “laboratory” for assessing vulnerability and impact of climate change and for introducing adaptation and emission reducing measures.

INTRODUCTION

Context

Ibn Khaldun during the 14th Century, promoted better and more extensive knowledge of the political, socioeconomic activities between the East and the West, Europe and North Africa, all 'united' by the Mediterranean basin. His important work was based upon the fact that one thing cannot be understood without the other, and beyond conflicts that did take place around the Mediterranean basin, intense and productive framework of cultural, commercial and human relationships in all direction, were linked no doubt to climate variability/change. The Mediterranean basin (MB) and its riparian countries, solid borders and constantly moving people, can be associated to a so-called 'Liquid Continent' according to the political and cultural writer Bruno Etienne[1].

It should be emphasized that, during the past 50 years, climate change already displayed its 'signatures' onto the Mediterranean Sea. Besides the possible scenarii and impacts presented here, the Mediterranean basin is seen as a natural "laboratory/incubator" to evaluate such changes and forthcoming ones.

The MB is a highly heterogeneous region where natural and anthropogenic activities interact in complex ways with climate variability/change on different spatio-temporal scales with a panoply of multidisciplinary impacts.

The following comments and examples illustrate the complexity of interactions between weather/climate and natural environment: in the Mediterranean Sea, would fast warming conditions enhance the hydrological cycle? There has been a 3% increase of the global recycling rate of water from 1988 to 1994 (Chahine, Haskins and Fetzer, 1997). Warmer dry air advected from Africa (Sirocco) could take up more water vapor over the sea (new results from French meteorologists). If this excess water vapor is over land, the latter could stay cooler (from larger cloudiness and/or enhanced evaporation). The above supposes that the Mediterranean basin will be exposed to enough solar radiation to warm up. This could happen only if cloudiness over the sea remains low over the sea. A high-resolution cloud climatology is therefore necessary for both sea and land. Precipitation must not necessarily increase with an increase in soil moisture[2] only and it might be seasonally dependent.

In the recent past, climate models were not very reliable with respect to simulating the regional impacts of the increasing greenhouse effect on the Mediterranean basin (Cubasch et al., 1996). Things have change considerably since then. The most recent modelling experiments and results have indeed been able to produce invaluable information on finer spatio-temporal scales for Europe and the MB.

In socioeconomic terms, there is a wide spectrum of interactions with climate variability/change and associated impacts. While such complex interactions have been established (IPCC, 4th Assessment Report, 2007), climate change is already having definite impacts on the Mediterranean basin and bordering regions. It is also important to remember that integrated impacts are also due to anthropogenic "local" activities responding to socioeconomic needs and are superimposed to climate change. Those multidisciplinay impacts (directly upon the environment and ecosystems, and/or upon human activities including public health issues) might then be amplified in turn, through non-linear effects.

[1] http://www.lapenseedemidi.org/revues/revue1/articles/19_grenade.pdf

[2] Water stored in/or at the continental surface and available for evaporation. The soil moisture parameter is commonly used in climate models. Today's models, which incorporate canopy and soil processes, view soil moisture as the amount held in excess of plant "wilting point".

This is why time has come for planning long-term sustainable development and adaptation for countries within the Mediterranean basin at local, national, and subregional levels. Assessing MB climate projections for the 21st century (from past studies or hindcasting, nowcasting and forecasting using latest downscaled models) along with associated multidisciplinary impacts has thus become of utmost importance.

<u>Objectives</u>

The objectives of this report are to 1) review all recent results and knowledge on climate change in the MB and to evaluate and disseminate latest input on projected climate change in the MB during the 21st century.; 2) impacts from climate change on the environment and natural ecosystems and linkages with human activities are also to be evaluated, since important socioeconomic adaptation measures are expected.

<u>Data Sources and Methodology</u>

Data and results on climate change include analyzes from paleoclimatology studies and proxies. Latest statements from the IPCC report (AR4) are also included. Climate projections for the 21st century are from global and regional climate models including those from ARPEGE-IFS. Selected results are from the main IPCC scenario: A1B, B1, and A2. Impact analyses and results are based upon multidisciplinary and sectoral applied research. Finally, results concerning post-Kyoto and from the Bali Conference are also presented.

<u>Content</u>

More specifically, issues on global climate change and linkages with regional signatures particularly over the Mediterranean basin (MB) will be presented in Section I, by using results (including uncertainties) going from general circulation models to regional (downscaled) climate models. Specific downscaling and spatio-temporal issues (geography, topography, population feedbacks) for the Mediterranean will be also discussed. Based upon historical climate (diagnostic and proxy studies) and present state of the climate, MB scenarii will be proposed for parameters such as temperature, precipitation, sea level changes (as observed from space). Based upon scientific and ongoing monitoring results, specific and regional climate projections will be proposed for the middle and the second part of the 21st century.

In Section II the multidisciplinary impacts, re-grouped in two sub-sections (environmental and human activities) will be presented, namely: a) hydrological, ecosystems and biodiversity; b) agriculture (food security), infrastructures and coastlines, and public health. At the end of sub-section b, linkages between impacts, policy and adaptation measures will be discussed.

I. PROJECTED CLIMATE CHANGE IN THE MEDITERRANEAN BASIN DURING THE 21ST CENTURY

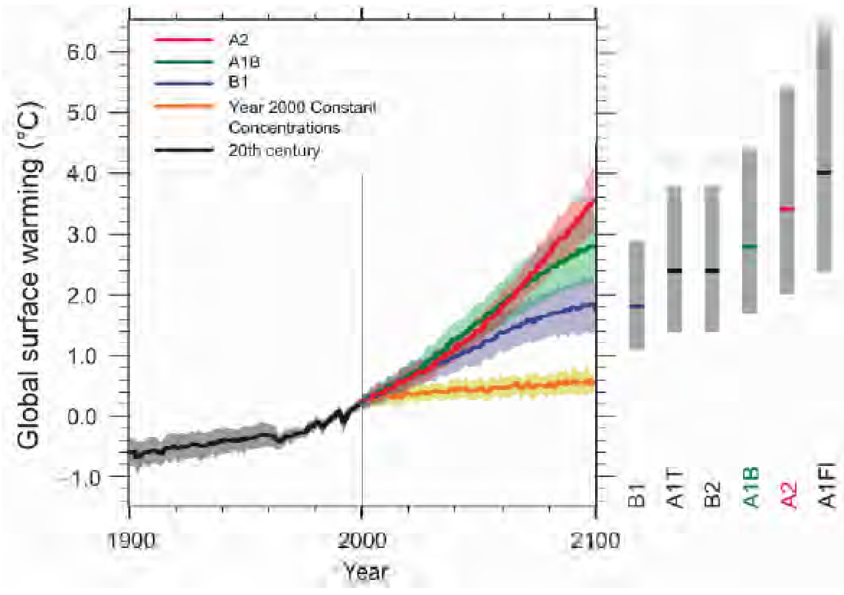
In this Section, the climate change projections for the MB are presented in two ways: overall evolution over the MB of physical parameters such as temperature, precipitation, sea level using latest results from global and regional (downscaled) modelling remote-sensing technology, then more specific/detailed projections for the middle and the second part of the 21st century. The latter is to be provided to be used by decision/policy makers and stakeholders at all levels for putting in place the best mitigation and adaptation procedures.

1. FROM GLOBAL TO REGIONAL SCALES

The global influence of greenhouse gases (GHGs) is rather well known and results in an average warming of the earth's surface. More than a century ago, the Swedish researcher Svante Arrhenius (1859-1927, Nobel prize winner in 1903), rightly suggested that our planet could be additionally warmed due to an anthropogenic increase of carbon dioxide concentration in the atmosphere. The earth's radiative balance also needs to be taken into account, since the changing albedo from various ground and clouds coverage, absorption of energy by water vapour, aerosols, play a fundamental role in terms of energy balance. GHGs include a lot of gases such as water vapour (the most efficient one in terms of blocking infra-red radiation from planet earth), carbon dioxide and ozone, methane among others, and the observed influence from anthropogenic activity on GHGs' concentration is sometimes difficult to model.

Political, industrial and commercial interests, as well as public opinions may shadow the debate on global climate change issues. Whilst a wide range of viewpoints is issued, scientists have a major responsibility in terms of addressing those issues and quantifying associated uncertainties. At the beginning of the 21st century, it is interesting to evaluate the latest IPCC report (Fourth Assessment Report or AR4, 2007) with the difference based upon six emissions scenarii. The multi-model averages and six assessed ranges for surface warming are presented in Figure 1 (IPCC Report, 2007).

Figure 1 - Multi-model averages and assessed ranges for global surface warming (°C) during the 21st century



Following six IPCC keys scenarii, namely: B1 (blue), A1T, B2, A1B (green), A2 (red), A1F1. The orange time-series assumes concentration from Year 2000 onward

Source: see IPCC Report, 2007, for details

By the end of that century, a spread for values of averaged surface air temperature increase exist among the six scenarii considered, ranging from nearly 2°C for the lowest scenario (so-called B1 and A2, with a likely range of 1.1°C to 2.9°C) and about 4°C for the highest scenario (so-called A1F1, with a likely range of 2.4°C to 6.4°C). The scenarii rely upon hypotheses, evaluating population growth, economic and trade activities, and energy consumption. For a medium scenario (so-called A1B), the best estimate is 3.4°C (with a likely range of 2°C to 5.4°C). The ranges are due to relatively poor understanding of physical mechanisms which include feedbacks from the carbon and carbon dioxide cycles. Interestingly enough addition of feedbacks in global circulation models (GCMs), provides higher values on uncertainty ranges. Also the globally averaged warming values presented through the different scenarii seemed small (last ice age was only about 5°C colder than present). But a relatively small change in average temperature can result in much greater intensity of extreme weather events, through non-linear interactions. It is those extreme weather events (climate related) that produce many of the significant regional and local impacts that affect human society as a whole. For example, it is very likely that heatwaves will increase in intensity (possibly frequency and duration), while heavy precipitation (lack thereof) events will be distributed differently from know climatology. These projected changes in extremes will continue contributing to trends which are already observed. Projection from global assessment/analysis becomes quite complex when it is to be regionally downscaled to the Mediterranean basin (von Storch et al*.,* 1993; Giorgi et al., 1992; Conway and Jones, 1998; Räisänen et al., 1999). Early-on, these assessments were the purposes of the ECLAT-2 [3] and ACACIA [4] European projects (Parry, 2000). Scientific conclusions with managerial/impacts issues had been thus presented to the French GICC[5] project.

One way to classify global climate change issues applied to the Mediterranean basin could be:

- What is the regional contribution of GHGs to energy equilibrium?
- What are the regional and local anthropogenic spatio-temporal evolutions?

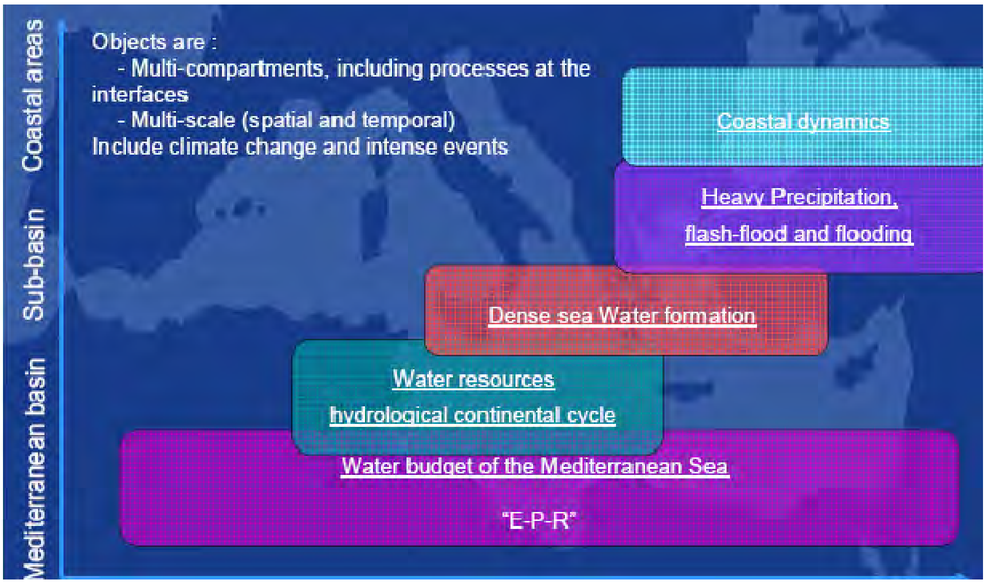
In addition, downscaling from GCMs to regional Climate Models (RCMs) and local spatio-temporal scales presents a scientific challenge in itself, since the MB represent high degrees of complexity, including processes which might be more difficult to apprehend. In (Figure 2) sea-atmospheric interactions and spatio-temporal complexity are highlighted (abscissa represents time scales from century to extreme events time scales including quasi-decadal and seasonal variability; adapted from HYMEX, 2007). Also understanding the MB climate change and the regional 'global carbon cycle' remains a challenge. Carbon stocks in known reservoirs and carbon flows between the latter and relevant to the anthropogenic perturbation are difficult to assess (Schimel et al., 1996). For example it is often assumed in 'balancing carbon flux' computation that the net ocean carbon uptake of the anthropogenic perturbation equals the net air-sea input plus runoff minus sedimentation (Sarmiento and Sundquist, 1992). Finally the important anthropogenic activity per-se in the MB is to greatly influence the so-called 'natural climate state' of the basin itself.

3 "A Concerted Action towards the Improved Understanding and Application of Results from Climate Model Experiments on European Climate Change Impacts Research". A secondary objective is to keep EU research into the climate change abreast of developments in climate modelling and informed about the availability of results from new climate change experiments performed in Europe and worldwide.

4 "A Concerted Action Toward a Comprehensive Climate Impacts and Adaptation Assessment for the European Union".

5 "Gestion et Impacts du Changement Climatique". French initiative on climate change and multidisciplinary impacts.

Figure 2 - Sea-atmosphere interface processes and associated spatio-temporal scales for the Mediterranean basin



Spatial scales are on the ordinates going from basin scales to coastal areas, whilst temporal scales on the abscissa going from century, decadal, seasonal, to extreme events (

Source: adapted from HYMEX, 2007

2. MODELLING ISSUES FOR THE MEDITERRANEAN BASIN

2.1. Global and regional climate modeling

While GCMs are meant to deal with global issues, each one presents limitations for regional applications. Indeed, some processes and physical mechanisms in the atmosphere, ocean and on land occur at much smaller scales (such as ocean-atmosphere wave propagations). GCMs may of course be improved (i.e., better parameterization of advection, subduction in the ocean…), but they will always have intrinsic limitations. Moreover, when applied to regions for impact studies, they do not always include pertinent information for a given geographic scale. For example, southern Italy or Sicily, are not well represented in most global climate models, while the representation of major mountain ranges (such as the Alps or the Atlas mountain ranges) which directly influence regional climate, is over-simplified.

2.2. Using and improving RCM

When dealing with the Mediterranean basin, where the typical resolution ranges from kilometers to tens of kilometers, RCMs must be used. These models can have a resolution of 50 km x 50 km over the region of interest, and are sometimes downscaled to 10x10 km, though over limited areas. RCMs in the Mediterranean basin are being developed. Some are forced by the thermal state of the sea, while fully coupled models will have to adequately describe the deep oceanic convection and the variability of the important THC (i.e., at first on seasonal and inter-annual time scales).

Improving RCMs is an active research field for the Mediterranean basin. According to Somot (2005), important factors to optimize and improve the quality of an RCM over the Mediterranean basin are:

- Improving understanding and simulation of the THC using ARPEGE-Climat and NEMO , and computing air-ocean fluxes;
- Identifying the systematic errors of the models, running simulations over several years or decades and testing the sensitivity of the model (feedbacks);
- Choosing specific regions forced by output from ERA40;
- Evaluating uncertainties and the spatio-temporal dependencies of the model;
- Quantifying global climate change impacts on bio-chemistry;
- Understanding and reproducing linkages between at least the Atlantic Ocean and the Mediterranean basin.

Validation will of course be a critical step when comparing results with other RCMs at least. Past RCM inter-comparison studies were conducted over Europe by Christensen et al. (1998) and led to a good simulation of the air temperature increase (with nevertheless a +/-2°C standard deviation), except over south-eastern Europe including the Mediterranean basin during summer..

3. FACTS ON CLIMATE CHANGE

3.1. Paleoclimatology and proxies

In order to refer to past climate conditions without instrumental measurements, scientists have used natural environment records (or "proxies" such as tree rings, coral growth, isotope ratios…). Recent climate changes in the natural record gathered using proxy data can thus be calibrated using the 140-year global time-series of sea level pressure and sea surface temperature (Kaplan et al., 1998). To understand and predict potential upcoming changes in the climate system, a more complete understanding of seasonal-to-century scale climate variability and diagnostic studies are necessary (Tourre and White, 2006). Some studies have indicated that the earth has warmed by 0.4°C to 0.8°C from 1860 to the present. It is interesting to evaluate the interactions and feedback mechanisms between low-frequency climate oscillations (such as the multi-decadal signal, among others) and that due to anthropogenic activities and the industrial revolution.

Physical laws are independent of time. Thus, any model which can be used to predict future climate can be checked "backwards" using paleoclimate records (so-called hindcasting). Such an invaluable validation can help answer questions such as:

- Why is the last century climate change unprecedented when compared to changes during the last 500, 2000 and 20,000 years?
- Do recent global temperatures represent new highs?
- Why is the recent rate of global climate change unique?

IPCC is greatly indebted to paleo-climatological findings for the consolidated information edited in its 2007 reports (AR4). These findings will be very useful for a better understanding of future climate change scenarii in the Mediterranean basin.

3.2. Past Mediterranean climate

(PMIP[6]), which had a double objective:

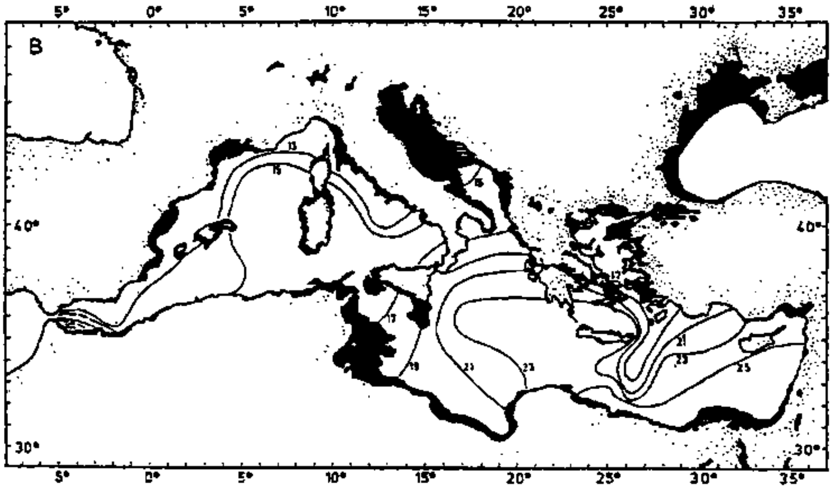
Analyze the natural climate variability at a multi-millennium scale in order to estimate anthropogenic impacts, and ii) test climate model sensitivity by using regimes different to the present one (Joussaume et al., 1999).

Twenty thousand years ago, cold steppes (with sparse forests) extended from the south of Spain to Caucasus. In the northern part of the Mediterranean basin, the temperature of the coldest month was 15°C lower than it is today (Peyron et al., 1998). Less water was available for vegetation. Modelling results tend to underestimate the winter coolness (-5°C instead of -15°C) and the dryness during the vegetation growing period, which can be attributed to a poor knowledge of the past thermal state of the Mediterranean Sea.

6 PMIP (Joussaume and Taylor, 2000): an international project involving members of all the major climate modeling groups worldwide under the auspices of the World Climate Research Programme (WCRP) and the International Geosphere-Biosphere Programme (IGBP).

Much more reliable results may be obtained 18,000 years ago (see Figure 3, where isotherms and coastal areas are depicted; from Doumenge, UNU lectures, 1997) or during the mid-Holocene 6,000 years ago. Vegetation and climate maps from that period were issued (Cheddadi et al., 1998). The deciduous and mixed forests, which progressively extended north-eastward, were also present in the Maghreb and in the Sahoura Valley, for example. The climate was warmer (+1°C to +3°C during winter), whilst more water resources were available for vegetation growth (an estimated 8% to 15%). Models evidenced a more contrasted seasonal situation than the current one, with hotter summers (+2°C), and colder winters (-1°C to -2°C), leading to similar mean yearly temperatures. Nevertheless, the models also tend to underestimate the rainfall pattern increase. A 1°C temperature increase could cause a mean 100-km vegetation shift towards the north. When simulations based upon a 2°C temperature increase and a doubled CO_2 concentration were made (Cheddadi et al., 1998), results did not simulate an extension of the arid Mediterranean zones in the northern part of the basin, but rather a development of the deciduous forest, as during the Holocene.

Figure 3 - The Mediterranean basin 18,000 years ago. Isotherms in °C are displayed (solid lines) and dark coastal zones depict the coastal line at that time



It is seen that the Eastern Mediterranean (EM) was much warmer than the western basin (by ~ 8°C), and the extent of the Adriatic Sea was extremely reduced at that time

Source: Doumenge, UNU, 1997

The above comparisons show that anthropogenic activities cause climate changes not only comparable to natural ones, but on a much faster timescale. Such impacts from human activities during the past 300 years will be studied using datasets from the BIOME 300[7] project, an initiative by PAGES (Past Global Changes, a core project of the International Geosphere-Biosphere Programme IGBP) and LUCC (Land Use Land Cover Change). It is to reconstruct global land cover/land use over the past 300 years, using both historical and pollen data (Thomson, 2000). Interestingly enough the first hydrothermal vents had been discovered through the JASON exploration project (from the Kleberg Foundation) in 1989.

[7] BIOME 300: A PAGES (Past Global Changes, a core project of the International Geosphere-Biosphere Programme or IGBP) and LUCC (Land Use Land Cover Change) initiative, aimed at reconstructing global land cover/land use over the past 300 years, using both historical and pollen data.

4. CLIMATE CHANGE PROJECTIONS : RECENT RESULTS

In the following it is difficult to present results based only on latest available results and climate projections using only one IPCC scenario. So a blend of results using the A1B, B1, and A2 more 'conservative' IPCC scenarii are presented from different research teams, with some consensus being highlighted at least in terms of changes in the rainfall regimes.

4.1. Overall regional scenarii

In 1996, J.P.Palutikof and T.M.L Wigley (Climate Research Unit, or CRU of East Anglia University), published a synthesis of available scenarii for climatic change in the Mediterranean basin. Using four downscaled GCMs: the UKMO - Meteorological Office model, the GISS (Goddard Institute of Space Studies) model, the GFDL (Geophysical Fluid Dynamics laboratory) model, and the OSU (Oregon State University) model. Since then, additional studies for recent changes and potential causes of large-scale and regional circulation indices have been explored over Italy, the Iberian Peninsula and Greece (Brunetti et al., 2001; Goodess and Jones, 2002; among others). In general, and since the seminal work by Palutikof and Wigley, the main objectives had been to investigate how the characteristics of daily rainfall and the occurrence of temperature extremes have changed over a Mediterranean transect from the Iberian Peninsula to Greece during the second half of the 20th century (i.e. the period when NCEP reanalysis data is available). The roles of the global variability/changes of climate indices such as the AO, AMO, NAO, NAWA (see Box n°1) atmospheric humidity, mean surface temperature, among others were investigated to see if empirical relationships could be derived in terms of rainfall input and temperature extremes. And finally would the above variability/changes coincide with GCM and RCM projections, taking into account anthropogenic climate change?

The emphasis of the completed work by Goodess and Jones (2002) is on rainfall (in particular, trying to explain the complex patterns of change in rainfall probability and intensity) rather than temperature, and on the Iberian Peninsula and Greece rather than Italy (for which a number of papers have recently been published by Italian researchers, based on a much denser network of stations. Even if it is shown that changes hide a more complex picture than could be expected, the integration from the above analyses and results can be used to establish scenarii for specific regions in the Mediterranean basin.

Mediterranean climate in a global context

The climate of the Mediterranean basin interacts with other parts of the world. It is directly linked to the Atlantic ocean through its '14 km umbilical cord', so that its full-body water is entirely renewed every ~100 years. The winter Arctic Oscillation[8] (AO) or Northern Annular Mode[9] (NAM), which have signatures on the northern Atlantic Ocean (North Atlantic Oscillation[10], or NAO), the Atlantic Multidecadal Oscillation (or AMO) and thermohaline circulation (THC, see footnote 14), and the Indian/Asian monsoons are also linked to Mediterranean climate indices such as the Mediterranean Oscillation (MO) and the North Africa Western Asian[11] (NAWA). Changes in the phase of the NAO are associated with storm track locations over the Mediterranean basin and observed eastern Mediterranean (EM) rainfall anomalies. Indeed, large-scale northern Atlantic atmospheric mass re-arrangement, primarily a modulation of the Icelandic low and the subtropical high pressure systems, tend to extend over the Mediterranean basin. For example, sea level pressure anomalies over Greenland–Iceland are thus associated with reversed-polarity anomalies centered over the northern Adriatic; elevated Greenland sea level pressure is accompanied by anomalous cyclonic activities over the Mediterranean, and a Mediterranean high pressure system is present when pressure over Greenland is reduced. In the EM, these anomalies result in anomalous southerlies during Greenland highs, and northerlies during Greenland lows (Eschel and Farell, 2000; Tourre and Paz, 2004). The modified large-scale circulation not only brings different climatic 'regimes', but also generates changes in the interactions between different scales of motion down to land-sea wind and mountain induced circulation systems. This in turn affects rainfall patterns and the partitioning of energy at the surface. These processes are also responsible for the large inter-annual variability of the regional 'Mediterranean climates'. The NAO is displaying more positive phases since the mid-to-late 70s which could be one of the Atlantic signatures of global climate change (Tourre and Paz, 2004). Finally, the NAWA index has a direct relationship with African/Sahelian precipitation rates (Öszoy et al., 2001; Paz et al., 2003; Tourre et al., 2006; Suŝelj and Bergant, 2006, among others).

4.1.1. Temperature scenario

The projected globally averaged temperature increase is reflected by complex regional and local patterns of regional precipitation/drought changes (see next section on rainfall scenario). This might explain why the regional temperature variation range from 0.7°C to 1.6°C evidenced (for a 1°C mean global temperature increase) is somewhat smaller than the 2°C increase from the global scenario. On the northern Mediterranean rim, a sharp transition zone is evidenced between small/large variations over the sea/inland. During winter, the regions over which temperature anomalies seem larger than the mean global temperature anomaly cover wide areas of the Iberian Peninsula and the EM. During spring, the opposite situation dominates. It is worth noting that these two regions are directly influenced by the NAWA index (Figure 4, from Paz et al., 2003). In Figure 3, large dots represent the grid-points associated with the NAWA poles as identified by Paz et al. (2003). Note that the EM is basically at mid-distance between the two poles, thus directly influenced by changes in temperature and moisture availability linked to atmospheric pressure gradients (see also Rimbu et al., 2001)..

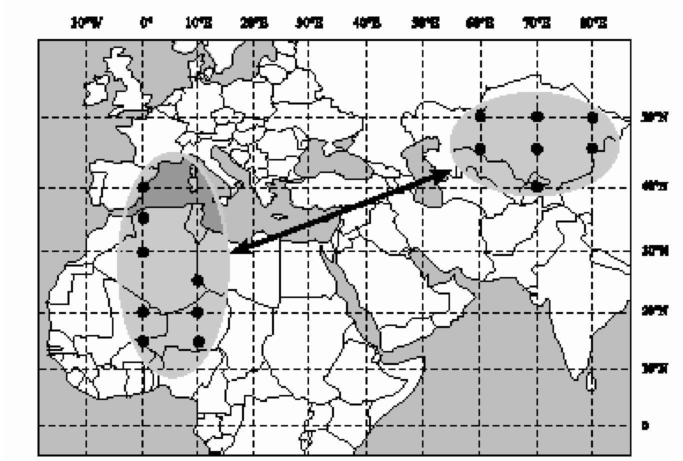
8 The winter Arctic Oscillation (AO) is linked to an atmospheric pressure pattern over the polar regions which varies in opposition with that over middle latitudes (~45° N), on time scales ranging from weeks to decades. The oscillation extends through the depth of the troposphere. It extends upward into the stratosphere where it modulates the strength of the westerly polar vortex.

9 A broader, hemispheric-scale NH annular mode associated with tropospheric pressure differences between the polar regions and the mid-latitudes. The AO and NAM are different ways of describing the same phenomenon.

10 Thompson and Wallace (2000) have argued that the NAO, or a difference in normalized sea level pressure between the Azores and Iceland, is not a regional North Atlantic phenomenon in its own right, but rather the local signature of the NAM.

11 NAWA is the normalized sea level pressure difference between North Africa (NA) and West Asia (WA) as defined by Paz et al. (2003). See also linkages between NAWA and AMO (Paz et al., 2008).

Figure 3 - The North Africa - West Asia (NAWA) index: large dots within key ovals represent the two NAWA poles as identified by Paz et al. (2003)



Note that the EM is basically at mid-distance between the two poles (dark double arrow), and is thus directly influenced by changes in temperature and moisture availability linked to large-scale atmospheric pressure gradients

Source: Rimbu et al., 2001

During fall, a large area displaying strong sensitivity to global climate change has been evidenced and includes parts of southern France, Spain, and northwest Africa (a 1.3°C temperature increase compared to a mean 1°C global temperature increase).

Based upon control run experiment (MC) and results from Mediterranean scenario (MS), detailed SST (in °C), 3-D averaged temperature (T3D in °C), sea surface salinity or SSS (in psu) at the end of the 21st century are given for the Mediterranean Sea and four of its sub-basins (Table 1). Observed values (OBS) are from the MEDATLAS-II database (MEDAR/MEDATLAS Group, 2002), and in parentheses from Smith et al., (1996). Values with * mean that the MS-MC difference is statistically significant at the 95% significance level (after Somot, 2005). SST and SS are seen to increase everywhere, with larger values for both SST and SSS found in the Levantine basin.

Table 1 - Sea-Surface Temperature (SST, in °C)

Basin	*Mediterranean Sea*		
°C or psu	*SST*	*T3D*	*SSS*
OBS	19.7 (19.5)	13.7	38.16
MC	18.7	13.2	38.18
MS	21.7 *	14.4 *	38.61 *
Basin	*Gulf of Lions*		
OBS	17.7 (17.5)	13.0	37.90
MC	16.8	12.4	37.98
MS	19.8 *	13.7 *	38.34 *
Basin	*Levantine Basin*		
OBS	21.4 (21.0)	14.0	39.06
MC	20.1	13.7	39.04
MS	23.3 *	14.7 *	39.47 *
Basin	*Adriatic Sea*		
OBS	17.7 (17.9)	13.8	37.76
MC	17.0	13.0	38.43
MS	20.2 *	15.7 *	39.19 *
Basin	*Aegean Sea*		
OBS	18.9 (18.7)	14.8	38.32
MC	17.9	13.9	38.44
MS	21.1 *	16.0 *	39.31 *

3-D averaged sub-surface temperature (T3D, in °C), sea surface salinity (SSS in psu) at the end of the 21st Century for the Mediterranean basin and sub-basins.

Source: The MEDAR/MEDATLAS Group, 2002

4.1.2. Rainfall scenario

Variables such as precipitable water and specific/relative humidity (as selected predictors for the models) are all shown to have decreased over the studied period and are positively correlated with decreased rainfall over the Iberian Peninsula and Greece. Nevertheless, some models are found to underestimate year-to-year variability, with problems in reproducing the observed trends when Spain and Greece are compared. This means that different underlying physical processes are at stake, and further investigation on downscaled processes is required. The pattern of future precipitation change indicates likely increases at higher latitudes, and decreases over subtropical land areas. Over much of the Mediterranean basin the general tendency is towards decreasing rainfall, with complex patterns particularly with respect to extremes (rainfall amount in quantiles). While over most of the Iberian Peninsula, for example, there is a trend towards more rainy days. However, in southeast Spain, the reverse is occurring, with high rainfall amounts. Over Greece, the main tendency is towards fewer rainy days, with little change in daily rainfall amounts (strongest effects over the Ionian and Aegean Seas during the wintertime). The rainfall changes observed over the Iberian Peninsula can, in part, be explained by changes in atmospheric patterns and circulation over the Atlantic. They are associated, for example, with a decrease in the frequency of cyclonic circulation types and increases in the frequency of anticyclonic circulation types and blocking (which could be linked to changes in the phase of the NAO and NAWA indices, see Tourre et al., 2006). The observed changes in circulation-type frequency over Greece indicate an overall increase in rainfall amount in winter, in contrast to what is observed elsewhere. This is true even if variables such as precipitable water and specific/relative humidity had decreasing values during the last 50 years. However, adding such parameters and their variability as predictors into regression models makes little difference. All models are found to underestimate the year-to-year variability and trends, and as such cannot be used for future projection, particularly at the regional scales. This also implies that underlying physical processes and mechanisms might be a function of the region under study. Differences between the Iberian Peninsula's two regions require further investigation.

4.1.3. Sea Level Scenario

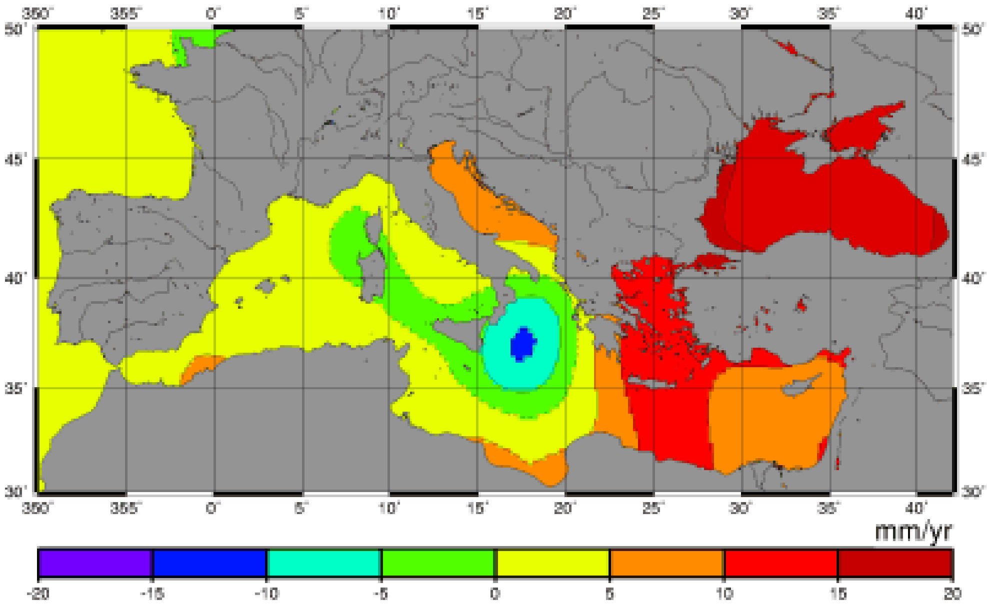
Rising global temperatures are very likely to raise the sea level by expanding ocean water and melting mountain ice caps and glaciers. Very recent results observed that ice sheet dynamical processes from Antarctica and Greenland could produce potentially larger contributions to sea level rise than accounted and are not fully included in models used for the IPCC AR4 report. Based on the existing models available for assessment, the central values for projections of sea level rise by 2100 range from about 30 to 40 cm, and about 60% of this increase would be due to the thermal expansion of sea water. There is less certainty with regards to the other components of sea level rise including the dynamic ice flow contributions from Greenland and Antarctica. This is an area of great concern, given the potential regional consequences (including changes in the Atlantic THC[12]). The rapid rate in ancient times remains relevant. It "offers a warning" to climate scientists that sea level changes can depend strongly on factors that influence ice formation and melting factors, somewhat underestimated by IPCC AR4 (Rohling et al., 2008). The per-century rate of 0.6 m predicted by models could be 1.0 m less than the new findings of Rohling's team. These differences clearly identify the need to improve Mediterranean climate models, in order to reflect additional impacts from glaciation and melting associated with anthropogenic climate change.

The Mediterranean Sea displays rugged coastlines indented into several smaller seas: Adriatic, Aegean, Alboran, Ionian, that require high-resolution observations for complete analyses. Altimetry from space (i.e., the TOPEX/Poseidon program launched in December 2001) has supplied

[12] THC or thermohaline circulation is the global density-driven circulation of the oceans, a function of temperature and salinity.

scientists with time-series of exceptional quality for the study of global sea level variations. For example, it has been found that most of the temperature variations cause most of the overall steric sea level change in the upper 400 m of the Mediterranean Sea (MEDAR[13] datasets). Between 1960 and the 1990s, cooling of the upper waters of the Eastern Mediterranean caused a reduction in the steric heights, while after 1993 warming caused the sea level to rise. The steric sea level changes in the upper waters of the Adriatic and the Aegean Sea seem also to be correlated with the NAO. Nevertheless the anomalous signals are weak (about 1-2 mm/year) and great care must be used before data interpretation. For example, Cazenave et al. (2001) found that the steric effects have a very small contribution to the observed rapid sea level rise in the EM. This suggests that the oceanic circulation changes linked also with the Eastern Mediterranean Transient (i.e., changes in the deep water formation region from the Adriatic Sea to the South Aegean) could be associated with observed recent changes (rapid sea level rise in the EM since the mid-90s). For the time being, the comparison between the steric sea levels and coastal tide-gauges is unsatisfactory. This discrepancy questions both the practice of estimating basin-wide sea level changes from point measurements and the use of steric height variations as measures of sea level variability. Moreover the diverse behavior of the EM at sub-basin scales questions the meaningfulness of climatic basin averages (Tsimplis and Rixen, 2000). This of course deserves further investigation in the climate change context. In the meantime, there is a constant need for continuous altimetry data for several decades in order to minimize uncertainties as presented above and get more insights into the physical processes linked to sea level variability/change. One of the goals of the Jason-1 satellite, which is celebrating its five years in orbit in December 2006, is to observe sea level variation with millimeter accuracy. Figure 5 shows the Mediterranean sea level changes during the first seven years of TOPEX/Poseidon (from LEGOS-GRGS-CNES laboratories and organizations).

Figure 4 - Mediterranean sea level changes as observed during the first seven years of the TOPEX/Poseidon project



Changes are in mm/yr from negative values (dark blue to dark green) to positive values (from light green to dark red). The east-west change is conspicuous, with a definite sea level increase tendency over the EM

Source: LEGOS-GRGS-CNES

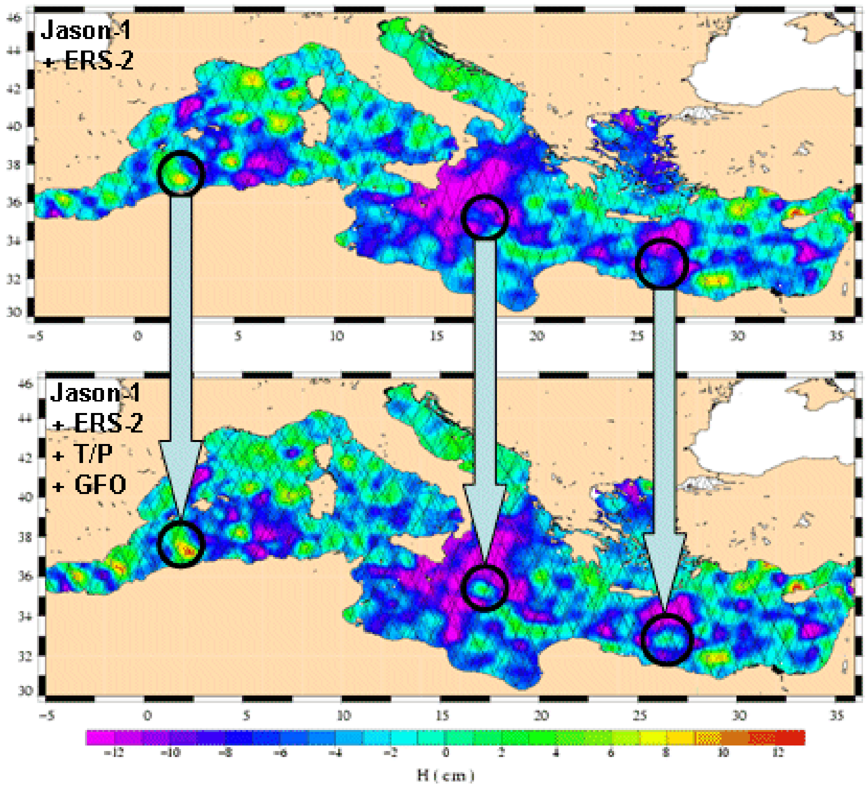
Rising sea level during the 21st century is expected to destroy areas where sand belts are essential for the protection of lagoons and low-lying reclaimed lands. The impacts can be very serious in Egypt where 1/3 of fish catches are from lagoons. Sea level rise would thus change the water quality and

[13] MEDAR datasets: provide annual 0.2 x 0.2 temperature and salinity fields for 25 levels in the Mediterranean Sea.

affect most fresh water fish. Valuable agricultural land would be flooded as well, threatening Alexandria and Port Said. Recreational tourism beach facilities are to be endangered with salination of groundwaters and increasing wave actions.

In-situ monitoring GPS buoys have been deployed under Jason-1 ground-tracks in the EM (Ionian and northern Aegean Seas) to minimize uncertainties in monitoring the sea level. These buoys provide instantaneous sea surface height (SSH) underneath the track, and specific evolution of mesoscale eddies (Figure 6). They also contribute to the validation and calibration of the radar altimeter data (Limpach et al., 2006). This is how, by studying the Ionian Sea off the tip of Italy and during the first seven years of operation, it was found that the sea level fell (see Figure 5). Mechanisms and potential socioeconomic impacts from such changes deserve further investigation. Using four satellites with altimetry capabilities (Jason-1, ENVISAT or ERS-2, TOPEX/Poseidon, and GFO), resolution of SSH measurements has been greatly enhanced. Three satellites are needed to observe eddies and mesoscale phenomena in the Mediterranean basin (see Figure 6). Continuity of such observations is a pre-requisite in a climate change context. The launching of Jason-2 is planned for 2008 (a joint-venture between CNES, Eumetsat, NASA, and NOAA).

Figure 5 - From the use of four altimetry satellites



Jason-1, ENVISAT or ERS-2, TOPEX/Poseidon (T/P), and GEOSAT Follow On (GFO), resolution of sea surface height (SSH) measurements has been greatly enhanced. Satellites are needed to observe small-scale phenomena such as eddies and mesoscale in the Mediterranean basin. Continuity of space monitoring (combined with in-situ measurements) is a pre-requisite for detailed assessment of sea level changes in a climate change context. The launching of Jason-2 is planned for 2008

Source: Joint-venture between CNES, Eumetsat, NASA, and NOAA

It is worth noting that models have been developed to run climate scenarios for given countries. For example, MAGICC/SCENGEN[14] uses a one-dimensional model of climate and allows a user to

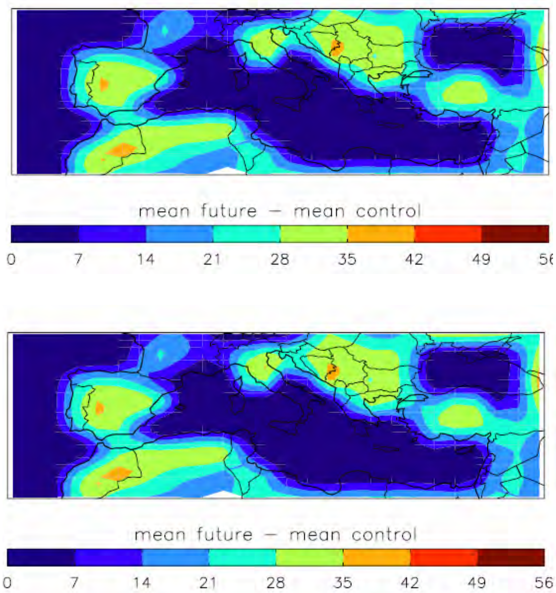
[14] MAGICC/SCENGEN: A user-friendly software package that takes emission scenarii for GHGs, reactive gases, and sulfur dioxide as input and gives global mean temperature, sea level rise, and regional climate as output. MAGICC is a coupled gas cycle/climate model. It has been used in all IPCC reports to produce projections of future global mean temperature and sea level change.

select regional/national emission scenarii, climate sensitivity, time scales and other factors (Wigley, 2005). The MAGICC component estimates change in global mean temperature and sea level rise. The SCENGEN component uses the global mean temperature output from MAGICC, to scale up the results from GCMs and give regional output on temperature and precipitation on a 5 x 5° grid. MAGICC/SCENGEN also allows a user to compare average changes in temperature or precipitation simulated by different GCMs. This is an indication of whether or not the models are in agreement on the direction of change. The model can be obtained at http://www.cgd.ucar.edu/cas/wigley/magicc/.

4.2. Projections in the Mediterranean basin: 2025-2050 horizon

Giannakopoulos and al. predict for the 2025-2050 period (average values under A1B, B1 and A2 scenarii, with different uncertainty ranges)the following changes (see Figure 7, Table 2) the number of summer days with temperatures higher than 25°C (top); the number of summer days with temperatures higher than 30 °C (bottom). In Table 2, four levels of temperature and rainfall changes (large to none) in the Mediterranean basin from a 2°C global temperature increase are given. Note the slanted black oval which depicts large temperature changes in the Mashriq (adapted from Giannakopoulos et al., 2005).

Figure 6 – (top) Number of summer days with temperatures above 25°C; (bottom) Number of summer days with temperatures above 30°C.



It is readily seen that for both the increase in the number days higher than 25° C and 30° C are around the Mediterranean basin, with values between 35-42 days above the Iberian Peninsula, the Maghreb, and over Bosnia Herzegovina/Serbia

Table 2– Temperature and rainfall extremes in countries from the Mediterranean basin

	HIGH TEMPERATURE					LOW TEMPERATURE			RAINFALL			
	Summer days	Hot Days	Tropical Nights	Days> 90 quantile	Nights> 90 quantile	Frost Nights	Ice Days	Days< 10 quantile	Relative Var.	Dry Days	Rain 1-10 mm	Max. 3-day Rain
NW Iberian Peninsula	1	1		1	1	-1		-2		2	-2	3
South of France (Inland)	3	1	1	2	2	-1		-2	-1	3	-2	3
Coast Southern France	1		2	2	2	-1		-2	-1	2	-2	3
Corsica	1	1	2	2	2	-1		-2	-1	2	-1	2
Sardenia	1		3	2	2			-3		2	-1	1
Sicilia	3		3	3	2 3			-3		3	-1	3
N. Adriatic	3	3		2	2	-2	-1	-2	-1	3	-2	1 2
Central Balkans	3	3		2	2	-2	-1	-2		3	-3	
Central Greece	2	1	2	2	2	-1		-2	-1	2	-2	1
Peloponese	3		3	2	2			-3	-1	2	-1	2
Crete	3		3	3	3			-3	-1	2	-1	
Coastal Turkey	1 2	1	1 2	2	2	-1		-2	-1	2	-1	-1 2
Turkey Inland	3	3		2	2 3	-2	-1	-2		3	-2	
Cyprus	1		3	1	1			-3	-1	1	1	
Lebanon/Israel Nile Delta	1	1	3	3	3	-1		-3	(2)	1	-1	
E. Egypt E. Lybia	3	1	3	2	3			-3	(2)		-1	
W. Lybia	3	1	3	2	3			-3	-3		-1	
E. Maghreb	2	3	3	2	2	-2		-2	-3	2	-2	
W. Maghreb	3	3	3	2	2	-2		-2		2	-2	-1
South Iberian Peninsula	2	2	2	2	2	-1		-2	-1	2	-2	
Central Spain	3	3	1	2	2	-2		-2	-1	3	-2	-1

Large Change =at least 1 mth duration
Moderate change = 2-3 wks duration
Small Change= 1 week duration
No Change

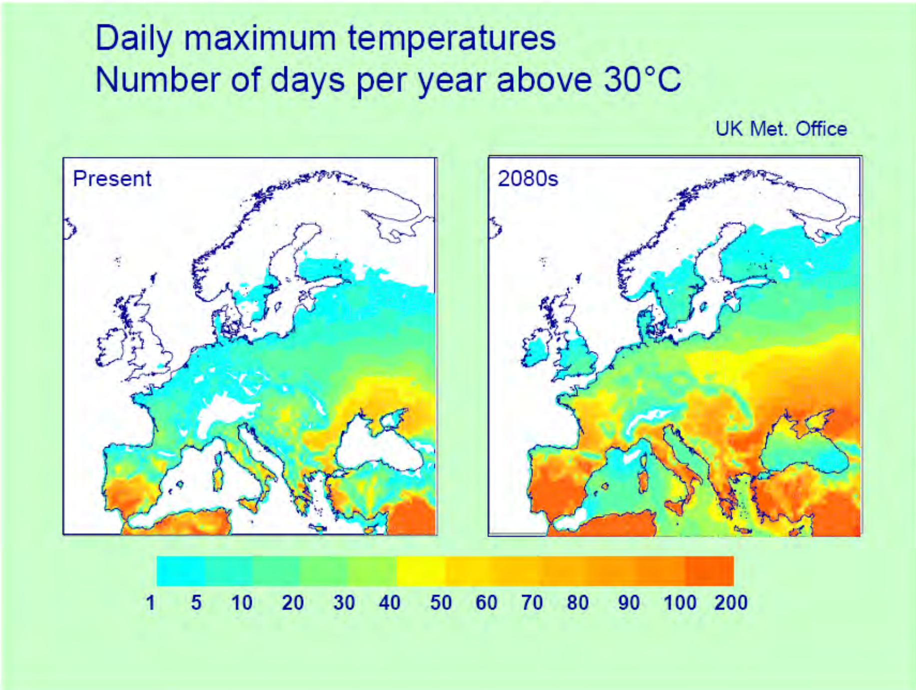
Assuming a "conservative" global 2°C temperature increase during the 21st Century. Largest temperature increases in the Mashriq are outlined by a black oval. Red rectangles are for large changes for at least one-month duration, yellow rectangles are for moderate changes for a 2 to 3-week duration, while grey rectangles are for small changes over a one-week duration. White rectangles are for no change at all

Source: Giannakopoulos et al, 2005

4.3. Projection in the Mediterranean basin: 2050-2100 horizon

The objective of the European ACACIA project is the assessment of potential effects and adaptations for Climate Change in Europe and the Mediterranean basin. As previously mentioned, various reports are now available through the IPCC WG II, co-chaired by Perry. They include general and specific conclusions and recommendations for Europe, and can be used directly here for the Northern Mediterranean rim, following the A1B, B1 and A2 scenarii. In Figure 8, the yearly number of days with temperature > than 30°C during the second part of the 21st century (according to ACACIA Project).

Figure 7 – Compared yearly number of days with temperature larger than 30°C between present and the second part of the 21st century



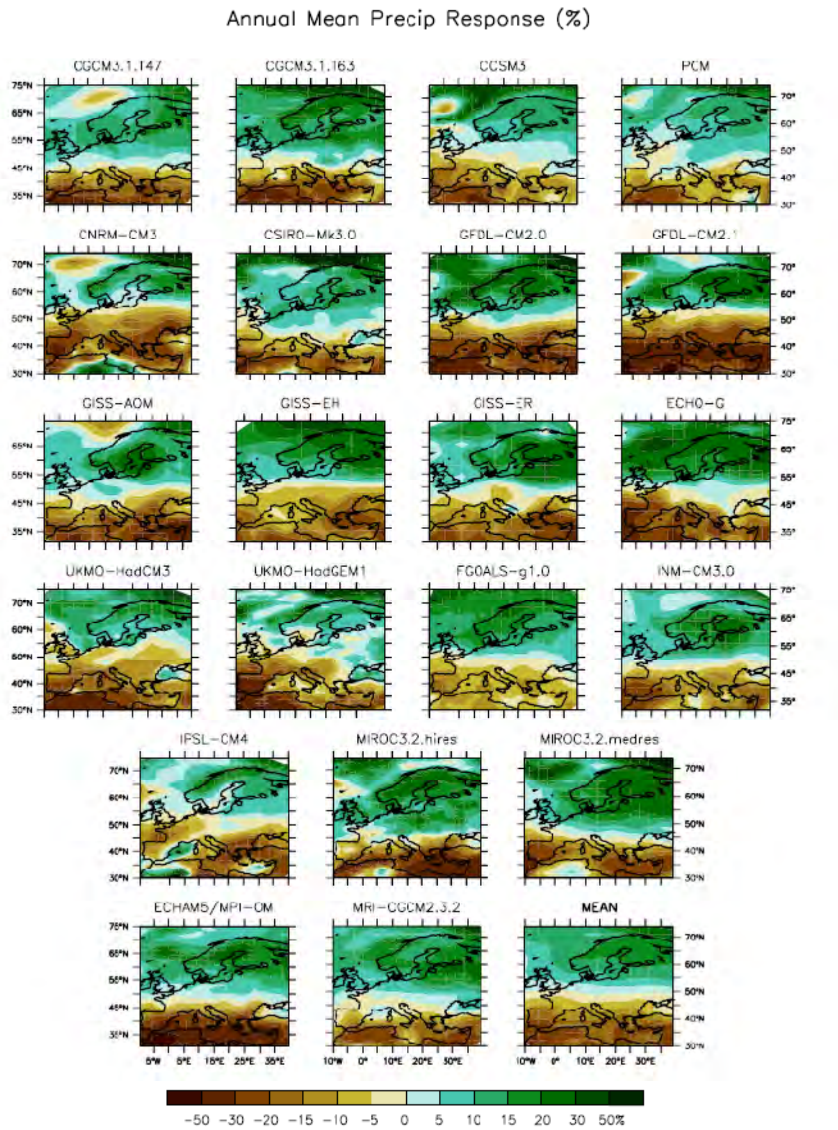
Larger values (reddish) during the 21st century are identified over southern France, the Iberian Peninsula, the Maghreb, Italy, Greece and the EM

Source: UK Met. Office, ACACIA Project

According to the results from recent climate change simulations and IPCC reports (AR 4, Working Groups I and II, on the 'Physical Science Basis' and 'Impacts adaptation and Vulnerability', 2007) the anticipated warming associated with the doubling of CO_2 concentration globally, is of the order of 2.5°C +/- 0.5°C over the Mediterranean basin (average of the 5 scenarios results), independent of the experiments and model resolutions. The warming should be slightly greater in summer than in winter. The simulated precipitation rate should display a slight decrease annually. The decrease in summer is less than 25%.

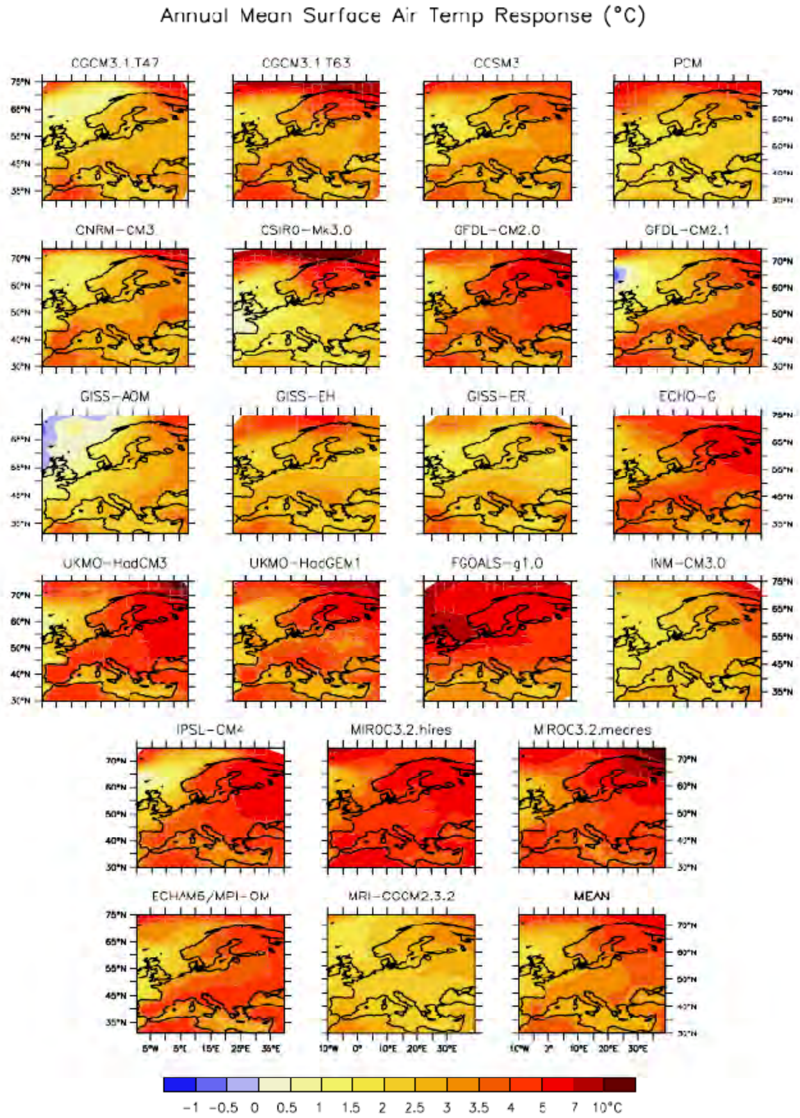
Figure 9 shows the annual mean temperature (bottom) and precipitation (top) response in Europe and the Mediterranean basin from 22 models. The temperature change is from 2080-2100 minus 1980-2000 A1B scenario (From IPCC WGI, Regional Climate Projections, Supplementary material, Chapter 11, 2007).Following this central scenario, the temperature increase will be between 2.3°C and 5.3°C for the Euro-Mediterranean states and between 2.2°C and 5.1 °C for the South and the East. For precipitations, the change will be 0 to 16 % increase for the Euro-Mediterranean states and a 4 to 27 % decrease for the South and the East.

Figure 8 – (top) Annual mean precipitation (in %) and (bottom) temperature changes (in °C) over Europe and the Mediterranean basin from a range of 22 models



The changes are from 2080-2100 minus 1980 – 2000, following A1B scenario. Consensus for large reduction in precipitation are readily seen (brown shading) over the entire Mediterranean basin, whilst the largest temperature increase (reddish areas) are over central Europe and countries around the basin such as the Iberian Peninsula and the Maghreb

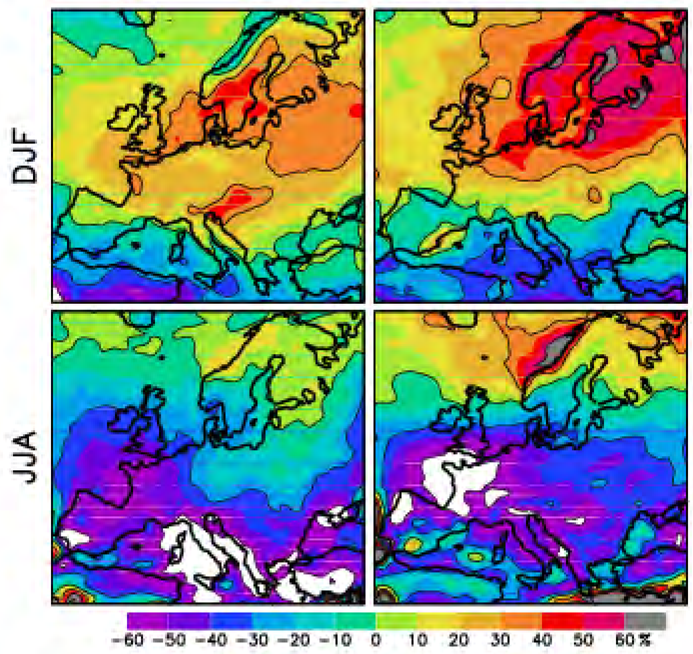
Source: IPCC WGI, Regional Climate Projections, Supplementary material, Chapter 11, 2007



Results integration with other projects such as PRUDENCE[15] may allow the drawing of overall conclusions over some parts of the Mediterranean basin. (Figure 10: Simulated precipitation changes from PRUDENCE during winter (top) and summer (bottom) when the 2080-2100 and 1961-1990 periods are compared (from RCMs used at the Rossby Center). Left/right column is for Hadley Center/Max-Planck Institute).

[15] PRUDENCE: Prediction of Regional scenarios and Uncertainties for Defining European Climate change risks and Effects. This European Union project focuses on improving projections of future climate change and producing high-resolution climate change scenarios for the 2071-2100 period and for Europe (including a part of the Mediterranean basin), and using dynamical downscaling methods (RCMs), performed at different European climate modelling institutes.

Figure 9 – Simulated precipitation changes (in %) during winter (DJF, top) and summer (JJA, bottom): 2080-2100 minus 1961–1990 periods

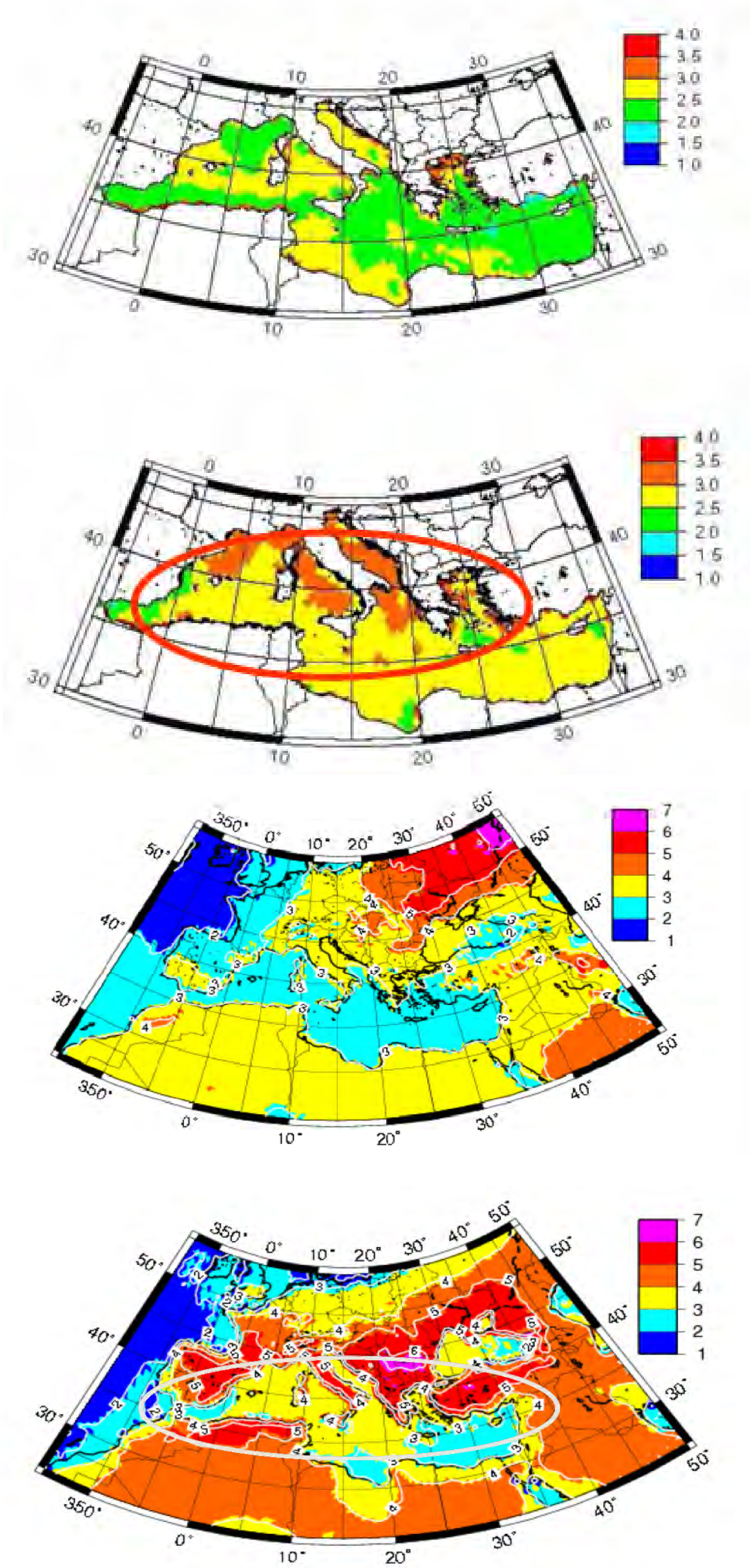


Left/right columns are from Hadley Center/Max-Planck Institute, respectively. The decrease in precipitation for both reasons are conspicuous over the Mediterranean basin, with largest negative values (in %) during summer over Spain, Maghreb, Italy, Greece

Source: from the PRUDENCE Project using RCMs, Rossby Center

The seasonal SST anomalies (°C) during the 2070-2099 period when compared to the 1961-1990 period, using Ocean-Atmosphere Regional Circulation Model (AORCM) and coupling (OASIS) between ARPEGE-Climat and OPAMED, using a 9-to-12 km grid-point system and IPCC Scenario A2 (i.e., [CO2] of 815 ppm at the end of the 21st century) are displayed in Figure 11 (from Jacob et al., 2007: Seasonal temperature (winter, top; summer, bottom) anomalies in °C). Note the large summer anomalies (bottom) within the northwest Mediterranean basin (orange oval).

Figure 10 – Seasonal temperature in °C (winter, top; summer, bottom) anomalies



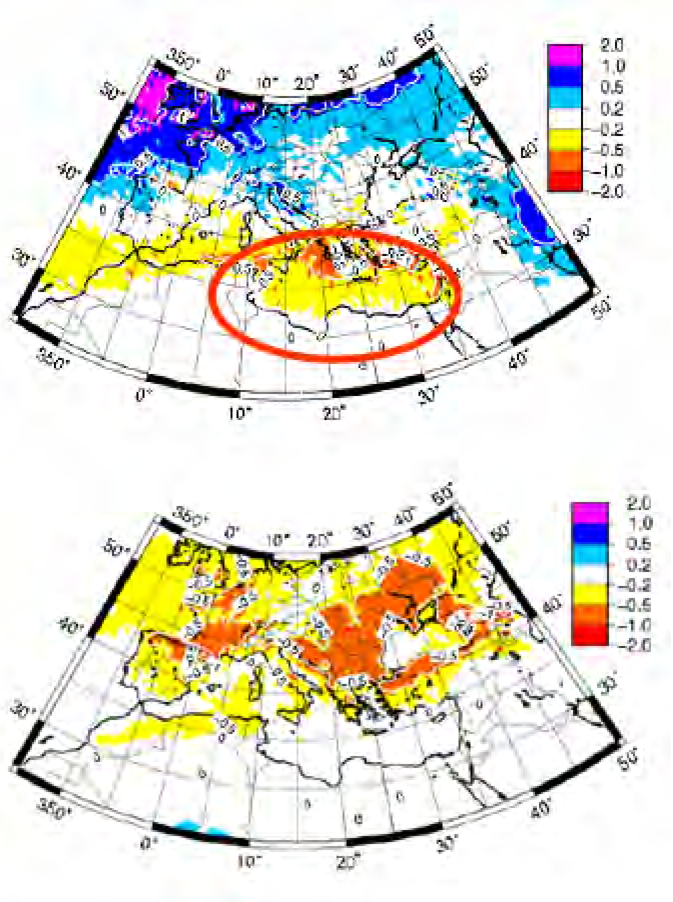
Note the large positive anomalies (orange oval) during summer (bottom) over the northwest Mediterranean basin

Source: Somot and al., 2007

At Tel Aviv University, RCMs were run and analyzed for the EM (Krichak et al., 2007). It was found that the average temperature over the Mediterranean area has increased by 1.5-4°C in the last 100 years. Temperatures for the 2080-2100 period, according to the IPCC A2 (and B2) scenario, are predicted to increase by about 4°C and 6°C respectively over Northern Israel when compared to the control run for 1961-1990. Whilst precipitation over most of Mediterranean basin shows a dominant negative trend in the last 50 years, a large negative trend in the A2 scenario is found over Northern Israel (while B2 scenario shows no significant trend?). Interestingly enough there is in parallel a tendency toward extreme rainfall events for the A2 (and B2) scenario. Standard deviation of the average annual precipitation (for the 2080-2100 period) is higher in the A2 and B2. Over Israel the tendency towards more extreme events/years could be traced to the increase in the intensity of the "Red-Sea trough" and associated increase in frequency of synoptic systems.

The seasonal precipitation anomalies (mm/day) during the period 2070-2099 when compared to the 1961-1990, using also the AORCM and coupling between ARPEGE-Climat and OPAMED, with the same grid scale and IPCC A2 scenario, are displayed in Figure 12 (from Jacob et al., 2007): seasonal precipitation anomalies in mm/day (winter, top; summer, bottom). Note the large winter anomalies over the north EM (orange oval).

Figure 11 – Seasonal precipitation anomalies in mm/day (winter, top; summer, bottom)



Note the large winter anomalies (orange oval) during winter (top) over the northern rim of the EM

Source: Somot and al., 2007

5. UNCERTAINTIES ON CLIMATE CHANGE IN THE MEDITERRANEAN BASIN

Ocean-atmosphere interactions, climate oscillations and associated meteorological events (including extreme weather events) can be stochastic (Hunt, 2004), non-linear (Canadell, 2000), often irreversible from a thermodynamical approach. From simple biochemical and structural threshold-like responses, cascading effects propagate and amplify throughout the climate system. Moreover, ocean 'climate signature' might also be a part of an integrated red spectrum from atmospheric random forcing (Strauss and Halem 1981). It should be underlined that, when applied to the Mediterranean basin, complex downscaled RCMs could very well enhance such non-linear and threshold effects, including artificial local instabilities, irreversible processes, thus increasing uncertainties. Considering what is known about the earth's climate, the latest climate events such as the small Medieval warming followed by the Little Ice Age with the Maunder minimum (1303-1859), one could mistakenly conclude that the present climate state is now stable and could 'modulate' climatic divergences under anthropogenic pressures (Gorschkov et al, 2000). Anticipated anthropogenic disturbances of natural ecological communities may cause abrupt transition of the Mediterranean climate? (Noilhan et al., 2000).

GCMs and RCMs still present "substantial uncertainties" (and have difficulties with simulating spatio-temporal variability/changes, which prevent them from representing not only the past, but the future of the Mediterranean climate at the regional/local (Cudennec et al., 2007). For instance, in the catchment basin of Greece, it is found GCMs provide future projections that are too stable when compared to climate uncertainty limits under natural variability (Koutsoyiannis et al., 2007). The influence of orography on atmospheric circulation and other climate indices such as NAO have been identified (López-Moreno et al., 2007, among others), and it is shown that, through the use of RCMs, changes in trajectories may lead to key redistribution of rainfall (Christensen et al., 2007). Moreover, given the influence of snow on water resources in areas such as Lebanon (Hreiche et al., 2007), Turkey (Tekeli et al., 2005), Spain (López-Moreno, 2004) and Morocco (Chaponnière et al., 2007), downscaled technology and physics become crucial issues.

In summary, two main sources for uncertainties have so far been identified: i) incomplete knowledge of physical mechanisms and processes to be included into RCMs and socioeconomic impact models; ii) unknown human evolution and activity in the near future. The first source of uncertainty is due to the fact that RCM shortcomings are mainly related to a somewhat crude description of unresolved processes using statistical parameterization schemes (Benestad, 2004). Parameterization schemes in RCMs are based on the range of observed values, which could be exceeded in the near future. Also some projections of temperature changes for the Mediterranean basin are based upon mean air temperature increase (both in minimum and maximum), which is not always realistic in a sense of daily averaged air temperature change. Results from regional projections are used in impact models, with their own uncertainties. It should be kept in mind that climate projections and scenarii represent only the direction in which climate may change. Thus it is not reasonable to consider climate projections with the same rate of change for the entire 21st Century. A reasonable approach would be for example to use different air temperature projections with different accuracies for the 2025-2050, 2050-2075, 2075-2100 periods, for example. Moreover, uncertainties are expected to be reduced with time since new knowledge and expertise on the climate system will be revealed. Also, entire ecosystems will change and modify the boundary conditions. The second source of uncertainties on human activity and evolution probably represents the most difficult socioeconomic aspect to be considered by a multidisciplinary approach. This source of uncertainty is considered crucial for the study of specific impacts on energy, water sources, food security and public health.

6. CONCLUSION

It is remarkable to see that outputs from different downscaled models agree upon the air temperature increase during at least the first part of the 21st century and the intensity of extreme weather/climate events. There is new and stronger evidence of the observed impacts of climate change on unique and vulnerable systems: environment/ecosystems and human activities. The levels of adverse impacts are increasing as temperatures increase further. Increasing risks of species extinction and biodiversity changes are projected with higher confidence as warming proceeds (see Section B). There is medium confidence that approximately 20-30% of plant and animal species identified so far are likely to face an increased risk of extinction, with a supplemental 2°C increase from the levels of the past 20 years. Confidence has increased that such an increase in the global mean temperature poses significant risks to many unique and threatened systems, including many biodiversity hotspots such as the Mediterranean basin. There is also a higher confidence in the projected increases in droughts/floods, heatwaves and thermal stress, as well as their adverse impacts (IPCC AR4 SYR, 2007). Concerning the sea level, there are still high levels of uncertainties which should be reduced in the near future through the continuous use of satellite altimetry blended with real-time tide-gauge observation networks. There are sharp differences across the Mediterranean sub-basins, but there is increased evidence that low-lying and over-populated areas should face greater risk (for example in drought-prone areas and mega-deltas).

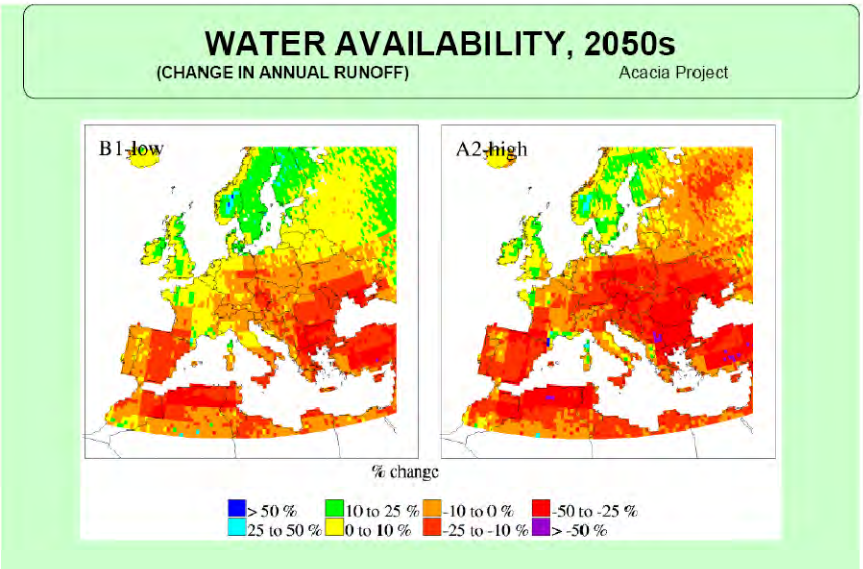
II. ENVIRONMENTAL AND SOCIOECONOMIC IMPACTS FROM CLIMATE CHANGE IN THE MEDITERRANEAN

There is high agreement and much evidence that with current climate change mitigation policies and related sustainable development practices, global GHGs emissions will continue to grow over the next few decades. The IPCC AR4 SYR reports an increase of global GHG emissions by 25-90% (CO2-equivalent) between 2000 and 2030, with fossil fuels maintaining their dominant position in the global energy mix to 2030 and beyond. Continued GHGs emissions at/or above current rates would cause further warming and induce many changes in the global climate system during the 21st century with impacts on the environment and human activities. There is high confidence that by mid-century, annual river runoff and water availability are projected to increase at high latitudes. There is also high confidence that many semi-arid areas such as the Mediterranean basin will have its hydrological cycle highly perturbed and will suffer a decrease in water resources due to climate change. The projected multidisciplinary impacts including those associated with the acidification of the Mediterranean Sea are presented in this Section B. Some on the agriculture and biodiversity have been observed for quite a while, others affecting public health are progressively appearing, such as those associated with vector-borne/water-borne diseases and thermal stresses.

1. THE OVERALL PICTURE

Upcoming climate change in the Mediterranean basin is going to alter social and economic dynamics and has the potential of damaging infrastructures and increase inequalities of neighboring countries. The above could result in economic migration, and slow down access to essential resources. Climate variability and changes had impacts in historical times in respect to the development of the Mediterranean culture, and definite impacts on the marine ecosystems. The above had been linked to varying sea surface temperature, sea surface salinity, as well as temperature in the water column. Other changes have been those of water availability, sea level changes, extreme weather events (intensity and possibly frequency) in the eastern Mediterranean basin, ocean acidification (changes in the carbonate budget), nutrient budget and nutrient cycling, modification of coastal areas (also associated with human pressure through population increase), public health. The water availability in the middle of the 21st century (in % change) following the B1 and A2 IPCC scenario is given in Figure 13.

Figure 12– Water availability (or change in annual run-off in %) during the middle of the 21st century following the B1 (low estimates) and A2 (high estimates) IPCC scenario

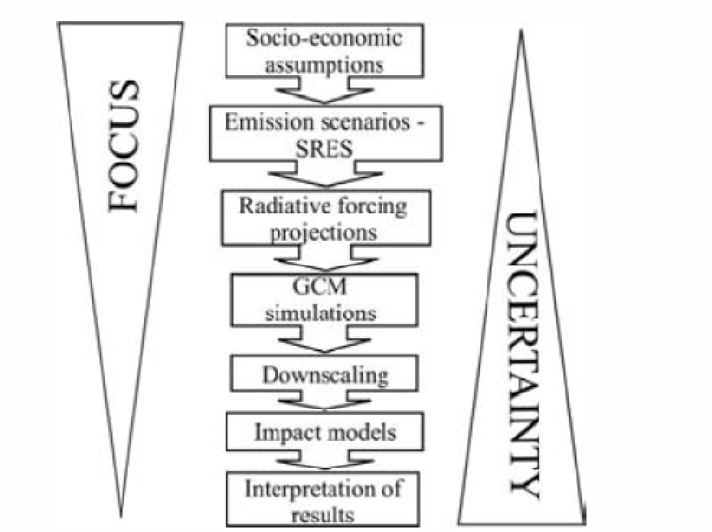


Highest changes (- 25 to 50 % changes) are noticeable from both scenario over the Maghreb, Sicily, Eastern Spain, Greece, Southeast Turkey

Source: from the ACACIA Project

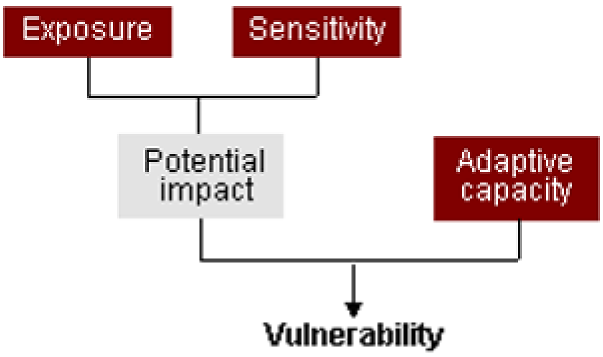
Socioeconomic consequences are not due only to direct global warming but are also associated with loss of inhabitable grounds (Chadly Rais, UNEP and IUCN). Human activities linked to the Mediterranean Sea will be associated with irreversible loss of daily income. For example sea level changes will disturb the movement of estuarine waters, impeding on clam ecosystems. Lagoon fishing activities will also be greatly perturbed through enhanced floods/droughts associated with extreme weather events. While the humid zones present in delta will be menaced, from the lack of water in general, drought and desertification processes will enhance each other (negative feedbacks). Global warming of the Mediterranean Sea will increase phytoplankton production, with less sanitary conditions (including Vibrios and associated digestive diseases, see section on Impacts on Public Health) and will affect tourism conditions (1/5 of the world). Socioeconomic consequences will be enormous. Evolution of uncertainty from general interpretation of results to regional socioeconomic impacts is given in Figure 14 (after Bergant et al., 2005), whilst the different vulnerability components are shown in Figure 15 (after Schrőter and the ATEAM, 2004).

Figure 13– Flow of growing uncertainty from general socioeconomic assumptions to regional interpretation of results including impacts, going from GCMs to RCMs



Source: see Bergant et al., 2005

Figure 14 - The "vulnerability components" from the merging of potential impacts and adaptive capacity



Source : Schröter, ATEAM, 2004)

Finally, when results from MAGGIC/SCENGEN as an example have been applied to the southern Mediterranean rim in general (and Algeria in particular), it was found that for the 2025 horizon, the shortage of atmospheric water resources would have sound impacts on fresh water (quantity and quality), agriculture (including food security), and public health (impaired immune systems and vulnerability to new and re-emerging diseases including epidemics). Additional detailed results and findings on possible impacts are developed in the following five sections: II2 and II3 sections are for direct and integrated impacts on the environment and ecosystems, while II4, B5, and II6 sections are about impacts on human activities and health.

2. IMPACTS ON HYDROLOGICAL CYCLE

2.1. The challenge

Water resources are scarce in the Mediterranean rim and their future availability is highly uncertain. The resource is increasingly threatened by factors such as urbanization, population growth and climate variability/change. The hydrological data in the Mediterranean Basin and per country (km3 /year) which include all the different processes is available in Table 3. The water resources from the MB are 600 km3 (including 81 km3 coming from non-Mediterranean countries). The final consumption related of the uses is 90 km3 per year. The outgoing flow (surface + underground) into the Mediterranean basin is approximately of 473.5 km3 (430 km3 + 43.5 km^3). Evaporation from surface water is ~ 46.5 km^3 (a third -13 km^3- is from dam evaporation) (source: Margat, MEDHYCOS).

Table 3 – Water resources from Mediterranean countries

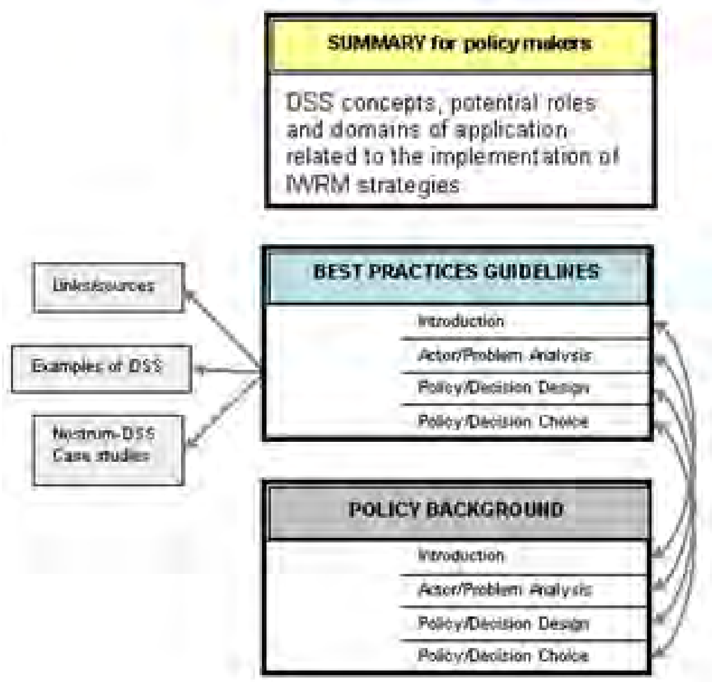
Countries	Precipitation	Resources and fluxes						Present fluxes going out of countries					Consumption and losses	
	1	2	3	3'	4	4'	5	6	7	8	9	9'	10	11
	Yearly Average Precipitation P	Internal Resources of Countries (P-ETR)	Groundwater (2-3')	Surface water resources (2-3)	External Contribution from neighbouring countries (surface water and ground water)	Contribution from non Mediterranean countries (included in 4)	Total Resources (2+4)	Real Rivers discharges toward the Mediterranean sea	Groundwater fluxes toward the Mediterranean	Real discharges towards the neighbouring countries	Discharges flowing out from countries (6+7+8)	Discharges flowing toward the Mediterranean (6+7)	Final Consumption by users including effluents in the sea	Losses by evaporation of dams
Spain	112	28	10.44	17.56	0.35	0.1	28.35	14.3	0.65	0.03	14.98	14.95	10.25	1
France	123	64	32	32	8.5	8.5	72.5	66	0.2	0.7	66.9	66.2	5	0.3
Italy	296	182.5	43	139.5	6.3	2	188.8	155.1	12	0	167.1	167.1	18	
Malta	0.165	0.05	0.05	0	0		0.05	0	0.04	0	0.04	0.04	0.03	
Slovenia	6.54	4.21		4.21	0		4.21	0.25	0.15	3.8	4.2	0.4	0.003	
Croatia	26.5	18	9	9	13.7		31.7	21.2	10.5	0	31.7	31.7	0.5	
Bosnia-Herzegovina	22	14		14	0		14	0.015	0.05	13.58	13.645	0.065	0.04	
Yugoslavia	22	16	2	14	0		16	1.5	1.6	12	15.1	3.1	0.27	
FYR Macedonia	18	5.42		5.42	1		6.42	0	0	6.3	6.3	0	0.77	
Albania	42.7	26.9	6.2	20.7	15.9	2	42.8	40.7	1	0	41.7	41.7	0.6	
Greece	113.4	58	10.3	47.7	11.2	10.2	69.2	48.7	2.5	2	53.2	51.2	6	1
Turkey	140	66	20	46	3.45	2.8	69.45	50	12	0.2	62.2	62	6	
Cyprus	4.42	0.78	0.28	0.5	0		0.78	0.178	0.23	0	0.408	0.408	0.17	
Syria	13.55	5	2.38	2.62	0.83		5.83	1.33	1	0.85	3.18	2.33	1.6	0.5
Lebanon	8.2	4.6	3.1	1.5	0		4.6	2	0.72	0.64	3.36	2.72	1	
Israel	3	0.63	0.45	0.18	0.38		1.01	0	0	0.01	0.01	0	1	0.12
Palestinian Authority	1.42	0.62	0.546	0.074	0.01		0.63	0.02	0.002	0.5	0.522	0.022	0.13	0
Egypt	12	0.8	0.5	0.3	55.5	55.5	56.3	13	0.03	0	13.03	13.03	35.1	10
Libia	10	0.7	0.6	0.1	0		0.7	0.05	0.05	0	0.1	0.1	0.5	
Tunisia	33	3.7	1.15	2.55	0.32		4.02	0.65	0.2	0	0.85	0.85	1.1	0.47
Algeria	68.5	14.5	1.33	13.17	0.03		14.53	11.3	0	0.32	11.62	11.3	1.7	
Morocco	21	5	1	4	0		5	3.65	0.1	0.03	3.78	3.75	0.9	
Total	1098	519	144	376	117	81.1	636	430	43.5	41	514.5	473.5	90	13.4

Source : http://medhycos.mpl.ird.fr/en/t1.resi&gn=Margat.inc&menu=fresimf.inc.html

Most fluxes presented in this table and which include most of the hydrological cycle processes (i.e. surface runoff, aquifer dynamics, river flows, evapo-transpiration, water availability and extreme events…) are to be modified by the Mediterranean climate variability/change.

The challenge in the Mediterranean rim is that sectoral approaches in water management are still prevailing while climate change has impacts on the use of renewable water, desalinization, re-allocation of irrigation water to more productive usages which will require a multidisciplinary approach (http://www.feem-web.it/nostrum/, see Figure 16). In this Figure an example of conceptual guidelines for Mediterranean IWRM and from the NOSTRUM-DSS decision-making strategies is given. Indeed Mediterranean countries especially from the South and East (Blue Plan, 2007) have large irrigation demand for water resources (81 per cent for the countries of the South and East and 45 per cent for the countries of the North; after Blue Plan, 2007) to be largely impacted by climate change, in terms of aquifers reserves, water quantity and quality such as in the Jordan region. For example the policy debate in Spain in order to overcome water scarcity and resource degradation, highlights the difficulties to attain a sustainable management of water resources, because of the conflicting interests by stakeholders at large (including environmental groups). The policy measures to solve water scarcity must include banning aquifer over use, water pricing, introducing water-pricing markets, subsidies to upgrade irrigation systems, and increasing supply with water from inter-basin transfers or from seawater desalination (see Table 4 where water-use for irrigation is spelled-out for some Mediterranean countries; adapted from OECD report, 2005).

Figure 15 - The multidisciplinary approach for decision makers, including linkages between regional/local policy background and best practices guidelines for the integrated design and implementation of DSS (Decision Support Tool) for IWRM strategies (Integrated Water Resource Management) in the Mediterranean basin



Source: from the NOSTRUM-DSS FP6 European Project, 2006

Table 4 – Water use (total water extraction in hm3) from Mediterranean countries, with irrigated land surfaces

Pays	Extraction totale d'eau (hm³)	Terres irriguées (1 000 ha)	Eau d'irrigation (hm³)
France	33 500	2 200	4 800
Grèce	8 900	1 450	7 700
Italie	56 200	2 700	25 850
Portugal	9 900	650	8 770
Espagne	37 700	3 650	24 600
Turquie	39 800	4 500	31 000
Total pour l'Europe	291 900	21 170	109 470

In 1000 ha and irrigation water only (in hm3). A third of total water extracted is used for irrigation purposes
Source : from OECD report, 2005

Sufficient freshwater availability has always been a central prerequisite for agricultural and industrial development in the water scarce environment of the EM. Political equilibrium in the region is strongly linked to adequate water supply in front of increasing water demands. Sustainable management of water resources requires scientific sound decisions on future fresh water availability. Moreover water crises are linked to political turmoil.

2.2. Impacts

Changes in rainfall patterns on different time-space scales affect river flow. At the same time, changes in runoff may be used as a climate change indicator. For example, records from Greece rivers' flow show a negative trend since 1920 (Koutsoyiannis et al., 2007) associated with a partial decrease in rainfall amount there. Detecting runoff changes is more complex since it must include the evaluation of groundwater pumping, such as in the Ebro River (Spain) mentioned later. The additional complexity is that large river basins extend over geographical areas with dams constructed over non-negligible time-periods and submitted to different climates. From modelled rainfall output for the 21st century and based upon OPAMED8[16], yearly mean river runoff fluxes (in m^3/s) applied to the Mediterranean Sea model during each decade of Mediterranean scenario for the main rivers and the Black Sea (fresh water input) are displayed in the Table 5. Decades are named by the first year, 2010 for the 2010-2019 decade for example. Climatology (clim) is applied for the 1960-1999 period in the control run model with A2 scenario results every 10 years (Somot, 2005). The results take into account the presence of the Assouan dam, which diminished the Nile flow (Vörösmarty et al. 1996). Thus values for the Nile are the 'clim'value multiplied by the ratio between the projected flow and the actual flow (using ARPEGE-Climat from the PRUDENCE project). Important decreasing runoffs are noticeable for the Rhone, Po, and Ebro rivers.

[16] OPAMED8: A high resolution Mediterranean version from OPA and NEMO to represent climate variability/change in the Mediterranean basin (after Somot, 2005).

Table 5– Yearly mean river run-offs (in m^3/s) for key rivers (and black sea) fresh water input around the Mediterranean basin, following the A2 IPCC scenario

Rivers	clim	2000	2010	2020	2030	2040	2050	2060	2070	2080	2090
Rhone	1700	1666	1615	1649	1581	1564	1530	1513	1462	1377	1360
Po	1498	1378	1288	1258	1183	1228	1228	1183	1183	1183	1213
Ebre	428	398	321	343	321	317	309	274	274	197	188
Nile	875	945	954	962	910	928	823	875	858	901	814
Black Sea	8036	6911	6027	5625	4902	4420	4661	4581	4018	2893	2330

Note: values for the Nile are corresponding to the yearly mean river run-offs in the delta area.
Source: Somot, 2005

Impacts from Mediterranean climate change on water availability in the Upper Jordan River Catchment (UJC) have been investigated through the GLOWA-Jordan River (GLOWA JR[17]) project, using a high-resolution coupled climate-hydrology RCM (http://www.glowa-jordanriver.de). As such, the GLOWA JR project provides scientific support for integrated water resources and land management using the so-called 'blue-green water concept' which includes surface, groundwater fluxes and evapotranspiration processes. It is reminded that the UJC is to provide 1/3rd of freshwater resources in Israel. Two 30-year time slices (1960-1990 and 2070-2100) from ECHAM4 GCM (following IPCC B2 scenario) were dynamically downscaled using the non-hydrostatic meteorological model MM5 in nesting steps with resolutions of 54 km and 18 km. The meteorological fields in turn are used to drive the hydrological model WaSiM applied to the UJC which has an area of about 850 km2. Surface and subsurface water flow and water balance are evaluated in details, dynamically coupled to a 2D groundwater model. Results indicate a mean annual temperature increase up to 4.5°C and a 25% decrease in the mean annual precipitation in the mountainous part of the UJC. Total runoff from the catchment basin is predicted to decrease by 23%, accompanied by significant decreasing groundwater recharge (Neuman et al., 2007). Different adaptation options are tested for their eco-hydrological and socioeconomic impacts. Eventually information from the GLOWA JR project is to be integrated with other regional results from other countries in order to derive a 'centralized decision-makers support tool' (see Table 6). In this Table, the number of people (millions) who should experience an increase in water-stress by 2055, due to climate change in the Mashriq region (Palestinian territories, Jordan, Lebanon, Syria, Iraq), from 6 models using IPCC A2 and B2 scenarii, are displayed (GLOWA Project, Arnell, 2004).

Table 6 - Number of people (in millions) to be exposed to water-stress by 2055, in the Mashriq, and using results from 6 models, following both A2 and B2 scenarii

	HadCM3	ECHAM4	CGCCM2	CSIRO	GFDL	CCSR
A2	150	157	169	114	72	128
B2	95	110	168	62	64	110

Source: Arnell, GLOWA Project, 2004

The yearly mean water-budget of the Mediterranean Sea is estimated as follows (in mm/yr): Evaporation (E), 1,100; Precipitation (P), 400; River Discharge (R), 100; Black Sea (BS), 75. Impacts on the hydrological cycle are of course "first order" impacts since they are linked to other multidisciplinary impacts (i.e., agriculture, ecosystems' evolution, biodiversity,…). Most current climate models indicate increased dryness over the Mediterranean area. Nevertheless, Cubasch et al. (1996) had compared results from five different low-resolution coupled atmosphere-ocean models with no consistent picture. The main conclusion was that simulations could be improved with downscaled and/or higher-resolution models (including complex topography).

[17] GLOWA Jordan River is an interdisciplinary and international research project providing scientific support for sustainable water management in the Jordan River region.

Agriculture and water supply are certainly the two economic sectors most severely affected by drought, particularly in southern Europe. Other regional studies have been undertaken, for instance in the Maghreb countries. Because of low initial water availability, climate change impacts on water resources will be more important over these regions: i) the average temperature increases will lead to higher temperatures within wadi waters, which will reduce their oxygen content and associated self-purification capacity; ii) decrease of runoff will result in higher pollutant concentrations; iii) lakes and ground water salinity will increase (from higher evaporation, increased water needs from increasing population, predicted sea level rise): iv) additional pollution of estuarine water from vibrios. As a result, the soils will be exposed to maximum erosion (see preliminary results from the DeSurvey European project).

Increase in extreme weather events in the Northern part of the Mediterranean basin during winter/spring may lead to increased frequency of flash flooding and catastrophic mudslides (ACACIA[18] conclusions). Mudslides in the Naples region killed 150 people (May 1998).

The hydrological regime of the Mediterranean rivers is quite specific (Graff et al., 2003; Wainwright and Thornes, 2003). Differences between high and low water discharge can be extreme. This results in the fact that the ratio of peak discharge on mean annual discharge in a drainage basin of 10,000 to 100,000 km2 can be one order of magnitude greater than for other rivers. This makes runoff very difficult to predict, particularly when associated to complex topography and sparse vegetation. This renders calculation of socioeconomic impacts even more difficult to assess. In the Mediterranean basin, the water cycle is also profoundly impacted by socioeconomic activities (see the Liminary) associated with efforts against water pollution, desalinization (with direct impact on crops), with negative feedbacks. Figure 17 shows examples of Chloride (left) and Boron (right) toxicity on vegetation such as avocados and citrus trees.

Figure 16 - Example of chlorides (left) and boron (right) toxicity (damages in leaf reduction, and/or health) on vegetation such as citrus trees (left) and avocados

A). The avocado tree is sensitive to chloride concentrations higher than 100-180 mg/l, whilst the citrus tree is sensitive to concentrations higher than 200 mg/l. Background chloride concentrations in water supply usually attain about 200 mg/l. Concentrations higher than 0.5 mg/l would harm sensitive crops such as lemons. The boron concentration in Israel's water supply is about 0.1 mg/l

Source: Weber and Juanicö, the Israel Project, 2005

[18] A multidisciplinary project that aims at offering models, methods and tools in order to assist engineers to acquire knowledge from multiple sources of expertize for building a corporate memory (i.e. knowledge capitalization), and a knowledge-based system.

3. IMACTS ON ECOSYSTEMS AND BIODIVERSITY

Species and ecosystems are important for the services they provide to humans, and investigating how climate change could affect their ability to fulfil this role becomes a prerequisite. There could be some profound effects over the course of the 21st century. For example, the Mediterranean Sea is already a warmer sea still mainly populated by cold species. It has been observed that in the late 70s new fauna had been entering in the EM, with changes/adaptation in fisheries' activities. In the Mediterranean, new species (with potential positive impacts) may thus render former ecosystems more vulnerable. Over land, offsetting negative effects from climate change are being studied/modelled with possible adaptation actions across a range of sectors (DeSurvey, BRANCH[19], MACIS[20] projects; see for example Harrison et al., 2006). In any case in most projects on impacts and processes, stakeholders and decision-makers must be involved to participate in the conservation agenda at all trophic levels.

The Mediterranean basin is considered as one of Earth's hotspot ecological areas. Legal frameworks do exist in order to protect biodiversity against some anthropogenic actions. Many Mediterranean countries have already signed the United Convention on Biological Diversity (CBD, June 1992). The present rate of species extinction may be four orders-of-magnitude greater than the typical rates seen in fossil records. Since there is little or no evidence for any increase in the rate of speciation, it can be deduced that in the years to come the Mediterranean basin (among other regions) will face a dramatic reduction in the species diversity (Catizzone et al., 1998). It has been shown that the rate of loss of important habitat/ecozone types is the most important threat to biodiversity [21], including diversity patterns of European mammals (Levinky et al., 2007). The latter used bioclimatic envelope models (BEM) to evaluate the potential impacts of climate change on the distributions and species richness of native terrestrial non-flying European mammals under IPCC scenario. Assuming unlimited and no migration, respectively, BEM predicts that 1% or 5-9% of European mammals risk extinction, while 32-46% or 70-78% may be severely threatened (lose > 30% of their current distribution). Under the no migration assumption endemic species were predicted to be strongly negatively affected, whilst widely distributed species would be more mildly affected. Finally, potential mammalian species richness is predicted to become reduced in the Mediterranean basin, but increase towards the northeast and for higher elevations. It should be noted that BEMs do not account for factors such as land use, desertification, land degradation, biotic interactions, human interference, and so forth.

Impacts of climate change on biodiversity are indeed quite complex: they may be direct, indirect, and include anthropogenic responses and adaptation. Some ecosystems could be reduced in size, cease to exist, whilst some species may become extinct, thus setting off a chain of extinction. Sudden and extreme weather events, and/or progressive events like sea level rise affecting coastal habitats (see also later) might modify marshes, wetlands, while anthropogenic influence like intense urbanisation on coastal zones (the famous 'concrete coastline') are among the major threats to ecosystems and biodiversity in the Mediterranean.

[19] BRANCH (Biodiversity Requires Adaptation in Northwest Europe under a CHanging climate): Provides the guidance and evidence for stakeholders to take action. Spatial planners must act now to create a landscape and coastline that can withstand the effects of climate change.
[20] Minimization of and Adaptation to Climate change Impacts on biodiversity: http://macis-project.net/
[21] The four main threats identified in Europe were agriculture, pollution, habitat destruction and sectoral policies.

3.1. Marine Ecosystems

The influence of water temperature on primary productivity of the Mediterranean phytoplankton is quite complex. Cold waters are usually more productive since vertical mixing is increased and more nutrients are present near the surface. This is particularly true in coastal zones when upwelling dominate. There has been a general increase in the total phytoplankton biomass (1991-1999) at the DYFAMED[22] site (Marty et al., 2002). This increase could be due to the specific response of small-sized phytoplankton to the lengthening of the summer stratification period. Also it has been shown that in the northwest the deep water convection zone has been reduced with a quasi-absence of fall bloom (Bosc et al., 2004). The above could be associated to environmental changes linked to climate change in the Mediterranean basin. The latter could also increase the fertilization role of the atmosphere, through stratification of surface waters.

Tuna school/stocks (and tuna fishing) are expected to be extremely perturbed not only due to changes in currents like in the Alboran Sea, if quotas were not being discussed. Also, sea bass needs specific temperature and photoperiodic conditions for laying eggs. Any changes in those conditions are going to disturb the subtle equilibrium between preys and predators. Already impacts on the copepod communities in the Gulf of Lyons have been noticed, and attributed to subsurface salinity increase in wintertime (Kouwenberg et al., 1999). In the EM changes in the deep and intermediate circulation had consequences on the epipelagic phytoplankton in the Ionian and Adriatic Seas (MARBENA E-Conference, 2004). Another example of already perturbed ecosystems is the invasion of the Genoa Gulf by *Caulerpa taxifolia,* "the killer algae" (Meinesz, 1999). Anthropogenic actions (different than climate change) have induced migration of planktonic fauna from the Red Sea (following the Aswan High Dam construction for example). The latter could also be intensified by recent observed rise of temperature and salinity there (Lakkis and Zeidane, 2004). Anthropogenic changes in nutrients such as increase in nitrates and phosphates while silica concentration remains constant might induce a shift in diatoms, from siliceous to gelatinous systems, and lead to eutrophic conditions and diseases (PSP, DSP). Such shifts are observed in Mediterranean estuaries, and may have additional impacts on fisheries and tourism. Other changes will occur with benthic species, where oxygen solubility is decreasing associated with an increase in organic matter decomposition.

The basic ingredients and biological machinery of the marine ecosystems are often not sufficiently resolved. Ecosystems changes associated with an uplift of the nutricline following the Aegean dense water outflow are suspected, and are perhaps associated with changes in deep zooplankton. Teleconnections can also occur: i.e. blooms in the Black Sea apparently produced atmospheric non-sea salt sulphate aerosols of marine biological origin, which were swept southward and detected in the southern Turkish coast (Özsoy, 1999).

Heavy threats to some specific species have already been reported, such as massive death of gorgons (sensitive to sea temperature) starting from the Genoa Gulf (where temperature has increased by more than 2°C in the last 15 years) and invading several places of western and eastern Mediterranean (MedOndes, 2000). Natural and anthropogenic factors may also endanger some species such as marine turtles very sensitive to increase of CO_2 concentration in water, and above all anthropogenic pressure over nidifications' areas [23].

The impacts of climate change on fisheries are not to be the same all over the basin. The Mediterranean Sea is almost a closed sea, but connected with the Atlantic by the Strait of Gibraltar. Mediterranean waters are generally warm and oligotrophic (i.e. have relatively low concentrations of

[22] DYnamique des Flux Atmosphérique en MEDiterranée. http://www.cnrm.meteo.fr/expert/contributions/resumeslongs/marty.pdf

[23] The national marine protected area of Zakynthos, Greece, has been officially set up in January 2000 to protect the most important nidification area of marine turtles *(caretta caretta),* within the framework of the European Habitats directive, in spite of a strong local opposition (MedOndes, 2000). Another important nidification area is Lampedusa island.

nutrients and low productivity) except in the vicinity of the rivers mouths, where river discharges bring nutrients to sea, and in areas where wind action and coastal upwelling allows for vertical transport of nutrients. The most productive areas are in the north-western Mediterranean owing to important river discharges from the Rhône and Ebro rivers and strong wind mixing. Annual discharge of these rivers appears to vary inversely with the NAO: discharges tend to be lower during positive NAO anomalies. It is very likely that the regional effects of climate change (e.g. sea warming, sea level rise, reduced river runoff…) will cause changes within the fisheries of this region, where pelagic, demersal and benthic species are heavily targeted by artisanal, semi-industrial and industrial fleets. In the NW Mediterranean, the most noticeable feature is that air and sea surface temperatures have shown an upward trend in all levels, stronger than in other part of the sea and other oceans. Air surface temperatures have increased by 2.1ºC in 30 years (0.07ºC per year). The sea surface temperatures have increased by 1.1ºC in 27 years (0.04ºC per year); at 80 m depth, the tendency shows an increase of 0.7ºC in 27 years (0.025ºC per year), and below 400 m depth the tendency shows an increase of 0.12ºC in 30 years (0.004ºC per year). Warming has been accompanied by an increase of 3.3 cm of sea level in 11 years (0.3 cm per year). It also appears that the NW Mediterranean is getting saltier: the salinity of NW Mediterranean deep water in the Gulf of Lyons is increasing at a rate of 0.007 psu/decade. All of the above is associated with the loss of fish habitats due to climate change and other anthropogenic effects (e.g. tourism, trawling, pollution; Lloret et al., 2004).

3.2. Terrestrial ecosystems

The impacts (positive and negative) of climate change on plant species composition will increase in the coming decades. Some of the potential effects of climate change are likely to be positive for agriculture and ecosystems worldwide. For example, warmer temperatures are likely to prolong the growing season, and the increased levels of CO_2 are likely to enhance plant growth and water use efficiency for many crops. This is particularly true for the Mediterranean basin where competitive crops are mostly warm-season crops. Switching to better suited warmer-season crops by farmers might seem as a successful response. Nevertheless this would introduce new 'competitors' and adaptability is thus very likely to be critical. Future climate change is also estimated to exacerbate the loss of species, especially those species with restricted climate and habitat requirements and limited migration capabilities (IPCC, 2001b). Land ecosystems are nutrient-poor, seasonally-stressed, yet species-rich. Almost all taxa exhibit high levels of diversity, at both specific and sub-specific levels. At least 30,000 of the MB plants taxa occur within a 2.3 million km^2 area. Roughly half of these species are endemic to the area, whilst 4,800 species are endemic to specific countries. Climate change is likely to change the phenology of plants. A 3°C increase in air temperature (within the range projected for 2100 by IPCC), corresponds to a shift in species distribution of 300-400 km to the north or ~500 m in elevation (Hughes, 2000). Moreover, Thomas et al. (2004) projected that, under such conditions, 15-37 % of all species globally might become extinct by 2050. In mid- and northern Europe, extinct plant species may be replaced by thermophilic species. Greatest effects are projected for Arctic regions, eastern Europe, and the Mediterranean region (Bakkenes et al., 2004). Current plant species richness in the Mediterranean area might be reduced over the twenty-first century due to the projected decreases in precipitation, more frequent forest fires, increased soil erosion and the lack of new species. Endemic species in northern Europe may become extinct and replaced by more competitive species in the long term (Sykes and Prentice, 1996).

Already more than 300 British plant species have their first flowering dates advanced by 4.5 days during the past decade (Fitter and Fitter, 2002). These are strong biological signals of climate change. Annuals are more likely to flower early than congeneric perennials, and insect-pollinated species more than wind-pollinated ones. It is thus obvious that anthropogenic pressure should play a major and similar role on the evolution of the Mediterranean ecosystems and plants.

It is also expected that in southern Mediterranean countries, cultivated areas will increase to the detriment of forests, while the opposite situation is expected in the northern Mediterranean countries where natural forest re-growth or reforestation appear on fallow and degraded lands/soils (like in the Italian Abruzzos). Air temperature is also an important factor, which regulates the potential evapo-transpiration. A temperature increase, in regions where the water resources are limited, causes the sclerophyll shrub areas to decrease, both in terms of extent and productivity. Vegetation also tend to react to atmospheric CO_2 increase by decreasing their stomatal conductance, which causes the potential evapo-transpiration to decrease. Such ecosystems also become more vulnerable to external risks such as parasite attacks and/or forest fires, with a definite increase in their occurrence (2003-2005-2006 in Portugal, Spain, southern France; 2007 Greece…). Indeed, summer heatwaves in southern Europe have severe implications on the occurrence of forest fires (Parry, 2000).

As highlighted in the European ACACIA project, exceptionally hot, dry conditions can have a devastating impact on the natural environment by reducing water availability in the soil for plant life and in open water bodies for bird and animal lives (with more brackish waters). For example the Ichkeul-Bizerte lakes, coastal lagoon, would share many of the problems identified in deltaic areas, and would experience a considerable shift from their present fresh/brackish water to linked terrestrial flora and fauna. These shifts, combined with the potential reduction in the area of wetlands, would significantly affect migratory bird routes, which depend mainly upon the availability of suitable Mediterranean habitats for overwintering and transit areas during their north-south migrations.

A survey of Global Biodiversity scenarios for year 2100 had been issued [24] (Sala et al, 2000), within the framework of GCTE Focus 4. Five 'drivers' were considered: changes in land use, climate, nitrogen deposition, CO_2 atmospheric concentration, and biotic exchanges. When all biomes are averaged, the two major biodiversity driving factors appear to be land use changes and climate change. Mediterranean ecosystems appear to be affected significantly by a combination of 'drivers', while land use and biotic exchanges being the major ones. Mediterranean ecosystems include biomes experiencing the largest biodiversity change, primarily due to the moderate-to-large effect of all drivers.

Forest management practices are strongly linked with the CO_2 cycle. Trees have an 'S-shaped' growth curve. At first, the growth rate of trees is rather slow, and then it increases rapidly. With time, the growth rate of trees decreases once again. In order to maximize forest and wood production, it is better to harvest trees at time when the growth rate (per ha and per year) is starting to decrease. Elevated concentrations of CO_2 have impacts on gas exchange (i.e. photosynthesis, respiration and stomatal conductance), aboveground growth, root and mycorrhizal growth and function, phenology, soil respiration and nutrient cycling (Karnosky et al., 2001). The use of FACE[25] (Free Air Carbon dioxide Exposure) systems for studying the impacts of greenhouse gases on forest ecosystems is of great value to understand how climate change may affect forests and how forests may influence in return the composition of the atmosphere. Global forests removed almost 40 % of the anthropogenic emissions of CO_2 from the atmosphere during the 1990s. How long forests will continue to be effective in this way is an important question in a climate change context. The substitution of old plants with younger plants with higher growth rates will enable to increase the

[24] These scenarios have been developed by GCTE Focus 4 in collaboration with the Inter-American Institute for global Change research (IAI) and the national Centre for Ecological Analysis and Synthesis (NCEAS), University of California, Santa Barbara.

[25] FACE: Free Air CO_2 Enrichment. FACE technology is capable of providing means by which the environment around growing plants may be modified to realistically simulate future concentrations of atmospheric carbon dioxide (CO_2).

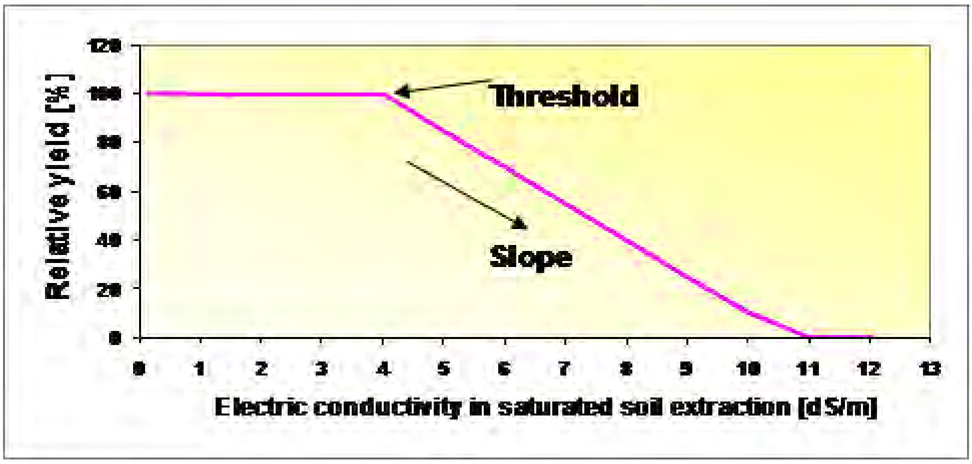
land carbon sink function, and the biomass production (wood and biofuel), which may compensate or lower GHGs anthropogenic emissions.

The European 'Climate Change and Impact Research: the Mediterranean Environment' (CIRCE) project is in its implementation phase and will include socioeconomic aspects linked to climate change (http://www.bo.ingv.it/circeip/).

4. IMPACTS ON AGRICULTURE

Present water consumption for agriculture is about 80% in the southern, eastern and north-eastern of the basin and of 60% when averaged over the whole basin. Climate change, transformations in agricultural practices, land use intensification, and deforestation are creating major changes in surface runoff, erosion and groundwater availability (see section B3, and Megnoufif et al., 2007, among others). Based upon climate change scenario in the Mediterranean basin, changes in agricultural crop yields using a well-established numerical model are investigated (Giannakopoulos et al, 2005). Results show a general reduction in crop yields (e.g. summer crops, legumes, cereals, tuber crops) basically in the southern Mediterranean rim where a decrease in precipitation and salinity increase are expected. In Figure 18, relative crop yield (Y) with minima or thresholds, versus salinity (a function of Electric Conductivity or EC) is given: Y= 100 – b (EC – a), where a and b are adjustment parameters.

Figure 17 – Crop relative-yield (in %, ordinates) versus salinity computed from conductivity (EC) in saturated soil (in dS/m, abscissa).

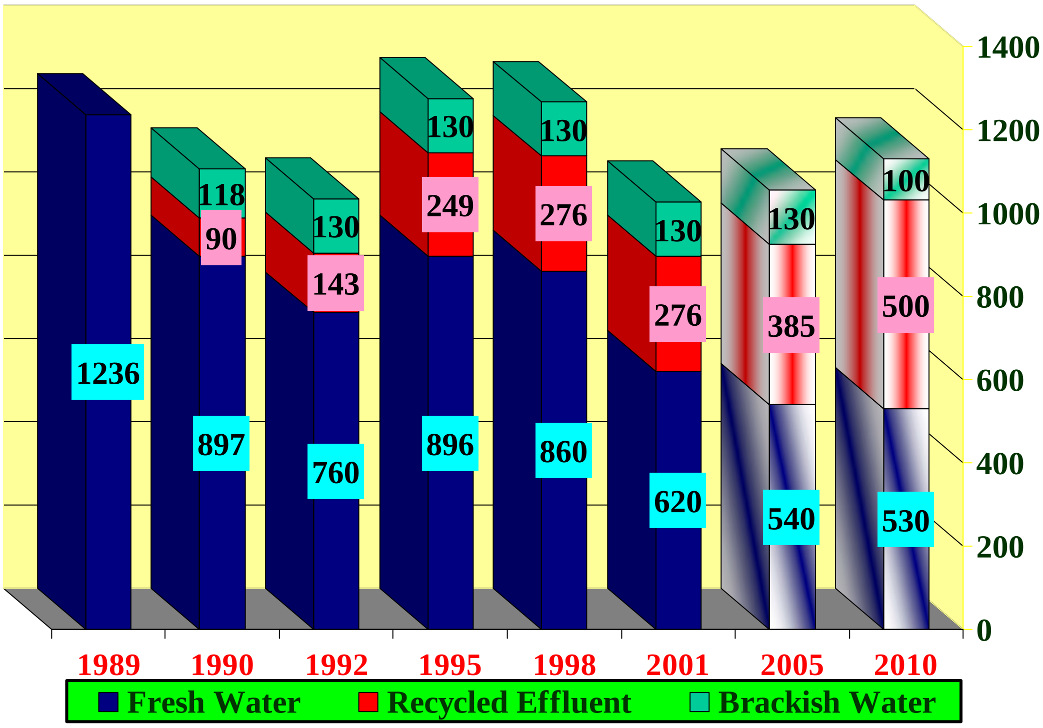


Between the two thresholds and between 4 to 10 dS/m, the relative yield follows the linear equation:
Y = 100 – b (EC – a)

Source: Weber, Israel Project, 2005

From combined effects of climate change and 'anthropogenic pressure', hydrologic fluxes and physical processes may evolve towards desertification, at least in the western Mediterranean regions (Puigdefabregas and Mendizabal, 1998), with major impacts on agriculture there. At some locations in the northern Mediterranean, the effects of climate change may have little or small positive impacts on yields, provided that adequate and additional water demands can be met. In the EM, sustainable agriculture will have to deal with a decrease in fresh water availability, and the extension of brackish water (Figure 19 where the decrease of fresh water input and increase of brackish water in the EM are displayed; dark blue for fresh water, red for recycled effluent, green for brackish water; adapted from Baruch Weber, Ministry of Environment, Israel, 2006).

Figure 18 – Decrease of fresh water (blue) input and increase of brackish water (green) (in million m³/year, ordinates) in the EM during the last 15 years, with expected values in 2010



Source: Baruch Weber, Ministry of Environment, Israel, 2006

The adoption of specific crop management options (e.g. changes in sowing dates or cultivars) may help in reducing the negative responses of agricultural crops to climate change. However, such options could require up to 40% more water for irrigation, which may not be available in the future (see above). Thus, overall results are partly in the hands of water management decision-makers.

High resolution downscaled climate models are more adequate to address impacts on agricultures for regions containing complex topography and coastlines. For example, the Italian landmass can be well represented using models with 50x50 km resolution such as the RegCM3[26] model (Giorgi et al., 1997). Still, particular aspects of uncertainty due to spatial scale in these impacts' assessment, such as crop yields have been highlighted (Giorgi and Mearns, 1999). The main features of the climate change simulated by the RegCM3 is an average temperature increase of ~5°C and a precipitation increase during winter, and decrease during April. The resulting moisture stress, occurring in April, an important month for wheat growth cycle explains the large decreases in yields generally observed when using the Crop Environment Resource Synthesis (CERES)-Wheat 2.0 model[27]. The model can aid in pre-season and within-season for management decisions and for cultural practices i.e., use of fertilizer and irrigation applications and pest and disease management. When making these management decisions, maximizing yield and net return as a function of inputs and production costs is one of the fundamental goals (Bannayan et al., 2003). Wheat yield and climate change showed much greater spatial homogeneity than for other crops due to the longer growing season for wheat, which may smooth spatio-temporal anomalies associated with climate variability/change.

[26] RegCM3 is a 3-dimensional, sigma-coordinate, primitive equation regional climate model. It is freely available at http://www.ictp.trieste.it/~pubregcm/RegCM3/

[27] Effects of climate change on plant growth can be estimated and evaluated using the crop growth simulation models or CERES (Crop Environment Resource Synthesis)-Wheat 2.0 model. Model sensitivity can be determined based upon climate-induced changes in several meteorological factors such as air temperature, precipitation, solar radiation and carbon dioxide (CO_2) concentration.

5. IMPACTS ON COASTAL AREAS, LOW-LYING AREAS, RELATED INFRASTRUCTURES, TRANSPORT

Scientists are very conservative in setting up qualitative evaluation of the mean sea level rise on a long-term basis under global change scenarii. This is the so-called 'scientific reticence' highlighted by Hansen (2007). This is due to the huge gap between what is understood on anthropogenic global warming and what is known from the public, decision- and policy-makers. It can be also argued that there is a political preference for immediate rewards.

5.1. Coastal areas and low-lying areas

The global results on sea level rise cannot be so easily applied to the Mediterranean. A perfectly closed sea would have a water-level variability of its own, mainly due to thermal dilatation, watershed runoff, and evaporation. The Mediterranean Sea with its 14km umbilical cord coupling it to the Atlantic Ocean would tend to follow the general regime, plus its regional/local variations described above. Moreover, since there evaporation is greater than precipitation, regional differences in altimetry and salinity tend to increase, rendering water exchanges through the Gibraltar Strait more complex. It should also be noted that Mediterranean basin is linked to the Black Sea where phenomena are also quite different (temperature, watershed runoffs, evaporation…), and bring cooler water in the EM, during springtime.

A large part of the population in the Mediterranean basin lives on the coastline, sometimes referred to as the 'concrete coast' or former 'Côte d'Azur'. There is a continuous increase in this phenomenon amplified by seasonal tourism. The socioeconomic impacts from sea level rise can thus be easily understood. It should be recalled that southern Europe is slowly sinking (a foreseen 5 cm sink by the 2080's) due to tectonic adjustment following the last ice age (Parry, 2000). This means that many coastal areas are also subsiding. An overall effect can be the famous "cultural" and spectacular example of the city of Venice water-submersion, leading to huge and expensive engineering actions (Consorzio Venezia Nuova, 1997). Rising sea level during the 21st century can have serious impacts in Egypt where 1/3 of fish catches are from lagoons. Sea level rise would thus change the water quality and affect most fresh water fish. Valuable agricultural land would be flooded as well, threatening Alexandria and Port Said. Recreational tourism beach facilities are to be endangered with salinization of groundwaters and increasing wave actions.

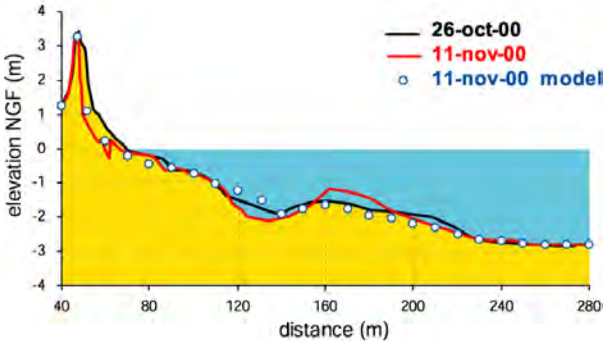
Less spectacular but as expensive impacts could occur from "extreme weather events" linked to thunderstorms and possible hydrodynamic resonance effects, in the context of an increased sea level (Figure 20, where a drastic result from an extreme storm event with sea surge on the Mediterranean littoral, is shown). Sand dune erosion, from storm and sea surge actions, using 'S-beach model' of the 'Liteau Program' from MEEDDAT (former MEDAD) are displayed in Figure 21. In Figure 22, the shoreline erosion at a north-western Mediterranean site and as a function of time is shown (IMPLIT[28] Project).

[28] Impact of extreme events (storms and sea surges) linked to climatic change on the French coastal Mediterranean hydro-systems (IMPLIT project of program GICC 2).

Figure 19 – Impacts on coastal roads and buildings from extreme weather events (i.e., storm, sea-surge) on the Mediterranean Littoral

Source: IMPLIT project

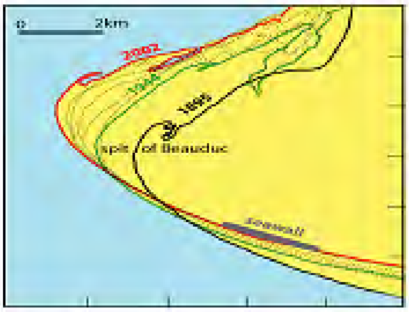
Figure 20 – Sand dune erosion, from storm and sea surge actions, from the "S-beach model" of the "Liteau Program"

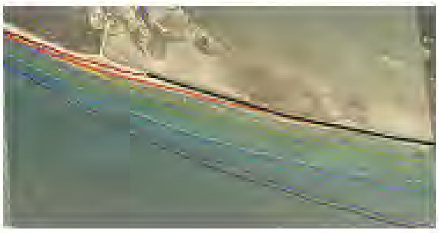


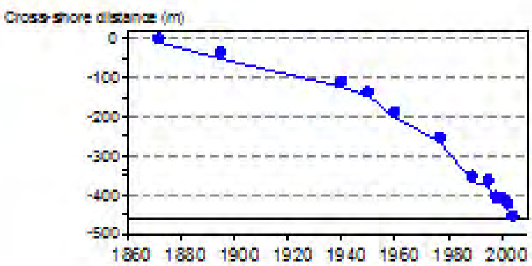
Elevation in meters (ordinates) and depth versus distance from the coastline, both in meters (ordinates and abscissa). The model's results (white dots) match the observed November 2000 profile quite well

Source: MEDAD

Figure 21 - One hundred fifty years of observations on shoreline erosion in the north-western Mediterranean.







Isochrones (with different colors from 1995 to 2002) show the evolution of coastline, (top, left and right). The decrease of the cross-shore distance (in meters) is also given (bottom), with a sharp increase in the last fifteen years

Source: the 'Spit of Beauduc' site, from the IMPLIT project

Some other consequences could be:

1) Submersion of exposed river deltas (Rhone, Nile) associated with additional subsidence of these regions from extreme sediment loading, no longer balanced by alluvial deposits, blocked by dams and artificial embankments. Offshore bars could thus be broken off, causing invasion of salted water in these regions, bringing additional stress to natural ecosystems. Some of these areas have a major environmental or economic interest and should be protected (such as the Parc du Valat).
2) Erosion of fragile coastline, should augment from swell action. Numerous limestone cliffs could then collapse under such mechanical erosion and cause huge economic losses.
3) The interface between underground water tables and salted water should shift toward land and increase the piezometric level. Fresh rainwater infiltration will be less efficient at feeding coastal water tables and aquifers. Coastal aquifers will therefore become more fragmented. The latter associated with ground salinity increase, will have negative feedback on agriculture.

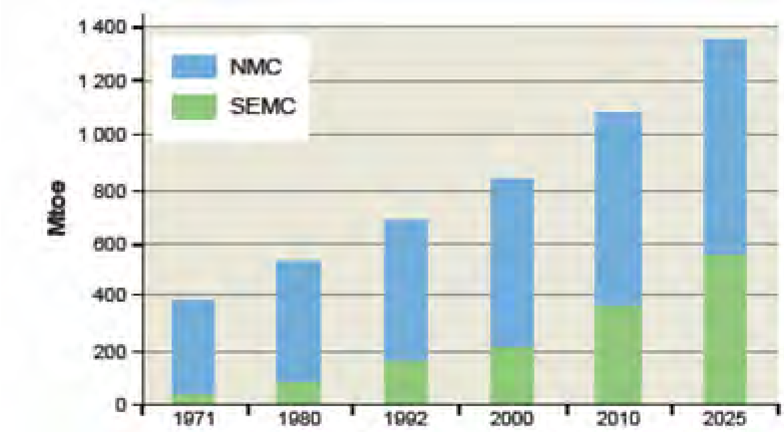
5.2. Infrastructures

Among the most likely consequences of sea level rise will be: increased direct wave impact on exposed infrastructures on coastlines (e.g. the coastal barrier of Venice lagoon, beach resorts of the Rhone delta) and on harbour installations (e.g. Alexandria, Port Said, La Golette-Tunis); worsening of existing shore erosion problems (e.g., the deltas of the Nile and Rhone). By the middle of the next century, the impact on coastal settlements and construction (e.g. harbours, coastal roads) might be considerable in places where they are only slightly above the present mean sea level (e.g., Venice). Historic settlements and sites may require special attention and expensive protective measures, while solutions for other structures should be addressed through their gradual transformation or translocation. Many unprotected shorelines and low-lying regions of the Mediterranean already suffer from erosion and experience periodic inundation during high sea level conditions from cyclonic activity.

5.3. Energy transportation

Based upon the population increase, the total primary energy demand has been increasing continuously and is expected to increase by ~60% on the southern rim and by ~150% in the EM during the first quarter of the 21st century. Climate change and extreme weather events could have thus non-negligible impacts on the ways and means the energy is first being produced and second being transported and distributed to the rural areas levels. The primary energy demand: trends and forecasts in Mtoe= Million Tons of Oil Equivalent for the NMC= Northern Mediterranean Countries, and the SEMC= South-Eastern Mediterranean Countries, are given in Figure 23.

Figure 22 – Primary energy demand: trends and forecasts in Mtoe (or Million Tons of Oil Equivalent) for the NMC (Northern Mediterranean Countries, in blue) and SEMC (South-Eastern Mediterranean Countries, in green) since the early 70s



Consequences of such energy demand are far for being compatible with objectives of sustainable development.

Source: Thibault, Plan Bleu, European Investment Bank, or EIB forum, 2007

6. IMPACTS ON PUBLIC HEALTH

Climate change perturbs important physical and biological systems to which human populations are biologically and culturally adjusted. The various environmental changes linked to climate, loss of biodiversity and land use changes (see above), will all have their own impacts on human health, particularly in the Mediterranean basin. Paradoxically enough, they may be beneficial/harmful, direct/indirect. Beneficial impacts such as decreases in cold-related deaths and reduced viability of mosquitoes in hot tropical regions are, however, anticipated to be outweighed by adverse impacts.

Direct influence of demographic factors is conspicuous for infectious diseases transmitted from person-to-person. The socioeconomic impacts from climate and environment changes on infectious diseases and public health require more attention. Most emerging (or re-emerging) infectious diseases are due partly to changes in "microbial traffics", that is the introduction of new pathogenic agents from wildlife into population at risk. Moreover mechanisms for the dissemination of diseases by vectors and their reservoirs into new habitats and linkages with the changing environment must be investigated. The latter processes may depend upon ecological and/or environmental factors (i.e., forcing, interactions, variability, changes…) even if the spreading of diseases is greatly facilitated by population movements, crowding effects (mainly demographics), sanitation level, and/or breakdowns in public health with important socioeconomic losses. Today, the apparent increase in occurrence of many infectious diseases reflects the 'compounded effects' from demographic and population increase, economical, environmental, social and technological changes.

The challenge for assessing socioeconomic impacts from infectious diseases (i.e., near 75% of actual infectious diseases in humans are zoonoses) cannot be addressed without considering the environmental factors - both abiotic and biotic - that affect the maintenance and transmission of the diseases. The last quarter century has witnessed an explosion of environmentally-related illnesses, i.e. diseases and disorders, due to strong environmental forcing and adaptation or lack thereof. For infectious diseases, this includes increases in the prevalence, incidence and geographical distribution across wide taxonomic ranges, related to practical changes in land use and climate/environment variability and changes. The large scale of these changes represents an important step in the understanding of disease from the individual-centered traditional view of microbiology and medical epidemiology.

Direct health effects of climate change include: changes in mortality and morbidity from heatwaves and thermal stress (such as in 2003 over southwest Europe; and to a lesser degree in 2007 over Italy and Greece); respiratory ailments associated with modified concentrations of aeroallergens (spores, moulds,…) and/or air pollutants; health consequences of extreme weather events, including storms, floods, windstorms, …

Indirect health effects, are to result from perturbation of complex ecological systems, and include: alterations in the ecology, range, activity of vector-borne infectious diseases (i.e., Malaria, West Nile Virus, Rift Valley Fever, Avian Flu, Chickungunya, Dengue Fever, among others) (Takken, 2006); alterations in the environment of water-borne diseases and pathogens (i.e., gastro-intestinal infections, Vibrio diseases including Cholera, diseases from polluted waters…); alterations in the atmospheric boundary layer, and transmission of air-borne diseases (meningitis, respiratory ailments, among others); alterations and regional changes in agricultural practices and food security (malnutrition, lack of fresh water,…). As already mentioned public health is also to be affected by massive population movements on narrow coastal regions, and by regional conflicts over declining agricultural and water resources. Leishmaniasis is already endemic in the rural Mediterranean basin south of Europe, the Maghreb, and in the EM. Outbreaks of West Nile Fever have already occurred during the 2001-2005 period (Paz and Albersheim, 2008). Climate change may extend the habitat of the sand fly and phlebotomes vectors northwards; the life stages of tick species responsible for transmission of the Lyme disease are directly influenced by temperature;

We have seen that climate change affects crop yields, particularly those of cereals. There would be regional socioeconomic cost/loss, reflecting the loss of local balance from temperature and soil moisture changes, use of fertilizers, and pest and pathogen activity. Whatever decision-making models are used they must include:

1) Identification of "normal" impacts of disease (in lives and Euros).
2) Definition of the "climate event" linked to the "health event" (epidemics, endemics…).
3) Definition of increased impacts on lives and in Euros (losses).
4) Identification of methods of mitigating the losses.
5) Definition of the costs (Euros) of implementation of the above methods.
6) Identification of the mitigated losses (in lives and Euros) if the "health event" do occur?
7) Quantification of the savings (in lives and Euros) if the "health event" does not occur?

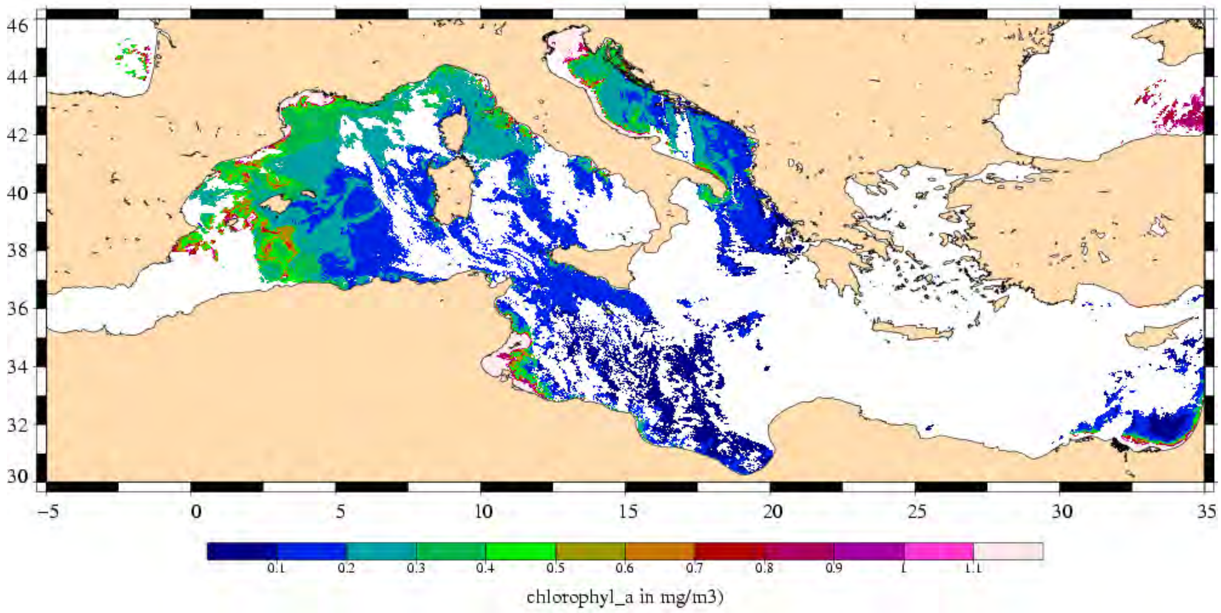
Regional modelling studies consistently indicate that tropical and sub-tropical countries would be most affected. Poor and economically disconnected populations in the Mediterranean basin will not be able to offset reduced yields via trade. Tensions over water shortages in the Mediterranean southern rim and EM, where adjoining countries share river basins, would be exacerbated.

Forecasting climate change impacts on human health requires the development of scenario-based risk assessments which must include generalized assessment of the consequences of complex demographic, social and economic disruptions. Integrated mathematical modelling must be used if one wants to estimate the future impacts of climate change on health (Martens, 1998a). Such modelling requires that each component of the chain of causation: climate, environmental and social changes are represented mathematically.

As with all future research, assessing the complex socioeconomic impacts of climate change in the Mediterranean basin entails uncertainties. The uncertainties are due to the future industrial-economic activities, interactions between and within natural systems, and differences in sensitivity of disease systems and vulnerability of populations. Moreover, while the above interactions are non-linear, uncertainties also arise from the stochastic nature of the biophysical systems being modelled. Local anthropogenic deforestation may directly alter the distribution of vector-borne diseases while also causing a local increase in temperature. Differences in population vulnerability will also occur due to the heterogeneity of human culture, social relations and behavior.

Human health indicators and disease surveillance activities could and should be integrated with in-situ observing systems such as Global Climate Observing System (GCOS), Global Ocean Observing System (GOOS), and Global Terrestrial Observing System (GTOS) which includes remote-sensing and the Earth Observation Systems. Today, the use of satellites allows us to monitor changes in environmental and climatic parameters with excellent resolution. This provides a continuum of observation scales in space and time of both oceanic and terrestrial environmental structures. This is particularly true over the Mediterranean basin, where ocean data from space is coupled with ecological-epidemiological data. The new joint datasets should allow to test in terms of socioeconomic values, for the significance of environmental factors (such as Chlorophyll A, see Figure 24) in the emergence of Vibrio population blooms (including cholera. See also Paz et al., 2007). In Figure 24 a real-time distribution of Chlorophyll A (favorable ecotones for Vibrios and phages) in the Mediterranean basin (Vibrio Sea [29] Project) is displayed, using the satellite and sensor MODIS AQUA, and NASA OC3 algorithm.

Figure 23 – Snapshot Chlorophyll-a (in mg/m3) distribution in the Mediterranean basin on October, 10, 2006, from MODIS-AQUA and using the NASA OC3 algorithm



Highest values were found between the Baleares Sea and the Maghreb, the Gulf of Gabes, the extreme north of the Adriatic Sea, the Bay of Port Said. White zones are either cloud covered, or did not pass the error-check levels

Source: from CLS, VIBRIO sea project, 2006

[29] Vibrio Sea Project is a satellite application for monitoring environmental factors influencing Vibrio concentration in sea waters. The overall objective of the Vibrio Sea project is to study the emergence and spread of waterborne diseases in a changing climate scenario.

7. IMPACTS, POLICY AND ADAPTATION

In order to properly carry out risk analyses and adaptation measures, the concept of adverse impact must be properly evaluated. Direct impacts from climate change upon welfare and human life values have to be distinguished. Direct impacts on welfare, such as the need for investing into adaptation types of infrastructure, might be the easiest to evaluate. Equity and ethical considerations must be parameterized. Changes due to climate change should not lead to impacts affecting only the poorest (Portney and Weyant, 1999). All of the above is based upon different spatio-temporal scales. In the Mediterranean basin we should first tackle what could happen over the next ten years (droughts, floods, wind storms…), and what could happen in the next decades until the middle of the 21st century (including demography, technology, soil exhaustion, water scarcity…). The insurance industry has developed a set of tools to assess local costs of the so-called natural disasters (Hallegatte et al., 2007). But the development of regional socioeconomic models will be useful for evaluating consequences from specific events in the Mediterranean basin and comparing the output with specific surveys (Rose and Liao, 2005). The above analyses and results are essential to prepare and manage recovery and minimize and adapt to future vulnerability. Other studies should assess the cost-loss ratio between investing heavily in water distribution and managing and reducing leakages and consumption habits, in order to reduce investment in new reservoirs.

In terms of energy distribution over western Europe and the Mediterranean southern rim, the main exporting countries are: France, Algeria, Libya, Egypt and Syria, whilst the main importing countries are: Spain and Italy from France; Tunisia from Libya and Algeria; Jordan from Egypt; Turkey from Syria. Integrated energy management is foreseen as a prerequisite in a climate change context in order to minimize socioeconomic chaos, local and regional vulnerability in terms of prices and supply. For example, socioeconomic benefits might be gained if derived from electrical interconnection of the so-called 'Mediterranean blocks' (see MedRing Feasibility Study, 2001-2003, by Bruno Cova).

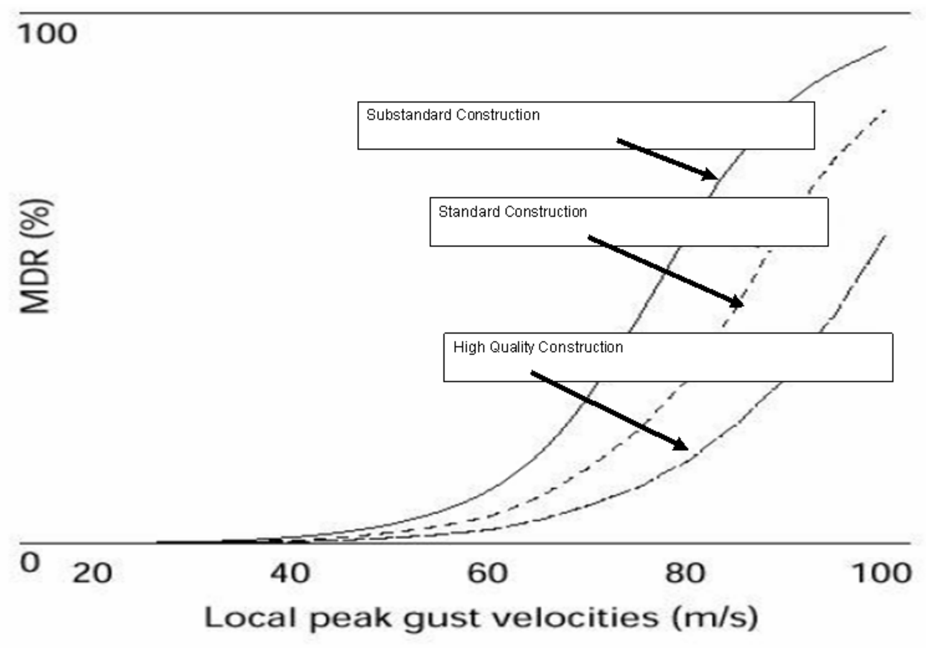
Water input from dams is very important for hydro-electricity, primary production of energy, renewable energy, as well of cooling of nuclear plants. Dams of various sizes can help to cope with interannual variability modulated by climate change. Dams may also cause changes in downstream hydrology and geomorphology leading to reduced soil fertility and impacting on agriculture. The delta of Ebro (Spain), which had first expanded due to deforestation, is now retreating from the construction of three retaining dams. Three hundreds dams in Mediterranean regions are trapping huge amounts of sediment loads (Vericat and Batalla, 2006). The presence of dams enhances loss of flow capacity from downstream rivers, exacerbating flooding from intense extreme weather events, and thus increasing vulnerability and impacts on population, like in northern Tunisian Wadi Mejerda basin (Zahar and Albergel, 2006). The same is happening in Greece, where scheduled artificial floodings are proposed to mitigation impacts (NTUA, 2007). Smoothing effects from dams reduce aquifer recharge processes through Mediterranean ephemeral wadi (see Leduc et al., 2007). As a result, pumping subterranean water and aquifers must thus be planned accurately for irrigating projects, or for transferring water from regions with exceeding volumes. In the climate change context, new treatment plans are also to be foreseen for usage of used and/or salted water. Means to transport water efficiently from one region/country to another must already be planned; grounds (including deserfication processes) and forests must be managed; while catchment basins will require specific and integrated maintenance and monitoring (in-situ and remote). Concerning agriculture implementation and adaptation, switching habits and cultivars must be considered in order to minimize the desertification processes and land degradation mentioned above.

Along the coastline where infrastructures are primarily exposed, whilst the demographic pressure must be reduced, tourism must also be developed, which will create serious socioeconomic upcoming challenges. Engineers have realized that climate change affects our environments and challenges their ability to plan, design and construct infrastructures and systems that can protect people from harm and maintain acceptable standards of economic well-being. Thus infrastructures must be improved/protected while preserving the environment, which represents a real challenge! Scientific knowledge and uncertainties on climate change must be the building block for engineering practices. The additional challenge is also to maintain a suitable environment and ecosystems for generations to come, by contributing to sustainable development. The elements to consider are:

- Long lifetime of infrastructure investments;
- Robustness of present infrastructures, using latest climate information;
- Existing infrastructures to replace or maintain at sustainable rates, without diminishing vulnerability;
- Examine in detail the 'apparent preferences' for more exposed or dangerous locations;
- Apply changes to the building industry, and building codes and standards;
- Keep in mind that land use and building materials (and designs) are dominated by short-term commercial interests.

Damage increase percentages can also results from strong winds and be given as a function of wind gusts (Herbert et al., 2005). In Figure 25, MDR are given in % as a function of standard of construction and local gust velocities (from SwissRe, www.swissre.com)

Figure 24 – Mean Damage Ratio (MDR, ordinates in %) as a function of standards of construction and local peak gust velocities (abscissa, in m/s)



Source: SwissRe, 2005

In the meantime and keeping in sight the elements presented above, two issues are of the foremost importance: (i) materials to use in the construction (or replacement) of new (older) infrastructures; and (ii) identify at least at the regional, national levels, the areas under risks from sea level changes. Concerning the second issue involved with coastal zones at risks, several task teams commissioned by UNEP and IOC/UNESCO have issued statements for different regions of the world including the Mediterranean. It has been reported early by the Mediterranean Action Plan (MEDU) that if general effects might be similar throughout the basin, considerable differences in the impacts could be expected at different sites, with different responses required. Therefore site-specific case studies had been prepared, including deltas of the rivers Ebro, Rhone, Po and Nile; Thermaikos Gulf and Ichkeul/Bizerte lakes. Since then climate change studies are included when relevant in the framework of Coastal Areas Management Programmes (CAMP) such as determining areas, systems, structures and activities that appeared to be most vulnerable to climate change, such as the northern rim where rapid transitions are expected. Indeed rapid sea level changes may lead to: increased intensity (possibly frequency) of coastal and increased inland extent of flooding which will require in the near future a rearrangement of coastal unconsolidated sediments and soils; increased soil salinity in areas previously unaffected. The overall objectives from results are to formulate in particular recommendations for planning and management of coastal areas, as well as for the planning and design of major infrastructures (see Table 7 which lists the major potential impacts on identified infrastructures in the Mediterranean basin; from CAMPS and after Georgas, 2000).

Table 7 - Major impacts on hydrological cycles, in some Mediterranean deltas, gulfs, countries, wetlands, coastlines

Zones considered	Major impacts
Delta of Ebro	Increased coastal erosion; reshaping of coastline; loss and flooding.
Delta of Rhone	Erosion of unstable or threatened parts of coastline.
France wetlands	Increased impact of waves
Delta of Po	Damage to coastal infrastructures
Delta of Nile and Egypt	Coastal erosion; overtopping of coastal barriers, Egypt increased flooding; damage to port and city infrastructures.
Thermaikos Gulf	Inundation of coastal lowlands.
Greece	Damages to coastal protective structures with extension of tourist season.
Island	Increased coastal erosion.
of Rhodes	Damages to infrastructures; Accelerated deterioration of historical buildings.
Kaštela Bay, Croatia	Erosion of beaches with damages to coastal structures and ongoing human settlements due to exceptional storm surges.

Source : Georgas, CAMPS project, 2000

Any increase in the mean sea level, or in the intensity (possibly frequency) of episodic but extreme events also affecting that level, would worsen the present situation. However, the dynamic character of costal processes and the long-term non-climatic coastline changes are not legislatively recognized as yet. Usually backshore space is lacking to accommodate the retreating coastline. Only the application of highly site-specific combinations of adaptive and protective measures can mitigate or avoid the problems caused by erosion and inundation. Response options can be either preventive or reactive. For example, in some instances entire economically important coasts and lagoon margins can be walled in to protect irreplaceable coastal uses and values (e.g., harbours, towns of historical value). Crops could be gradually replaced with lagoons or ponds destined for aquaculture and natural reserves and act as buffer zones, since their inner margins can be more easily protected than the exposed coast. One way to cope with damages associated with extreme weather events is to develop insurance products for marketing through the private insurance industry, such as weather derivatives, cat loss bonds, underwriting of national insurance programmes, and to make insurance available at concessionary rates initially. It is also to Include development of adaptation strategies and policies as eligibility criteria with deductibles or lower premiums for applying adaptation measures.

Concerning public health issues, preventive measures based upon early warning systems (EWS) must be implemented by including all organizations involved with the health information services (HIS) and appropriate research laboratories. Special attention must be given to water quality by monitoring and possibly eliminating most of the vibrio sources (including cholera) in a foreseen warmer Mediterranean Sea with blooming phytoplankton-A.

III. CONCLUSION

There is high confidence that neither adaptation nor mitigation alone can avoid all climate change impacts as presented above. However, the two approaches can complement each other and thus significantly reduce the risks. Adaptation is necessary in the short- and longer-term to address impacts resulting from Mediterranean climate change and that would occur even for the lowest stabilization scenarii assessed and agreed upon. There are socioeconomic barriers, limits and costs, but these are not fully understood as yet. Unmitigated climate change would, in the long term, be likely to exceed the capacity of natural, managed and human systems to adapt. The time at which such limits could be reached will vary between sectors and regions of the Mediterranean basin. Many impacts can be reduced, delayed or avoided through mitigation. Mitigation efforts and investments for the next three decades will have a large impact on opportunities to achieve lower stabilization levels. Delayed emission reductions significantly constrain the opportunities to achieve lower stabilization levels and increase the risk of more severe impacts. This why all actions taken in the upcoming years (including Carbon Capture and Sequestration, or CCS, already being implemented in Iceland at the instigation of its President Ólafur Ragnar Grímsson), and particularly after the end of the Kyoto Protocol in 2012, are becoming crucial. This is well articulated by the combined action/efforts of/from the United Nations Framework Convention on Climate Change (UNFCCC), the United Nations Convention to Combat Desertification (UNCCD) and the more recent UN Biodiversity group. The Bali conference is a first critical step in that direction.

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CHAPTER 2

Review of the Economic Literature on Impacts of Climate Change in the Southern and Eastern Mediterranean Countries

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Plan Bleu/CEFI

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KEY MESSAGES

Based on the economic analyses available, certain cross-sector and sector-based economic costs for the Southern and Eastern Mediterranean Countries (SEMCs) were identified.

Although it appears that none of the studies has addressed specifically the potential climate-related economic impacts in this region, there may be found - in works encompassing all the countries of the world (global studies) or those that analyze certain sectors (such as agriculture, tourism, etc ...) - a few results relevant to the Middle East North Africa (MENA) region.

Global studies:

- They share a distant time-frame (2100-2200),
- Their quite disparate results hardly lend themselves to comparison, as they are closely dependent on the assumptions and methods selected,
- In spite of this, they all concur to the conclusion that: (i) beyond 2°C to 3°C, world economy will suffer considerable losses, (ii) the costs for the Southern Mediterranean region will be particularly high within the near future, and this, in view of the structure of their economy and their geographic exposure, and (iii) there will be observed, in the absence of any relevant measure, a widening of income gaps between the Northern countries, for which a rise in temperature below 2° creates new opportunities, and the Southern countries, which will bear a heavy toll.

More precise studies:

- The vulnerability of the Southern Mediterranean Countries (SMCs) to climate change varies according to the share of their economy that is sensitive to climate (agriculture, tourism, infrastructures, energy, and ecosystem). Accordingly, the costs of non-action are likely to be more significant for agricultural countries (Syria, Egypt, Morocco, and Tunisia): between 2 and 9% of the countries' agricultural GDP by 2050.
- Studies focusing on specific regions reveal that, for a 2,5°C increase in temperature, loss will be around 7% of GDP per capita in average for Africa (North Africa included) and around 4% for East Europe up to 2100 ((Nordhaus et al., 2000) (the upper cost in the range of estimate for the world). The location of the Mediterranean and those results let think that the Southern Mediterranean will be among the regions of the world most affected, and most rapidly, by the adverse impacts of climate variability.
- The main problem factor by which climate change will affecting all sectors of the economy is connected to the rarefaction of water resources.
- The interactions between the sectors and the chain of effects - which are not taken into consideration in the economic studies - may further add to the costs of non-action.

The economic analysis of adaptation in Mediterranean countries has been fairly limited to date. The cost of action is fairly unknown. The few sector elements available (agriculture, in particular) lead one to believe that appropriate measures investment (in timing and actions) to adapt and reduce vulnerability are likely to have a cost lower than the benefits (mitigation of damage) that they might yield. .

However, the capacity of adaptation of the Southern and Eastern Mediterranean Countries (SEMCs) is limited. Accordingly, both a coordination of the private and public sectors and the role of international institutions are dominant in helping the region adapt to the new climate context. The issue of financing the actions remains a key question currently under discussion.

GENERAL INTRODUCTION

Context

According to the IPCC (Inter-governmental Panel on Climate Change), climate change signifies "a statistically significant change of the average state of the climate or of its variability, over a long period […]. Climate change may be due to natural endogenous processes, external constraints, or persistent anthropogenic changes of the composition of the atmosphere or land allocation".

Today, one notices that greenhouse gas (GHG) concentration has never been so high. There is now scientific consensus that this recent and violent phenomenon, which is disrupting the climate, is directly connected with human activities.

In the face of such a situation, most countries of the world have recognised, via the United Nations Framework Convention on Climate Change (UNFCCC) in 1994, the need to act as promptly as possible to reduce their emissions.

Why and how do economists address the issue of climate change?

Mitigating the impacts of climate change has become one of the world's most significant environmental challenges. Far-reaching changes need to be envisaged in order to reduce GHG emissions, particularly in the fields of energy production and consumption. In addition, several adaptation measures are necessary to address the impacts of climate change. In view of the costs related to the adoption of alternative, less carbon-intensive production and consumption methods, and so as to justify this action, an economic evaluation of the impacts due to climate variability has become a priority (Hallegatte, 2005).

The economic analysis of climate change invokes the concept of sustainable development founded on the sound sustainability notion, since it requires a parallel consideration of the economic, social and environmental aspects. Besides, it argues for the principle of prevention according to which the only monetary compensation is insufficient to mitigate the impacts of climate variability by the integration of externalities; indeed, there must be implemented a set of measures, upstream, in order to reduce emissions and, by doing, be aware of the cost of non-action (Harribey, 2002).

As a matter of fact, climate change may be analysed, to a certain extent, as an economic externality, because it is at once the individual, corporate, and country actions that incur future costs to other parties than those at the origin of the action via GHG emissions (Llewellyn, 2007). This phenomenon may not only have impacts on people's consumption and health, and on productivity and capital, but also may have irreversible impacts on the ecosystem (Stern, 2006; UNEP, 2007a). The pricing system must, therefore, take into consideration this factor with a view of enlisting the financial participation of those responsible for such emissions and of covering the costs that they generate.

The "cost-benefit" approach is widely used in the analysis of climate change, though it is not free from certain limitations. The empirical literature uses the notion of "cost of non-action" (Cline, 2005; Kuik et al., 2006). It assumes that, in order to underscore the need to act, it is important to have a vision of what the world would look like if nothing were to be done. This involves, in general, estimating the net costs of the impacts due to climate change, that is, in the case where there is no other measure to reduce emissions. The costs of action and of non-action would then be compared to define the most cost-effective preventive policy, that which helps mitigate the adverse impacts by means of an investment that remains lower than the cost of non-action.

Such evaluations are bound to run against many difficulties. Indeed, they are all the more complex to work out as they require consideration, in the long term, of the intricate interactions between the various market and non-market sectors of the economy. A further significant problem stems from the lack of knowledge and uncertainty about climate dynamics, the reaction of ecosystems and economic damage. Furthermore, there is some debate concerning what discount rates to apply, as well as considering interactions between the short term and the long term. For all these reasons, the results obtained remain fairly imprecise.

Studies on this subject were, at first, applied to developed countries in order to assess the economic impacts of climate variability and the preventive policies (reduction of emissions) to be implemented. This was justified by the will of decision-makers to quantify the effects of several options and to compare them in order to best handle the constraints of GHG emissions reduction under the Kyoto Protocol.

Focus on developing countries has increased in the past few years, ever since the various climate scenarios highlighted the fact that these countries are the most geographically and economically exposed to climate change, and were set to face very rapidly major difficulties, while having limited means to adapt, and that they have had, as yet, a relatively small responsibility in terms of GHG emissions. This particularly applies in the case of the Southern Mediterranean Countries (SMCs).

Methodology and content of the study

For purposes of this study, we have undertaken a systematic search of the economic studies conducted and published in the scientific reviews of international renown. We have also perused a whole range of documents and reports issued by international institutions, foundations and NGOs, of which we have selected the works of relevance to the countries of the region under consideration.

After a review of the literature, it appears that no study has addressed specifically the potential economic impacts of the climate on the Mediterranean region (Southern and Eastern Mediterranean countries) as a whole. However, there emerge - within the works encompassing all the countries of the world (global studies), or those that analyse certain sectors (agriculture, tourism, etc…) - a few results related to the Middle East North Africa (MENA) region, which could be harnessed to the task. They highlight the catastrophic situation in which the countries would end up if no action to reduce their vulnerability were to be taken as promptly as possible.

The objective of this chapter is, accordingly, to take stock of:

- The global economic costs of climate change and the implications derived from there for the Southern and Eastern Mediterranean Countries (SEMCs);
- The sectoral economic costs and transmission channels of the adverse impacts of climate change in Mediterranean countries;
- The importance to be granted to adaptation and the related costs likely to be incurred.

In order to meet this objective, the study has been divided into three sections.

- Section One is dedicated to an overview of the empirical literature related to the issue of the economic impacts of climate change. It invokes the most comprehensive and most recent global studies, which it then narrows down to the conclusions pertaining specifically to the Southern Mediterranean region. Two observations may be derived from this at first sight. On the one hand, few of the works take into consideration the specific features of the countries of the Middle East North Africa (MENA) region. On the other hand, there is a significant heterogeneity of the results, which reveals the influence of the climate scenarios on which the analysis is based, as well as the parameters chosen and the methodologies selected by the authors.
- Section Two contains an analysis of the impacts on the main market and non-market sectors of the countries of the zone, which complement and refine this global vision. According to the

specialization of the production of the countries, the share of their economy that is sensitive to climate change varies. Consequently, the costs will differ from one country to another. All, however, will be concerned with a major difficulty related to the rarefaction of water resources, which will have cross-sector negative impacts. It must be noted, though, that it is the agricultural countries, which will suffer most from this problem. Coastal cities and infrastructures will be more vulnerable to sea-level rise and extreme events. Also, the poorest populations will remain the ones most affected by epidemics and famine. Lastly, in order to assess more precisely the impacts of climate change, it would be essential to consider, in parallel, economic growth and future population growth which will induce a significant increase in energy needs.

- Section Three allows a consideration of the actions, which may be taken by the countries to prevent climate change and to mitigate its adverse consequences. In the short term, it is recommended to adapt measures of the "no regret" type, allowing a reduction of the vulnerability of the economies to the climate, while benefiting them regardless of the evolution of future climate. Such measures must belong within a vision of the longer term so as not to accentuate future climate change due to additional emissions in the atmosphere. The importance of the costs of action having been proven, the international institutions - in partnership with the public and private sectors of the countries - will have a key role to play in focusing and financing these policies.

I. GLOBAL STUDIES

The growing interest granted to the problem of climate change is justified by the catastrophic consequences that may be entailed by non-action. In order to elicit prompt reaction on the part of decision makers and so that policies of preventive action are adopted at once - which would be geared towards reducing GHG emissions - or of adaptation - which would seek to address in the most appropriate way possible the phenomenon of climate change -, it is necessary to highlight the relevant future economic costs for the countries. Such is the main objective of the economic studies conducted in the past few years on this topic. This new approach seeks to integrate - within the same analysis - physical, climatic and economic considerations. The difficulty related to encompassing the whole range of these factors, as well as their interactions, within the same study often gives rise to an under-estimation of the costs of climate change.

However, while the most optimistic anticipations sought to demonstrate that, in the case of a temperature change less than 2° (Mendelson and al.. 2000, 2006; Tol 2002 b) compared to the pre-industrial period (years 1960 to 1990), several countries (in particular the Northern countries) can derive benefits from global warming (energy saving, evolution of crops), once the temperature rise is above the 2-3° range (Nordhaus and al., 2000, Nordhaus, 2006, Stern, 2006), it is unanimously held that all the economies of the world will incur an additional cost related to the climate (Smith and al., 2003).

Given the complexity and the innovative nature of this approach, there is only a limited number of studies on this subject.

The merit of the analyses conducted over the past ten years, addressing the economic impact of climate change, lies in the fact that they propose an evaluation of these effects based on a common unit, the US dollar; with one caveat though: this is not sufficient to allow for an objective comparison of their results. Being largely dependent on the underlying assumptions, the conclusions cannot be established without specifying the analysis framework.

Indeed, even if the authors agree on the fact that a global warming will induce, starting from a certain threshold, significant global losses, there exists a great diversity between the analyses as to the identification of this threshold and the assessment of the impacts. Besides, if on a regional scale, there emerges from the disaggregated analyses a particularly strong exposure of Mediterranean countries, the latter differs according to the climate scenario selected, the evaluation method adopted and the analysis scope covered.

This is why we have deemed it essential to emphasize these factors in a first section so as to subsequently move on to considering the global and regional results of the reference studies on this topic, in order to develop a clearer vision of the economic impacts of climate change on the Mediterranean region in the next section.

1. ANALYTICAL FRAMEWORK AS A FACTOR DETERMINING RESULTS

1.1. Decisive role of uncertainty

The uncertainty inherent in the future socio-economic, climate and environmental evolutions of the countries mainly accounts, to a large extent, for the variances between the results of recent analyses aimed at quantifying the future impact of the climate on the economies. It takes various forms and affects every stage of the analysis, from GHG emissions all the way to the assessment of the impact of climate change (Stern, 2006).

This uncertainty concerning the future may be evaluated according to the degree of probability of occurrence of each anticipated climate and economic scenario.

1.1.1. Uncertainty inherent in the future evolution of the climate

As a first step, the task consists in considering the uncertainty in terms of future evolution of the climate. Indeed, it is difficult to anticipate the response of the climate to an increase in GHG concentration in the atmosphere and to define a threshold beyond which climate changes could be particularly dangerous. Upstream, it is quite as complex to forecast the future level of emission of the various countries taking into account, on the one hand, the objectives of the Kyoto Protocol for the countries of Appendix 1 and, on the other hand, the economic development of emerging countries. Finally, feedbacks of the climate systems, being liable to induce an intensification of climate change, are hardly foreseeable.

In order to examine the various possible alternatives, the authors do not refer to a single climate forecast scenario but to several simulations based on different assumptions. In the face of this difficulty, economists adopted several options. They vary according to the authors, which makes it difficult to conduct an objective comparison of their results. On the whole, the studies rest on the assumption of an identical temperature rise for all the countries according to one or several more or less pessimistic scenarios. One alternative would be to consider an average global temperature increase based on the change in the climate of each zone. The main baseline scenarios selected are those proposed by the 3rd IPCC report1 (generally A2 and B2) (Mendelson and al.. 2000; Nordhaus, 2006, Stern, 2006).

However, although it is particularly difficult to anticipate the evolution of the climate on a regional or local level, the most precise studies used climate scenarios that are detailed and issuing from distinct models. Such is the case of Mendelson (2006), for instance, who bases his study on climate anticipations worked out according to three different processes: the "Panel Climate Model" (Washington and al., 2000), the "Center for Climate Research Studies Model" ((Emori and al., 1999) and the "Canadian General Circulation Model" (Boer and al., 2000). The advantage is to highlight the regions and even the countries which will be the most subject to climate change and which will, therefore, incur the most significant costs. It is, however, particularly difficult to anticipate the frequency at which certain regions will be subject to extreme events. Accordingly, there will always be a fairly large confidence interval with regard to each of the climate scenarios due to uncertainty.

[1] As the fourth IPCC report was issued as late as 2007, the economic studies quoted in this section refer only to the previous versions of this work. Currently, scientists give priority to the use of scenario A1B as a baseline since most meteorologists calibrate their models on the latter scenario, which is an intermediate one (increase in CO2 concentrations from 380 ppm today to 700 by 2100).

1.1.2. Socio-economic uncertainties

As a second step, in order to assess the future economic impact of climate change, it would be necessary to consider the countries' capacity and adaptation costs. This depends, to a large extent, on the institutional environment of the economy and its access to technology (Tol, 2005; Stern, 2006). Besides, the impacts vary according to the different population groups, the poorest being generally the most exposed, as well as according to the characteristics of the economy. Indeed, the impacts will not be the same in view of the specialisation of the country that determines its exposure to the climate. This underlines the need to disaggregate the costs as per sector ((Mendelson and al., 2000; Nordhaus and al., 2000; Tol, 2002 b; Tol and al. (2002); Smith and al., 2003). However, the costs incurred by one sector may have repercussions on the rest of the economy. The impact of climate change is, therefore, multiplied via the interdependence between the sectors, which should not be neglected in the estimations (Smith and al., 2003).

Besides, it is important to measure, in each country, the proportion of the firms whose production is carbon-intensive, and which will, thus, be more exposed to the variation of the prices of fossil energies and to regulation policies. But the future evolution of the prices of raw materials remains difficult to predict and requires the authors to consider various scenarios (Edenhofer and al., 2006). Furthermore, the uncertainty concerning the future policies conducted pursuant to the latest phase of the Kyoto Protocol precludes an anticipation of the investment decisions of companies and, hence, the response of the private sector (Stern, 2006; IEA, 2007).

Thus, several scenarios based on materialisation of the priority objectives, to which there are sometimes appended certain probabilities of achievement, are compared with a "business as usual" scenario (Stern, 2006). The latter is defined as maintaining the status quo. Such a comparison then makes it possible to examine the impacts of climate change taking into account the country's economic or technological development. The evaluation of the country's adaptation capacity, thus, depends on the assumptions selected in terms of future socio-economic development being likely to considerably influence the results (Mendelson and al., 1999; Tol, 2007). Consequently, the preferences of the author in terms of the policies to be implemented and anticipation of the future are reflected in the choice of the baseline model.

Lastly, it is worth emphasizing the fact that there is an uncertainty, concerning the impacts of climate change on security and international conflicts, which is generally overlooked in the economic studies or considered under the future migration of populations. Indeed, droughts, access to energy and land use are some of the difficulties likely to give rise to discord between regions and nations. This problem may particularly be seen in the Middle East. For instance, the Nile zone is one of the most sensitive zones, and is exposed to possible conflicts related to access to water (Stern, 2006).

There is thus an uncertainty concerning the future evolution of the climate, an uncertainty regarding the policies implemented as well as their effectiveness, an uncertainty related to the future conditions of the market, to the economic, technological and demographic development and growth of the countries considered, to the promptness and capacity of adaptation of companies, to the effects on the non-market sector and interactions between the sectors, and to the evolution of the prices of raw materials. Each uncertainty is coupled with a risk that is difficult to assess (OECD, 2007). This phenomenon highlights not only the significance of the assumptions on which the model is based but also the extent to which the results are lacking in precision - particularly as regards the global analyses -, as well as the impossibility of comparing between the various analyses.

These studies constitute, thus, a set of elements tending more to help alert the international community to the phenomenon of climate change, than to precisely quantify the real economic cost of the future variation of the climate (Stern, 2006; Tol, 2007).

1.2. Empirical methods used

Environmental modelling may be regarded as a multidisciplinary tool reflecting reality and allowing, via a set of simulations, an assessment of the impact of certain phenomena or the opportunity of the adoption of certain measures, according to precise evaluation criteria (environmental, political, economic...) (Kieken, 2003). The main contribution of such models is, therefore, to provide global information, by cross-checking various complex phenomena according to several possible scenarios, thus facilitating decision-making with regard to the future policies that need to be implemented. The major difficulties are related to the choice of the parameters to be selected - in view of the impossibility of introducing the whole range of the components of a system -, and to the uncertainty concerning dynamics that are still to come, as we have just seen. Accordingly, the task would to define an issue, which allows for setting with precision the grounds of the analysis.

One of the early prospective models, simulating the overall dynamics of the economic social and environmental interactions, was the subject of the report issued by the Club of Rome under the supervision of Meadows and al. in 1972. The objective of this analysis was to consider the future growth of the population and of industrial production and the issuing impacts on the environment taking into account non-renewable natural resources, the useful farmland area and the capacity of absorption of pollution by the ecosystem.

For some fifteen years now, the literature has focused on the study of the impacts of climate change on economies. The early analyses addressing this topic were conducted in the early 1990s. Their objective was to highlight the main impacts expected from such a phenomenon. More recently, the purpose was to quantify these impacts (Mendelson, 2007). In the beginning, the scope of analysis was focused essentially on the case of the United States (Cline, 1991; Rosenthal and al., 1994; Skiff and al., 1998; Mendelson and al., 1999). Then, the authors became interested in the global impacts of climate change (Mendelson and al., 2000, Nordhaus and al., 2000; Tol, 2002 B, Mendelson and al., 2006; Nordhaus, 2006; Stern, 2006; Tol, 2007), sometimes seeking to distinguish the impacts according to regions (Mendelson, 2000; Tol, 2002 B; Nordhaus and al., 2000) and sectors (Mendelson and al., 2000; Nordhaus and al., 2000; Tol, 2002 B; Tol and al., 2003); Smith and al., 2003). Among the main models selected, there may be found either methods of experimental simulations, or analyses of cross-section data. More precisely, the authors seek either to anticipate the impact of various climate variabilities on certain sectors, or to opt for direct measurement of the vulnerability of the countries (Mendelson, 2007). The integrated assessment models, which harness these two types of models, are particularly efficient (Mendelson and al., 2000; Tol, 2002a.). They benefit of the advantages of the two methods jointly by bringing into play at once a global approach and a more detailed vision (by taking into account the adaptation of the systems, but also the impacts of carbon concentration...). Among these various types of methods, several models are regularly used:

Table 1 - The various types of models used in the empirical literature on the economic impacts of climate change2

Models	Objective	Advantages	Limitations	Examples
Integrated assessment models	Set the amount of GHG emissions in order to maximize benefits, and minimize costs	Economic policy decision making support tool	Results dependent on the assumptions Problem of global nature of climate models when it comes to regional studies	DICE model (and its regional version RICE) Nordhaus (1994) and Nordhaus and al. (2000)
"Bottom-up" models	Evaluate the cost of climate change and the options of substitution among the sectors so as to mitigate the impacts	May be integrated in the IA model Analyses focused on one or several sectors	Lack of information with regard to the more global evolutions of consumption or of production	Mendelson and al. (2000). Computation of the global impact of climate variability following the same logic as that of the "top-down" models, while refining their results in view of the details offered by the "bottom-up" model
"Top-down" models	Evaluate the cost of climate change and the options of substitution among the sectors so as to mitigate the impacts	May be integrated in the IA model Take into consideration both costs, production function and consumer preferences Computation of global impacts Include the computable general equilibrium models	Lack of effectiveness in the case of targeted studies Questionable empirical foundations when they rest on experts opinion and not on empirical tests	
Computable general equilibrium models	Quantify the costs and benefits of environmental policies Allow identification of optimal policy to be implemented, taking into consideration climate constraints	Easy to handle Decision making support models They rest on the economic literature They are adaptable enough to address various environmental issues	Are not tools to forecast the future level of the variables Dependent on the assumptions Variance between model and real world Difficulty to obtain a single stable and efficient balance Uncertainty runs counter to the concept of optimal allocation of resources by the market	Conrad (2002)
Partial equilibrium models	Evaluate the cost of the action, while considering the market conditions and the processes of substitution of production and consumption	Focused on climate impact on the most sensitive sectors of the economy	Do not take into account the links between all the sectors of the economy	
«Ricardian » models	Measure long term variation of incomes or of capital cost, according to climate change and other factors across various sectors of the economy (agriculture, in particular)	They rest on the assumption according to which, for all climate-sensitive sectors, there is a temperature that maximizes the thriving of the sector concerned Possibility to monitor the adaptation strategies and evaluate the benefits ensuing thereof	Results very closely dependent on the period on which the analysis rests	Mendelson and al. (2000) ; Kurukulasuriya and al., (2006)
Dynamic models vs. static models	They consider, on the one hand, climate change and, on the other hand, the country's socio-economic changes	Dynamic models are a closer representation of the evolution of the real world This dynamics allows consideration of the countries' adaptation capacity and relative assessment of the adverse impact of climate change Such a dynamics may be found in the IA models	Integrate a targeted vision Take into consideration a large number of additional assumptions with respect to the static model The parameters vary according to the period, the country or the region selected	Tol (2002 a, b)
Marginal cost of carbon dioxide emissions	Allows measurement of the cost of non-action by calculating the current anticipated cost of damage caused by one additional ton of carbon dioxide emitted in the atmosphere	This cost is generally denominated in monetary unit May be compared with the marginal cost of reduction of such emissions in order to allow comparison between action cost and non-action cost	Highly dependent on the assumptions related to the value of the discount rate which depends on the level of consumption and the unit in the future, as well as the weight of the country	Tol (2005), (2007)
Aggregated analyses	Sum of the anticipated impacts of the climate in every country and region of the world in order to evaluate the impact of climate change on international level	Readability of the indicators used Synthesis of a set of complex information in order to offer a simplified vision of the global results	Difficulty to monitor simultaneously the whole range of impacts Problem of an objective comparison between the regions and the sectors, and over time	Nordhaus and al. (2000) Tol (2002b) Stern (2006)

Source. L'auteur

1.2.1. Common features to all methods

To calculate the economic impact of climate change, most of the authors start from a climate model in which they mainstream an economic vision. For so doing, they resort to the traditional

[2] A more precise description of each method is proposed in Appendix 1.

econometric tools used in the economic literature.3 However, each of these tools presents significant limitations, since they are all applied to the issue of future climate variability. This is due to the difficulty of anticipating the future. There is thus a significant subjectivity attendant upon choosing the value of the parameters of the models. The approach is, generally, to set assumptions with regard to the value of time, economic development and growth of the future population, all the more so as one is reasoning in dynamics. Consequently, the main overall criticism to be levelled at these studies is that their results are highly dependent on the bases of the model, which vary from one author to the other.

The majority of these models lend themselves to application within the framework of static or dynamic analyses. Besides, the results obtained according to various regions of the world are sometimes aggregated to reflect the total cost of climate change.

While the earlier studies looked upon things from a static point of view, one notices a greater preference today for the dynamic models, which have that virtue of being closer to reality. It seems important to take into consideration the present and future vulnerabilities of a country that vary according to the regions. Indeed, it seems that emerging countries are particularly sensitive to climate change. On the whole, the large majority of the economic activity of these countries rests on agriculture and is concentrated on coastal zones. It is, therefore, largely dependent on weather conditions (droughts, water level rises, natural disasters). Today, most of the countries of the South seem to be scarcely prepared to address this type of problem, but significant efforts have recently been made to anticipate this phenomenon. In the long term, it is necessary to regard this dynamics as being largely able of influencing the capacity of adaptation of the countries and to confer a relative dimension on the adverse impacts of climate change. Yet, the effectiveness of the measures envisioned will not be homogeneous for all countries, nor even within the same country, according to the exposure to the risk of the various regions, production sectors and population; hence the importance of mainstreaming in the dynamic analysis a targeted vision of the future impacts of the climate (Tol, 2002b).

Indeed, although the aggregated models may be quite useful within the framework of global studies, they are less and less used, because a problem arises when it comes to conducting an objective comparison between regions and sectors, and over time. This depends on the relative importance given to the various countries and to certain productions, and on the value allotted to the future (Tol and al., 2001). To bypass a difficulty, most of the aggregated studies are static analyses. Yet, the influence of the weighting method selected to assess the global impacts based on the regional impacts cannot be ignored, and it accounts, to a large extent, for the difference between the results of the various analyses. The objective is to account for the future costs borne by the developing countries in the computation of the global impact of climate change, though their economic weight on the international scene is low. Indeed, if weighting is a function of the Gross Domestic Product (GDP) of the country relative to the world GDP, the positive impacts of a small climate change on industrialized countries will be dominant in the global result. However, if one were to consider the number of affected people, it is the negative impacts that would have greater weight. This is due, on the one hand, to the fact that a small fraction of the world population contributes to the largest proportion of the production and, on the other hand, to the significant concentration of people in the zones most subject to the adverse impacts of climate change (Tol and al., 2001). Moreover, the value of the production, the environment and health, in monetary terms, differs according to the country's development level. For an equal production loss, the costs will be all the higher, in monetary terms, for the industrialized countries. Besides, the cost of living is higher in the countries

[3] We surveyed the most recurrent models of the literature dedicated to the analysis of the economic impacts of climate change. However, it is possible that some studies may be similar to certain models when they rest on the same assumptions. Such is the case of the analysis of Nordhaus (2006) that invokes the bases of the "Ricardian" analysis, for instance.

of the North because of their higher incomes and, hence, of a stronger willing to pay on the part of individuals (Stern, 2006).

In order to bypass these problems, several studies compare several possibilities. Among the authors who insist most on this aspect, one may mention Nordhaus (2006). The author uses three distinct weighting systems: by population, in order to take into account the variation in average incomes; by production, and by land space, in order to assess the variation in land price according to localization. He underscores the superior nature of the results, in terms of measure of the real cost of climate change, based on a weighting according to the population.

Other authors, Nordhaus and al. (2000), Anthoff and al. (2007), argue - on the other hand - for the advantages related to a “fair” weighting, based on the "equity weighted" principle, to measure, in particular, the marginal damage induced by carbon dioxide emissions. The approach consists in considering the impact on persons’ incomes, while taking into account the impacts in terms of well-being according as to whether the populations are rich or poor. Weighting must, thus, reflect the income distribution disparities between the countries, generally overlooked in aggregated studies. It has to be reckoned based on a function of well-being and prospects on the level of social policies in the country. Their model is divided into several regions, according to their income level, as well as into several time-periods. Various scenarios based on income evolution assumptions (pace of income distribution change, disparities, and widening inequalities) are compared, and a parameter of aversion to inequalities is incorporated in the analysis. The authors emphasise the importance of mainstreaming the income distribution in a region within the studies of the impacts of climate change, as well as the sensitivity of the results to the weighting method selected. The studies using the equity weighted approach, thus, have higher estimates but which are prone to a higher level of uncertainty.

In fine, there emerges from our comparative table a fairly high number of critiques concerning the computable general equilibrium models. Indeed, the theoretical bases on which certain empirical studies rest are so removed from reality that the results do not yield an objective vision of the future impacts of the climate. This is why they are scarcely selected for addressing this issue.

1.2.2. Specifics of the studies dedicated to an economy or to a sector

The choice of the model is made according to the issue selected. Thus, according as to whether one envisages the global climate impact on the countries or the vulnerability of a given sector or a given economy, the method used will not be the same.

That is why the so-called "Ricardian" models are particularly suitable for studies that focus on a sector in particular, especially in agriculture. The characteristic feature of the standard model is that it rests on the assumption according to which, for each sector of the economy, there exists an average optimal temperature. When the countries are below this temperature, they gain several benefits. On the other hand, beyond this temperature, their benefits decrease gradually and give way to costs which go on increasing as the temperature rises. Besides, the partial equilibrium, or even the "bottom-up", models help conduct more detailed studies.

These models can be studied separately (Kurukulasuriya and al., 2006) from, or integrated in, a more global model (a General Circulation Model (GCM)), for instance (Mendelson and al., 2000, 2006).

1.2.3. Possible solutions to make up for certain limitations of the models

In order to remedy the shortcomings of certain methods, while benefiting from the various advantages they offer, it would be possible to combine them. For instance, Mendelson and al. (2000) integrate to a "top-down" analysis a "bottom-up" model to further refine these results.

Besides, in order to assess the relevance of a given result, a comparison between the conclusions of two analyses resting on two distinct methods is recommended. A comparison of the results of a study based on cross-sector data and of an experimental model, on a smaller scale for instance, to make up for the limitations of either method by the contribution of the other, attests the soundness of the results (Mendelson and al., 2000).

1.3. Assumptions of the empirical models

In view of the difficulty of measuring all the repercussions of climate change on the economies in the short and long term, each study based on each type of model rests on a set of restrictive assumptions. It is important to define upstream of the study the analytical framework selected and to objectively justify the choices made in terms of selection of the variables, and this, in order to anticipate criticisms levelled at the weaknesses of the models.

The assumptions on which the analyses are based constitute essential elements to be envisaged when comparing the results. Indeed, a comparison of the conclusions of the various studies is possible only when the latter have the same bases.

Besides, decisions related to investment and to the policies to be implemented must be taken in full knowledge of the fact, that is, in view of the influence of certain variables. For this reason, most of the analyses claim to be information tools, rather than decision-aid tools.

1.3.1. Choice of climate scenarios

It is necessary, at the outset, to specify the climate scenario selected for anticipating the future evolution of temperatures and rainfalls. The results of the analyses are largely dependent on this choice, insofar as the interpretations may be completely different and, sometimes, even opposed - according to the period selected and according as to whether the scenario is more or less optimistic.

Various possibilities are offered to the authors. The latter may either evaluate the impacts of an even increase in the temperatures concerning all countries (Mendelson and al. 2000, 2006; Tol 2002 b), or refer to the scenarios put forward by 2nd and 3rd IPCC reports by comparing the results based on various points of view (Mendelson and al., 2000; Nordhaus and al., 2000, Nordhaus, 2006, Stern, 2007), or still resort to other climate models by specifying the future climate change according to the regions (Mendelson and al., 2006). Moreover, the evolution of the climate remains fairly slow and gradual; so the costs are thus all the more significant as the analysis period is extended.

1.3.2. Market and/or non-market sectors

A second essential point refers to the sectors taken into account during the evaluation of the impact of climate change. Economists differentiate the impacts on the market sector from those on the non-market sector.

The impacts of climate change on the market sector are calculated according to the variation of the quantities and prices of goods and services, or with respect to the evolution of the productivity of the various sectors. Although it is very difficult to examine the whole of the impacts on this sector, and that the authors concentrate in general their study to a field in particular, these effects are fairly easy to measure.

The problem arises rather from the estimate of the variations in the non-market sector. This estimate requires a consideration of the evolutions of the ecosystem and biodiversity, as well as the impact on health, which one cannot always evaluate in monetary units or according to a homogeneous reference to all sectors. Moreover, this variation depends on the region studied and its initial characteristics to anticipate its future evolution. It thus seems more interesting to conduct a disaggregated analysis. Furthermore, such an analysis has a multi-dimensional aspect, particularly in relation to the ecosystem; the impacts may be observed according to several scales by considering, on the one hand, the impact on isolated species and, on the other hand, on the whole species which form the ecosystem, which generates additional difficulties when selecting the indicators (Fleischer and al., 2006). Lastly, due to the interactions between the sectors, the impacts of climate change may reflect one on the other and multiply the costs.

In view of these difficulties, certain authors are exclusively interested in the market impacts, while knowing that their results will be largely under-evaluated (Mendelson and al. 2000, 2006; Nordhaus, 2006). The most representative analyses are, nevertheless, those which seek to model the non-market impacts and to integrate them in the total cost (Nordhaus and al., 2000; Tol, 2002 b). Thus, even though the measurements may be approximate,4 the estimated impacts are more faithful to reality.

1.3.3. Difficulties and relevance of taking into consideration extreme events

The most precise analyses are not only those which take into account the impacts of climate change both on the market and non-market sectors, as has already been seen, but also those which integrate, in addition to this, the occurrence of extreme events, as well as the additional cost - it being non negligible - that they generate (Stern, 2006). There is no precise definition of these phenomena in the literature, but they can be perceived as exceptional climate events which cause significant destruction of assets (of infrastructures, in particular, but also of agricultural production) and have catastrophic social effects (deaths, injuries, epidemics ...) over a time-period ranging from one day (as in the case of cyclones, for instance) to a few weeks (as in the case of floods) (Hallegatte and al., 2007). They take the form of heat waves, floods, storms or droughts. They are characterized according to several common criteria. In the first place, they reach and exceed a minimum threshold of economic losses, set in general by insurance companies. Secondly, they follow a probability function established by taking into account the capacity of adaptation of the countries and the intensity of the event (Hallegatte and al., 2007). As the costs imply heavy investments for reconstruction of the infrastructures, which could have been avoided, this underlines the need for a preventive political intervention.

The most comprehensive studies on this topic are those conducted by large insurance companies (Munich Re, 2005; Swiss Re, 2005). Indeed, since it is these organizations that cover most of the additional costs generated by this type of occurrences, they are interested in working out precise statistics to predict their future expenditure and calculate the contributions of their insurance policy holders. Certain companies even require a secondary insurance to cover the bigger losses. Among the major re-insurance companies, one may mention Munich-Re and Swiss-Re.

[4] For a detailed overview of the indicators used to measure the effects of climate change on the non-market sector, cf. the second section of this chapter that addresses the impacts as per sector.

Based on the analyses already conducted by these organizations, there emerges an average of 650 natural disasters in the world per year, over the past ten years. Fifteen per cent (15%) among them are of a purely geological origin (volcanic eruptions, earthquakes...); the remaining 85% are, for the major part, related to the climate (storms, cyclones, floods...). They strike, in particular, in America and Asia. They are responsible of 180 000 human deaths per year, and their cost for 2004 amounted to 145 billion dollars, of which 100 billion may be attributed to extreme climate changes, that is about twice the amount compared to the previous year (Munich-Re, 2005).

Scientific analyses lead to the assumption that these phenomena will intensify in the decades to come, and the occurrence routes will change, which will extend the percentage of areas concerned. Their frequency grew almost twofold between the 1960s and the 1990s, inducing increasingly heavy economic costs (Munich-Re, 2005). The latter would increase by 2% per year according to certain estimates (Hallegatte and al.., 2007). They are likely to reach 1% of the world GDP within the coming hundred years and are set to keep rising with climate change (Stern, 2006). The countries that will mostly bear the impact of it will be emerging ones because of their geographic position, but the most significant aggregate losses will be borne by industrialized countries, due to their massive investments in capital-intensive infrastructures (Stern, 2006).

The costs will be particularly high in the regions newly concerned with this phenomenon and little prepared to address them. Moreover, they will experience an exponential increase as from a certain temperature level causing irreparable damage (Stern, 2006). Furthermore, meteorologists have highlighted not only a generalised temperature rise but also a significant variation of this temperature likely to reach extreme levels and generate disastrous consequences (Schär and al., 2004).

It is very difficult to predict the frequency and the strength of these events. That is why most of the authors do not integrate these phenomena in their analysis, particularly when they set their analysis within a global framework.

The fact of not including these events may also be justified by the specificities of the models used. Indeed, within the framework of the analyses based on cross-section data, only the changes occurring over the analysis period and with regard to the sample of countries considered are taken into account. Besides, the analyses conducted based on long-term growth models do not consider short term shocks. Lastly, very few IA models integrate these phenomena.

To address this problem, Hallegatte and al. (2007) proposes an innovative study on this topic. It is based on a non-equilibrium dynamic model (NEDyM), allowing for the introduction of transitory disequilibrium, which may be attributed to exogenous shocks coming to disrupt the growth path. To measure these events via the costs of reconstruction, the authors use an economic amplification ratio of an extreme event. The latter is calculated by comparing the average production loss to the direct costs of this event.

There emerges from this analysis the influence of the characteristics of the economy concerned at the time of establishing the model. Besides, these works highlight the weight of short-term extreme events in the computation of the long-term total costs induced by climate change. In addition, the estimated GDP loss related to extreme events depends in a non-linear manner on the occurrence of the latter and the country's capacity of reconstruction over the short term; hence the need to organise the economies in such a way as to envisage such events in order to limit their costs. The authors thus conclude that this phenomenon can contribute in reducing the economic development of certain emerging countries by damaging the infrastructures installed and requiring significant financial means, thus increasing their dependence vis-à-vis the Northern countries.

1.3.4. Discount rate: discussions and ethical choices

One of the key assumptions, on which economists find it hard to agree, is setting the discount rate. This may be defined as the "time price", i.e. the relative value that the community assigns to the future. Consequently, the higher this rate, the more the community's interest is focused on the present, as compared to future stakes. It is difficult to set because, within the framework of the issue of climate change, it should not be forgotten that the costs of adoption of mitigation measures are immediately borne by society, while the benefits only obtained over the longer term.

The disagreement among the authors is also exacerbated partly by the fact that the time scales over which the analyses rest are quite long, on the one hand, and differ from one author to the other, on the other hand.

The discount rate is one of the elements used to calculate the costs and benefits of the implementation of GHG reduction policies. More particularly, in order to evaluate the social cost of carbon emissions in the atmosphere, there must be set at the same time the equity-based weighting method and the time value.

One of the methods selected by the authors to calculate this rate consists in assigning a "fictitious price" to the capital, while taking into account the collective preference for the present (Cline, 2005). The latter is evaluated according to the rate of households applied to consuming today rather than in the future ("pure impatience" or "pure preference"), and to the rate set by households for their future consumption, insofar as they anticipate that they will be richer in the long term. In the latter case, if the standard of living of people rises, their marginal utility decreases. For so doing, the task is, moreover, to anticipate the total growth rate of income per capita and per year.

The main problem for economists is the value of the "pure preference rate". Some set a zero rate, arguing that a positive rate would be equivalent to accepting a lower income in the long term in favour of the present, which is difficult to envisage (Cline, 1992). Besides, uncertainty as to the evolution of the rates in the long term leads certain authors to choose the lowest discount rates. Indeed, if future growth is uncertain, the discount rate should gradually decrease to reach its lowest level. This obtains from the observation according to which the net current value of two discount rates is dominated by the lower rate (Weitman, 1998).

On the other hand, the assumption behind the setting of a "pure preference rate" is its closeness to the real in view of the fact that people's behaviours translate into a marked preference for the present (Nordhaus and al., 2000).

It is also possible to consider this rate according to the market, although the forecasts are well beyond the period that it covers. In this case, the rates are fairly low.

The setting of these two rates to consider the discount rate is of dominant importance and must be founded because it largely influences the results. Indeed, for a rate variance of more than 2 points, the impacts may vary by several million, over the long term; while for high discount rates, the effects will be minor, which does not justify the implementation of emission reduction policies (Cline, 2005). However, even if a priori these policies are not indispensable, their beneficial effects on the long term are multiplied in the event that future interest rates vary in a random way, and whatever the baseline rate (Newell and al. (2000)).

The criticism levelled by Tol and al. (2007) at the works of Stern (2006) stands as a perfect illustration of this debate. The reproach related to the conclusions developed by the latter author concern, in particular, the choice of the discount rate. Indeed, the results are very sensitive to the assumptions of the model, and the estimated costs may vary in the range of -84% to +900% compared to Stern's data (2006). The latter uses a fairly low discount rate, with a "pure preference" rate of 0.1% per year. The value granted to the future is then significant. For Tol and al. (2007), the time frame seems too short to warrant such a choice. In addition, this rate does not correspond to the anticipated low risk aversion rate. He argues, accordingly, for the opposite point of view, holding that it is necessary to favour high discount rates because they are closer to reality and yield less uncertain estimates.

2. MAIN RESULTS OF THE LITERATURE

All that has been said above attests the difficulty, risks and controversies likely to arise when one embarks upon economic estimates of climate damage.

Having demonstrated the influence of the assumptions, as well as the various modelling patterns used in the empirical literature on the evaluation of the impacts of climate change, it is now possible to proceed to a review of the results of the main analyses. It is important to specify, for each study, the bases on which it rests, and which are likely to account, partly, for the more or less optimistic character of the conclusions. Thus, even if a direct comparison between each one of them is more than one can do, an overall vision of the future impacts of the climate may be attempted.

The task consists in considering, as a first step, the global results, then in focusing on the analyses conducted on a regional scale by targeting the particular case of emerging countries, and in particular those of the Mediterranean region.

2.1. Global studies: A wide range of results

The main divergences between the analyses lie in the estimate of total costs[5] of a rise in temperature less than 3°. According to the weighting method chosen, there obtains either a benefit or a low total cost. Indeed, industrialized countries (Northern Europe, the United States) will derive, initially, certain benefits in terms of additional opportunities in the agricultural sector and of energy saving, in particular due to a decrease in the demand on heating. Thus, even if the adverse impacts of climate change are immediately felt in the other areas of the world, their GDP being relatively low compared to the world GDP, when it comes to calculating the global impact, favourable impacts will prevail. On the other hand, for a rise in temperature above 3°, the studies agree as to the damage undergone by all the countries of the world, which translates in a total cost that is more or less high according to the authors.

The results of the global analyses are presented according to an anticipated increasing cost level. Only the most recent studies and those most regularly quoted as reference in the empirical literature are considered in detail.

The impacts are generally considered in terms of percentage of global GDP. However, the impacts may be expressed according to per capita GDP or in terms of well-being, which sometimes yields quite different results. It all depends on the weighting method selected. In general, the estimated costs are much higher when considered according to a logic of per capita impact;[6] hence the need to emphasize the bases of the analyses before interpreting and comparing the results within the same study or among the studies.

5 This generally consists in the sum of the damage reported in the market and non-market sectors of the countries considered in the study, weighted by their relative importance. In some studies, the total costs are measured by taking into consideration the countries' adaptation capacity. This is specified in the body of the text.
6 Such as specified section 1.1.2.

2.1.1. Exclusive consideration of the market sector: Under-estimating the total cost

The "most reassuring" studies are often those which underestimate the future impacts of the climate by exclusive consideration of the market sector and non-consideration of the short-term costs induced by extreme events.

Among the most widely known, one may mention the studies of Mendelson and al. (2000), (2007). The authors refer to various types of climate models. In 2000, they base their work on the conclusions of three scenarios of the third IPCC report, anticipating a low (+1°), average (+2°) and high (+3, 5°) temperature rise. In 2006, they enlist various climate studies issuing from three different research centres, which offer a disaggregated vision, per region, of the evolution of the climate. In this regard, it is worth noticing a real effort to limit the uncertainty related to future climate change. In both cases, the time horizon is 2100. The countries' adaptation capacity is included in the analysis. The individuals maximize their net benefits (i.e., their gross profit less the adaptation cost). This amounts to the assumption that the countries will specialize in the production of goods and most productive services taking into account the evolution of the climate. The most vulnerable sectors will thus have a low weight in the economy relative to the others, which will help minimize the total negative impact.

The results of the analyses converge in the sense that the authors observe an increase in the total benefits of a temperature rise of 1 to 2° according to the models, followed by a decrease afterwards. These increase remains however low, with a maximum level of 0.16% of total GDP. In the article published in 2006, these results are qualified, since according to two of the three climate scenarios advanced, the countries will experience, on the whole, losses ranging, in 2100, between -0.01% and -0.1% of total GDP, which means a per capita cost in the range of -2 to -28,7 US dollar per year. In any case, the benefits and the costs are largely more significant according to the empirical method as compared with the cross-section data based analysis. However, the benefits are higher within the framework of the "Ricardian" analysis with respect to the reduced-form model of the version 2000.

While Nordhaus and al. (2000) conducted a quite informative study in view of the scope of the phenomena included in their model, Nordhaus (2005) contents himself with a fairly basic analysis which, after the manner of Mendelson and al. (2000), (2006), measures exclusively the impacts of climate change on the market sector. This is partly explained by the fact that the major contribution of the model lies in the introduction of a new geographical vision to analyse the impacts of climate change. Indeed, the results are proposed at once according to GDP and population, as well as according to surface area in order to measure the impact according to geographical location. Although the two scenarios selected are derived from the third IPCC report, they are more catastrophic than those described above as they assume a homogeneous temperature rise of 3° with respect to the pre-industrial level, with, in the latter case a reduction in rainfall of 15% in the zones of mean latitude (between latitudes 20 and 50 north and south) located within less than 500 km of the coast and an increase of 7% elsewhere.

The results of the cross-section data based analysis yield an appreciable total cost for the time frame 2100, according to the various scenarios and the weighting methods considered. In the former case, these costs vary from -0.93% of GDP, for a production-based weighting, to -1.73% for a population-based weighting. According to the latter climate scenario, these losses amount to -1.05% and -2.95%, respectively. This study thus emphasises the urgency of implementing regulation and adaptation policies, for while a part only of the economy is considered, the anticipated costs already reach hardly manageable/sustainable levels for the majority of the countries of the world.

2.1.2. Introduction of the non-market sector: More precise results and higher costs

Within the framework of an intermediate, more precise study, Tol (2002b.) extends his analysis to the non-market sector by taking into consideration the impacts of climate change on the ecosystem, as well as the cardiovascular and respiratory diseases and problems. The climate scenario is derived from a general circulation model, and the analysis period extends until 2200. The capacity of adaptation of the countries to climate change is included in the analysis.

From this dynamic study, there emerge more or less alarming results, according as to whether one reasons according to GDP or in terms of equity. For an initial temperature rise by 0.5°, the total benefit will be of 2.5% or 0.5%, respectively. Should this rise be higher than 2°-2.5°, in the former case the countries would undergo a notable reduction in this benefit. This decrease would obtain as from an additional 1° in the later case. Beyond this rate, the total costs are likely to reach - 2% of GDP.

2.1.3. The more comprehensive studies: Taking into consideration extreme events

The more comprehensive studies are those of Nordhaus and al. (2000) who are among the first economists to include the influence of extreme events in addition to taking into consideration the market and non-market sectors in their analysis, then to Stern (2006). Logically, the estimated costs are more significant than in the framework of the previous studies.

a. Nordhaus and al. (2000)

Nordhaus and al. (2000) base their anticipations on two climate scenarios. The first assumes an increase in temperature of 2.5° by 2100; the second applies in the case of extreme events, the temperatures being likely to rise by 6° compared with the pre-industrial period.

The results of the DICE model reveal that, even without the incidence of extreme events, the countries will experience a significant total loss due to temperature rise. As in the other analyses, the latter are higher, when weighting is considered according to the population, than according to production. The anticipated costs are -1.88% of GDP and -1.50%, respectively. When extreme events are introduced, they reach catastrophic levels: -7.12% and -6.94% of GDP, according to two aggregation methods.

b. Stern (2006)

It is important to underline the impact of the works of Stern (2006) in calling the attention of the international community to the issue of climate change. One of the assets of this report lies in the fact that it offers a quantified evaluation of the future costs of climate change, directly intended for political decision makers. It thus highlights the need to bring an economic vision to bear on climate change in order to persuade governments as to the need to adopt, as of now, prevention and adaptation measures so as to mitigate certain incidents that could be partly avoided if GHG emissions were substantially reduced. It paved the way for recent economic studies (Mendelson and al., 2006), Tol, 2007), which sometimes represent a further enriched, updating version of older analyses.

By emphasising the dominant role of the theoretical framework on which the model rests, Stern lays down his scientific orientations through the choice of the assumptions on which his analysis is based. The latter are subject to criticisms on the part of authors not necessarily sharing the same vision of the reaction of people with respect to their perception of the future, as regards "time price" in particular (Tol, 2007)[7]. The analysis of Stern (2006) has the merit of being integrated in the empirical literature on the topic of evaluating the costs of climate change, by seeking to make up for the shortcomings of the other analyses. Thus, the integrated evaluation model established (PAGE 2002 (Policy Analysis of the Greenhouse Effect 2002)) includes the market sector, the non-market sector, as well as the possibility of extreme events.

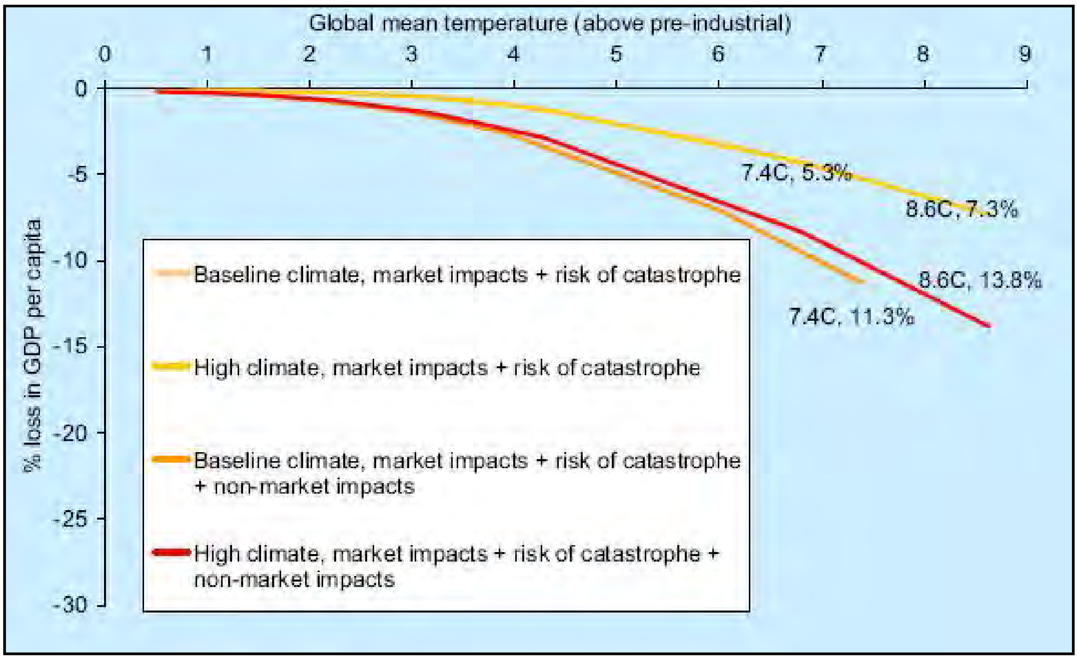
One of the assets of this analysis is to consider, in addition to the costs related to production, the impacts in terms of variation in the well-being of people. This consists in identifying per capita consumption at each period according to the total production, then calculating the total social utility. This technique requires a justification of a certain number of points. One difficulty lies in comparing the marginal utility between the richest and poorest populations. The second requires the anticipation of future consumption and setting a discount rate.

The estimates are worked out based on two different climate scenarios. The former corresponds to the A2 scenario presented within the framework of the 3rd IPCC report which assumes an average temperature increase of 3.9° by 2100, knowing that the rises vary in the range of 2.4° to 5.8°. The latter is much more alarming as it is developed by combining two amplifying types of impact due, on the one hand, to low absorption of carbon and, on the other hand, to the increase in natural methane emission. In this case, the rise in temperature will be of 2.6° to 6.5°.

The results are quite detailed and worked out according to several scenarios:

[7] This is a reference to the debate on the discount rate level, presented on page 16.

Graph 1 - Results of the analysis of Stern (2006)



Source : Stern (2006), p178

According to the former climate scenario, temperatures will rise by 3.9° in 2100 and by 7.4° in 2200. The impacts will be as follows:

- A fairly low loss in GDP per capita in case only the market sector is considered, generating an average cost of 2.2% in 2200,
- Once extreme events are included, this cost amounts to 0.2% in 2060; 0.9% in 2100; and 5.3% in 2200,
- This cost amounts to 11.3% in 2200, when the non-market impacts are introduced.

According to the latter climate scenario, which assumes a temperature rise of 4.3° in 2100 and 8.6° for the time frame 2200, the impacts will be as follows:

- A cost in terms of GDP per capita of 1.2% in 2100 and of 7.3% in 2200, if only the market sector and extreme events are selected,
- The introduction of the non-market sector raises these costs to 2.9% and 13.8% for the same time frames.

In any case, the costs will not be strongly felt until 2050, due to the low climate change over the first fifty years.

Impacts on well-being will be quite significant. They are calculated based on the difference between the balanced growth of discounted consumption and that, which takes into consideration climate change.

According to the former climate scenario, in view of climate change between 2001 and 2200:

- The costs for the market sector are estimated, on average, as -2.1% of current and future per capita consumption,
- This consumption loss is of -5 % when extreme events are introduced,
- It reaches -10.9% once the non-market sector is introduced.

Now, according to the latter climate scenario:

- The market costs will post a -2.5% consumption loss on average,
- The market costs and those connected with extreme events are of -6.9%,
- The market, non-market and extreme events impacts add up to 14.4% of loss.

Thus, no matter the weighting method selected, the climate scenario chosen and the extent of the sectors and events considered, the Stern report shows that the world will incur an appreciable cost in the years to come, due to climate change.

Table 2 - Overview of most recent analyses

	Tol (2002)	Nordhaus (2006)	Mendelson et al. (2006)	Stern (2006)
Time frame	2000-2200	2100	2100	2060; 2100; 2200
Climate model	+1°	- +3° -+3° and -15% rainfalls within 500 km of the coasts in mean latitude zone and +7% elsewhere	- From +2.3° to 6.2° - From +11.9 % of rainfall to –10.3%	- Temperatures: +3.9° - Temperatures from +2.6 to 6.5°
Country	9 zones	Emerging and industrialized countries divided into territories	Industrialized countries and emergent countries divided into quartile according to their income	Industrialized countries and developing countries
Limitations	No extreme events taken into account	Impact on market sector only	Impact on market sector only	Impact on market and non-market sectors and considering extreme events
Main results	-Temperatures: +0.5° +0.5% to +2.5% of total GDP - Temperatures > +2-2.5° -0.5 to -2% of total GDP	- Negative impact on production ranging from -0,9 to -1,7% of GDP - Negative impact especially in zones where density is strongest (-3% of GDP)	- For the poorest, most vulnerable first quartile: from -12 to -24% of their GDP - For the richest last quartile: + 0,1 to 0.9% of profits	- Loss in terms of total AGDP: 1.3% in 2060; 5.9% in 2100; 24.4% en 2200 - Loss in terms of well-being from 10.9% to 14.4%

Source. L'auteur

2.1.4. Cost of an additional CO_2 unit emitted

The estimated marginal costs[8] are reckoned based on anticipation of the total costs. The works of Tol (2005) constitute a major reference because they are a summary of the results of 28 analyses on this topic (that is, 103 estimates), revisited by Tol (2007) who extends the number of analyses to 48 (that is, 210 estimates). The estimates of these analyses are gathered in a function of probability (Probability Density Function - PDF), while taking into consideration the assumptions inherent in

[8] A precise definition of marginal cost is suggested Appendix 1.

each of them. The use of an equity-based weighting seems to largely influence the results, just as the adoption of a more or less high discount rate.

A marginal cost of 104 US dollars, on average, emerges from these analyses. It is quite unlikely that the marginal cost of an additional ton of CO_2 be nil (as little as 2% chance). This cost can be lower than 25 US dollars an additional ton, according to a probability of 54%. It is quite probable that it is be less than 50 US dollars (68% chance) and strongly probable that it is be less than 100 US dollars (81%). This probability reaches 100% for a high discount rate (3%), knowing that the possibility that the marginal cost would be low is much greater. On the other hand, a low - near zero - discount rate increases the probability that this marginal cost be particularly high, far beyond 100 US dollars (the probability that it be higher than 250 US dollars is 26%). Similarly, in the case of an equity-based weighting, the probability that the marginal cost be high will be greater.

Various recent analyses, based on distinct assumptions, have revealed that climate change will incur a significant cost to society as a whole in the years to come. This cost will be more significant as from the next century. The objective of these studies is to evaluate the future losses in monetary units, taking into account uncertainty, in such a way as to call attention of political decision makers to the need for action. However, a global vision remains approximate and necessarily requires differentiating the impacts according to regions. Our present concern is to highlight the impacts specific to the Mediterranean region as emerging from these works.

It is worth pointing out that few studies target the Mediterranean region directly, preferring a continent-based decomposition. The results we will consider, therefore, astride the conclusions made for Africa and those made for the Middle East.

2.2. Generally high costs for the Mediterranean region

The estimated global cost is an average of the impacts of climate change on the various regions of the world, according to a selected weighting method. According to the geographical and economic situation of the countries, the effects will be of variable intensity. On the one hand, the change of temperature and rainfall will not be homogeneous. As shown in the first chapter of this report, the Mediterranean region will be particularly concerned by a strong increase in temperature, a decrease in rainfall and a rise in sea level. On the other hand, because of its intermediate development level and of the specialization of its production in sectors heavily dependent on the climate[9] (agriculture, for instance, but also tourism or oil exploitation), this region would be particularly vulnerable to climate change, if no risk prevention and adaptation measure was taken (Shérif, 2005).

2.2.1. Influence of the geographical position: The disadvantage of Mediterranean countries

As regards the geographical position, climate studies show that most southern regions will be more subject to climate change than the countries of the north. Indeed, the latter now have low and moderate temperatures. Even if warming were to be more significant in the medium and high latitudes, compared to the rest of the world (scenarios A2 and B2, IPCC, 2001), it would be beneficial to these regions, insofar as it would offer new opportunities in the agricultural sector, in particular, but also for tourism, the ecosystem and health, as well as energy saving in matter of heating, while the air-conditioning demand would remain low.

9 The impacts of climate change on the Mediterranean region, according to various production sectors, will be addressed in the second part of this section.

Within the African continent itself, the impacts of the climate will differ according to the countries. Nordhaus (2006) demonstrated the influence of the geographical position on the economic situation of the countries of the north and of the south. According to the latitude and longitude, the exogenous shocks, in particular those related to the climate, will be of more or less strong magnitude. Thus, although the author makes his results relative afterwards, he highlights the disadvantage of Africa concerning access to drinking water, proliferation of diseases, food security, inducing a significant loss of growth and persistent inequalities. This disadvantage may worsen, as the countries of the region will be more rapidly concerned by climate change in view of the current problems already connected with the climate.

Indeed, North Africa, which is a fairly hot region, will be exposed to a northward shift of bioclimatic stages, which will result in temperature rises and a reduction of rainfall. Based on the climate models developed for the region, there may be anticipated a temperature increase of 1° and a reduction of rainfall likely to reach 10% by 2020. On the longer term, this climate situation will worsen, with an anticipated rise of 3° and 5° in 2050 and 2100, respectively, accompanied by a drop in rainfall ranging from 20% to 50% for these same time frames ((Rousset et al, 2006). Besides, the frequency of extreme events (drought periods, in particular) will intensify, just as abrupt temperature variations (Nyong, 2006; Stern, 2006). Lastly, coastal zones will undergo the adverse consequences of sea level rises. Flood risks are set to increase, generating a degradation of coastal infrastructures, loss of arable land and displacement of the populations[10] (Nicholls and al., 1999)

Besides the forecasts put forward by MEDIAS within the framework of this report, one may also consider the estimates of other meteorological models concerning this region, and which are used in the recent economic literature addressing the costs of climate change.

For a detailed vision of the evolution of the climate, Mendelson et al. (2006) resort to distinguishing the variation of temperatures and rainfalls by region according to three meteorological models, weighted by population. An optimistic model ("Panel Climate Model" - PCM, Washington and al., 2000), a pessimistic model ("Canadian General Circulation Model" - CGCM, Boer and al., 2000) and an intermediate model ("Centre for Climate Research Studies Model"-CCRS, Emori and al., 1999). Focusing on the African and European continents, there emerges from these models a rise in temperature in 2100 ranging from 2.3° (PCM, Africa) to 6.2° (CGCM, Africa) compared to the pre-industrial level. Regarding this aspect, all models agree as to emphasising that these two continents will rank among those most subject to global warming. On the other hand, the models diverge with regard to the future evolution of rainfall. While at best, these will increase (+11.9 %, for the model PCM, Africa), other cases predict a risk of reduction in water resources (-10.3% for the model CGCM, Africa). These differences are due to uncertainty as to climate evolution and generate significant variances in the estimates; and this, although according to the same evolution, one notices, however, that the temperature and rainfall variances are less marked for Europe than for Africa.

The continent already experiences drinking water shortages. The quantity of water resources is highly dependent on climate change. A temperature rise and a reduction in rainfall are thus likely to have catastrophic effects on this region, which are likely to hamper certain economic activities and have repercussions on the growth and development of the countries (UNDP-GEF, 1998). Moreover, this phenomenon will be exacerbated by the fact that a too high temperature level is likely to affect the productivity of certain sectors.

10 This aspect is further discussed under item 2.4.

2.2.2. A greater socio-economic vulnerability in the South than in the North of the Mediterranean

The Southern Mediterranean Countries (SMCs) count among those for which the temperature level will be the highest and the future rainfall variation will be the most significant. However, the major problem lies in the fact that, due to their intermediate economic development level and the vulnerability of their environment, they are all the more sensitive to the future climate changes. Indeed, the costs incurred by the countries are a function of the sectors dependent on the climate in the economy and of their capacity of adaptation to the future temperatures and rainfall. By way of comparison, the Northern Mediterranean Countries (NMCs) will undergo an almost equivalent global warming but with a lesser economic impact. To begin with, owing to the specialization of the economies in the tertiary sector, the importance of the economic activities sensitive to temperature variation is relatively low. Besides, due to a more advanced economic development level, these countries will have financial means to adapt their economy to climate change and to compensate the possible costs of extreme events. The situation in the South is different.

First of all, among the Southern Mediterranean Countries (SMCs), many are those that are passing to the last stage of their demographic transition. The population will, accordingly, multiply in the years to come, thus multiplying the needs in water and food. The increase in the working population will change the modes of consumption, which will result in an increase in the needs in matter of energy, infrastructure and housing. The coastal cities will, therefore, be over-strained due to incapacity to accommodate the flows of migrants in terms of public utilities and sanitation conditions in particular. The massive and precarious urbanization will result in an increasingly greater risk-taking especially in terms of exposure to the climate of the new housing sites.

Secondly, the Southern Mediterranean Countries (SMCs) derive several resources from agricultural production, which is highly dependent on climate conditions. Water reserves will decrease and the needs will increase. This will, then, give rise to difficulties in terms of food security, a vector of proliferation of epidemics. The countries will, thus, be led to increasingly resort to imports.

In the absence of a dedicated policy, this dependence on foreign countries may grow stronger with the increasing energy demand. On the one hand, there will gradually obtain an industrialisation of certain countries and a growth of the tertiary sector whose energy needs will be constantly on the increase. On the other hand, global warming will generate an additional energy demand for air-conditioning.

Besides, their environment being already subject to high temperatures and being vulnerable, the losses in terms of ecosystem are, therefore, likely to be felt. This phenomenon will have consequences on the poorest populations which use the services offered by the land for subsistence (subsistence products...) and will, in addition, translate into a reduction of tourism. The increase in inequalities will not only be felt in the widening gap between North and South, but also within the countries themselves. The social groups to be most affected are already the poorest ones (farmers, fishermen, populations living in precarious housing and in risky zones...) who have least financial resources to adapt to the climate and who remain the least prepared to respond. Within these groups themselves, the women, children and the elderly will be the ones most concerned by these difficulties (in this regard, one may mention the case of the devastating effects of the wave heat in Europe in 2003 on the most vulnerable populations).

Mendelson and al. (2006) highlight the influence of the country's economic development level on the cost related to climate change. Even for a climate change identical for all countries, the highest costs are borne by the poorest, and this, particularly in view of the large proportion of their economy that is sensitive to climate change and of their lack of adaptation capacity. In this regard, their results converge with the majority of the authors (Tol, 2002b; Nordhaus and al., 2000; Stern, 2006). Nevertheless, the most significant costs will not be incurred by the Mediterranean region, but by the countries of central Africa and South East Asia.

2.2.3. Main results for the Southern Mediterranean

Since we intend to conduct a detailed analysis of the economic impacts according to the sectors of the countries of the Mediterranean region in the second part of this report, we will content ourselves here with the overall costs borne by the region.

In spite of their geographical position, the Mediterranean countries are not the most vulnerable to climate change. As emerging countries, they belong, for most of them, to the third highest quartile in terms of income, in view of the breakdown of countries according to their level of wealth, as proposed by Mendelson and al. (2006). As may be seen from their results, most of the scenarios concur to estimating their loss as -1% of GDP in 2100. In the case of the CCSR and CGCM climate models and of the experimental study, these costs reach -2% of GDP. However, only the market sector is taken into consideration in the analysis, which means that these results are largely under-estimated.

The same may be said about the analysis of Mendelson and al. (2000). Although the authors integrate in their study a geographical parameter, they omit the non-market sector and extreme events. Indeed, they choose a distinction of the evolution of the climate by latitude and longitude according to two models of atmospheric circulation (University of Illinois at Urbana-Champaign – UIUC, atmospheric general circulation model). The losses estimated for Africa and the Middle East are thus quite low and, often, even positive. The anticipated benefits are in the range of 0.28% of GDP for Africa according to the "Ricardian model", to 1.34 for the Middle East, according to the same model, for an average increase in global temperature of 2°. The most significant costs are -1.82% of GDP, within the framework of the reduced-form model for Africa.

The study of Nordhaus (2006) presents the same shortcomings, but the results help clarify the influence of the geographical position on the impact of the climate. Indeed, even if Africa incurs an appreciable economic disadvantage due to its geographical position as compared with the countries of the moderate zones (geography accounts for 20% of the differences in the GDP of the countries), this disadvantage is marginal by comparison with the regions of smaller latitude.

For Tol (2002), the negative impacts of climate change will be mainly felt in Africa and Central and Eastern Europe. They are evaluated as a percentage of global GDP for an average increase in temperature of 1°. For Africa, the losses will be immediate and will amount to 2% of GDP in 2200. They will increase over time. The costs incurred by Central and Eastern Europe will be much higher and will reach some 8% of GDP for the same time frame. However, during a first period extending from 2000 to 2050, these countries will see their benefits increase to nearly 3% of GDP, to subsequently fall in a considerable way. This is due to the fact that the countries will suffer high losses in terms of forestry, water and energy in order to meet increasing demand on air-conditioning in particular.

Within the framework of the more comprehensive studies, Nordhaus and al. (2000) estimate that, for an average temperature rise of 2.5°, Africa will incur losses amounting to 3.91% of the country's GDP, with - in the context of extreme events (and of a temperature rise of 6°) - an additional cost of 2.68% of GDP. For the countries of Eastern Europe, these costs will be lower, amounting to 0.71% of GDP and 3.23% of GDP in the case of extreme events.

Stern (2006) argues that, in either of the two climate scenarios, when considering only the market sector or when introducing extreme events and the non-market sector, the most significant economic impacts will be experienced by Africa, and the Middle East, as well as India and South East Asia.

3. CONCLUSION

The objective of the first part of this chapter has been to conduct an overview of the major global economic studies on the impact of climate change. In view of the significant differences between the results of the authors, it has proved necessary - before presenting them - to highlight the influence of the assumptions underlying the various models used for this purpose. These divergences are due, on the one hand, to the difficulty of predicting the future and, on the other hand, to the fact that the analyses are complex, integrating at the same time a physical, climatic and economic dimension. Indeed, the anticipated future evolutions of the climate, the environment and development of the economies suffer from a considerable uncertainty. The latter is all the greater as one is concerned with the interactions between these various fields of analysis.

Global reference studies in the recent empirical literature on this topic are relatively quite few. They all differ considerably, due to distinct analytical frameworks and assumptions. This influences their results to a large extent. The most optimistic analyses are those that focus exclusively on the market impacts of future climate change. The most complete studies are the most alarming. And even though the data provided by the authors are given for the sake of information only, they help underscore the need for prompt action in order to limit the impacts of climate change on the economies. Indeed, the estimated future global costs may be in the range of 7% (in 2100) to 14% (in 2200) of world GDP per capita within the framework of the most comprehensive studies which take into account the impacts of the climate and the extreme events both on the market and non-market sectors (Nordhaus et al., 2000; Stern, 2006).[11]

Several common criticisms may be levelled at these analyses (Hitz et al., 2004). Certain sectors whose weight in the economy is significant are often not included in the study because of the difficulty related to the economic evaluation of non-market impacts. Moreover, the interactions between the sectors of the economy are often neglected. They multiply the costs for the countries, though. The results are, therefore, under-estimated, even in the case the market and non-market sectors, as well as extreme events, are included in the analysis. Lastly, the forecasts concerning the future economic development of the countries, as well as their adaptation capacity, are generally considered in a rather superficial way. On this aspect, future works need to seek to make up for such weaknesses.

The Mediterranean region is very little represented, as it lies halfway between Africa and Europe. The results show, however, a significant cost for the countries related to an increase in temperature and a reduction in rainfall in the years to come. In view of their geographical position, these countries already experience high average temperatures and a lack of water resources; such problems are set to worsen in the coming years, while in the Northern countries, the adverse impacts of climate change will only be felt within a longer time frame (2050). The scope of these impacts will vary according to these countries' future economic development and their adaptation capacity. The results of the studies may, therefore, have been over-estimated as, most of the time; they do not consider this parameter.

The more precise studies reveal that the Middle East North Africa (MENA) region will be one of the regions most affected by the adverse impacts of climate change (Stern, 2006). The losses

[11] Cf. summary table of Appendix 2.

anticipated by 2100 will be around 7 % of GDP per capita on average for Africa and around 4% for Eastern Europe (Nordhaus et al., 2000)[12].

The regional costs are, however, but a mean value of inter-country impacts. Some will be more vulnerable than others according to the specialization of their production and the exposure of the poorest populations. This distinction will be the subject of the second part of this chapter.

12 Cf. summary table of Appendix 2.

II. SECTORAL ECONOMIC IMPACT OF CLIMATE CHANGE IN THE SOUTHERN MEDITERRANEAN COUNTRIES (SMCS)

The total cost for a country, due to climate change, is the sum of the costs for each market and non-market sector of the economy. Either of these sectors is subject to various types of exposure which vary according to the regions, all depending directly or indirectly on the climate (Llewellyn, 2007).

Firstly, according to the geographical position of the country, certain sectors will experience a more or less strong exposure to temperature change. In the Mediterranean, the sectors which are most water consuming and most exposed to meteorological risks (agriculture or tourism, for instance) will be the most affected.

Secondly, the Kyoto Protocol and the adoption by the countries of regulation policies urge the companies to take into consideration the problem of climate change as it induces additional costs for them. Thus, according as to whether the companies which use or produce carbon intensive goods are based in a Appendix 1 country or not, have an international presence and subsidiaries in different regions of the world or not, they will be more or less concerned with national and international regulation policies.

Thirdly, these same companies which will see their production cost increase will, therefore, seek to adapt, to reconsider their production. The objective will be to set up an efficient production process in terms of energy use. International competition concerning "cleaner" goods will, thus, intensify. Accordingly, the countries that are not as yet concerned with regulation policies are likely to undergo a disadvantage on the international scene.

Fourthly, this disadvantage will be all the more significant as certain companies in certain sectors, which are highly polluting, will experience a fall in demand due to a bad reputation, in a world where carbon intensive productions will be increasingly blacklisted and where respect for the environment will be an essential condition. Consequently, the hydrocarbon production sector—being of paramount economic importance for several Mediterranean countries—could be particularly impacted in the medium term.

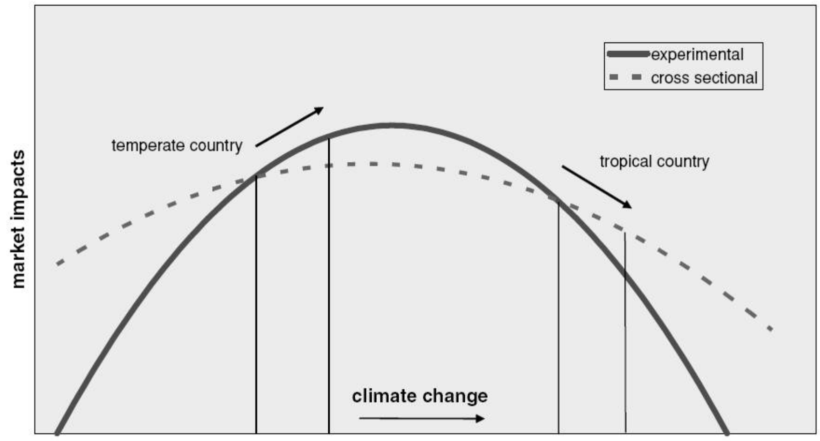
Lastly, according to the sectors and the countries, technological opportunities are not the same, some being able to benefit from recent progress and accessible technology which, thus, facilitate adaptation to climate change.

All companies, all sectors, in all countries are, accordingly, called upon to anticipate while taking into account, as of now, the problem of climate change, and to mainstream this phenomenon in their production process. This will help, on the one hand, mitigate the costs of climate change and, on the other hand, cut a niche in markets requiring little carbon and energy intensive production and consumption processes.

With regard to Southern Mediterranean Countries (SMCs), the effects of international regulation policies will have only an indirect impact on their production, just as the reputation effects, except for the oil-producing countries, albeit in the longer term.

However, their physical exposure gives rise to a major problem because, as we have already seen, these countries already experience high temperatures and water scarcity, and these difficulties will only be exacerbated by the rise in temperature and the reduction of rainfall predicted by the various climate scenarios. If one assumes the point of view according to which each sector has an optimal temperature for which its production is optimal, the risk for the majority of the sectors of these countries is to be already beyond this threshold and that their benefit decreases even though their cost goes increasing[13] (Graph 2). This temperature varies according to the sectors and the countries. In this section, we will consider the results of the authors for each sector.

Graph 2 - Quadratic relation between climate change and impact



Source. Mendelson et al. (2006)

According to each country's part of the production that is dependent on the climate, the future costs will be quite different from one economy to another for an almost identical climate change. It is thus significant, first, to compare the countries' production structure because the level of development of the economies and the population distribution are necessary to appreciate the extent of their vulnerability to the climate and, therefore, the potential economic impact.

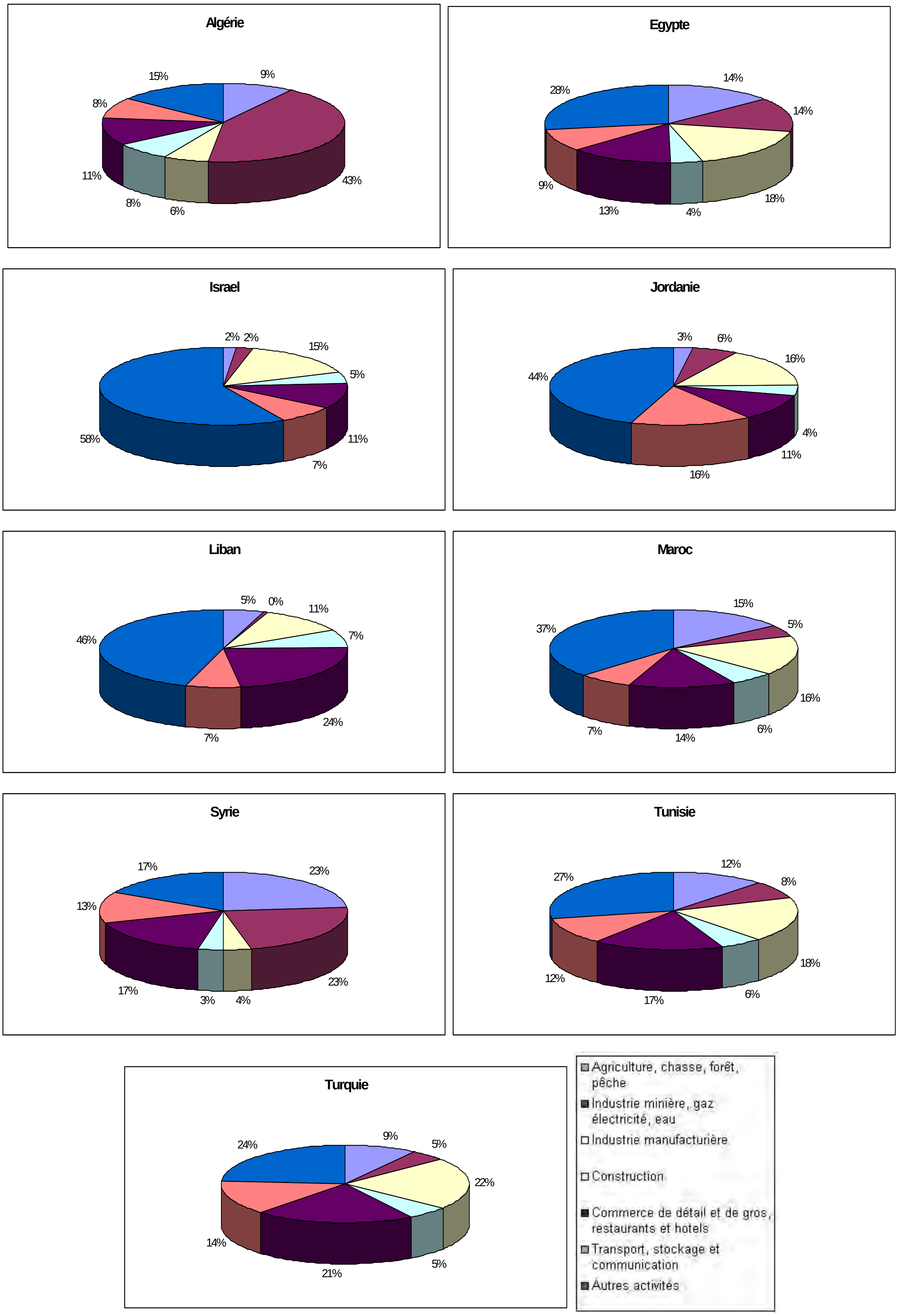
Each of the sectors will, afterwards, be considered independently from the others. The objective is twofold: the purpose is, on the one hand, to highlight the causes of their vulnerability to the climate and, on the other hand, to evaluate the future impacts of the climate change, using the empirical literature. The references are at the same time global studies and targeted analyses. Emphasis is placed, in particular, on the units used by the authors to evaluate the future costs in the market and non-market sectors.

1. ECONOMIC STRUCTURE AND VULNERABILITY OF THE COUNTRIES OF THE REGION

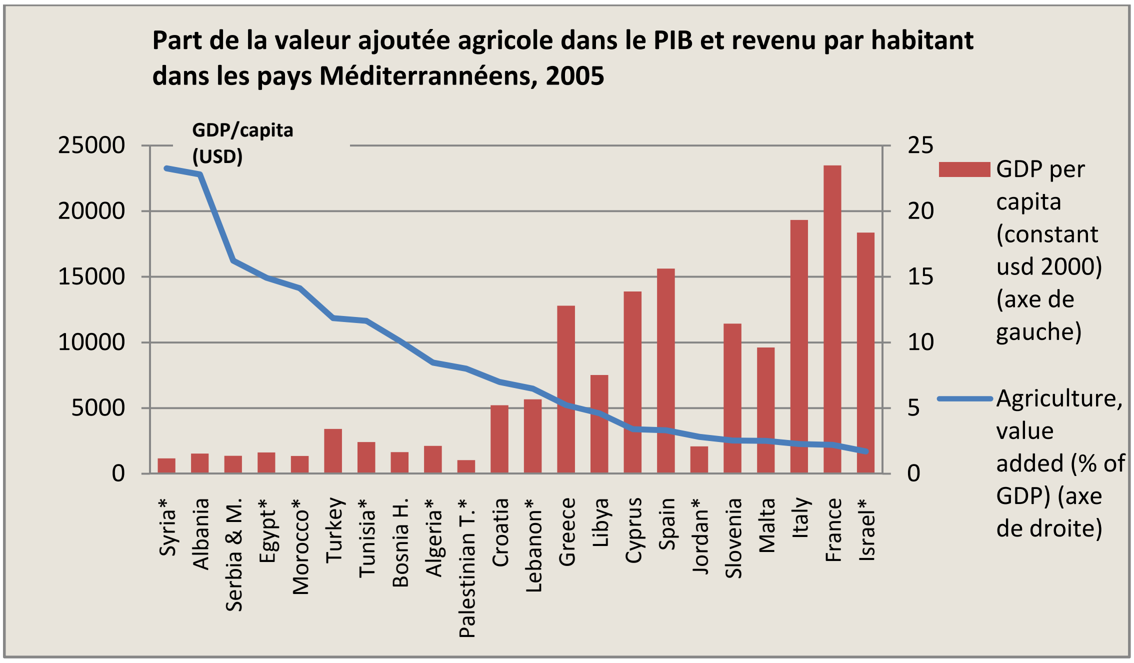
Before focusing on the impact of climate change on the various sectors of the economy, it is important to gather an overall vision of the share of each sector in the countries of the region. The availability of data compels us to consider only certain market sectors. These are agriculture, industry (of which manufacturing industry), construction, transport and trade (cf.Graph 3). The data are supplied by the United Nations Statistical Department (UNSD)[14] for 2006.

13 For further detail, cf. "Ricardian" Models in Appendix 1.
14 http://unstats.un.org/unsd/databases.htm

Graph 3 - Distribution of value added by the sectors of the economies of the Southern Mediterranean (in percentage of total value added) in 2006



Source. The author based on UN data



Source. The author based on UN data

The remarks that may be made based on these graphs are only for the sake of information and do not allow to develop a precise analysis of vulnerability. First of all, as the non-market sector is not considered, it is impossible to appreciate the total exposure of the economy. Besides, the distribution of economic activities is far from being detailed, certain sections grouping various distinct specializations (transport and communication, for instance). Lastly, the number of tertiary activities grouped in the section 'other activities' is quite substantial, which does not allow a precise vision of the role of the public, financial and private sectors in each of the countries, respectively. Furthermore, the figures used reflect only imprecisely the specialization of the countries, in the sense that what is considered is the value added of each activity. Indeed, it is possible that the agricultural sector may produce only little income, for a poor crop year, though its relative share, in terms of working population, for example, is fairly more significant than in the other sectors (see Table 3). Finally, one should take into account the fact that, according to the countries, the sectors are already more or less adapted to significant weather variations (for instance, agricultural production in Morocco is much more dependent on weather conditions than in Egypt).

Syria is a country whose production is largely based on the agricultural sector. In this regard, the structure of the economy of this country contrasts with that of Israel, Jordan and Lebanon for which the share of agricultural production is extremely small (less than 5% of the total value added). For the other countries of the region, it ranges between 9% (for Algeria and Turkey) and 15% (for Egypt and Morocco) of the total value added. On the whole, the agricultural sector does not exceed the fourth of the total value added for the countries of the region.

The share of industry (mining, manufacturing, electricity, gas, water) is fairly significant for the majority of the countries. It is dominant in Algeria where it accounts for about a half of the total value added. Similarly, in Lebanon and in Syria, manufacturing and mining industry accounts for more than a fourth of the total value added. It stands at about 30% for Egypt, Tunisia and Turkey. It is fairly low in Lebanon, in Jordan and in Morocco.

Construction has a constant weight in the total value added of all the countries of the region, of less than 10% but higher than 5%, except in Syria, Egypt and Jordan where its share is quite low.

Transport, storage and communication are fairly significant activities for the majority of the countries (Jordan, Syria, Tunisia, Turkey) and non negligible for the others. It should be noted that transport dominates, the share of storage and communication being fairly small.

The trade, catering and hotel business are dominant activities in the countries where the economy is rather focused on the development of tourism: Tunisia and Turkey and, to a certain extent, Lebanon and Syria, where the weight of trade is dominant. Let us note that it is the same countries for which transport occupies a significant place. This rather stands to reason, as these two activities are very closely interrelated. The share of this sector remains above 10% in the other countries.

Lastly, the part dedicated to ‘others activities’ is quite large and is concentrated mainly on the tertiary sector. This involves, in particular, financial intermediation, real estate, public services (defence, social security ...), education, services to self-employed individuals and workers. One deplores a lack of availability of data concerning the relative share of each of the components of this sector. Nevertheless, this is informative, on the one hand, about the specialization of the countries and, on the other hand, about their level of development. Indeed, the countries for which this sector is dominant with respect to agricultural and industrial production have the same profile as the countries of Western Europe. This is the case, in our sample, of Israel which offers many good quality public and banking services, just as is the case for Lebanon and Jordan. They are also countries for which agricultural production is the lowest.

These activities are, however, largely developed in the other countries of the region, as they account for not less than 15% of the total value added of each one of them.

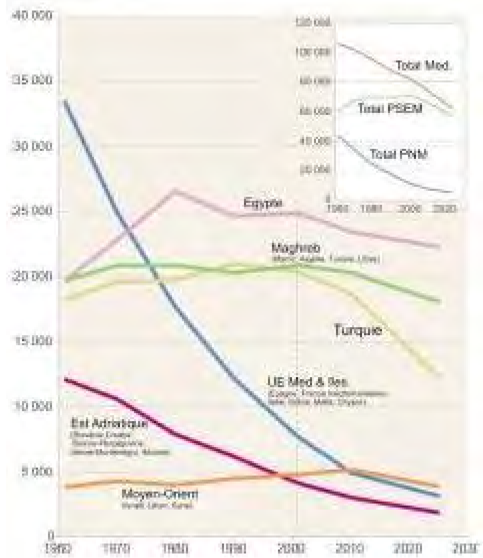
Table 3 - Distribution of working population in the various sectors of the economy of the Southern Mediterranean Countries (SMCs)

	Agriculture			Industrie			Construction			Services		
	1995	2000	2001	1995	2000	2001	1995	2000	2001	1995	2000	2001
Algérie	17,4	15,7	21,1	13,3	12,6	13,8	13,3	11,7	10,4	56,0	60,0	54,7
Chypre	10,5	5,4	4,9	16,3	14,1	14,0	9,8	10,0	10,0	63,4	70,5	71,1
Egypte	33,4	29,6	..	15,6	13,4	..	6,4	7,9	..	44,6	49,1	..
Israël	2,9	2,2	1,9	20,7	18,0	17,5	7,2	5,3	5,2	69,2	74,5	75,4
Jordanie	6,9	5,5	4,1	15,7	14,5	15,1	10,1	7,3	6,7	67,3	72,7	74,1
Maroc	..	47,1	45,2	..	13,0	12,8	..	6,0	6,4	..	33,8	35,5
Malte	1,7	1,7	2,1	23,2	26,2	24,1	4,6	6,9	7,7	70,5	65,2	66,1
Ter. Pales.	12,7	13,7	12,0	18,0	14,3	14,0	19,2	19,7	14,6	25,6	29,9	34,5
Syrie	28,6	32,0	26,9	17,3	13,1	12,2	12,6	12,4	11,2	41,5	42,5	49,7
Tunisie	21,9	22,1	22,0	21,8	20,5	21,7	13,2	12,7	12,2	43,1	44,7	44,1
Turquie	43,4	34,5	35,4	16,2	18,2	18,3	6,1	6,4	5,3	34,3	40,9	41,0
Moyenne Sud-Med	23,5	25,0	23,8	16,8	14,9	15,4	11,6	10,5	9,5	44,6	46,7	47,7
Moyenne PM	**17,9**	**19,0**	**17,6**	**17,8**	**16,2**	**16,4**	**10,3**	**9,7**	**9,0**	**51,6**	**53,1**	**54,6**
UE-15	5,2	4,3	4,3	21,0	19,5	19,2	7,4	7,2	7,2	66,3	68,9	69,3

Source: European Commission, Eurostat, Statistics in Brief 24/2002. .

The table above shows that the major part of the working population is to be found in the agricultural sector in most of the Southern Mediterranean countries, particularly in Morocco, Turkey, Syria and Algeria. This corresponds to the countries for which the value added in the agricultural sector is comparatively the highest. These are also countries liable to be among the most vulnerable to climate change. A significant segment of society will thus be concerned by the difficulties related to climate change. In this sector, evolutions since 1995 are low. However, the estimated scenarios anticipate a shift of the working population of this sector to the other sectors of the economy (see Graph 4).

Graph 4 - Agricultural population in Mediterranean countries: Evolution and projection



Source. Plan Bleu (2007a)

Moreover, we can notice an increasingly marked shift towards the tertiary sector in the economies of the region (particularly in Israel and in Jordan and, to a lesser extent, in Tunisia) which is in keeping with a significant weight of these activities in the total value added of the countries. This sector will be more spared by the impacts of temperature change. There may be anticipated, therefore, a lower cost related to the future climate for the populations of these countries.

Finally, we can observe that the secondary sector is particularly efficient as it employs a low part of the population of all the countries, though it contributes for the larger part in the total value added.

In sum, the specialization of the production of the economies of the region varies from one country to another: Syria is a mainly agricultural country; Algeria, Egypt, Tunisia and Turkey have a significant industrial production; Israel, Jordan and Lebanon are countries for which the tertiary sector is quite developed. Morocco and Egypt have a production which is fairly evenly distributed between the various sectors of the economy. One also notices the great closeness between the structure of the economy of Turkey and Tunisia. Thus, in view of the disparity between the countries and the regions of the same country, the North being often more industrialized and the South more agricultural, as well as of the share of the population segment employed in each sector, the impact of climate change will not be even across the region.

2. AGRICULTURE: A PARTICULARLY SENSITIVE SECTOR

2.1. Specificities of economic analyses

The impact of climate change on agriculture has been the subject of several recent studies. The models developed to measure these impacts tend generally to be of the Ricardian type and they examine the relation between temperature and rainfall variation and agricultural income (Kurukulasuriya and al., 2006; Mendelson and al., 2006). According to a review of the literature on this topic, Hitz and al. (2004) emphasised the relevance of applying the inverted U-curve to this sector. In the areas where the climate is favourable, a moderate rise in temperature offers new conditions for crops and crop growth. Beyond a certain threshold, the lack of water resources and the extension of the dry season generate significant costs for the farmers.

The setting of this temperature threshold varies according to the authors. For Mendelson and al. (2000), the optimal temperature for the agricultural sector is of 14.2° according to the Ricardian model and 11.7° for the reduced-form model (with a rainfall of 10.8 cm/mo). Tol (2002b) estimates this threshold as +3° with respect to the level of 1990 for Africa and +3.08° for the Middle East.

The indicators selected in the quadratic equation can be of various types. There may be considered the net income or profit ofto the farmers (Mendelson and al., 2000; Kurukulasuriya and al., 2006), the number of people likely to suffer from famine (Rosenzweig and al., 1995; Fisher and al., 2002), land productivity (Darwin and al., 1995), total agricultural production (Tol, 2002b) or even a composite indicator encompassing at once the farmers' income and the share of agricultural production in total GDP (Nordhaus and al., 2000).

With regard to the general and targeted analyses, the losses in terms of GDP in the agricultural sector vary according to the assumptions selected. In the case of the global analyses, the results are often the extension of the data obtained for the United States (Mendelson and al., 2000). Similarly, many studies use the analysis of Darwin and al. (1995) as a reference. These studies estimate the impacts of a climate change per region, but with a major focus on the United States, Japan, Europe and China, the other zones being grouped within a section entitled "rest of the world".

One of the factors likely to account for the divergences between the results is related to the fact that certain analyses introduce into their study the beneficial effects of an additional CO_2 concentration in the atmosphere (Rosenzweig and al., 1995; Mendelson and al., 2000; Nordhaus and al., 2000), while others do not (Fisher and al., 2002; Kurukulasuriya and al., 2006). Actually, an additional CO_2 concentration may have a positive impact on certain crops by stimulating their growth and reducing their water needs. It seems, however, that there is a tendency to over-estimate this physiological effect and that this gets saturated beyond 700 ppm.

Furthermore, certain studies invoke the capacity of adaptation of the countries (Mendelson and al., 2000; Tol, 2002b). But this assumes either considering a long time period allowing the farmers to vary their production (use of new seed, planting, growth of crops, harvest ...); in this case, the adaptation follows the temperature variation. Or else, this may require setting the assumption according to which agriculture responds quickly to climate, with the extension of new, more adapted crops; in this case, adaptation goes alongside with climate change (Mendelson and al., 2000).

2.2. Agriculture in the Southern Mediterranean

The main problem faced by farmers today, but which will grow more important in the years to come, is related to water scarcity (Plan Bleu, 2007b). The losses in terms of water resources following a temperature rise of 1° may amount to 2 million US dollars in Africa and 1 million US dollars in the Middle East (Tol, 2002b). Agriculture is a large water consumer: 61% of the water resources are used on average for the crops (particularly in the southern part of the region), 28% are claimed by industry (manufacturing, power production in the North in particular ...) and 11% by households (Plan Bleu, 2007b). These differences between the Northern and Southern regions are due, on the one hand, to the specialization of the regions and level of economic development (the North being more industrialized than the South which is more agricultural and more exposed to high temperatures) and, on the other hand, to a concentration of the populations in coastal cities.

Table 4 - Water quantities currently used in the Mediterranean basin

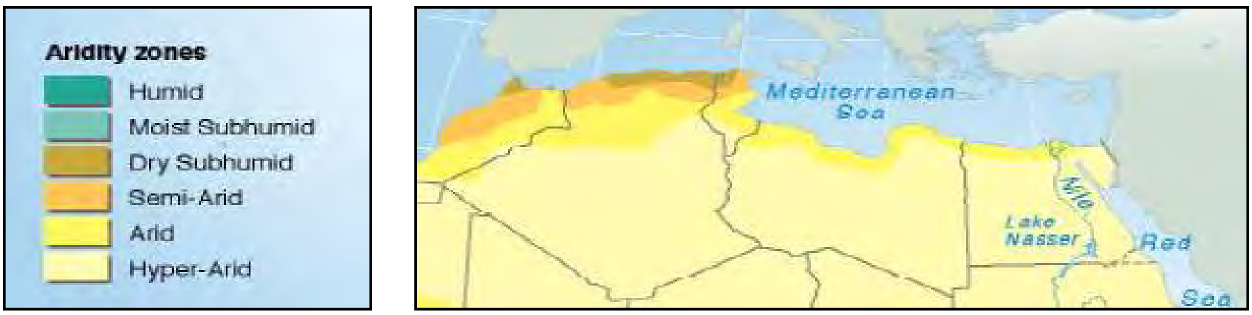
Sous-régions (dans le bassin méditerranéen)	*Volume d'eau utilisée par secteur (km³/an)*				Total km³/an
	Collectivités	Agriculture	Industrie non raccordées	Centrales thermiques km³/an	
Nord	10	29,6	10,4	21,6	71,6
Est	3,1	10,1	1,2	0	14,4
Sud	3,4	54,1*	8	0,2	65,7
Total	**16,5**	**93,8**	**19,6**	**21,8**	**151,7**
%	*10,6*	*61,8*	*12,9*	*14,4*	*100*

Source. Plan Bleu 2007

In the region, not only will rainfall decrease, as already seen, but also some climate variations will appear in the course of a same year. Thus, since rainfall will concentrate over a short period and not extend over the whole year, the losses will multiply due, in particular, to a lack of infrastructures allowing the storage of the surpluses to respond to future needs, and due to the adverse impacts related to periodic water surpluses (floods, loss of crops ...). Consequently, if a production is made vulnerable during a critical period of its cycle, crops may considerably decrease. Moreover, soil quality will be deteriorated, thus reducing its fertility (ISVA, 2002).

The area allocated to agriculture will decrease in favour of the expansion of arid and semi-arid zones. Nearly 250 million people are likely to experience a water shortage in Africa by 2020. The yield of rainfed crops is likely to be cut down by 50% by 2020, thus creating some problems of food security, malnutrition and epidemics in the region (IPCC, 2001). One can anticipate a reduction in the yields ranging from 10% to 50% in Morocco in 2020, for crops requiring significant water resources, and from 5% to 14% of the average yields in Algeria for the same time frame (Rousset and al., 2006). Indeed, the impacts will be all the higher as the poorest populations live in rural environment and subsist on their crops. In the Middle East – North Africa (MENA) region, agriculture already meets barely half of the needs of these people (World Bank, 2005). Difficulties to get food will, moreover, be exacerbated by the reduction of fishery resources attendant upon the increase in temperature and over-fishing (ISVA, 2002).

Diagram 1- Distribution of North African arid zones



Source: World Meteorological Organization (WMO), United Nations Environment Programme (UNEP), *Climate Change 2001: Impacts, Adaptation, and Vulnerability*, Contribution of Working Group II to the Third Assessment Report of the Intergovernmental Panel on Climate Change (IPCC).

Source. Nyong (2006)

2.3. Anticipated costs for the Southern Mediterranean Countries (SMCs)

Most of the analyses underline an increasing benefits in the agricultural sector for the countries of the North as induced by a low temperature rise (of up to 3° generally) and a significant and immediate cost for the Mediterranean region. For less alarming studies, these losses remain marginal.

Nordhaus and al. (2000) estimate a rate of 0.06% loss for Africa and of 0.58% for Eastern European countries for a doubling of CO2 concentration in the atmosphere corresponding to an increase in temperature of 2.5°. These differences between the two regions are due mainly to the share of agriculture in the total production of the countries.

For Tol (2002), the African countries will experience an increase of 0.18% of agricultural gross product for a temperature rise of only 1°, which will be 0.23% for the countries of the Middle East.

Mendelson and al. (2000) reach quite different results. According to the model selected, their estimates pass from an additional benefit of 11 billion US dollars, for the African countries, and 80 billion US dollars, for the countries of the Middle East, to a loss of 137 billion US dollars and a gain of 37 billion US dollars, for the same countries, respectively, following a temperature rise of 2°. The disparity in these results is due not only to the model but also to the fact that they are founded on extrapolations of conclusions formulated for the United States, which gives very approximate figures.

In most cases, the costs for the countries of the region are significant. Fisher and al. (2002) estimate these losses in the range of 2% to 9% for Africa. In North Africa, these losses will be especially important in Algeria, Tunisia and Morocco. In Eastern Europe, in spite of a reduction in farmland (ranging from –0.2% to –5.9% of total farmland space), the value added in the total production of the countries will be maintained at a level close to that of today.

Stern (2006) argues that a temperature rise of 2° can generate a reduction in world grain production by 5%. This impact is multiplied in the Middle East – North Africa (MENA) region where this production may experience a decrease in the range of 15% to 35% according to the real effect of fertilization of additional CO2 in the atmosphere.

It is however necessary to differentiate the impact of climate change according to various types of crops. The climate change impacts will not be the same on cattle, irrigated crops and rainfed crops. Kurukulasuriya and al., (2006) estimate that, in Africa, for a temperature rise of 1°, the incomes losses will be of 27$ per hectare for rainfed crops and of 379$ per farm for cattle, while irrigated crops will report a gain of 30$ per hectare. Indeed, for the latter, an increase in temperature will be beneficial for the countries of North Africa, where the climate is more moderate, though it will generate additional costs for the southern, hotter regions. The impacts on rainfed crops will be felt at once. In the long term, the global impacts will depend on rainfall. If rains intensify throughout the year, all farms will obtain a benefit from it. Otherwise, only those irrigated crops which will not suffer from a water shortage will survive to climate change.

However, these optimistic conclusions as for the situation of irrigated crops must be perceived within a relative context. Indeed, the water needs for this type of agriculture will also increase due to a concentration of rainfall over certain periods and, thus, to increasingly frequent drought periods, as well as due to an increase in the evapo-transpiration connected with global warming likely to disrupt the production cycle. (Rousset and al., 2006)

The interdependence between the sectors can further exacerbate the negative impact of climate change. The decrease in water resources may accentuate the reduction of agricultural production.

This phenomenon will induce a decrease in the wages and employment of the poorest populations segments for which agriculture is the main source of income. This may give rise to catastrophic impacts in terms of food security and proliferation of epidemics, as vectors of reduction of life expectancy of the most vulnerable populations with, in particular, an increase in infant mortality. This will be followed, in the short term, by a displacement of the rural area to already over-populated cities. Consequently, the needs for infrastructures, public services and housing will increase in urban areas. Then, in the longer term, the populations will migrate to the north, to the already vulnerable coastal cities.

3. ENERGY AND INDUSTRY

The industry sectors will be seriously concerned by climate change. The first to be impacted by the latter is the energy sector. Climate change will have impacts not only on the supply side (production) but also on the demand side.

3.1. Change in demand on energy

3.1.1. Specificities of economic studies

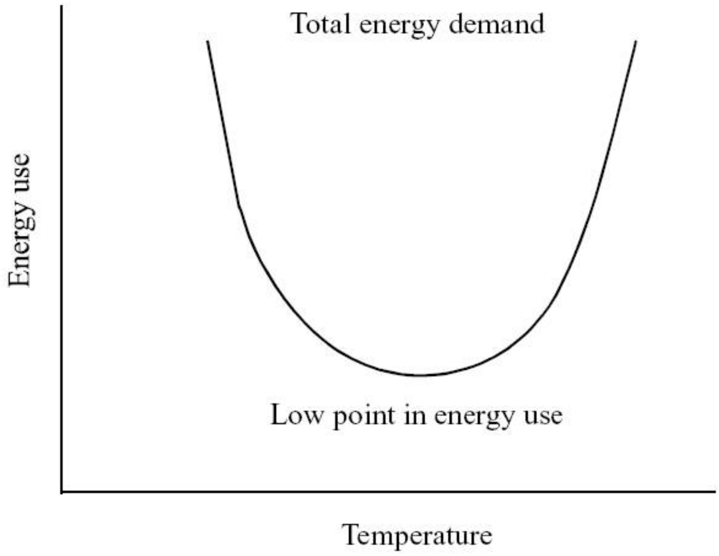
On the demand side, the increase in temperatures will cause a reduction in demand on energy for heating, but an increase in air-conditioning needs for the summer season. The further south, the more marked will these be. However, it is difficult to define precisely the relation between climate change and variation of energy demand (Hitz and al., 2004).

As is the case of the agricultural sector, certain authors argue that there is an optimal temperature for which energy demand is lowest (Mendelson and al., 2000). The approach would, then, be to compare temperature variation and energy expenditure to identify this threshold. The graphic representation of demand takes the shape of an inverted U curve with, on the ascending part, an increase of benefits and, on the descending part—beyond the maximum—a reduction in benefits and an increase in losses. This is owing to the fact that, in the ascending part of the curve, the increase in temperature induces a reduction in the use of heating that is higher than the increase in demand on air-conditioning, thus giving rise to a reduction of the costs for the country. In the descending part, this relation is reversed and induces an increase in production costs. According to the same logic as above, it is the countries with already the more moderate climate which will know the larger benefits. The optimal average temperature stands at 8.6° for Mendelson and al. (2000) within the framework of the Ricardian model and 10° according to the reduced-form model.

However, when the heating and cooling needs are disaggregated, there is a linear relation between temperature variation and energy demand for heating (decreasing relation) and for air-conditioning (increasing relation) which varies according to the total population, the average income and level of technological development of the country. Then, the value of the income-demand elasticityas to be set. In the case of industrialized countries, this elasticity tends towards zero. On the other hand, in emerging countries, it is closer to 1 because of a stronger sensitivity to income.

More synthetically, the economists put forward the assumption that energy demand decreases with a temperature rise to a certain threshold, though difficult to define, from which the air-conditioning demand is substituted for the heating demand (Graph 5). But to highlight such a phenomenon, it is necessary to look from the standpoint of a climate scenario on the long term so that climate change be sufficient enough to induce a marked variation in energy demand (Hitz and al., 2004).

Graph 5 - Variation of energy demand according to temperature variation



Source. Hitz et al. (2004)

The indicator representing energy demand can take various forms. Thus, one may select total expenditure on energy of the commercial and housing sectors (Mendelson and al., 2000), or expenditure on heating or air-conditioning only, or still the total amount for both (Tol, 2002b). However, because of the lack of availability of this type of data, in their attempt to determine the energy demand per country or region, the authors opt, quite often, for extrapolating the results obtained from studies dedicated to Northern countries (Mendelson and al., 2000; Tol, 2002b). In order to avoid too large variances with respect to reality, the level of the parameters of the model is adapted to the profile of the countries.

3.1.2. Impacts of climate change on energy consumption in the Southern Mediterranean

Consumption of primary energy in the Southern and Eastern Mediterranean Countries (SEMCs) is markedly on the increase. It increased by 68% between 1990 and 2005 and is likely to double up between 2005 and 2020 (WEO/Plan Bleu, 2006). The share of the SEMCs in the total energy consumption of the Mediterranean basin (Northern rim and Southern rim) would pass, in this case, from 28% in 2005 to 40% in 2020.

The increase in demand in the SEMCs is due to the needs related to the countries' economic development and the growth of the population whose standard of living and consumption patterns change (urbanization, transport, comfort ...). The population of the SEMCs would increase by 64 million inhabitants between 2005 and 2020. The electricity demand, which had grown fourfold between 1980 and 2000 in the SEMCs, could thus be multiplied by 3 between 2000 and 2025.

Energy demand is partly determined by the change of temperature. Thus, although it is quite difficult to distinguish the influence due to climate change in the total rise of energy consumption, it seems that global warming could lead to accelerated energy demand in the Mediterranean, particularly in the summer season. This may be connected, for instance, with an increased growth in air-conditioning demand for the housing sector, commercial buildings and vehicles. In Malta, demand on electricity has already become more significant in the summer than in the winter season, following—in particular—the penetration of new equipment, especially air-conditioning (Plan Bleu, 2007). In winter, energy demand for heating could be less high.15 Similarly, a reduction in heating energy needs has been observed in Greece (Giannakopoulos and al., 2006).

The energy needs for water treatment could also prove to be a significant factor of an accelerated growth of total demand. Indeed, climate change increases the process of water scarcity. Several countries already resort to desalination (Cyprus, Israel, Malta ...). Certain Southern countries (Libya, for instance) point out this factor as being determining in future growth of energy demand. Besides, wastewater treatment, irrigation and water transfers will accentuate this phenomenon.

In any case, extreme events of the heat-wave type, such as reported in 2003 in Europe, are likely to generate very high consumption peaks.

3.1.3. Anticipated costs for the Southern Mediterranean Countries (SMCs)

The main results of the empirical economic literature on the Southern Mediterranean region highlight a considerable cost in terms of additional energy demand in the wake of climate change. This is due, to a certain extent, to the fact that the countries have already exceeded the threshold beyond which the air-conditioning demand will be steadily on the increase, with average annual temperatures above 24° for Africa and between 8° and 9° for Eastern Europe. These losses are of -3 billion US dollars for Africa and -8 billion dollars for the Middle-East, according to the Ricardian model, for a temperature rise of 2°. They amount to -7 and -17 billion, respectively, according to the reduced-form model.

For Tol (2002b), whose analysis is based on a more optimistic climate scenario (+1° on average), the countries of the Middle East derive benefits of about 8 million US dollars from saving on heating which largely compensate for the losses of -1 million dollars due to demand on air-conditioning. For the African continent, there are no additional benefits but only losses of -5 million dollars for an increasing demand on air-conditioning.

In sum, despite the potential reductions in energy consumption for heating, the necessary increase as regards air-conditioning will no doubt be higher (Report from the EU project "Climate Change and Employment", 2007). Regardless of the net balance, the trend scenarios highlight the fact that demand on primary energy will double up in the Mediterranean by 2025 (Plan Bleu, 2005), which will incur the countries a significant cost, requiring beyond any doubt an increase in supply.

3.2. Impact of climate change on energy supply

On the supply side, climate change may have direct economic impacts (for example, on the infrastructures, production or renewable resources) or indirect impacts, through increases in prices on international level (and hence an energy bill), related to the energy policies not only of the Mediterranean countries but also of the countries outside of the region.

The variation of the supply responds, on the one hand, to the increase in demand and is, on the other hand, imposed by climate risks (particularly with regard to renewable resources and infrastructures) and by the regulation policies aimed at reducing GHG emitting productions (which involves, in particular, the hydrocarbons sector: coal, oil, gas).

The Mediterranean region epitomises, in itself, the whole range of global energy issues: increase in energy dependence (for importing countries), increase in demand on energy and infrastructure (notably electricity), problems related to the production of hydrocarbons (for the exporting countries: Algeria, Libya, Egypt, and Syria). Accordingly, whatever the possible impacts (be they direct or indirect) of climate change, the region will be affected.

In 2005, fossil energies (oil, coal, gas) accounted for 95% of the energy supply of the SEMCs. In order to meet the growing needs of the Southern Mediterranean countries, it is anticipated to have an increase in primary energy production particularly in Algeria, Egypt and Syria. This production is likely to double up by 2025 mainly in view of the countries' oil and natural gas resources (Plan Bleu, 2005).

In this context, the acceleration of energy demand due to climate change may translate into a trend towards an increased trade deficit for importing countries[16] (already increased by the anticipated reduction in agricultural production and the rise of the prices of fossil energies, of which oil, in particular). Not all industries are, however, affected with the same intensity by the changes in energy prices (Table 5).[17] Such a trend will intensify with climate change and the increase in extreme events. The example of a record price of a barrel of oil at 83$ reported in October 2007 and partly due to anticipation of a tropical hurricane on the Gulf of Mexico likely to damage the oil infrastructures, attests the sensitivity of oil prices to the climate.

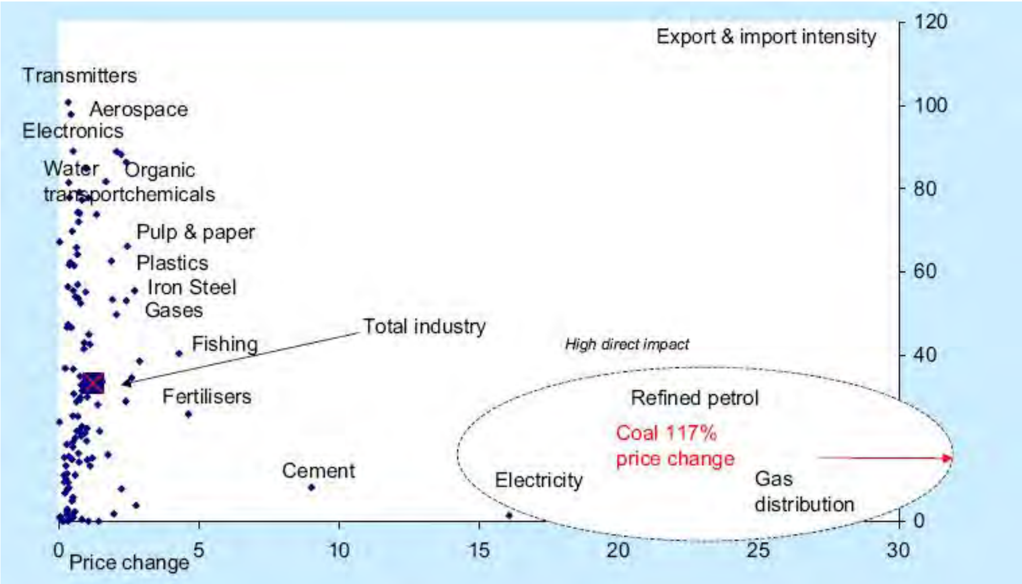
The situation is set to worsen over the longer term with the reduction of fossil energy resources and the shift of international demand towards less expensive and less polluting energies. International competition will evolve at the expense of the oil exporting countries. As the current price of exhaustible fossil resources comprises a significant element of revenue, in particular for oil and natural gas, there is a risk that the price of fossil energies should slump in response to a stepping up of climate change policies, which could consequently undermine their effectiveness (Stern, 2006).

The climate change policies currently conducted by the consumer developed countries, in particular the EU, give rise to a significant concern among the national oil companies, because they have a negative anticipated impact on oil consumption and on future use of petroleum products.[18] The financial losses for the national oil companies induced by a reduction in the growth of oil consumption[19] would amount to between 210 and 265 billion US Dollars over the period 2005-2015, for a barrel at 60 US Dollars. Moreover, the lack of certainty concerning future demand discourages investment, which may have a negative impact on security together with similar risks to the sectors producing oil by-products. The sum of these impacts could reduce future consumption and the price of oil.

It is, thus, the countries which produce electricity based on non fossil energy and on gas, whose prices will vary in a less marked way, which will be the least vulnerable to the indirect impacts of future climate change and the most able to meet the additional domestic energy demand (Stern, 2006).

16 Or those which will become so in the short/medium term for certain types of fossil energy (case of Egypt).
17 The 'pick oil' date (moment when oil production will start to decrease) is currently the subject of debate among experts.
18 "The Impact of Climate Change Policies on National Oil Companies", report prepared for the Environmental Working Committee of the National Oil Company Forum, 2007.
19 The report rests on the assumption that despite climate policies, oil consumption increases by 2% per year.

Table 5 - Variation of energy price and sensitivity of the industries



Source. Stern (2006)

3.2.1. Direct impacts of climate change on infrastructures and power production

The equipment of the Southern Mediterranean countries in basic energy infrastructures is still considerably short of meeting future demand. Indeed, in 2005, over 9 million people located in the Mediterranean region, particularly in Syria, Egypt and Morocco, did not have access to electricity (Plan Bleu, 2006).

Climate change directly affects the conditions and potential of power production. Moreover, extreme events impacting the infrastructures can considerably disrupt energy production and distribution.

Climate change will affect hydroelectric production in two ways: firstly, by a reduction of rainfall; secondly, by a rise in evaporation of lake water due to the rise in temperature. In 2005, for instance, rainfall in Spain was lower than the normal rate for the second consecutive year, which considerably reduced the water capacity available. The average rate of recharge was lower by 50% for the first time since 1995 which caused a reduction by 34% of the hydroelectric production between 2004 and 2005.[20] Among the SEMCs, this source of power production is particularly significant in Morocco, Tunisia, Egypt, Lebanon, Syria and Turkey.

The change in wind regimes may, in its turn, affect wind energy production. Besides, temperature rises[21] can disrupt the cooling of the power stations. In the longer term, sea level rises can have an adverse impact on coastal activities related to refinery activities and transport of energy (in particular of hydrocarbons). Moreover, climate conditions may hamper proper logistic operation of certain energy extraction or transport activities (land transport, sea transport, pipeline conveyance ...).

Besides, degradations of infrastructures due to extreme weather events are on the increase: risks of production or distribution disruptions, accidents, accelerated ageing.

[20] In this year (2005), the drop in hydroelectric production was partly compensated by wind-energy based production, imports (+26%) and production of conventional thermal stations (+17%).
[21]The heat-wave of 2003 caused problems for the French nuclear reactors, which many are cooled by river water. In certain French regions, river water levels dropped so low due to the drought that the cooling process became impossible.

Thus, from an economic point of view, the cost of climate change will take the form of a poor allocation of capital: the productivity and useful life of factories or infrastructures will be reduced by the new climate conditions (Hallegate, 2007).

On the whole, the considerable increase in demand at periods during which the production capacity is reduced causes 'black out' and/or spill-over impacts, which would induce huge economic costs by crippling entire sectors of the economies. To this, there must be added the possible impacts of extreme events on the infrastructures, and of increasing instabilities and uncertainties with regard to hydrocarbons.

3.3. Costs of climate change for industrial enterprises

The decrease in water resources, of which a quarter of the total use meets the needs of the industrial sector, will incur very heavy additional costs. This is the case for certain manufacturing enterprises, such as semi-conductor enterprises. Indeed, this problem is likely to disrupt the supply of firms whose production process is mostly dependent on this factor. Accordingly, these costs will be all the higher as these firms would not have anticipated the changes in rainfall and are faced with drought periods.

The firms of the Mediterranean region are not directly concerned by the measures taken within the framework of the Kyoto Protocol, except for multinational firms which have subsidiaries in other countries of the world; but these remain a minority. However, clean production processes will be encouraged. Oil industry will undergo the effects of regulation policies in the Northern countries which will translate in an additional cost in the use of this energy, due to taxes. World demand will, therefore, be gradually shifted towards goods whose production is low in carbon, which will be—in the long term—less expensive. Polluting companies will, moreover, suffer from a bad reputation likely to cause disinterest among people for their goods (Table 5). Everywhere in the world, firms that have not readjusted their production will suffer from a notable comparative disadvantage, including the companies that are not subject to regulation policies. This will be the case, in particular, of basic industries (chemistry, coal, steel) and manufacturing industries. Firms that do not resort to new technologies to reduce their emissions may then be left behind in the competition race and will even have, in the long term, to get their supplies from competitors. Furthermore, although demand turns on from polluting companies to cleaner firms, the main energy producers, such as gas companies, will not report any boom in their profits because of a reduction in demand for heating in the Northern countries.

With regard to railway, maritime and air transport, the difficulties likely to be faced by companies are also due to rises in oil prices induced by the additional charges levied on carbon. In addition, some of them will have to reorganise their specialization at the risk of experiencing a drop in their earnings due to a change in the countries' patterns of energy use. There will be observed, for instance, a reduction in the use of coal, on international level, which can be substituted by gas or electricity. Their future costs and profits will thus depend on their adaptation capacity.

Furthermore, Mediterranean countries are incepting the last phase of industrialization of their economy. Their CO2 emissions will be all the more significant as the countries of the region resort mainly to fossil energies. Thus, the forecast baseline scenario indicates a doubling up of CO2 emissions due to energy use in the Southern Mediterranean region between 2005 and 2020 (reaching 1400 million tons of CO2), (Plan Bleu, 2006). The countries are, therefore, likely to be soon called upon to take measures aimed at reducing pollution.

The direct and indirect costs induced by climate change for the industry and energy sector in general could be quite significant. The adverse effects will be exacerbated by the degradation of the ecosystem which will be attendant upon the development of heavy infrastructures. Besides, the increase in energy consumption and industrial activities may give rise to a doubling up of CO2 emissions on the part of the SEMCs by 2020, which will have a significant impact on pubic health, particularly in urban areas and in major coastal cities. Measures aimed at making the energy system less vulnerable to climate change and adapted to a low carbon emission world economy are likely to quite significantly reduce the costs and derive quite significant spin-offs (cf. part II of this report).

4. COASTAL AREAS: VERY HIGH COSTS INDUCED BY EXTREME EVENTS

The major problem faced by coastal areas, in relation to climate change, is the rise in sea level. However, on this aspect too, anticipations differ according to climate scenario and region. On average, the economic estimates rest on the assumption that the rise in sea level in 2100 will range between 0.5 centimetres and 1 meter. In order to have a vision closer to reality, the extreme events should be added to this phenomenon which will intensify in these areas in the years to come (storms and floods, in particular), as well as take into consideration the possible protection systems set up by the countries. Besides, the estimates vary according to the population density and economic activity of the coastal areas considered in the study. The results are, therefore, closely dependent on the analytical framework and the assumptions selected. However, there emerges from these studies a point of convergence concerning the linear and increasing relation between climate change and the costs incurred by coastal areas.

4.1. Specificities of the economic analyses

The early studies were essentially dedicated to the situation of the United States. This is why their results are regularly taken up and adapted to the other areas of the world (Nordhaus and al., 2000; Mendelson and al., 2000; Tol, 2002b).

To estimate these impacts, indicators may be of various types. The procedures range from adopting an approach in terms of "population at risk" (Frankhauser, 1995), or rather an approach according to capital losses.

Mendelson and al. (2000) opt for considering the coastal area, in kilometres, for each country according to the average value of the land, based on a study concerning the United States. Indeed, according to the area and quality of the land, this value can vary widely. Useful farm space has a far higher value than that of arid land, for instance. Taking into consideration this diversity requires, however, a focus on a given area. In order to address this problem, within the framework of a global study, Tol (2002) distinguishes between the loss of arid and of humid land for an 1 meter rise in sea level based on an extrapolation of the results obtained within the framework of the studies dedicated to OECD countries. The average value per square kilometre is 4 and 5 million US dollars according to land type, respectively. The value of dry land is assumed to be linear in density of income, i.e. in US dollar per square kilometre; and the value of humid land follows a logistic trend according to per capita income. Water rise thus generates movements of the population which vary according to the population density of the zone and land loss, particularly in wetlands. Besides, the author considers the additional cost of protection of coastal areas in order to assess the need for action. This parameter can have a significant influence on the results in the sense that protected areas will incur lower costs than other areas. Only the adverse impacts of extreme events are not considered.

Lastly, this impact may be measured via an evaluation of persons' willing to pay to prevent climate change. Following this logic, Nordhaus and al. (2000) estimate as 0.1% of income the average persons willing to pay of in the United States to avoid a 2.5° temperature rise, taking into consideration the probability of extreme events which differs according to the activity on the coasts (i.e., within the 10 km area along the sea). The value of the coasts increases with the income (elasticity with respect to income is of 0.2).

4.2. Coastal areas in the Southern Mediterranean

The impact of climate change on coastal areas will induce very high costs for the Mediterranean region. This is due to the fact that a large majority of the population and of economic activity is concentrated in the major cities on the coastline within a close radius (Plan Bleu, 2007c).

Indeed, among the coastal cities, there are many capitals (Tunis, Algiers, Tel-Aviv, and Beirut) and, further south, Cairo and Rabat, which are, for the most part, key activities centres. This phenomenon is set to be exacerbated in the coming years due to a high demographic growth, as we have seen, and because of a significant rural migration which will intensify in view of the increasing difficulties of the agricultural sector that linked to climate change. Thus, assuming that the coastal population growth rate in the Southern Mediterranean were to stand at 1.4% per year, the cities would count 90 million inhabitants by 2025 (Plan Bleu, 2005) to which are added about as many tourists according to the seasons. This region will, therefore, be particularly vulnerable to climate change. Nicholls and al. (1999) estimate that 90% of the people for whom flood risks are highest are located in the regions of South and East Asia and of the Southern and Eastern Mediterranean.

Fixed capital losses will also be particularly high, because several transport infrastructures are located within the 10 km coastline area (roads, ports ...) in order to meet the increasing needs of both inhabitants and tourists, together with tourist facilities (marinas, restaurants …), factories (desalination, refineries, for instance) and heavy infrastructures. Besides, protection measures are quite limited and insufficient to mitigate the negative impacts of extreme climate change. Considerable effort still needs to be made in this respect.

4.3. Anticipated costs for the Southern Mediterranean Countries (SMCs)

Thus, even though the studies do not consider the whole range of these parameters, they all converge in highlighting the huge costs of climate change incurred by the coastal areas of the Southern Mediterranean.

As we have seen, the study of Mendelson and al. (2000) yields quite optimistic results because only the impact on the market sector is included in the analysis. Albeit, according to the reduced-form model, the losses for the coastal areas induced by an average climate change of 2° are estimated as 4 billion US dollars in the Middle East.

It is difficult to evaluate this impact in the Mediterranean region through the study of Nordhaus and al. (2000), because their estimations are reckoned according to a "coastal zone index" which represents the part of the area located within 10 km of the coast. However,they decompose their study by continent and not by zone, which necessarily reduces the relative proportion of coastal areas with respect to our analysis zone. Thus, for Africa, the losses are estimated as 0.02% of GDP and, for Eastern Europe, as 0.01% based on the scenario which anticipates a 2.5° temperature rise.

Tol (2002b) offers the most precise analysis. As a first step, he estimates the level of protection of the areas. Then, he evaluates the losses of humid and dry spaces in terms of surface area and monetary unit. Finally, he measures the impacts on the movement of population. It appears that the levels of protection of coastal areas in Africa and in the Middle East are quite low, about 0.89% and 0.30%, respectively, which induces a loss of surface area, following a 1 metre rise of sea level, amounting to 15 400 km² and 600 km² of dry land for Africa and the Middle East and 30800 km² of humid land for Africa. That corresponds to a cost of 6.16 billion US dollars, 0.3 billion US dollars for arid land, and 12.32 billion US dollars for wetland. The impacts on the population will be catastrophic and there will be 2.74 million immigrants in Africa and 0.05 million in the Middle East by 2200. The costs of the action in order to limit the losses would be of 92 billion US dollars for Africa and 5 billion US dollars for the Middle East, hence the difficulty of implementing adaptation measures based on the construction of protection infrastructures.

Several additional impacts are not included in these analyses, which implies that the results are underestimated. These involve in particular impacts on the non-market sector. The sad examples of the tsunamis or cyclones in Indonesia or in the United States have shown that in extreme cases, impacts on the population are catastrophic. The number of deaths reaches very high levels at the time of the catastrophe and the deteriorated sanitary conditions can give rise to outbreaks of epidemics. Moreover, the variation of water level and extreme events will induce a significant degradation of the ecosystems. Lastly, the destruction of coastal infrastructures will reduce the attractiveness of the zone for tourism, a sector whose economic weight is dominant in certain regions.

5. TOURISM: A KEY ECONOMIC ACTIVITY DEPENDENT ON THE CLIMATE

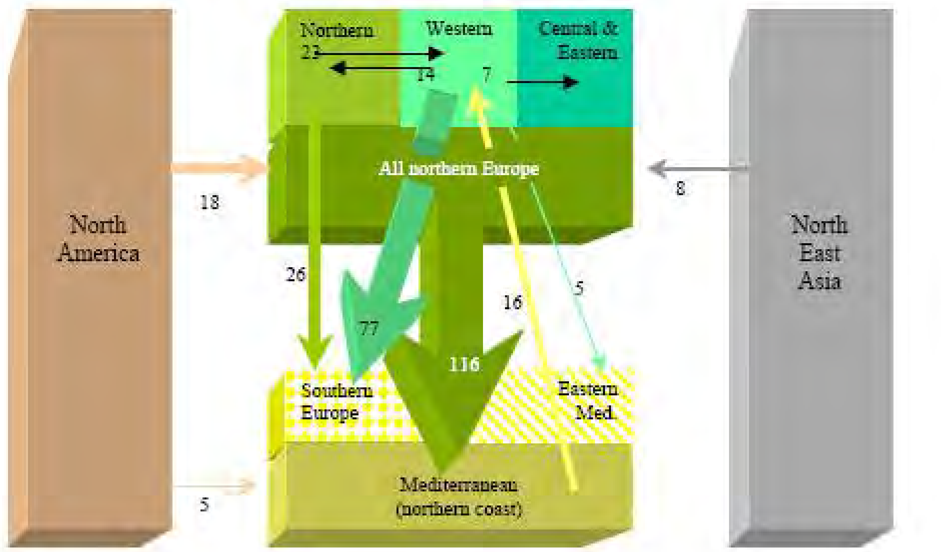
Few studies analyse the impact of climate change on tourism. They focus mainly on the link between distance and tourist zone, the identification of the reference destinations… However, the climate plays a major role in the choice of persons' holiday location and remains the third determining factor for tourists (Lohmann and al., 1999). Are regarded as tourists, according to the definition of the WTO (2003), people who sleep between one and 364 nights away from home, knowing that in the case of international tourism the persons need to have crossed the borders of their country. It is, nevertheless, necessary to exclude from this sample the travels made for purposes of work, studies or health care (Hamilton and al., 2005). It is important to consider at the same time the supply and demand, for regions are in competition to attract the most well off tourists, and people seek the destination that best meets their expectations (Hamilton and al., 2005).

5.1. Tourism in the Southern Mediterranean

This activity has a significant weight in the total income of most of the economies of the Mediterranean region. Indeed, this sector has reported a growth in the range of 3 to 4% per year on average in the past few years. The region now receives about a third of international tourism, coming mainly from Northern Europe. The most attractive countries are Turkey, Egypt, Morocco and Tunisia. These regions claimed 36.1%, 16.3%, 12.07% and 9.9%, respectively, of the total number of tourists coming from the country (national) or from outside it (international) in 2000. National and international tourism are expected to grow threefold by 2025 in this zone, the share of each of the countries remaining constant. Indeed, the region knows much sunshine and a rich cultural heritage which attracts a large number of people in the summer season, as well as in spring and autumn. This, accordingly, helps the country to develop and operate reception facilities (hotels, restaurants…), which is advantageous for growth; besides, international tourism is a major source of foreign currency reserves.

However, this sector is particularly vulnerable to climate change as the region already experiences high temperatures and a lack of water resources, especially in the summer season. Moreover, most of the tourist activities are concentrated in the coastal cities which are prone, as we have seen, to experiencing major problems due to sea level rise and intensification of extreme events (in Tunisia, for example, 90% of the tourism activity is concentrated on the coasts (UNEPb, 2007)).

Diagram 2 - Southern Mediterranean inbound tourist flows (in millions)



Source : Travel Research International from World Tourism Organization data (2003)

5.1.1. Specificities of the economic analyses

The relation between tourism and climate change is, initially, increasing. This is due to the fact that, although the destinations vary according to people, their culture, their age and various other parameters, on the whole people are much attracted by hot areas. However, beyond a certain average temperature, this relation stagnates then decreases, low latitude areas having become too much exposed to global warming and altitude areas suffering from lack of snowing for winter sports (Hamilton and al., 2005). The relation between tourism and climate change is quadratic. For Hamilton and al. (2005), curve reversal point corresponds to an annual average temperature, over 24 hours, of 14° in the case of international tourism and 18° for domestic tourism. The same applies to outdoor recreation. The practice of sport, for instance, is no longer possible beyond a certain threshold (Nordhaus and al., 2000).

According to a more detailed vision, the impacts of climate change on tourism can be of four types (UNEPb, 2007). Thus, although direct impacts seem to dominate, certain indirect impacts can influence the choice of the tourism destinations of people. The main impact is related to temperature rises, reduction of rainfall and increase of risks related to extreme events. However, the change of the overall environment plays a significant role, with in particular the more acute problems related to water resources, to an increasingly high pollution level in the cities, to epidemics, as well as to a modification of coastal landscapes due to a rise in sea level. The implementation of regulation policies in the Northern countries, may, in addition, disrupt transport (air traffic, in particular). Lastly, the country's development level, itself being highly dependent on the future variation of the climate, will be an element taken into account by tourists in matter of offer of services and comfort, for example.

The studies which link these two phenomena follow different logics. The approach consists either in anticipating the variations in terms of offer of services related to tourism, or in estimating the future expenditure of tourists according to various destinations, or still in considering the destinations of people according to their forecasts concerning the future climate, or finally in analysing the evolution of demand on recreation according to climate change (ski, beach ...). Indeed, the indicators used in the empirical literature often reconcile the tourism demand with the recreation demand, while these two activities are not necessarily identical, by definition. Indeed, in the second case, the approach consists in taking into consideration the number of hours dedicated to outdoor recreation during people's spare time. This period may be estimated on average as 2% of people's spare time in the United States (Nordhaus and al., 2000). According to this point of view, these activities are very sensitive to climate change. The overwhelming majority of these studies are focused on Northern countries.

5.1.2. Anticipated costs for the Southern Mediterranean Countries (SMCs)

The most comprehensive analyses on this topic focus mainly on international tourism. Of these, one may mention the works of Amelung and al. (2004) which deal in particular with the supply side and the potential tourism flows in various regions of the world (defined according to their latitude and longitude). They emphasise the importance of temperature, rainfall, moisture and wind in the choice of destinations. The analyses point out shifts in behaviour on the part of tourists in lower latitude areas. After having favoured the summer period, people go to the countries of the South in spring and autumn, then in winter. In the long run, their preferences tend towards destinations further north and in altitude where the environment is more hospitable. It may be deduced from this, then, that in the Mediterranean countries, tourist flows will initially intensify in autumn and in spring and will be reduced in the summer. Afterwards, tourists will prefer the winter season. If the phenomenon of global warming becomes more acute, tourism in this region will decrease gradually. The loss of earnings in terms of economic resources will then be quite high.

In a more recent study, Hamilton and al. (2005) confirm these conclusions using a dedicated model (Hamburg Tourism Model – HTM) based on 206 countries and various scenarios of economic and population growth. Following a rise in temperature, people living in temperate zones will prefer domestic tourism over international tourism, thus reversing the current trend. This is due, in the first place, to a phenomenon of saturation of international tourism due to a reduction of growth. It is largely amplified by the future climate. The Mediterranean region will report a reduction by 10 to 25 % in the number of international tourists by 2025, while becoming one of the major departure zones. Thus, the cost for the countries of Africa in this field will be not less than -0.25% of GDP following a temperature rise by 2.5° (Nordhaus and al., 2000). The countries of Eastern Europe, located further north and being of a less important tourism calling, will be less affected.

The tourism sector interacts with the majority of the other sectors of the economy. Thus, the impact of climate change on tourism in the Mediterranean will translate, initially, into an increase in energy use (for air-conditioning, in particular) and an acceleration of the depletion of water resources, in the summer season. Over the longer term, however, it will be conditioned by the impacts of the climate on coastal cities, transport and the ecosystem. Indeed, although the economic studies scarcely include the non-market sector, its role remains fundamental.

6. THE NON-MARKET SECTOR: A SIGNIFICANT PART OF TOTAL COSTS

One major weakness of the climate change impact assessment studies arises from the under-estimation of the results, due to insufficient consideration of the non-market sector and of its interactions with the other sectors of the economy. This phenomenon is mainly related to the difficulty of evaluating, in monetary unit, the adverse impacts of climate change on environment and health.

6.1. Natural ecosystem

The impacts of climate change on the environment are often irreversible and result in a destruction of the interdependences of the natural ecosystem. In the Mediterranean region, the ecosystem is quite vulnerable, and the anticipated risks are an increase in desertification and a degradation of the environment close to the coasts (80% of the arid or dry areas are liable to experience desertification in the Southern and Eastern Mediterranean (Plan Bleu, 2005)). However, evaluating changes in the ecosystem remains very complex. It is not possible to distinguish the impacts according to each species because some are more resistant with a better capacity of adaptation, others will migrate in areas where the climate is more favourable to them, or will become extinct… Then, the estimates suffer from a considerable uncertainty.

6.1.1. Specificities of the economic analyses

The qualitative studies represent an appreciable step in this direction, but they remain targeted and are not easily amenable for use within the framework of evaluating the economic impacts of climate change.

One solution consists in evaluating the current services offered by the ecosystem thanks to natural resources, via regulation and within the framework of outdoor activities which will disappear in the wake of climate change. These include food, water, wood, fossil energies; absorption of GHG which slows down climate change; water purification; and, finally, the environment for recreation activities; the attractiveness of the zone thanks to the beauty of the landscapes… In this regard, it is necessary to consider the changes in distribution of vegetation and its productivity, using a dynamic model (White and al., 1999). Certain services can be easily measured in monetary unit. This is the case, for instance, of the price of wood, fishery and fossil energies, according to the quantities on the market. But it is insufficient to consider only these resources

This is why, within the framework of the economic approaches, the value of the ecosystem is calculated according to people's willing to pay to avoid that the temperatures should reach a certain level and limit the total supply of services offered by the environment. It varies according to the countries' economic development level. It increases with the income. The disparities in wealth between the countries must, therefore, be included in the estimates, and in particular in the case of an extrapolation of the studies dedicated to the United States (Nordhaus and al., 2000). Moreover, it is necessary to weight the results according to the surface area concerned and the vulnerability of the natural system, taking into consideration the fact that certain hot and dry areas are already very sensitive. This value is around 50$ per capita in the OECD countries for Tol (2002b).

Besides a distinction by country, it is more precise to distribute people's willingness to pay according to latitude, in view of the ecosystem of the region and the probability to tend in future towards an environment closer to that which is currently further south (Fleischer and al., 2007). It seems relevant to relate the locations of the various animal and plant species in view of climate distribution. According to future climate anticipations, it is then possible to foresee how the ecosystem in the various regions zones of the world will be like (Halpin, 1997).

The relation between the ecosystem and climate change is difficult to evaluate and is not the same in all regions. However, one assumption commonly adopted is that, to a certain extent, this relation is parabolic. That is to say, initially, the additional carbon dioxide concentration in the atmosphere may have a beneficial effect on the ecosystem. But this phase is quite short and the harmful effects of a temperature rise (accompanied by an increase in evapotranspiration) and a reduction in rainfall will very soon come to counterbalance this trend (Hitz and al., 2004). This will give rise to an exponential relation between temperature rise and loss of biodiversity. In the Mediterranean, already, more and more plant species are regarded as rare or endangered. The degradation of the ecosystem is thus likely to accelerate in the coming years to become catastrophic.

As regards the particular case of the forest and of climate change, it is important to anticipate an increase in extreme events such as large-scale fires, in view of the frequency and the length of drought periods. This impact is often regarded as linear with respect to the global average temperature rise. It should be noted, however, that this sector has a negligible weight in the Southern Mediterranean countries as the forestation rate stands at a mere 4.7% in the region (Plan Bleu, 2005).   .

6.1.2. Anticipated costs for the Southern Mediterranean Countries (SMCs)

The different analyses highlight the negative impacts of the climate on the ecosystem. The hotter the environment gets, the higher the change in biodiversity (Halpin, 1997). This phenomenon is due to the fact that though certain species may be highly resistant, they will not be able to withstand a too significant rise in temperature. Moreover, considerable climate change limits their adaptation capacity (Hitz and al., 2004). Further north in the Mediterranean, where the winters are the wettest (mean rainfall is about 780 mm and average temperature is of 18.1°), biomass is greater and vegetation is richer and denser (total biomass is estimated as 19.1 tons per hectare). For a rise in temperature of 2°, some 15 to 40% of the species will be endangered (Stern, 2006). Climate change tends to largely transform this environment into more arid areas following a reduction in rainfall (ranging between 90 and 300 mm) and a warming of mean temperatures (likely to reach 19.1°). Total biomass is then reduced to 2.8 – 6.1 tons per hectare according to the extent of climate change (Fleischer and al., 2007). This highlights the vulnerability of the environment in the Mediterranean to low climate variations.

Current losses of species, ecosystem and landscape amount to 0.25% of world GDP. Estimates show that they will double up by 2200; the loss of well-being is likely to reach 1% of GDP for this same time frame (Tol, 2002b). It will be of 0.10% in Africa and Eastern Europe following a temperature rise of 2.5° (Nordhaus and al., 2000).

People's willingness to pay is quite significant in the lower latitudes, in high-income regions. In order to maintain the vegetation to a same level, people - in Israel - are will to pay 2$ per ton of biomass per lost hectare and 0.05$ per year for a millimetre of rainfall. In sum, the population agrees to pay about 100 million US dollars per year to prevent that the wetter areas should become arid. This is a cost much higher than the services rendered by the land in terms of cattle feed (estimated as 20000 US dollars on average), as the populations seem to attach much importance to the environment for their recreation. However, these results must be considered largely in their relative value with regard to the other countries of the region, and this, insofar as they remain quite dependent on the level of the country's income and of GDP per capita. Thus, in certain areas, it is more likely that people's willingness to pay might be lower than or equal to the services rendered by the land.

Photograph 1

Wet Mediterranean landscape

Photograph 2

Arid Mediterranean landscape

Source. Fleischer et Sternberg (2007)

With regard to the sea, the temperature rise will result in a decrease in productivity of the marine ecosystem that is especially marked in the lower latitude areas. Thus, within an 80-year time period, the production and exportation of sea products will drop by 20% in the Southern Mediterranean (Bopp and al., 2001).

The reaction of the forest would obtain on the longer term, if one were to ignore the increasing fire hazards. Indeed, the consequences of forest fires in human and material losses are considerable (approximately 150 euros per hectare and per year (Plan Bleu, 2005)). For a temperature rise of 1°, the impacts in the countries of Africa and the Middle East are nil (Tol, 2002b). Consequently, in the years to come, it is possible to report an increase in wood supply (Hitz and al., 2004). However, in the long term, the total costs will reach 0.003% of GDP by 2100 and 0.06% of GDP by 2200.

The changes in the ecosystem induced by a rise in temperature will have adverse impacts both on the population and the economy. By offering fewer services, in particular food (reduction in resources, fishery and soil quality), the changes will cause the poorest people, the vulnerable categories, to suffer from famines. In addition, the depletion of energy resources will result in an increasing dependence of Mediterranean countries vis-à-vis the rest of the world. Lastly, environment degradation will reduce the attractiveness of certain zones that will suffer losses because of a reduction in tourism. This deterioration of the ecosystem will be all the more significant as pollution is intensified, as demographic growth rises steadily and as the needs in infrastructure increase.

6.2. Health

6.2.1. Health related problems in the Southern Mediterranean

Global warming could generate a reduction in food resources in Mediterranean countries due to a drop in agricultural production and a degradation of the ecosystem. The poorest categories of the population will be faced with problems of malnutrition and famines which are contributing to the development of epidemics. This phenomenon is made even more acute by the rarefaction of water resources, which induces a resort to non-potable water. One risk consists in the development of fatal tropical diseases, of the malaria or yellow fever type, in the more temperate zones, following global warming, as well as a proliferation of diseases that add to the vulnerability of young children (diarrhoeas...).

Besides, the countries of the zone will report a large increase in their CO2 emissions in the coming years, which in turn will increase the air pollution of the cities. Respiratory diseases will then multiply, while a segment of the population will not have the financial means necessary to seek care.

Lastly, demographic growth and rural migration will swell the ranks of the urban population, while the cities are not yet capable of offering sufficient basic infrastructures to meet the needs of the people living in urban environment. Accordingly, there will be increasing health related problems giving rise to a proliferation of diseases.

These impacts on health due to variations of the climate come to considerably increase the total cost of climate change in Mediterranean countries. However, because of a lack of indicators allowing measurement of these impacts, they are often not included in the economic analyses or are integrated only partially. In this regard, the studies conducted on the case of the United States, during the heat waves, can by no means account for the total impact via an extrapolation of the implications - in particular in the countries of the south - of climate change for the population.

6.2.2. Specificities of the economic analyses

In the more precise general analyses on this subject, a distinction is made between the factors likely to deteriorate people's health and the means offered to these people to get care. While certain persons will be more concerned with pollution (in the North and in the South), others will be more liable to epidemics (in the South). Besides, according to the income of the country, access to health care will not be the same. In this regard, most authors refer to the pioneer works of Murray and al. (1996) (Nordhaus and al., 2000; Tol, 2002b). To calculate these impacts, it is possible to reason in terms of loss of years of life. Separating the impacts of pollution from those of epidemics on health allows for a specification of the impacts according to the countries. It thus emerges that the relation between epidemics (malaria and yellow fever, in particular) and global warming is linear (Tol, 2002b). With regard to pollution, the cardiovascular diseases, which result from it, affect in particular young children and old people and are concentrated in the cities. It is thus difficult to establish a full relation between these two phenomena. Lastly, access to health care depends on people's income and seems to be linear with respect to their per capita income. Accordingly, persons with an average income of over 3100 US dollars are not concerned by epidemics (Tol, 2002). These relations apply in the countries of the Middle East but not in the regions of Africa where the mortality rate is particularly high.

6.2.3. Anticipated costs for the Southern Mediterranean Countries (SMCs)

Nordhaus and al. (2000) estimate that, of the total years of life lost, 11.76% are due to the climate in Africa for an average regional temperature of 25°; the estimate is 0.97% in the Middle East for an average regional temperature of 18.9°. In both cases, pollution plays a major role, but the part due to epidemics is particularly significant compared to the other regions of the world, except for Latin America.

However, it is very difficult to assign a money value to a life. To translate these results into monetary unit, one assumption would be to estimate that one year of life lost would correspond to two years of per capita income (Nordhaus and al., 2000). The price of a life may also be evaluated as 200 times the per capita income (Tol, 2002b). Yet, when one considers total loss of well-being, the figures expressed in monetary unit are low, since it is the poorest people who are the most concerned by epidemics.

For a global warming of 1°, the additional deaths due to epidemics are about 57000 in Africa and of 155 in the Middle East per year. These figures are amplified by the effects of pollution claiming 1820 additional deaths in Africa and 890 in the Middle East per year, for a temperature rise by 1° (Tol, 2002b).

Following a temperature rise by 2.5°, the costs in terms of health (loss of years of life) will be, on average, 3 % of GDP in Africa and 0.02% in Eastern Europe (Nordhaus and al., 2000).

In the event of a temperature rise by 4°, over 80 million people will be exposed to epidemics in Africa (Stern, 2006).

Climate change will thus have a direct impact on people's health, but which will be more or less significant according to the region and the vulnerability of persons in terms of income, in particular. Besides being a problem connected with resistance to heat, the increase in epidemics and pollution will be a consequence of the adverse impact of climate change on agriculture, the ecosystem, urbanization and energy. In addition to the significant cost in terms of lives lost, the economic cost will also result from the loss of attractiveness of these areas with regard to tourism. The interactions between the sectors will, therefore, only increase the future total cost due to the climate, for the region.

7. CONCLUSION: REDUCTION OF WATER RESOURCES AS MAJOR VECTOR OF ECONOMIC COSTS IN EACH OF THE SECTORS

7.1. Quite high costs for the Southern and Eastern Mediterranean Countries (SEMCs) ...

As a consequence of climate change, agricultural countries - and more particularly, economies specialised in the growing of large-water consuming products - will be the most affected. This is especially the case of Syria and, to a lesser extent, Morocco, Egypt and Turkey in our sample.

Also, in addition to the rise in temperatures and the depletion of water resources, the development of all the countries of our analysis, which are entering a phase of intensive industrialization of their economy, will generate a soaring demand on energy. This phenomenon is taking place at a time when the natural reserves are on the decrease and when carbon-intensive productions, which represent a majority in the zone, increasingly suffer from their bad reputation. The basic infrastructures and power production will be negatively affected. The high energy demand periods will increasingly coincide with the most constraining periods for production: the summer season, and during the extreme events of the heat wave type. Following population growth, the coastal cities will receive an additional number of people, while their vulnerability will increase due to sea level rises and extreme events.

Tourism is a major financial resource for the countries, but it will contribute in the rise of energy and water needs in coastal cities, in a first phase. Afterwards, it is likely to diminish in the following years because of temperatures that are too high, thus impoverishing the countries in foreign currency.

Lastly, the environment and the poorest populations, already made more vulnerable, will experience a worsening situation. Climate change will increase the loss of ecosystem and the proliferation of epidemics, especially in the regions further south, inducing catastrophic losses for the people, the environment and the economy in all the countries of the region and exacerbating the development and income disparities between the countries of the Northern rim and those of the Southern rim of the Mediterranean.

7.2. ... which are perhaps under-estimated and which result from a reduction in water resources

These scarcely optimistic visions about the future, following climate change, are a synthesis of recent global empirical works[22] and of research dedicated to the Mediterranean region. They often appear to be incomplete and not easily comparable. However, they all converge to affirming that the costs of climate change for the Mediterranean will be quite considerable if no measure is taken.

Yet, it seems that these studies could under-evaluate the anticipated costs insofar as they do not take into consideration the effects of the interaction between the sectors.

The following summary diagram illustrates the possible interactions between the various sectors of the economy following the impacts of climate change. One notices that the reduction in water resources in the Mediterranean is a cross-section problem, which will affect all the sectors of the economy.

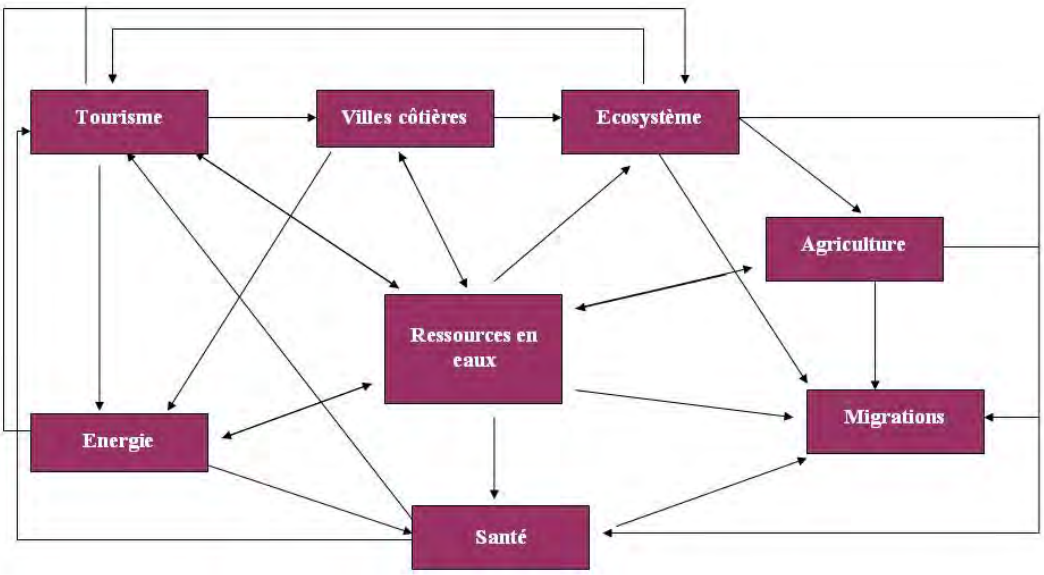
The table, which accompanies it, highlights the under-evaluation of the economic impacts when the authors consider only the direct effects on each sector of the economy without taking into consideration the interactions between these sectors. The columns give the main sectors of the economy that undergo the direct impacts of climate change. The lines give the possible repercussions of this initial shock for the other sectors of the country.

22 Cf. summary table of Appendix 2.

Table 6 - Interactions between the various market and non-market sectors of the economy following climate change in the Mediterranean

		CROSS SECTORS REPERCUSSIONS							
		Energy	Tourism	Coastal cities	Migration	Agriculture	Health	Water resources	Ecosystem
DIRECT IMPACTS	Energy					Land use (bio-fuel) Biomass	Pollution	Use of energy for water desalination	Degradation Construction of heavy infrastructure
	Tourism	Increasing energy needs		Urbanisation of seaside areas				Drying up of reserves in summer	Degradation of the environment
	Coastal zones	Increasing energy needs					Health-related problems	Depletion of water resources	High urbanisation
	Migration								
	Agriculture				Famine		Famine	High water consumption	
	Health		Decrease in attractiveness (epidemics)		Pollution and epidemics				
	Water resources	Lack of water for energy production	Decrease in attractiveness	Lack of water for city needs	Lack of resources	Decrease in production	Epidemics		More arid areas
	Ecosystem		Degradation of the environment, loss of attractiveness		Depletion of resources	Less fertile soils (Erosion)	Malnutrition		

Source : The Author



7.3. How to respond to the costs of climate change?

It is advisable to consider the results above in their relative dimension, insofar as they derive from studies that do not integrate, for the major part, the possibility of reduction of the costs of climate change based on adaptation measures. The results of these analyses may, therefore, be interpreted as being the likely costs of the "business as usual" scenario and be qualified as the "cost of non-action".

Indeed, in view of the expected impacts of climate change, and in order to limit the costs, two types of strategy may coexist: (i) prevention, by reducing GHG emissions and/or storing them in order to participate in the effort of slowing down climate change and (ii) adaptation to the reality of climate change by anticipating the impacts that the latter will inevitably exert on one's development.

Today, the Southern and Eastern Mediterranean Countries (SEMCs) are low GHG emitting countries (2 to 3% of the world total), and 70% of the Mediterranean emissions originate from the Northern rim. Accordingly, the policies of immediate GHG reduction are, in the region, the main concern of the countries of the Northern rim, which have targets under the Kyoto Protocol.

Given the huge amounts related to the probable costs of non-action in the SEMCs, such as previously identified, it seems much more strategic economically for them to systematically anticipate the environmental risks in the development patterns to come in order to minimise the costs of climate change.

However, trend projections show that, within 20 years, the SEMCs will emit as much CO2 as the countries of the Northern rim. Thus, within the framework of the adaptation policies, it is advisable to start integrating, as of now, the most 'cost effective' options.

The following part analyses the results of the economic literature on adaptation to climate change in the Mediterranean.

III. ADAPTATION TO CLIMATE CHANGE: A NECESSITY FOR MEDITERRANEAN COUNTRIES, BUT INSUFFICIENT QUANTIFICATION

Since one is interested in the response of the countries vis-à-vis climate change, one must set the scope of the analysis in a precise way. For so doing, it is important to distinguish between the two possible responses of the countries, which are: adaptation to climate change and 'mitigation' of it.

In both cases, the objective is to minimize the costs related to the climate. The difference between these two options is that the effects of adaptation are more targeted and will be felt rather rapidly. On the other hand, the more general benefits of mitigation can be identified from a hundred years onwards (Stern, 2006). They are, however, complementary in allowing, at the same time, risk management in the short term and a reduction of GHG emissions in the long term. The relative importance of either of them varies according to the situation of the countries (Stern, 2006). Broadly speaking, developed countries seem to be more concerned by pollution reduction measures than emerging countries, for which priority lies in prompt action in order to limit the catastrophic consequences of climate change in the decades to come. However, the richest countries have the means of resorting more easily than developing countries to adaptation measures (access to new technologies, institutional environment, infrastructure, specialization of the production...).

In view of the extent of the costs in the short term for the SEMCs, such as highlighted above, our focus in this chapter will be on the former option, i.e. adaptation.

1. FORMS AND ACTIONS

1.1. Theoretical forms of adaptation

"Adaptation" can take, from a theoretical point of view, various forms that may be complementary or substitutable (Frankhauser and al., 1999):

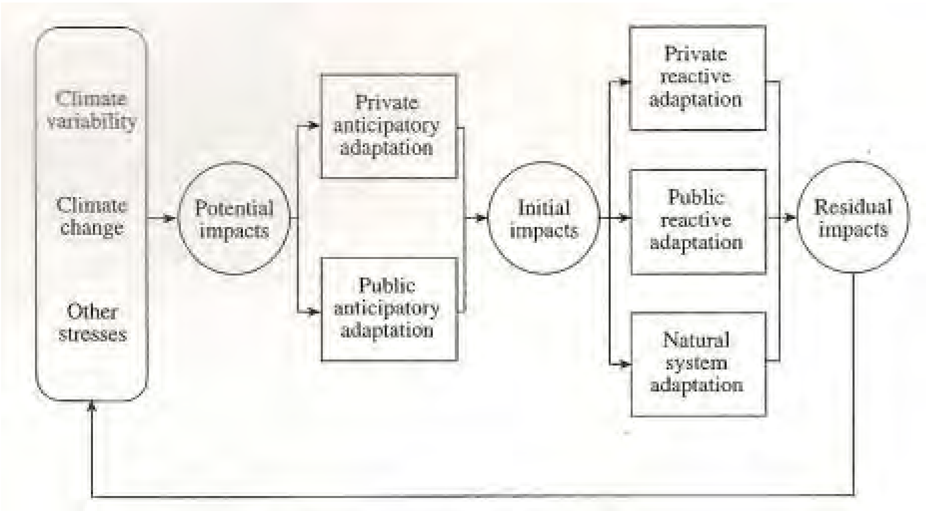
Firstly, it can be a preventive or a reactive ('corrective') solution. The former is recommended when the anticipated costs are high, putting at risk whole sectors of the economy. The latter allows a compensation of the one-off and specific impacts of a shock, following the impact. The adoption of preventive measures depends on the net balance between the cost of non-action and the cost of action. The latter varies according to the exposure of the country to the climate and, hence, the extent of the reforms necessary to be implemented. In the industrialized countries, the sectors with a massive use of energy are the most concerned. In emerging countries, agriculture is added to the latter sectors.

Secondly, it is possible that it may be self-driven or planned. Whereas the former option follows naturally the changes in the environment (of which, in particular, the evolution of the ecosystem), the latter implies an exogenous intervention by an agent. The latter is either public or private. In the former case, decisions are taken by the government (on a national or international scale); in the latter case, they are taken by individual persons or by companies.

In general, natural system adaptations are reactive, since they occur at the same time with, or immediately follow upon, the climate change. Public adaptation may be preventive (development of infrastructures) and reactive (management of extreme events). Similarly, private adaptation may obtain either via a reform of the production system and the taking of insurance, or via a prompt reaction to finance the damage (Klein, 2001).

In order to assess the efficiency of the adaptation actions implemented, the potential impacts, without any adaptation option, may be compared with the residual impacts, following the adoption of various measures leading to a reduction of the vulnerability of the countries to climate change (cf. Graph 6 below) (Klein, 2001). Looking for effective measures is a crucial point for the countries in order to optimise their action. The objective is to maximize the net benefit, i.e. the gross profit from which the adaptation cost is deducted (Stern, 2006) (cf. Graph 7 further down).

Graph 6 - Adaptation

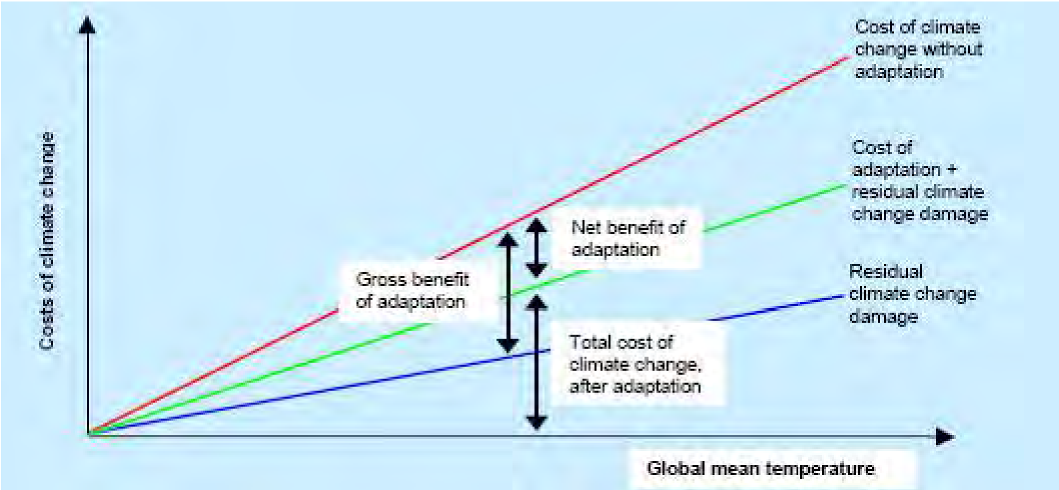


Source. Klein (2001)

In any case, the countries seek to confer flexibility on their economy so that it prevents or mitigates efficiently this exogenous variability. More concretely, certain activities - the less CO_2 emitting ones - must be given priority order, compared with others that are more polluting and more vulnerable to the climate. Similarly, the adoption of new technologies -more energy saving - must be granted priority, even though their cost is initially higher.

In fine, given the uncertainties, the countries seek to implement policies whose effects they will not regret later (‘no-regrets policies’), i.e. those which will provide net social benefits, even though climate variability is different from that which was anticipated and is not necessarily due to anthropogenic action (IPCC, 2001). For this purpose, information must be transparent; for one of the major problems encountered by decision makers (politicians, company managers) is connected with the uncertainty as to real evolution of the climate, the possible implementation of regulation policies and future behaviour of the population. The occurrence and extent of extreme events are most difficult to anticipate. This is why they require not only ex-ante preventive measures, but also ex-post corrective measures.

Graph 7 - Benefits of adaptation



Source. Stern (2006)

1.2. Adaptation actions from a concrete point of view

Adaptation covers a complex range of actions. There is no single and general policy to be implemented by the countries in order to address the problem of climate change. Countries are unequal vis-à-vis climate variability and its consequences. All depends on the country considered, the sector under threat and the period selected (Stern, 2006). According to the economies, their development level, their specialization, their natural resources and the reaction of producers and consumers, the constraints will not be the same. The effectiveness and the cost of adaptation thus depend on the countries' level of awareness as regards global warming, their responsiveness to the need to opt for preventive measures and their adaptation capacity. For certain countries, it will be necessary to completely shift part of their production, the one most vulnerable to the climate, in order to minimise future costs. This will require a long period and heavy investments. For others, all that is needed is to make some effort in matter of energy efficiency, in particular, which will imply nothing more than a change of production process, and can be done in the short term.

The studies reviewed concur that the countries of the Southern Mediterranean must adapt more promptly than other regions of the world, since they are among those which will be most rapidly affected by climate change. In most cases, it is probable that the cost of action be lower than that of non-action. The necessary reforms involve all sectors of the economy. This consists, particularly, in pursuing goals that are compatible with sustainable development. As a matter of priority, the objective would be to reduce the sensitivity of the countries' agriculture. Then, seeking energy efficiency will be an essential objective to pursue, so that the countries can maintain and extend their position on international markets. For doing so, the countries will have to diversify their economic activities, so as to be more flexible and to diversify the risks. The institutional environment must be favourable to these reforms. Besides, the modernization of their production processes will require promoting access to education, in order to train the workers. Moreover, in order to mitigate the future impacts of extreme events, it will be of paramount importance to provide for the management of such crises. An immediate action will be organized and will have to be reinforced via improving access to the health care system. Lastly, in order to mitigate the global impacts, it will be important to act as promptly as possible in order to limit the most exposed portion of the population. Yet, as we shall see, the economic studies on the Mediterranean that highlight, in a quite specified manner, the reduction of the costs of climate change (avoided damage) via the adoption of adaptation measures, are rare. Furthermore, and even though sector-based economic studies do not necessarily show it, large-scale actions will be necessary with regard to the water issue. In order to remedy this deficiency, and in view of its extreme importance for the region, elements derived from the "engineer" type approach will be included in this part. We shall focus on the sectors most vulnerable to climate change (agriculture, energy/industry, water and coastal areas). This point will form the subject of the first two sections of this chapter.

In view of the fact that the Mediterranean countries do not have sufficient resources to finance the heavy investments necessary to reduce their vulnerability to climate change, it is important to consider the alternative solutions enabling these countries to opt for preventive measures. Several possibilities are offered to them, though - in any case - looking for effectiveness in the identification of priority projects must be granted priority. This topic will be very briefly addressed in the third and last section which will put forward some of the options that may be considered.

2. SHIFTING AGRICULTURAL PRODUCTION

The adaptation of the agricultural sector is a priority for the countries, in particular for those whose relative weight of agricultural production remains significant compared to the other areas of the economy. The aspect of food security of the countries makes of agriculture a strategic sector and, as we have seen, this sector ensures the subsistence of the most vulnerable populations. It provides them both with work and food (on average, 34% of the population in the Southern Mediterranean work in this sector). Accordingly, a reduction in crops can have catastrophic impacts in terms of famine, epidemics, etc... Indeed, although 70% of the poorest population live in rural areas in the MENA (Middle East – North Africa) countries, agriculture already meets the needs of only 43% of the population concentrated in this region (World Bank, 2005). Moreover, this sector is the largest water user.

In this region, the adaptation measures selected must necessarily belong in a process of sustainable development. For this purpose, they need to be in line with the Millennium Development Goals (MDGs) and, hence, provide not only an additional benefit for the farmers (exporters, in particular), but also a reduction of poverty, famine and malnutrition, which foster serious intestinal diseases; for it is obvious that climate change will have an adverse impact which, in the absence of any action, will exacerbate the already existing problems (Downing and al., 1997).

The adaptation of this sector can take several years. It is estimated that 3 to 10 years, on average, are necessary for the farming of new land and resorting to new varieties. It is also estimated that between 50 and 100 years are necessary for heavy investments: change of infrastructures and shifting production to new crops (Reilly, 1997). Consequently, the countries must respond as of now according to the forecasts of the future climate. In this regard, various options are offered to them. They are at the same time general and targeted according to the regions and the crops, and they vary according to the period selected.

In the short and medium term, the countries' possibilities of adaptation require a shift of certain crops and a change of the production processes in order to cope with climate variability and meet the increasing needs of the population. It is worth pointing out that the Ricardian method can introduce this factor (Mendelson and al., 2000; Kurukulasuriya and al., 2003). The latter takes into consideration the fact that the farmers seek to maximize their profits - and, hence, their yield - and, for this purpose, use alternative methods or substitute certain crops for others. To evaluate the cost of the action, the approach is to compare several balances of the economy before and after adaptation by the farmers to the climate variability (Kurukulasuriya and al., 2003)[23]. More generally, adaptation is one of the components of the integrated assessment models (IAM), but which do not normally distinguish between the costs and benefits assigned to it (Stern, 2006).

Yet, these individual initiatives are not sufficient, on the whole, and need to be accompanied by policies of a more drastic readjustment. In the long term, the task would be to consider a significant reduction of the share granted to the agricultural sector in favour of other economic activities.

2.1. In the short and medium term

As regards the countries' response in the short term, it must be focused on the key issue, which is the reduction of the water resources, an aspect that is more or less marked according to the regions. To evaluate the actions to be granted priority, the task would be, first of all, to differentiate the impacts according to the areas and to land quality. The adverse impacts on irrigated crops will be felt only in the longer term as compared with the negative impacts on the more arid land and on the cattle (Kurukulasuriya and al., 2003). This is why it is possible to promote their yield in the years to come to compensate for the losses in the other crop types. This gain in productivity requires, as a prerequisite, investments to facilitate irrigation, tools and varieties of seeds, which will be more resistant to the future climate conditions (i.e., whose water needs are lower and whose vulnerability to temperature rises is little).

Moreover, the crop calendar will have to be drawn up according to the future seasonal variability in order to optimise the growth of the crops and to reduce the losses. In addition, all crops will be selected according to soil features: irrigated crops will be abandoned in areas becoming more arid and will be developed in the wetter areas. Besides, high-water consuming crops will have to be limited (Rousset and al., 2003).

The farmers will not be able to launch in such reforms of their own initiative only. Their reactions are likely to be insufficient, and too belated. In addition, their means are too inadequate to assume such investments. Consequently, the role of the public sector is crucial both in disseminating the information and directing the measures to be taken so that they are the most efficient possible, as well as in bearing the most significant costs in terms of infrastructures (Challinor and al., 2007). The first step would be to build awareness among farmers to the problem of climate change, then to persuade them of the effectiveness of these measures and financially assist them to acquire the necessary capital ... This requires, first, building the country's capacity in terms of scientific research, both in the meteorological and the agronomic fields. It is fundamental that the country should be able to anticipate climate variability and the reaction of the crops - while considering a margin of error related to uncertainty - to choose, among the options offered to it, whichever is needed to adapt the agricultural production. An investment at this stage should not thus be neglected. Lastly, the management of extreme events must be ensured, for the major part, the public sector whose objective would be, in the first place, to minimise the share of the economy and of the population vulnerable to this type of events and, thereafter, to mitigate the financial damage and the impacts on people's health based on an immediate and effective action.

[23] One must be cautious when interpreting the results, as this modelling does not allow, though, a consideration of the costs of transition from one situation to another (Kurukulasuriya *and al.*, 2003).

2.2. Adaptation of the agricultural sector directly related to the problem of rarefaction of water resources

Apart from the actions focused exclusively on the agricultural sector, other solutions must be adopted in order to meet the crop water needs (Rousset et al, 2003, Plan Bleu, 2007b). The major difficulty they give rise to, however, is - besides the implementation costs, which may be rapidly amortised - the time it takes these measures to become operational, while the needs are already felt and will increase significantly in the years to come. The options may be classified as follows:

- In the medium term, one option may be to develop the water desalination techniques. One should bear in mind, however, that this involves not only a significant fixed cost during the construction of the plants - knowing that this cost will be increased by the installation of infrastructures for water conveyance to the land -, but also a variable cost, which is not negligible, due to intensive energy use. This solution must then be coupled with investments in energy production (construction of nuclear thermal power plants, for example). El-Fadel and al. (2001) estimate this cost at 1.5 US dollars/m 3/day.
- - Another option requires the construction of barrages for water collection, and thus supplying the crops throughout the year, even when rainfall becomes less frequent and in drought period. However, in the Mediterranean, potential sites are very few and one of the disadvantages of temperature rises is increased evaporation.
- In the very short term, priority should be granted to an optimal management of water resources and demand. The objective is that all sectors of the economy become aware of this problem and that each one seeks to limit and control its consumption. For this purpose, it may be envisioned to have a fixed rate in order to elicit such behaviour.
- It may also be envisioned to promote the re-use of wastewater, which will be then treated then redistributed in the agricultural and industrial sectors. However, the fixed costs incurred by this type of option remain very high. Water savings would be quite significant, though. They would amount, respectively, to 0.9 and 0.5 billion cubic metres per year for Algeria and Morocco, for instance (Rousset and al., 2003).[24] On global level, these costs are estimated as in the range of 3600 to 5700 US dollars on average, per hectare, in Sub-Saharan Africa, and vary according to the regions (Kurukulasuriya and al., 2003).

The implementation of adaptation measures to address the problems of rarefaction of water resources is all the more founded as it benefits all sectors of the economy.

2.3. A change of specialisation of the countries over the long term?

Over the long term, the costs of adaptation will be steadily on the increase with the impoverishment of the region in water and the frequency of extreme events (drought periods). The efficiency of the action adopted initially may then be revised in favour of another type of measures: gradual abandonment of agriculture and a shifting of production and workers to sectors that are less vulnerable to climate change and for which the country's comparative advantage is dominant. It would then be more interesting for the countries to buy abroad those agricultural goods which would cost less than if they were produced. This strategy is all the more sound as agriculture is the highest water-consuming sector (70% of the total consumption), that, over the long term, this situation is likely to penalize the more productive activity sectors, and - above all - that it would

[24] These points are developed in more detail in the third part of this report in the section on adaptation of the "water-energy" system.

cause a depletion of the reserves intended for the needs of the population. The strong pressure on the water resources could then be alleviated by importation of water-rich agricultural produce by the economies of the Southern Mediterranean, which would also help ensure the food security of these countries. Therein lies the principle of "virtual water" (Allan, 1993) exchange on international scale: the most water-consuming crops being produced and exported by the countries with the highest rainfall ("green water") and/or the largest quantity of groundwater ("blue water") (Fernandez, 2007).

This evolution can follow naturally the process of climate change (Julia, 2005). Indeed, the production costs of agricultural products will increase in certain countries and will decrease in others due to more or less favourable conditions related to climate variability. The productivity of the agricultural sector will decrease in the South and increase in the North. On international markets, demand will automatically turn to the less expensive goods. The distribution of countries according to their relative advantages over the international scene will then gradually change via international trade. This will make it possible to meet the total demand in terms of primary goods. However, it is not impossible that the prices of agricultural goods will increase, in particular grain and cattle prices, for expenditure in agricultural production will be higher with respect to people's incomes in this sector (Julia, 2005). But this rise could slacken and be reversed following adjustment to the climate by the countries concerned (Darwin and al., 1995).

Yet, the transition of the economy need not be of the exclusive doing of individual persons. It must be necessarily accompanied by public organizations so that it would be as efficient as possible and to prevent that the most vulnerable populations should end up in catastrophic situations. By reducing their agricultural production, the countries of the region can extend their dependence vis-à-vis the rest of the world. To guard against such a situation, the country must specialize in the production of the goods that ensure it the best position on the international scene. In order to be attractive and help gain market share, the goods proposed need to be among the best and the least expensive.

The institutional environment must, therefore, sustain this transition by facilitating administrative procedures in particular. Besides, financial opening up will allow an inflow of foreign currency and foreign direct investments (FDIs). Provided that risk-taking by individuals is properly coached, the inflow of financial resources will be a decisive factor of economic growth. They will enrich the banks and allow the development of credit. This, in turn, will sustain investments by private developers and companies. Moreover, the establishment of new foreign companies will be beneficial to the countries insofar as they will bring in new technological knowledge and will create employment.

But this transition requires a reallocation of workers from one sector of the economy to another, which gives rise to several problems. In the first place, this implies that agricultural areas are deserted in favour of already over-populated cities, which would not be a solution to be envisaged. Industrial development must, therefore, extend throughout the country and not remain concentrated around coastal cities. In addition, with regard to less skilled labour, re-conversion of farmers does not pose any major problems. On the other hand, the industrialization of the economy will induce a recourse to increasingly advanced technologies. Accordingly, job offers on the part of companies will concern the most skilled workers. So that the transition of the economy can be effective, it will be necessary to promote access to education and training for an increasing number of people.

2.4. Adaptation in studies on the economic impact of climate change on agriculture

The analyses, which introduce the countries' possibilities of adaptation, compare, in general, the results in case of adoption of these measures and in case of non-action. Certain studies consider several degrees of adaptation (Rosenzweig and al.,1995; Tol, 2002b). The same assumptions are often found in the studies. This consists in assuming that the farmers modify their planting dates, their water charges, the variety of their crops, and mix their production according to the prices of the goods, which involves investments but also additional profit (Darwin and al., 1995; Rosenzweig and al.,1995; Mendelson and al., 2000; Fisher and al., 2002; Tol, 2002b). The possibility of a reorganization of the economy is not considered within the framework of the global studies of the economic impact of climate change, particular since the time frames are too short to envision such adjustments.

It emerges from the results of these analyses that adaptation has a fairly beneficial effect on production, particularly in developed countries. According to the most precise study on this aspect, it helps mitigate the drop in world grain production from -7,6% to -0,5%, and -11% to -10% on average in developing countries (Rosenzweig and al., 1995).

The capacity of adaptation of the industrial sector is much more complex to introduce within the framework of an analysis of the impacts of climate change, as this sector is quite large and covers various types of production.

3. ADAPTATION OF THE INDUSTRIAL AND ENERGY SECTORS

Unlike in the agricultural sector, where the implementation of adaptation policies is necessary for the survival of the populations, in the industrial sector, it is rather related to the pursuit of profit by companies. One needs to consider this aspect at an international scale to appreciate the motivations of people to use cleaner energies, for environmental and financial performances will be increasingly interdependent. Companies will be prompted to act if the profit to be generated by action comes to compensate its cost. To evaluate their future advantages, it is necessary that they consider this aspect from a long term perspective.

The issue of reduction of emissions and of adaptation of the energy sector in the Mediterranean is addressed in detail in parts 2 and 3 of the study. This section offers an overview of the conclusions of some economic studies on the topic.

3.1. Economic and climate factors influencing decision-making

The Kyoto Protocol requires, as has already been seen, the companies of the Northern countries to opt for production processes that emit little GHG in the atmosphere. These measures do not affect directly the countries of the South. Indeed, the Mediterranean countries contribute only in a quite marginal way in climate variability. Kuik and al. (2006) evaluate the responsibility of the North African countries in terms of marginal cost of the damage in US dollars per ton of carbon as 0.16 in 2005 and 0.13 in 2055, while for the United States, this figure is 2.26 and 1.80 for the same years. However, the Mediterranean region will, all the same, be indirectly concerned by this problem, which will result in a shift in demand in favour of less carbon intensive goods. It is, therefore, necessary that the companies of the Mediterranean countries which produce and use energy gather awareness, as of now, about this phenomenon and adopt alternative options, so that they do not find themselves, in the longer term, lagging behind international competition. Therefore, to be really effective, the adaptation measures must be accompanied by mitigation elements. Companies may find it beneficial to integrate in their investment decisions the will to reduce not only their exposure to the climate, but also - and above all - the future rise in the price of carbon intensive energies, as well as look for technological efficiency in order to reduce their GHG emissions (Stern, 2006). This factor is all the more important in countries experiencing a loss of comparative advantages in the agricultural field, and which will subsequently readjust their production.

The reorganization of the countries' productive system must be done according to strategic considerations in view of the countries' anticipated situation. It is, therefore, important that the countries should opt, as of now, for cleaner production systems, on either small or large scale, in order to address the increasing energy demand (cf. part 2 of this report). Preventive adaptation will, thus, help avoid future additional costs related to a restructuring of less efficient companies in terms of energy saving. The companies which will have an appreciable advantage in the various production sectors will be those which have taken this phenomenon into consideration the earlier possible and which will readjust the more promptly their production process (Mansley and al., 2001; ISVA, 2002; Llewellyn, 2007).

Besides, it is necessary that the companies should consider the new risks, related to the climate, in their decision-making. In most cases, these translate into heavier production costs.

With regard to fossil energies, the approach would be to anticipate the difficulties likely to arise during energy extraction and transport, especially in the case of extreme events.

The problems experienced by certain areas close to the sea will have to be one of the major elements likely to enlighten the choice of location of certain industries.

As regards renewable energies, their use is only founded when their amortization allows for recovering the initial investment. However, their efficiency is, for the major part, dependent on the climate to come.

3.2. Possible orientations

In view of these factors, several adaptation alternatives exist according to industrial activities. They generally consist in looking for energy efficiency and gradual recourse to renewable energies.[25]

Considering the wastage of energy resources in Mediterranean countries, the first solution - a less costly one - must be granted priority order in these countries. It is estimated that energy saving in the Southern Mediterranean countries of about 50% of the total demand would be possible by 2025 (Plan Bleu, 2005). It will thus allow an increase in the overall productivity of companies. It requires, in particular, a diversification of the offer in order to mitigate the negative impacts on companies of a rise in the prices of certain energies or of a depletion of the resources. Moreover, it implies an improvement of distribution, which requires especially a better performance of the networks. It does not necessarily require heavy investments in infrastructures (Llewellyn, 2007). Accordingly, it is an option that can be adopted promptly. It involves all sectors of the economy, though the building construction is particularly concerned (renovation of buildings with recourse to a proper insulation, more ventilation, better orientation of new buildings, use of new building materials capable of withstanding extreme events...).

[25] This aspect will be detailed in the third part of this report.

The principal characteristic of these countries is that most of them hold considerable fossil energy resources, but whose combustion is highly polluting. Before resorting to new energies, the challenge is to make use of the solutions that would allow them to use these resources that they have, according to a clean production process.

An option already adopted by certain Northern countries is to reduce the carbon intensity of the use of these energies by encouraging CO2 capture and storage systems. This option is under study in the Southern Mediterranean.[26] However, it seems that this alternative is effective only to a certain extent, and this, for several reasons. First of all, it does not actually meet the objectives of reduction of emissions and implies significant fixed costs (in terms of infrastructures) and variable costs (energy use). Moreover, the environmental impacts must be analysed in greater detail. In addition, it must be justified by external (public) actions in the Mediterranean countries, which are not concerned yet by the regulation policies. Lastly, there is no general agreement as to whether it will lead, in the long term, to limiting the variation of the price of fossil energies for which demand will necessarily decrease. Rather than oil, the countries should, as a first step, give priority order to the use of natural gas.

Another alternative currently under consideration by Mediterranean countries is the recourse to nuclear energy - which is CO2-emission free - to respond to the region's increasing needs. The concern attendant upon this type of solution is related to increasing dependence of the countries vis-à-vis the rest of the world. This situation could be avoided if the countries were to opt for a cooperation between the European and North African countries (4th EUROMED Energy Forum for 2003-2006). This should help facilitate investments in infrastructures via common interest projects, as well as energy exchanges between the two regions. Nevertheless, many drawbacks and risks related to nuclear energy must be taken into consideration.

Moreover, a strengthening of relations between the European Union and the Mediterranean region, within the framework of a cooperation on reforms of the energy sector - as a support for the development of effective energy policies, as well as for the promotion of renewable energies -, would allow the Southern Mediterranean countries to achieve significant gains in terms of energy saving (Marquina, 2004).

The advantages for the Northern countries will rather belong in the framework of the Kyoto Protocol. Indeed, by supporting the "Clean Development Mechanisms" in countries not belonging under Appendix 1, they will benefit from new emissions credits.

The adoption of new technologies belongs in this course of action. It would, therefore, be advisable to replace the obsolete production systems by new processes, which - though requiring heavy investment in an initial phase - are soon amortized thanks to the energy saving obtained over the long term. Besides, in order to prevent that the outputs of the infrastructures in place should decrease and that their vulnerability should increase, considerable rehabilitation actions must be considered as regards the existing installations and the integration of appropriate technologies for the new constructions, while taking into account the considerably long useful life of the majority of the investments in this field (40 years for a gas power plant, 60 years for a nuclear thermal power plant). There will arise, however, the difficulty of the massive financing necessary and the non-market costs related to the environmental impact of the installation of such facilities.

With regard to renewable energies, Mediterranean countries have an advantage with respect to other countries; this is due, in particular, to their exposure to sunshine and to wind. They will have to necessarily benefit themselves of this asset. On national level, it will be useful to gradually substitute the use of certain polluting and increasingly expensive conventional energies with renewable energies (hydraulics, solar energy, wind mills...), all the more so as their capital cost in the necessary

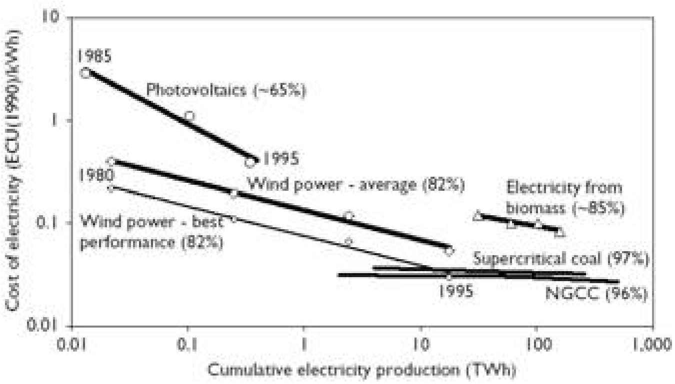
[26] Analysed in more detail Part II

equipment is generally lower than the renewal of the infrastructures for conventional energies. Of the success stories in this field, one may mention the adoption of solar water heaters in Tunisia.

On a more global level, the development of these new energies is likely to generate new opportunities for the countries in terms of uses and market share. Indeed, the countries which will make more rapid progress in this regard will have a comparative advantage on the international scene and will be able to export their energy and their processes in the other countries of the world which seek to diversify their resources in order to reduce their dependence on oil (Mansley and al., 2001; ISVA, 2002; Stern, 2006; Llewellyn, 2007).

The problem lies in the cost up-stream of the adoption of such energies. This field is labour-intensive, which will - to a certain extent - contribute in reducing unemployment, but which requires significant efforts in matter of education and training. Besides, it will be necessary for the country to develop its scientific research in order to make best use of these processes, as well as develop familiarity with second-generation renewable energies. These activities could be organized in coordination with European countries. It is, however, necessary to bear in mind that, even though the initial investment is huge, these costs will be quickly amortized according to the scale and experience of the countries (Stern, 2006). The table below, derived from the IEA report (2000) and taken up by Stern (2006), gives a clear illustration of this phenomenon as regards several new energies.

Graph 8 - Evolution of the costs of renewable energies



Source. IEA (2000), Stern (2006)

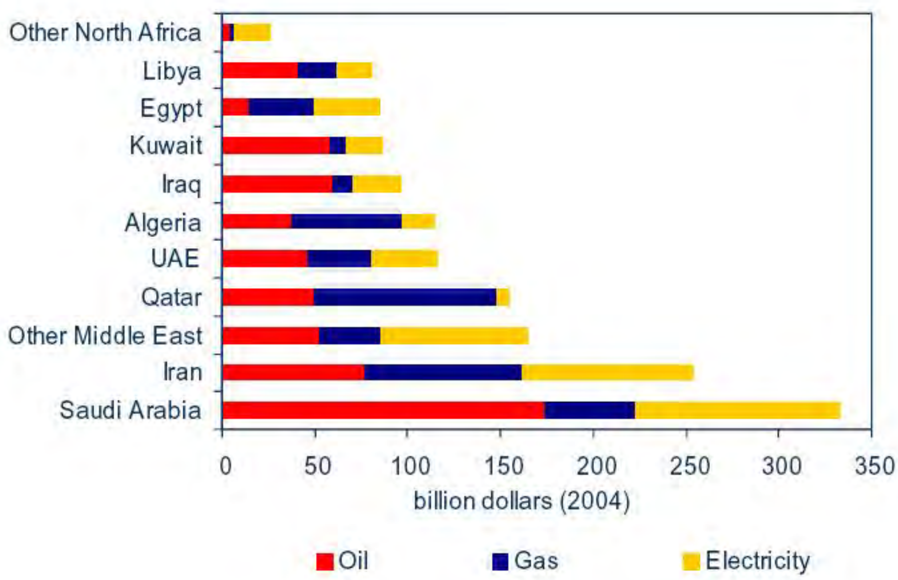
To encourage the use of this type of energy, it is necessary, on the one hand, to build awareness among the population about these new resources and, on the other hand, to set up financial incentives.

Although the key decisions belong to the private sector, the public sector does play, there again, a significant role (Stern, 2006). It must offer an economic, financial and institutional environment that is congenial for new investments by individual persons, while directing their decisions thanks to transparency of information, in such a way as to enhance their effectiveness. Besides, it must adapt to corporate needs by offering services that meet them. This is why it must take responsibility in setting up an education system that is accessible to all and which helps to enhance the qualifications of the labour force. Moreover, it must encourage the introduction and development of new technologies, which can be substituted for certain large energy-consuming processes. In this regard, it is necessary to open up the countries' financial markets, of which - in particular - introducing flexibility in the legislation concerning the conditions of repatriation of company profits, in order to make the economy more attractive with regard to foreign direct investments (FDIs).

3.3. Evaluation of costs in the energy and industry sectors

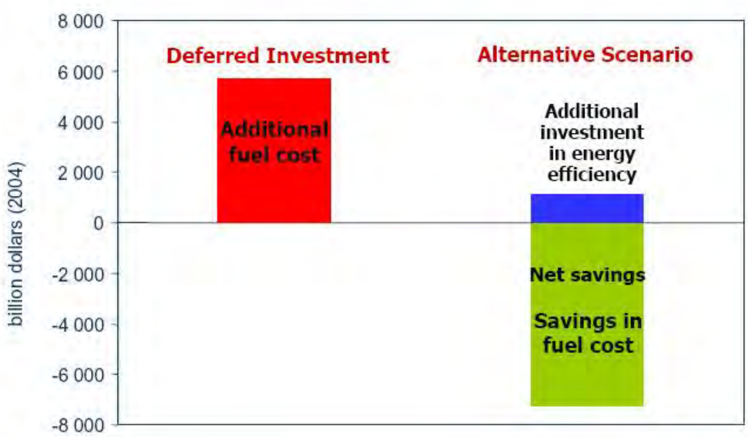
The necessary investments to adapt, in the short term, the energy supply to the increasing demand in the MENA region require an increase in production capacity and a renovation of obsolete structures. In the three major energy sectors (oil, gas and electricity), these costs will range from 30 billion US dollars to more than 150 billion US dollars according to the countries of the region by 2030 (Graph 9). However, these figures do not include the costs related to seeking energy efficiency and the use of - less polluting - renewable energies, as they do not consider the mitigation measures that the countries will be obliged to adopt. In the latter case, the investments required would be much lower and the endeavour to seek energy efficiency would allow the countries a significant saving (Graph 10).

Graph 9 - Required energy saving in the MENA countries by 2030



Source. AIE (2005)

Graph 10 - Costs and benefits related to looking for energy efficiency by 2030



Source. AIE (2005)

The economic literature dedicated to a study of the costs of climate change with the adoption of preventive measures in the energy field remains rather lacking in precision. Rare are those that measure the costs of implementation of adaptation options in the industrial and energy sectors. This is due to the fact that the investments required vary according to the activity sectors, the technologies available in the country, the exposure of the country to the climate, flexibility of the labour force, etc ... They tend to focus, in general, on evaluating the costs of the mitigation policies. This is the outcome of several factors. First of all, unlike the agricultural sector, the energy sector is as much concerned by adaptation as by mitigation in order to be able to offer solutions in the short term while mitigating the adverse impacts of pollution in the long run. In addition, the interest dedicated to the effectiveness of various possible measures has been fostered over the past few years by the Kyoto Protocol, and this, in view of the will of the countries to choose the least costly solutions. Lastly, from a methodological point of view, it is relatively simple to estimate costs based on the evolution of the price of energy resources, both conventional and new, according to several scenarios. Moreover, it is possible, by using an analysis of the social cost of the emission of an additional ton of carbon in the atmosphere (Tol, 2005, 2007), to evaluate the price of this additional ton and to compare this result with the marginal cost of the reduction of this emission, according to various processes.

Within the framework of mitigation, the costs are related mainly to the adoption of new, more efficient and less emitting technologies and which are passed on to the price borne by the consumers within the framework of the readjustment of their energy supply, knowing that the new resources still remain more expensive than conventional ones. On the whole, the costs generated by maintaining emissions on a level lower than 550 ppm by 2050 based on the substitution of low carbon energies for fossil energies are estimated as 1% of GDP on average (Stern, 2006). The larger portion of the costs will be borne by the most polluting countries.

The most detailed studies, focused on energy in particular, introduce - as an additional factor - the behaviour of producers and consumers (Barker and al., 2006, for instance). The results are highly dependent on the underlying assumptions of the model concerning the country's current emission, the evolution of energy prices, the consumers' and producers' substitution elasticity ... The recourse to a cleaner production process thus generates costs which vary between a 2% GDP gain per year as from 2050 in countries where the conditions are most favourable and for which climate-related policies are new opportunities for growth, and a 4% GDP cost in countries which experience the largest problems (Stern, 2006). They remain generally lower than the costs of non-action. In all cases, the costs of implementation of preventive policies are marginal, in view of the countries' anticipated growth.

3.4. Protection of coastal areas

One solution to mitigate the impacts of sea level and climate variability would be to implement an efficient protection of the coasts. The amount of the direct investments required for the protection of the coasts with regard to 1 metre rise in sea level is estimated as 92 billion US dollars for Africa and 5 billion US dollars for the Middle East (Tol, 2002b). The substantial amount of this cost is due to the fact that a major part of the economic activity is concentrated in this area in Mediterranean countries.

These investments remain significant, in particular for emerging countries. The actions in terms of adaptation in Mediterranean countries are, therefore, strongly connected with the financing opportunities offered to them. Accordingly, several solutions must be envisaged to help these countries to bear the costs of adaptation and mitigation necessary for the growth and development of their economy.

4. TOTAL COSTS AND FINANCING: WHO WILL PAY ?

So that the Southern Mediterranean countries manage to mitigate their vulnerability while resorting to solutions that are sustainable over the long term, various financing options - being, for the major part, complementary - may be adopted. They require, on the one hand, a participation of the private and public sectors on the national level and, on the other hand, aid by international institutions, in particular.

It is obvious that the Southern Mediterranean countries do not have sufficient financial resources to adapt their economy to climate change when one considers the preliminary estimates of the cost of action. However, the lack of quantitative and precise information on the needs of the countries and of the various sectors represents an impediment to effecting the funding.

4.1. A coordinated action?

In order for the action to be efficient, the choice of the programs to be adopted must be necessarily conducted within the framework of a coordination between the private and public sectors for each economic activity (Kurukulasuriya and al., 2003, Mendelson and al., 2006). This choice, sustained by international institutions, should promote, and assist in, the implementation of national strategies. Its intervention can take various forms.

Within the framework of the management of public goods, action must be conducted -with the assistance of international institutions – for the protection of natural resources, coasts, and populations. This requires, on the one hand, establishing clear regulations to manage urbanization and constructions and, on the other hand, facilitating access to health care by the most needy. In addition, and as has been shown, this should involve offering education and training accessible to all so that companies could enlist more skilled labour. Lastly, this must take in charge the development of scientific research in order to anticipate the future impacts of climate change and propose relevant policies.

As regards the orientation of the market sectors, its role would be to assess the real needs of the economy, manage demand, relay information, lay down rules to best coach investments and ensure that environmental standards are complied with. Thus, there would be a mixed approach, according to each sector, coupled with expertise for specific problems. It would ensure in addition, via assistance by international institutions, the heavy investments in infrastructures necessary for each activity. Besides, it would play a key role in financing the damage caused by extreme events, by extending assistance, in particular, to the poorest populations. The stability and efficiency of the programmes being assured, this should generate attractiveness of private investors (Bode, 2005; Winkler and al., 2005).

This strategy is defended by the World Bank, especially in the agricultural field, where this organization requires further decentralization. It must take into account the local interests of the people and their own strategies, as there can be a different adaptation alternative for each agricultural area according to its characteristics (Kurukulasuriya and al., 2003). The public sector not only must take responsibility over the management of water resources (price setting, development of infrastructures...) but also contribute to the integration of certain landlocked regions by developing access to energy, for instance. As an additional contribution, the private sector will have to invest enough effort in enhancing agricultural production, marketing of the products, extension of technologies and modernization of production patterns (World Bank, 2005).

But the extension of the private sector on national level requires a development, upstream, of financial services to both individuals and companies. The banking sector will have a dominant role in the years to come. By offering opportunities of funding via credits, it will encourage private initiative. A prerequisite, in this regard, is that risk taking should be coached in order to minimise excessive behaviours responsible for large-scale financial crises jeopardising the stability of the economy as a whole. These guarantees will also help the banking and financial sectors attract a sufficient amount of international liquidities to meet the increasing needs of the economy. Moreover, if projects that are compliant with environmental standards are promoted, this will encourage people to seek to achieve energy saving. At the same time, this will help meet the Millennium Development Goals (MDGs) since, by offering financial resources for each goal, it will be one of the vectors of reduction of inequalities (Daymon and al., 2007).

As regards the financial sector of these countries, a more marked and better-coached opening up would enable them to participate in international exchanges of pollution rights. Thus, they could benefit from additional liquidities. Moreover, this factor would foster a greater diversification of the investors' portfolio, allowing efficient allocation of resources, by granting preference to the least polluting companies (ISVA, 2002). This, however, will require a multiplication of financial intermediaries facilitating links with industrialized countries and international institutions (Stern, 2006).

Alongside with this, it is necessary to ensure development of private insurance companies for both individual persons and firms in order to cover the one-off and significant costs due to extreme events. In certain cases, cooperation with the public sector will be necessary and will offer individuals a greater room for manoeuvre (UNEP-FI, 2006)

4.2. Role of international institutions

International institutions seem to be the best placed to manage on global level the funds allowing the poorest countries to adapt, with a view to mitigating the impact of climate change.

One option requires the adoption of a compensation system after GEF (Global Environment Facility) model which implements the objectives of the UNFCCC[27] (United Nations Framework Convention on Climate Change), with support by the World Bank and UNEP. The objective is to help finance programmes based on energy efficiency and renewable energies in developing countries. This initiative was consolidated by the Marrakech agreements (2001), which set up three funds of assistance to adaptation by the countries: a fund dedicated to climate change, a fund for least developed countries, and an adaptation fund. However, the investments must be likely to generate future global benefits to be adopted.

A second proposal put forward in the economic literature would be to create a climate insurance fund for the countries most exposed and largely affected by climate change and extreme events due to CO_2 emissions. But such a mechanism would be very difficult to set up because it would imply that the compensations depend on responsibility over carbon emissions, which is impossible to identify. Besides, there is a risk of "moral hazard" (in the same way as arose on the eve of the exchange crises in emerging countries (Hellman *and al.*, 2000)). Indeed, cashing on compensations on behalf of international bodies to finance the impacts of the climate on their economy, the countries would be little moved to adopt measures allowing a reduction, upstream, of their vulnerability.

[27] http://unfcc.int/cooperation_and_support/financial_mechanism/items/4053.php

One alternative would be to consider the setting up of an international insurance fund dedicated exclusively to financing the catastrophic impacts of extreme events in developing countries (Linnerooth-Bayer *and al.*, 2006). Its role would be to sustain the action of private and public sectors at the time of exogenous large-scale shocks due to the climate. It would constitute an option to protect the poorest populations, as its access would be extended to the whole society. To be really efficient, it would be accompanied by prevention measures. The funds could come from donor countries, which would be the world's richest economies.

Finally, a last resort would consist in setting up development aid programmes for the poorest countries, directed and managed by the World Bank. They would help meet the Millennium Development Goals (MDGs). Alongside with this, the task would be to reduce inequalities in order to limit the exposure of the most sensitive populations and to boost economic growth, but within the framework of regulations that allow improving their energy efficiency and protecting the environment. Thus, the Southern countries would reduce their vulnerability to climate change. The funds would be provided by the countries, which contribute most to carbon emissions.

5. CONCLUSION

The few elements of economic character identified above concur to the conclusion that if the Southern Mediterranean region gathers awareness, as of now, about the future difficulties due to climate change and that it seeks to mitigate their impacts, the costs related to future temperature and rainfall variability can be largely reduced.

Indeed, priority order must be granted to efficient management of water resources. As a first step, this implies the adoption of the necessary reforms in the agricultural sector, with a view to reducing water consumption. The measures taken, aimed at reducing the vulnerability of agricultural areas, will depend on the features of each area. There may be a need to shift from certain crops to others - that are more resistant and better adapted to the climate -, or to abandon agricultural production in the more exposed areas in favour of the secondary sector. On a more general level, the country must focus on dissemination of information, management of water demand and provision of the infrastructures necessary to sustain private initiative. In this sector, priority order will be granted to adaptation, for the adverse impacts will be rapidly felt.

In the energy sector, several synergies exist between mitigation and adaptation actions. Water and energy saving and efforts in matter of energy efficiency will, at the same time, help mitigate the country's sensitivity to the climate - while meeting increasing energy demand - and reduce, over the longer term, its GHG emissions. This requirement is further accentuated by the current trend, on international level, to favour low-carbon goods and services. The cost of the action in this sector is quite high because it is dependent on investments in infrastructures, the adoption of new technologies, training of people, and research and development. However, the use of new, low-carbon energy resources may be doubly advantageous for the country. First of all, it would enable it to achieve a significant energy saving. Besides, the region having assets to exploit this type of resources, if it acts promptly and in coordination with European countries, it will present a considerable comparative advantage in this sector compared to the rest of the world.

The most arduous difficulties to address are related to extreme events. They are not easily predictable and the costs that they generate are quite heavy. This is why, it is important to scale up international aid to compensate the damage due to these catastrophes in developing countries.

Besides, adaptation and mitigation policies must be selected with the help of a precise study in order to efficiently respond to the needs of the countries. To achieve this objective, it is required to combine national and local approaches with an improvement of governance (transparency in decision-making, civil society action...). The stability of the economic environment will thus encourage private sector participation. Indeed, coordination between the decisions taken by the public sector, international institutions and the private sector will help address in the best way possible the problems generated by climate change. In the Southern Mediterranean countries, it is Northern Europe that will have the major role to play.

IV. GENERAL CONCLUSION

The results of the whole set of studies considered conclude that the economic impacts of climate change on the countries of the Southern Mediterranean will be considerable if no measure is taken to reduce their vulnerability to these variations.

Although only very few comprehensive studies focus on this region, there emerges from the global analyses a very significant cost for the countries in the decades to come. The latter is all the higher as there are many interactions between the various sectors of the economy of these countries. The results are largely fraught with uncertainty as to the future evolution of the climate and the economies; therefore, they should be quoted for the sake of information only. Besides, they are quite dependent on the underlying assumptions of the model. Thus, the most objective studies are those which rest on several climate scenarios which evaluate at the same time the impacts of the climate and of extreme events on the market and the non-market sectors from a dynamic point of view, which compare various weighting processes and which set the discount rate at intermediate levels.

With climate variability likely to accelerate, the countries of the Mediterranean region with already high temperatures and difficulties in terms of water resources will see their problems further accelerated. Even though global warming may be beneficial to the countries that have not yet reached the temperature allowing an optimisation of their production, the Mediterranean countries have, for the most part, already exceeded this threshold and have experienced a reduction in their benefits and an increase in their costs. Accordingly, the studies emphasise that adaptation efforts must, therefore, be stepped up and that - in order for them to prove really efficient over the long term - need to be accompanied by mitigation policies. An association between the private and public sectors, as well as international institutions, is recommended by most of the authors in order not only to ensure the development of a stable economic environment and an effective orientation of policies, but also to offer some form of insurance in the case of large-scale extreme events.

The countries most concerned by these problems are those whose production is specialized in agriculture, a sector highly exposed to the climate (particularly Syria, but also Morocco, Egypt and Turkey). It is particularly the most arid zones that will report the most rapid decrease in productivity. Thus, it is important to implement preventive measures aimed at reducing the vulnerability of agricultural countries to climate variability. The options to be adopted vary according to the local features of the land; but, in certain cases, a shift to more resistant crops is not sufficient. Accordingly, the countries may find it beneficial to favour a development of their secondary and tertiary sectors before demand on agricultural products shifts to other countries benefiting from better climate conditions. The farmers alone cannot address this problem in full. Although they have a significant capacity for adaptation, the latter response follows upon climate variability and does not anticipate it. Besides, it implies very high costs, in irrigation infrastructures in particular, which cannot be borne by the private sector alone.

Finally, in order to help decision makers adjust production efficiently, a more comprehensive and precise information is deemed, by several studies, as of dominant importance. The role of the public sector is, therefore, a key role. Besides providing a stable structure for decision-making, it has to manage extreme events and ensure that rural areas get access to energy, water and education. Additionally, the private sector is called upon to invest in strategic sectors. However, to finance this adaptation process, international institutions must extend their support by obtaining compensation on the part of the most polluting countries, for instance.

Regarding the industrial and energy sectors, two problems are worthy of consideration. On the one hand, the countries will experience, in the years to come, an increasing energy demand induced not only by the climate but also by the growth of industrial production and of the population, as well as rise in people's standard of living. But this increase will be accompanied by a shift of international demand from carbon-intensive products. This is why the countries must accompany the measures of adaptation of their sectors by longer-term considerations focused on energy efficiency. Although relatively few analyses on the cost of adaptation are available, the anticipated costs seem considerable. But, as long as the countries focus on promising industrial strategies (renewable energies equipments, for instance), they can derive benefit from a comparative advantage on the international scene. In order to maximize the efficiency of the new energy producing or consuming industries, several considerations must be adopted. The authors recommend that the public sector should encourage the private sector to optimise its installations in line with the direct constraints of the climate and of extreme events, as well as with the indirect influence of regulation policies in the other countries as to the price of energy resources. Moreover, it must promote investments by developing the banking sector and by improving the institutional framework. Furthermore, by offering appropriate training to the labour force, it is likely to efficiently meet its needs. In this sector, too, the role of international institutions and of Euro-Mediterranean cooperation is dominant to mainstreaming new technologies, financing and orientating priority projects.

Considering the other sectors of the economy: a main preventive action would target coastal zones to limit constructions in areas exposed either to a rise in sea level or to extreme events. The constructions must also be optimised to save a maximum of energy. Regarding transport, it is likely to undergo the side effect of the regulation policies in the other sectors. For the time being, few alternatives are offered to the transport sector, apart from passenger cars. Lastly, in the non-market sector, the adverse impacts of the climate on the ecosystem can hardly be avoided. An action in the field of improvement of access to health care can, however, significantly reduce risks of epidemics. In any case, priority in the immediate future must be granted to measures intended to reduce the vulnerability of the poorest populations, by acting towards a reduction of inequalities. In this regard, the most 'cost-effective' measures in the Mediterranean will belong in the framework of the Millennium Development Goals (MDGs) and the sustainable development objectives that the region has set itself.

ANNEXES

ANNEXE 1. MOST COMMONLY USED ECONOMIC MODELS IN THE EMPIRICAL LITERATURE

1.1. Integrated Assessment Models (IAM)

The Integrated Assessment Models (IAM) help evaluate the costs and benefits of an action, taking into consideration future climate variability. These models may take various forms: optimisation models or evaluation models (Tol, 2006). While the former model is mainly used by economists as a tool assisting in the orientation of economic policies, the latter forms the subject of more comprehensive analyses that are more dedicated to natural science fields (study of carbon cycle, of land use change ...) (Weyant and al., 1996).

In the optimisation models, there appear both economic and climate components. They tend to focus on the objectives to be set in terms of GHG emissions (which mitigate impacts of climate change) in order to maximize the benefits and to minimize the costs (generated by the regulation policies). Future economic growth and evolution of the climate are jointly simulated. The purpose, then, is to assess the consequences for a given economy in terms of production, income or usefulness of various regulation policies. However, the assumptions on which the models are based can influence the results and must, therefore, be amply clarified and justified (choice of the climate model, description of economic growth—while specifying whether technical progress is taken into account, capacity of adaptation of the economy ...).

Among the most commonly cited examples, one may mention the work of Nordhaus (1994) and Nordhaus and al. (2000) which rests on the development of the DICE model (and its regional version RICE), characterized by coupling a climate model and a simple economic model, derived from the literature. The purpose is to maximise a function of social utility under a double economic and environmental constraint. However, a difficulty arises as to the global nature of the climatic models when it comes to regional studies (Nordhaus and al. 2000). An alternative to the optimisation model of simultaneously considering the costs and the benefits of an action is the model exclusively focused on an evaluation of the costs in which the objectives to be reached are generally set in an exogenous way (Tol, 2006).

1.2. "Bottom-up" and "Top-down" models

Among the empirical models of assessment of the cost of climate change and the options of substitution among the sectors to mitigate the impacts of this change, one often finds the "bottom-up" and "top-down" models which can be integrated in the IA model (Mendelson and al., 2000). The former ("bottom-up" model) is generally used within the framework of analyses dedicated to one or several sectors, as it encompasses the direct individual impacts of climate change. Hence, it may be reproached for not giving sufficient information with regard to the more global evolution of consumption or production. The latter ("top-down" model), being more comprehensive, takes into account at the same time the costs, the function of production, and consumer preferences. It thus allows for a computation of the global impacts related to temperature variability. Hence, one of its limitations is related to its lack of efficiency in the case of regional or local studies (Goulder and al., 2006). Besides, its empirical grounds may be largely questionable since they rest on expert opinion and not on empirical tests (Mendelson and al., 2000).

In view of the respective limitations of these models, it would be judicious to integrate them within the same analysis in order to conduct a more comprehensive study (Mendelson and al. (2000)).

1.3. Computable General Equilibrium (CGE) models

It is worth pointing out that the "top-down" approach includes the computable general equilibrium (CGE) models. These models are used to quantify the costs and benefits of environmental policies. They have the advantage of being more handy than the conventional economic models, integrating macroeconomic behaviours. They are not tools to predict the future level of the variables, but a decision-making tool thanks to the evaluation of the impacts of the various policies implemented. They rest on the economic literature. In general, they are established after the general equilibrium model of Arrow-Debreu. The computable general equilibrium models can take several forms to handle various environmental problems (global warming, deforestation, degradation of air quality, water, land ...) (Conrad, 2002).

In the field of climate change, they are used within the framework of studies dedicated to the interactions between energy, the environment and economy. The objective is to identify the optimal policy to be implemented, while taking into consideration the climate constraints. These models imply joint integration of the physical and economic spheres in order to assess the impacts of climate variability or the implementation of regulation policies on well-being. This consists in setting assumptions concerning the economic and environmental development of the country concerned (particularly in terms of substitution elasticity, exogenous variables, technological change). It is more common to consider environmental impacts as exogenous due to the difficulty of considering a retroactive loop between the economy and the environment. In addition, traditional assessment of well-being, measured by income variation, must be made more telling by integrating environmental quality.

Besides, partial equilibrium models are used to assess the cost of the action, by considering market conditions and the production and consumption substitution processes. However, they do not take into consideration the linkages between all sectors of the economy (Conrad, 2002). In the context of the studies on climate change, the computable general equilibrium models rest on the assumption according to which temperature variability will influence the supply and demand of all goods and services, thus modifying their relative prices. However, climate change is not quite marked and will have visible impacts only in the long term. Accordingly, it is sound to use this method to appreciate the global economic impacts of climate variability (Mendelson and al., 2006). In this case, the partial equilibrium models focused on the most sensitive sectors of the economy are more suitable.

Peters and al. (1999) underline the lack of efficiency of these models as regards the evaluation of the benefits and the costs associated with the policies implemented in order to mitigate the adverse impacts of climate change. Their criticisms relate, in particular, to the variance between the model and the real world. They point out the fact that many significant parameters are not taken into consideration (of which technical progress, structural changes, etc ...) which can, in certain cases, distort the results. Besides, they highlight the difficulty in obtaining a stable and effective single equilibrium. Moreover, introducing the uncertainty—inherent to studies related to assessment of the impacts of future climate variability—runs against the concept of optimal allocation of resources by the market. According to them, the model needs to be largely improved to yield concrete results likely to be used by the policies dedicated to climate change.

1.4. "Ricardian" models

The cross-section data models of the "Ricardian" type are particularly used in the framework of the studies dedicated to the impact of climate change on agriculture (Kurukulasuriya and al., 2006), but can be extended to other sectors (Mendelson and al., 2000). They consist in an elaborate empirical study based on the ideal Ricardian model (Ricardo, 1815) which was promoted in particular by the work of Mendelson and al. (1994). The objective is to measure the long term variation of the farmers' incomes or the value of the land, according to climate variability and other factors. In the context of the other sectors, the impact is considered in terms of modification of the price of wood or energy expenditure in the forestry and energy sectors, for instance (Mendelson and al., 2000).

The standard model is a quadratic function of the climate to highlight the non-linear relation between the variation of temperature and that of agricultural income. In general, it is assumed that the relation between these two variables is concave (Mendelson and al. (2000); Kurukulasuriya and al., 2006), i.e. the net income increases with the temperature level up to a threshold beyond which this relation is reversed. This assumption may be extended to all climate-sensitive sectors, which means that for each one of them there is a temperature which maximizes the well-being of this sector (Tol, 2002a; Mendelson and al., 2006). Indeed, according as to whether the country experiences lower or higher temperatures with respect to this maximum, it derives benefits or incurs costs accordingly. It is, however, necessary to take into account the influence of seasonal variations, especially with regard to the agricultural sector (Kurukulasuriya and al., 2006). Lastly, the curve will not have the same form according to the level of development of the country and the exposure of the sector to climate variability (Mendelson and al., 2006).

The advantage of this method is that it offers the possibility of observing the adaptation strategies and evaluating the benefits derived from them. On the other hand, it is highly dependent on the period on which the analysis rests. Indeed, it is impossible, for instance, to measure the impact of the variation of carbon concentration, which is a variable that changes only slightly over the analysis period considered. In this case, it must be coupled with an experimental analysis. In addition, the impact of extreme events cannot be measured unless they obtain over the analysis period (Kurukulasuriya and al., 2006).

1.5. Dynamic vs. static models

The dynamic models are a representation closer to the evolution of the real world than that of the static models. Indeed, they consider, on the one hand, climate variability and, on the other hand, the country's socio-economic changes, i.e. the future growth of industrial production and of the population, technological progress and institutional changes.

The introduction of this dynamics requires taking into consideration a large number of additional assumptions when establishing the model, which gives rise to several criticisms. The starting point of the study is, in general, a static analysis which one seeks to extrapolate according to various climate and economic development scenarios. This, therefore, consists in setting the parameters of the analysis according to the main conclusions of the literature or by computation. For Tol (2002b), it is indispensable to measure economic vulnerability to climate change according to the countries' per capita income. In view of the weight of uncertainty, the results must be controlled by a confidence interval.

This dynamics may be found in the IA models. Such is the case of the assessment study on the impact of global warming on social well-being, as developed by Frankhauser and al. (2005) for example, and which rests on the neo-classic theory of growth which introduces the future evolution of saving and accumulation of capital within the framework of the DICE model of Nordhaus (1994).

Thus, it is obvious that dynamic analyses are much more comprehensive than static analyses, though it is advisable to be careful when formulating the conclusions. Indeed, the results are largely dependent on the assumptions in terms of anticipations of the future system and the country's adaptation capacity, as well as the parameters which vary according to the period and the country or the region selected.

1.6. Marginal cost of carbon dioxide emission

One technique to measure the cost of non-action ("*business as usual*") is to calculate the marginal cost of the carbon dioxide emission, i.e. the present anticipated cost of the damage caused (in terms of well-being or usefulness) by an additional ton of carbon dioxide emitted in the atmosphere. This cost is generally expressed in monetary unit, in US dollar. This estimate results from a cost-benefit analysis.

In order to calculate this cost on a global level, it is necessary to add up the costs in the past related to carbon emissions in the various regions of the world. The impact depends at the same time on the duration of stay of gas in the atmosphere, and on the total GHG stock. Then, assumptions are set with regard to the value of time (discount rate) which depends on the level of consumption and usefulness in the future, as well as on the weight of the countries. This necessarily calls upon a subjective judgement. The results of the studies on this topic seem to be largely influenced by the choice of these parameters, which explains the diversity of the results in the recent empirical literature.[28] Indeed, anticipations range from 0 US dollar per additional ton of carbon to 400 US dollars according to the year 2000 prices (Stern, 2006).

So as to decide on the implementation of a regulation policy, it is advisable to compare the cost of action and that of non-action. Consequently, the social cost of emission of an additional ton of carbon is set against the marginal cost of reduction of this emission. The objective is to appreciate and classify the various policies of reduction of carbon emissions according to their effectiveness, i.e. in terms of social costs. The policy which will be selected is that for which the cost of reduction is the lowest compared to the social cost. However, it is not possible to appreciate all the alternatives offered to political decision makers in view of their large number. This is why, most of the analyses have but little microeconomic ground.

This type of model is much used to address the issue pertaining in the climate policies to implement in each country within the framework of the Kyoto Protocol. The cost of action varies according to the initial situation of the countries and is all the higher as the percentage of reduction necessary to achieve the set objectives is greater.

[28] For a more detailed vision of the results of the various analyses, cf. the works of Tol (2005).

1.7. Aggregate analyses

The aggregate analyses rest on the principle according to which assessing the impact of climate change on global level requires adding up the anticipated impacts of the climate in each country and region of the world. The advantage of this method lies in the readability of the indicators used. Indeed, to establish a correct comparison between the countries, the impacts are often measured in the same unit, most of the time in monetary units. In addition, this technique streamlines a whole range of complex information in order to offer a simplified vision of the global results, provided that the analysis is based on common assumptions. However, this method is fraught with several limitations likely to distort the main results.

To begin with, in view of the difficulty of simultaneously observing the whole range of impacts on a given economy, the choice of the authors is generally focused on a selection of a few indicators. Most of the analyses rest on reduced-form models (Mendelson and al., 2000, 2006). Thus, many impacts are not measured.

Besides, there arises the difficulty of an objective comparison between the regions, the sectors and over time.

ANNEXE 2.SUMMARY TABLE OF MAIN GLOBAL STUDIES

8	*Nordhaus (2000)*	*Mendelson (2000)*	*Tol (2002)*	*Nordhaus (2006)*	*Mendelson (2006)*	*Stern (2006)*
Period	*2100*	*2100*	*2000-2200*	*2100*	*2100*	*2060 ; 2100 ; 2200*
Meteorological model	*+2,5°(RICE-99) and extreme events 6°*	*3 IPCC scenarios: low (1°), medium (2°), high (3,5°). To each scenario are applied 2 GCM (General Circulation Model) concerning global climate (atmospheric warming, water level rises)*	*General Circulation Model +1°*	*2 scenarios resting on IPCC 3rd Report : - +3° across the grid (change depending on latitude (cf GCM models)) (1) - same change and -15% rainfall as within 500 km in medium latitude coastal areas and +7% elsewhere (2)*	*- Parallel Climate Model - Centre for Climate Research Study - Canadian General Circulation Model Different climate scenario according to the regions*	*- Baseline climate scenario (IPCC 3rd Assessment Model) (1), (IPCC 3rd Report: +3,9°/pre-indust in 2100) -High climate scenario (2) (Business As Usual (BAU): t) + 2-3° by end of century) rise in t° between 2,6 and 6,5°*
Simulation method	*"Willing to pay" approach (insurance premium) Creation of an "impact index" θij(T, yj) for each sub-region/ per capita income per people, given temperature rise and income/ index elasticity*	*2 response functions of the net productivity of the sectors to climate change: - Reduced-form model (1), - Cross-section model (Ricardian model) (2)*	*Cost-benefit analysis of reduction of emissions (model dedicated to each sector based on the static analysis of Tol (2002a))*	*- Ricardian technique (comparison of total economic productivity with existing climate and according to the 2 scenarios) - Boostrap simulations(100)*	*Impact measurement according to an experimental method and cross-section data*	*PAGE 2002 IAM - Computation of costs in terms of GDP, - Computation of costs in terms of well-being (Consumption) Monte-Carlo estimate*
Countries	*13 sub-regions belonging to 8 regions (USA, other Industrialized countries, Western Europe, Russia and Eastern Europe, Middle-income countries, China and LICs).*	*178 countries in the world*	*9 regions : OCDE-America, OCDE-Europe, OCDE-Pacific, Central and Eastern Europe, Middle-East, Latin America, South and South-Eastern Asia, Central Asia and Africa*	*Emerging and industrialized countries divided into territories (25 572) according to a grid (latitude 1°and longitude 1°)*	*Industrialized countries and emerging countries divided into quartile*	*Industrialized countries and developing countries*
Sectors	*Agriculture, sea level (coasts), other market sectors, health, other non-market sectors (outdoor recreation), diseases, ecosystem*	*Agriculture, forestry, commercial and residential energy, water, coastal areas*	*Agriculture, forestry, water, energy use, sea level, ecosystems, diseases and cardiovascular problems*	*Global analysis*	*Sum of impacts (as per t and per GDP) of the climate-sensitive sectors in the economy*	*Global analysis*
Assumptions	*- Following 1st generation studies (sector based) - Market and non-market sectors -Catastrophic impacts -Weighting per surface area (1), population (2) and output (3) -Vulnerable sectors to climate change: 7% economy - Coastal vulnerability index, 'Year of Life Lost', 'outdoor recreation'*	*- Market sector only -Dynamic model -For each sector, there is a temperature that maximizes the production of the said sector (inverted U curve) -Extrapolation of the results of the USA-based analyses, hence approximation for Developing Countries (under-estimation) -Impact in the countries not considered -Weighting by output*	*- Dynamic approach - Market and non-market sectors - Weighting by GDP (1) and by equity (2) - Measurement of vulnerability - Parameters estimated based on the literature -Current variation of vulnerability (Rev/t) used to estimate the effects of economic growth on vulnerability to climate change*	*- Long term equilibrium of economies/ to climate (Ricardian model) - Aggregation : weighting/ population (Income) /output (W)/surface area (location) - Market sector only - no extreme events - Dynamic models to be improved*	*- Market sector only - Dynamic model - Calculation of impact per capita and with respect to GDP - For each sector, there is a temperature that maximizes the production of the said sector (inverted U curve) - Criticism of the CGEMs : not taking into consideration the impacts per sector (1 equilibrium for the economy) - Impact in the countries not considered*	*- Market sector and non-market sector - Catastrophe risk*

Cont'd

	Nordhaus (2000)	Mendelson (2000)	Tol (2002)	Nordhaus (2006)	Mendelson (2006)	*Stern (2006)*
Période	2100	2100	2000-2200	2100	2100	*2060 ; 2100 ; 2200*
Résultats principaux	- De +0,7%PIB en Russie à -5% en Inde et Afrique - Impact moyen global : 1,5% (3), 1,9% (2) - Choc - : Europe (catastrophe), Inde (mousson), Afrique (maladies) - Choc + : Russie, Japon, USA, Chine (amélioration agri et loisirs)	- Globalement, impact positif mais faible (0,16%PIB) du réchauffement durant une première période (jusqu'à 1° (1) et 2° pour (2)) - Bénéfices les plus importants pour les USA, l'Asie et l'Europe de l'Est - Pertes les plus lourdes pour l'Afrique, l'Am Latine et l'Océanie (après 2° (2) -2 à -5% du PIB) - L'agriculture est le secteur qui s'ajuste le plus rapidement (sans agri, impact 0,01%PIB) - Coût important pour l'Europe (Est et Ouest), Asie à la suite de la montée des eaux	- Dans le CT la sensibilité estimée d'un secteur au changement climatique est un paramètre crucial - Dans le LT, importance du changement dans la vulnérabilité de ce secteur - Dans les régions les plus pauvres, dans le LT, les effets négatifs dominent - Augmentation initiale des t° (+0,5°) augmente le bénéficie global (2,5%) (1) et (0,5%) (2) - Augmentation initiale des t° (>+2-2,5°) (1) et (1°) (2) baisse le bénéficie global de 0,5 à 2% PIB global	- Nécessité de prendre en compte une nouvelle variable qui inclut l'aspect géo et environnemental (Gross Cell Product / aire) calculé par territoires - Relation output/t° négative si mesurée par tête et positive selon une surface - (1) impact négatif sur l'output selon les 3 pondérations (de -0,9 à -1,7%) - (2) impact négatif surtout dans les zones où la densité est la plus forte (-3%)	- Impact différent selon la richesse du pays, de l'exposition de leur production (agriculture), des technologies, et surtout de la position géographique - Population mondiale divisée en quartile, 1er le pus pauvre, le plus vulnérable : de -12 à -24% de leur PIB et + 0,1 à 0,9% de gains pour les PI !! - Les pays industrialisés doivent aider les pays du Sud (UNFCCC, Accords de Marrakech, GEF, Fonds d'assurance pour le climat ou Investissements guidés par la Banque Mondiale)	*- (2) : impact marchand + risque de catastrophe : pertes en terme de* ***PIB/t global*** *0,4% en 2060, 2,7% en 2100, 12,9% en 2200* *+ impact non marchand : 1,3%, 5,9%, 24,4%* *- (1) : perte en terme de Bien Etre (consommation) : Baisse de 2,1% (impact marchand) à 10,9 (+ non-marchand+ catastrophes)* *(2) : perte en terme de Bien Etre (consommation) : de 2,5% (impact marchand) à 14,4 (+ non-marchand+ catastrophes)*
Coût par secteurs Région Méditerranée	-Agriculture, coûts : ME 0,46% du PIB, AFR 0,05% du PIB - Zones côtières, coûts : ME 0,01% du PIB, AFR 0,05% du PIB - Santé, coûts : ME 0,02% du PIB, AFR 3% du PIB - Loisirs : ME +0,36% du PIB, AFR -0,25% du PIB - Evènements extrêmes, coûts : ME de 0,47% à 3,23% du PIB ; AFR de 0,39% à 2,68% du PIB supplémentaires	- Agriculture : ME de +80 milliards de $ (2) à + 37 milliards de $ (1) ;AFR de +11 milliards de $ (2) à -131 milliards de $ (1) - Forêt : ME de +3 milliards de $ (2) à + 4 milliards de $ (1) ; AFR de -1 milliards de $ (2) à 2 milliards de $ (1) - Energie : ME de -8 milliards de $ (2) à -17 milliards de $ (1) AFR de -3 milliards de $ (2) à -7 milliards de $ (1) - Eau : ME +18 milliards de $ (2) et (1) ;AFR -6 milliards de $ (2) et (1) - Côtes : ME -4 milliards de $ (2) et (1) ;AFR 0 milliards de $ (2) et (1)	- Agriculture : T° optimale ME :+3,08/1990 AFR :+3/1990 - Eau, coûts : ME 1 million de $, AFR 2 millions de $ - Chauffage, gains : AFR 8 millions de $ - Climatisation, coûts : ME 1 millions de $, AFR 5 millions de $ - Morts supplémentaires dues aux maladies liées au climat : ME 1000, AFR 60000 - Augmentation du niveau de la mer. Perte de terres humides : AFR 38000km² Pertes de terres arides : ME 600 km², AFR 15400km²			
Coûts totaux Région Méditerranée		- Selon les 2 fonctions de réponse, l'Afrique est parmi les + touchés par le réchauffement (surtout UIUC11), tous les secteurs enregistrant de forts coûts.	Coût pour l'Afrique pour un réchauffement de 2,5° coût de 4,1% du PIB	- Désavantage de l'Afrique par rapport aux autres pays : géographie explique 20% des différences d'output entre l'Afrique et les pays t°modéré, Impact marginal par rapport aux régions de faible latitude	- Selon les 3 modèles climatiques, l'Afrique est parmi les plus touchés par le réchauffement (surtout GCM1)	

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CHAPTER 3
Carbon Dioxide emissions from energy use in the Mediterranean economies: trends and pattern

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Future CO_2 emissions of the Mediterranean: towards a much greater contribution by the Southern Mediterranean Countries

Increase in CO_2 emissions is much faster in the SEMCs than in the NMCs. With 1393 MTCO2 due to energy emitted in 2004, the NMCs report an 18% rise between 1990 and 2004. SEMCs emissions are of 663 MTCO2, and they increased by 58% over the same period. This growth rate exceeds by twenty points the global rate. According to the baseline scenario, the share of the SEMCs in the emissions in question originating from the Mediterranean would be around 50% by 2020.

Contribution of the Mediterranean to CO_2 emissions: past responsibility resting mostly with the Northern rim

The 21 Mediterranean countries emitted, jointly, 7.4% of the aggregate world emissions of carbon dioxide related to energy use between 1850 and 2005. They emit today about 8% of these same global CO_2 emissions. The aggregate emissions of the Southern and Eastern Mediterranean Countries (SEMCs) since 1850 account for a mere 1.4% of the aggregate global emissions, and they emitted in 2005, less than 3% of the global CO_2 emissions due to energy. Thus, in 2005, the Northern Mediterranean Countries (NMCs) emitted approximately two thirds of the CO_2 emissions due to energy use for the whole Mediterranean basin. Per capita CO_2 emissions range from 2.6 t in the SEMCs, to 2.4 t in FEMIP countries (beneficiary of the Facility for Euro-Mediterranean Investment and Partnership), to 7.1 t in NMCs.

CO_2 due to energy use in the Southern Mediterranean: main source of GHG, these emissions are increasing at a faster pace than the global average

In 2000, 72% of the Mediterranean GHG emissions were due to CO_2 arising from energy use. This share reaches 77% in the NMCs and 64% in the SEMCs. These rates are higher than those related to the world situation. In the SEMCs, these CO_2 emissions are, indeed, rising at a faster pace than global emissions. The carbon intensity of the economies of the SEMCs (464 TCO2/million dollars of GDP) and FEMIP countries reported a very slight decrease between 1990 and 2004. It is also worth noticing that the total past variation of CO_2 emissions since 1990 results above all in the NMCs from an increase in per capita wealth, while in the SEMCs, population growth is the main factor.

CO_2 emissions due to energy by sector and their evolution since 1990

- Emissions due to electricity and heating constitute the main sector of CO2emissions due to energy use in the Mediterranean (38% in 2004). This sector is, particularly in the SEMCs, the first contributor to the rise in emissions since 1990.
- Emissions of the transport sector are closely connected with the level of wealth. They are thus high in the NMCs where they account for 29% of the total emissions and where they constitute the main component of the rise in emissions. A decoupling of emissions with economic growth is observed neither in the SEMCs (+55% since 1990) nor even in the NMCs (+30%).
- The industry and construction sector (direct emissions) accounts for 20% of the CO_2 emissions due to energy in the SEMCs. Growth has been lower than in the two preceding sectors: + 11% in the NMCs and + 46% in the SEMCs between 1990 and 2004. However, these emissions are on the increase, whereas at the same time the EU-27 has reported a marked drop in this type of emissions. The issue of emissions arising from cement factories in the SEMCs call for special attention.
- CO_2 emissions due to "other fuel combustions" arise mainly from direct combustion of fossil energy in the residential and commercial sector. These emissions are at 70% emitted by NMCs, but they are increasing more rapidly in the SEMCs (such is the case of Tunisia, with 20% of the total of its relevant CO_2 emissions and over 77 % between 1990 and 2004). As for fugitive CO_2 emissions in the Mediterranean, of which more than 50% originate from Algeria, they are steadily on the decrease. Simultaneously, methane emissions issuing from the same origin have strongly increased.

CO_2 emissions: a global stake and specific challenges

Thus, while the NMCs are faced with the need to immediately reduce their CO_2 emissions, for the SEMCs and the FEMIP beneficiary countries, the stake lies in achieving control over future emissions which will, themselves, depend on the extent of the anticipation mainstreamed in the development investments and choices made as of now. The key sectors which will determine the future emissions will be connected, in particular, with the building sector (construction, cement plants, trade, tertiary and residential) and with the use of electricity (particularly in buildings: heating, air conditioning, household appliances), as well as with those connected with transport (passenger and goods). If the investment and development options selected in matter of energy were to be identical with those prevailing over the past 30 years, and in view of the demographic and economic growth in the SEMCs, a very high rise in emissions would be likely to occur on the southern rim of the Mediterranean basin.

INTRODUCTION

Context

« Anthropogenic activities contribute to climate change insofar as they change the land atmosphere by modifying GHG quantities and aerosols (minute particulates), as well as by altering nebulousness. The decisive factor most known is the use of fossil fuels which emit carbon dioxide in the atmosphere. GHGs, as well as aerosols, affect the climate by altering incoming solar rays and outgoing infra-red rays rising from the Earth. The change in density or in the properties of these gases and particulates in the atmosphere may induce a warming or cooling of the climate system. Since the industrial revolution (around 1750), the whole range of human activities has induced a global warming. The anthropogenic impact on the climate during this period exceeds by far that of natural processes, such as solar and volcanic eruptions. »[1] »

The contribution of the various countries of the world and of the Mediterranean to the process described above appears, however, to be quite varied and heterogeneous. Thus, the structure by gas or type of activity of the emissions of greenhouse gas (GHG) and carbon dioxide (CO2) is very specific to each sector and country. Accordingly, a significant step in the reflection on the reduction of GHG emissions is that of quantification of the emissions and analysis of their structure, in particular those of CO_2 due to energy use.

Objective

This chapter aims at a factual stock taking of the extent of CO_2 emissions generated by energy use in the total GHG emissions, of their evolution and structure in the Mediterranean countries.

Throughout this chapter a whole range of indicators will be selected, calculated and analysed in order to:

- highlight the evolution and the relative importance of the CO_2 emissions generated by energy use within the total Mediterranean and global GHG emissions;
- highlight the trends, structure, explanatory factors and sectoral dynamics of CO_2 emissions issuing from energy use, in the whole Mediterranean basin (20 riparian countries of the Mediterranean[2] + Jordan);
- define these evolutions by intra-Mediterranean geographical zone based on analysing and comparing the origin and the evolution of the CO_2 emissions generated by energy use in the Southern and Eastern Mediterranean Countries (SEMCs) and FEMIP beneficiary countries with those of the Northern Mediterranean rim;
- characterise, as much as possible, the respective share of the various parameters and industrial sectors (per sub-region) generating CO_2 emissions related to energy use.

Content

In order to address these objectives, this chapter is composed of three parts. A first Part analyses CO_2 emissions on the very long term (1850-2005) and highlights the evolutions of the Mediterranean countries, those of the South and of the North, with respect to global trends. This

1 Source : IPCC (2007). (Translated from the French)
2 Absence of data relating to the Palestinian Authority.

first Part also analyses the share of the CO_2 emissions generated by energy use in the total GHG emissions. The second Part of this chapter focuses exclusively on the CO_2 emissions generated by energy use. The analysis is detailed for the recent period (since 1990) as per country. The carbon intensity of the countries is compared, and a breakdown of the factors commonly used to explain CO_2 emissions is presented. Finally, the third Part analyses the CO_2 emissions generated by energy use as per sector and helps highlight, as much as possible, the sectors presenting the major challenges and inducing the current and future growth of CO_2 emissions.

Sources of information and methodology

The figures on GHG emissions presented and analysed in this chapter are extracted from the "Climate Analysis Indicator Tool" (CAIT) of the "World Resources Institute (WRI)".3 This database was selected as it seems to be the most exhaustive source of quantified information on this subject to date. The most recent possible data available in this database at the time of preparation of the various parts of this chapter have been used. Thus, version 4.0 of the "Climate Analysis Indicator Tool" was used for Part I (in October/ November 2007) and version 5.0 for Parts II and III (December 2007/ January 2008). Detailed methodological information on the data is included in Box 1. The Euro-Mediterranean Statistical cooperation programme, MEDSTAT II, environment sector, has also been consulted to check methodological information in the MEDA countries. The results are aggregated by geographical zone (SEMCs, FEMIP4, NMCs…: cf. detailed composition in Annex 1). Moreover, additional sources (in particular IEA and MEO) are used to supplement certain series or for the baseline scenarios. Figures related to population, GDP and other complementary information are mainly derived from the WRI data base.

[3]http://cait.wri.org/

[4] The FEMIP aggregate is included in the analysis of Parts II and III.

I. GHG EMISSIONS: GLOBAL AND MEDITERRANEAN ELEMENTS

This part presents, first of all, the historical carbon dioxide emissions generated by energy use. Afterwards, time-located elements, for each GHG and for each sector, are supplied for more recent periods. Here are a few quantified * key elements worth mentioning:

The Mediterranean countries have contributed 7.4 % of the aggregate global carbon dioxide emissions related to energy use since 1850. As from now, they contribute about 8% of the global CO2 emissions. The SEMCs emit less than the NMCs: they accounted for less than 3% of the global emissions in 2005, as against 5% for the NMCs.

The SEMCs currently account for about a third of the CO2 emissions due to energy use in the Mediterranean, though their emissions are rapidly increasing. They, in particular, multiplied by over 5 times their emissions between 1969 and 2005. According to the MEO trend-based scenario, this share would be about 50% by 2020.

From a broader angle of approach to GHG emissions of an anthropogenic origin in 2000, 72% of Mediterranean emissions are due to CO2 related to energy use. This share amounts to 77% in the NMCs. For the same year, the total volume of GHG emissions* thus represented 941 million TECO2 in the SEMCs and 1757 million in the NMCs.

From a sectoral point of view, the GHG emissions of the SEMCs are characterised by a relatively high portion of fugitive emissions (9% in 2000), emissions generated by wastes and cement plants.

Energy use accounts for over 75% of GHG emissions in the NMCs. The fairly dominant sectors of the NMCs are the transport sector (22%) and the residential and tertiary sectors.

*Cf. Infra for details on the data.

1. TRENDS IN GLOBAL EMISSIONS FOR THE WORLD, THE EU AND THE MEDITERRANEAN

1.1. 1850-2005 : Global and Euro-Mediterranean carbon dioxide emissions due to energy use

1.1.1. 150 years of steady increase in global emissions

The combustion of fossil energies emits carbon dioxide. The consumption of commercial fossil energy had accompanied the nascent economic growth in Europe in the 19th century. The industrial revolutions thus involved a tenfold increase in the carbon dioxide emissions due to energy use.[5] The data available[6] allow a reasonable observation of these emissions since 1850. Graph 1 illustrates these long term evolutions over the past century and a half for the world as a whole, the EU-27, the Mediterranean and the SEMCs. The evolutions observed are characterized by the major following stages:

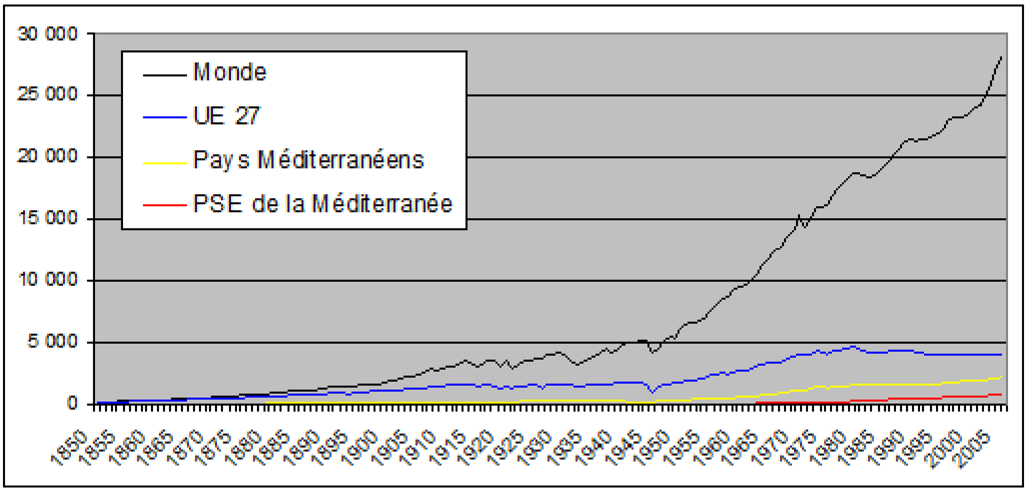
- The global emissions related to energy use reported a slack between the two wars, the economies of many countries having been made vulnerable over these thirty years (1915-1945). The following decades were to particularly report an economic and demographic boom by the

[5] In parts 1.1.1 and 1.1.2., when the term "energy use" is employed, the emissions generated by cement making process are included because the historical data of "CAIT-Excel®" do not distinguish between them; thereafter, the distinction is always made.
[6] WRI CAIT data as derived mainly from the CDIAC, cf. Box 1.

industrialized countries thus driving the whole world into a spiral of a marked growth of carbon dioxide emissions due to energy use.

- The oil crises of the 1970s, the rise of nuclear power and a slack growth of industrialized countries slightly slowed down the growth of emissions. Nevertheless, since 1968, global emissions have more than doubled, thus reflecting evolutions which have also affected the world since the mid-1980s. The slump in production in the Eastern European countries in the late 1980s and in the early 1990s, the boom reported by the Asian countries and, in particular, the marked growth in coal-rich energy consumption emanating from China and India are some of the events which marked the recent history of carbon dioxide emissions.
- The current world situation indicates that over the past three years available (2003-2005), the emissions related to energy use have reported an average annual increase by 4.4%. This variation is higher than the historical pace of increase which is of 3.2% per year.

Figure 1 - Historical carbon dioxide emissions related to energy use from 1850 to 2005, in million T of CO2



Source: Plan Bleu computations, based on WRI CAIT data and other sources.
Note: Carbon dioxide emissions generated by fossil fuel combustion (baseline approach) and by cement making (1850-2002) WRI CAIT, Module "CAIT Excel". For the 2003 data, the "national totals" of aggregate carbon dioxide emitted as per region are derived from the on line WRI CAIT interface. Plan Bleu estimates for the 2004 and 2005 data after MEO (Plan Bleu Report, 2006), EEA (Internet site), WEO (2006) and IEA ("CO2 Emissions due to energy combustion", 2007). Plan Bleu estimates for 2004 and 2005 are made based on a variation method applied with common recent baseline year. .

1.1.2. EU and Mediterranean emissions: "A differentiated pace"

The carbon dioxide emissions trend, as reconstructed for the EU-27, reveals a gradual divergence by the latter with respect to the global trend (cf. Figure 1). As from 1905, the countries gathering to date the EU-27 members contributed for less than a half of the global carbon dioxide emissions due to energy use. After the second World War, the growth pace of European emissions was accelerated, fuelled by the dynamics of the "glorious thirty years". Emissions were then to report an absolute maximum in 1980. The policies related to energy use and the drop in production in Eastern Europe contributed in stabilising the regional carbon dioxide emissions. In 2005, the EU-27 accounted for a barely 14.6% of the world total, while its historical contribution amounts to 26.6% (cf. Table 1).

Table 1 - Carbon dioxide emissions due to energy use from 1850 to 2005

Région	Cumul des émissions de 1850 à 2005, Millions de T de CO_2	Part dans le cumul mondial des émissions de 1850 à 2005, %	Emissions en 2005, Millions de T de CO_2	Part dans les émissions mondiales de 2005, %
Monde	1 147 890	100.0	28 224	100.0
UE 27	305 166	26.6	4 116	14.6
12 nouveaux membres de l'UE depuis 2004	53 768	4.7	738	2.6
Pays méditerranéens	85 397	7.4	2 211	7.8
PN de la Méditerranée	68 805	6.0	1 454	5.1
PSE de la Méditerranée	16 592	1.4	757	2.7

Source: Plan Bleu computations after WRI CAIT data and other sources
Note: Same as for Figure 1.

The emissions generated by the Mediterranean countries as a whole (20 riparian countries[7]) seem to be low on global level until 1950. Thus, in 1926, the Mediterranean region emitted five times less carbon dioxide than the EU-27. The development of the countries of the Northern rim of the Mediterranean (NMCs), then, more recently, of the Southern and Eastern Mediterranean countries (SEMCs), has raised the total emissions of this region to about a half of that of the EU-27 in 2002. At the beginning of the 21st century, the Mediterranean accounted for about 8% of the world total carbon dioxide emissions. This trend is strongly influenced by the countries of the Southern and Eastern rim. Indeed, the emissions of the latter countries had grown tenfold every 25 years in the 20th century, thus raising the global share of SEMCs by 2.7% in 2005. Nevertheless, it clearly appears that, to date, the countries of the Southern rim have contributed much less to CO2 emissions than those of the Northern rim (about 4.1 times less, according to the aggregate for 1850-2005).

These main trends of global and regional emissions are sometimes not easy to interpret, and will therefore constitute the subject of an economic and energy breakdown for the recent period 1990-2004.[8]

1.2. 1950-2020: Carbon dioxide emissions related to energy use and regional scenarios: worrying dynamics of the Mediterranean basin

Carbon dioxide emissions related to energy use are analysed with respect to the sub-regions over the period 1950-2005, as well as their baseline scenario[9] for the time frame 2020, wherever the latter is available.

The emissions of the European Union were affected by the oil crises of the 1970s and the energy policies resulting from them. This situation is strongly marked for the countries of the EU-15 (cf. Figure 2). This same zone has since the early 1980s almost stabilised its carbon dioxide emissions related to energy use. The EU-27 region is characterized by a falling trend in absolute emissions since 1979, although, over the past decade, this trend has slackened rather significantly. The carbon dioxide emissions of the EU-27 have been influenced since 1990 by a drop in the contribution of the twelve new member States of the EU. This sub-group has reported a fall by a third since 1989. Thus, these new members, which are for the major part Eastern European countries emitted in 2005 less than what they had emitted in 1969. These countries have undergone changes in their economic structure and changes in their production level, which explains this evolution.

7 Absence of data relating to the Palestinian Authority.
8 Cf. Part II.
9 The baseline scenario or trend scenario results from an extension of the trends by international institutions specialised in the energy question, and does not incorporate the possible consequences of a behavioural change among the players.

The situation of the new Member States of the EU contrasts with that of the Southern and Eastern Mediterranean Countries (SEMCs). The latter have, for the sake of comparison, multiplied by more than five their emissions since 1969. The increase in the carbon dioxide emissions of the SEMCs is fairly stable; it remains within an annual growth bracket of 5.9%. This growth presents a much more steady trend than that of their Northern Mediterranean neighbours (NMCs). Nevertheless, the NMCs have reported a high increase in their carbon dioxide emissions related to energy use since 1995.[10] The Eastern Adriatic Countries (EACs) have been, for thirty years,[11] more dynamic than the rest of the NMCs (which are in fact the Mediterranean countries member of the EU-27); however, the size of the economies of the Adriatic remains small with respect to that of their European neighbours.

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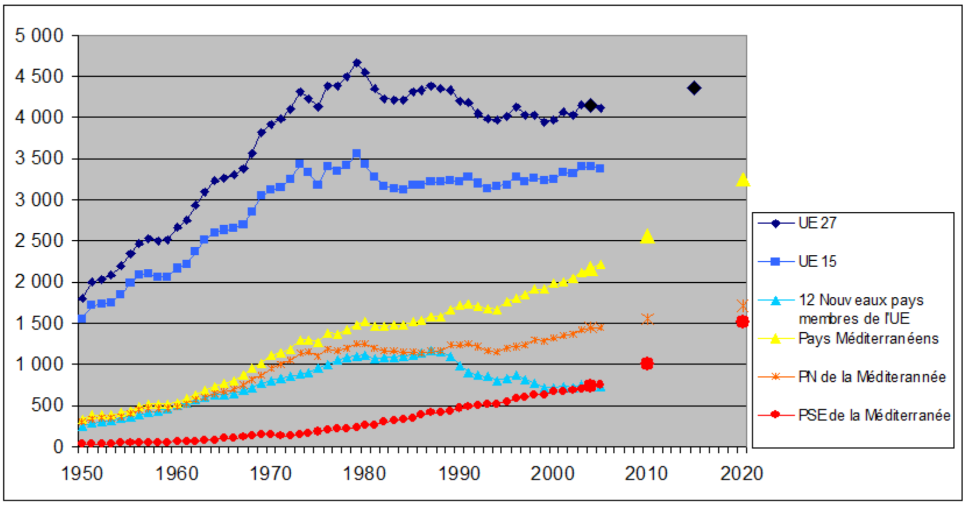
Figure 2 - CO2 emissions due to energy use of the EU and of the Mediterranean and baseline scenarios, 1950-2020, million tons of CO2



Source: Plan Bleu computations after WRI CAIT data and other sources.
Notes: CO2 emissions generated by combustion of fossil fuels (baseline approach) and cement making (1850-2002) WRI CAIT, Module "CAIT Excel". For 2003 data, the "national totals" of carbon dioxide, aggregated by sub-region, are derived from the on-line WRI CAIT interface. Plan Bleu estimates for 2004, 2005 data and baseline scenarios from MEO (Report for Plan Bleu, 2006), EEA (Internet site, exclusively for 2004 and 2005 data), WEO (2006) and IEA ("CO2 emissions due to energy combustion", 2007, exclusively for the global estimate of 2005). Plan Bleu estimates for 2004, 2005 and baseline scenarios are developed based on a variation method applied with a common recent baseline year.

The baseline scenarios for the Euro-Mediterranean sub-regions help elicit the dynamics and the relative share of regional emissions likely to emerge within the time frame 2015 or 2020 (cf. Figure 2), on the assumption that the trends observed in the past remain unchanged. Thus, these scenarios establish an annual increase in emissions by 0.5% for the EU-27, while this increase is likely to amount to 2.7% for the Mediterranean region.[12] This growth differential would lead the Mediterranean riparian countries to emit by 2020[13] as much carbon dioxide due to energy use as the EU-15 in 1999, thus raising the share of the Mediterranean to 8.7% of the world total.[14] The Mediterranean region is, however, not homogeneous in terms of internal dynamics of the emissions baseline scenarios. Indeed, the SEMCs are likely to report a more rapid increase in their emissions, due in part to a South/North convergence of the economies. In 2005, the SEMCs emitted, for the first time, more carbon dioxide related to energy use than the twelve new members of the EU. This

[10] The bordering countries of former Yugoslavia are included in the NMCs.
[11] Except for the periods 1991-1994 and 1999.
[12] As throughout this study, the Mediterranean region is considered as the NMCs plus SEMCs.
[13] The growth of emissions for the time frame 2020 for the Mediterranean is derived from the MEO scenario (2006); the EU 2015 is derived from the WEO (2006).
[14] This share was of 7.8% for 2005, cf. Table 1.

trend is likely to lead, for the time frame 2020, to a share of the SEMCs in the world total emissions due to energy use amounting to 3.8%.[15]

1.3. Recent evolution of GHG emissions in the Mediterranean

After having studied the regional historical trends of carbon dioxide emissions due to energy use, more recent data will allow us to appreciate the emissions in a more comprehensive way by integrating in the analysis the following GHGs:

- Carbon dioxide [CO_2]
- Methane [CH4]
- Nitrous oxide [N_2O]
- Fluoride compounds [HFCs, PFCs, SF6].

The purpose of this breakdown by gas[16] is here to study the temporal dynamics[17] specific to each type of gas, and this for "the world as a whole", the SEMCs zone and the NMCs zone, as well as to identify the share of CO_2 generated by energy use (which in turn will be analysed in detail in Parts II and III of this Chapter).

The carbon dioxide inventoried (cf Figures 3-4-5) is due to energy use, international fuel reservoirs and biomass.[18] Thus, the total share of carbon dioxide in total GHG in 2000 is at least equal to 70% in the three studied zones. Methane emissions result mainly from agriculture, wastes and oil and gas systems in energy producing countries. Nitrous oxide is emitted upon use of fertilisers in agriculture or during incomplete combustion processes.

Finally, fluoride compounds are generated during industrial processes.

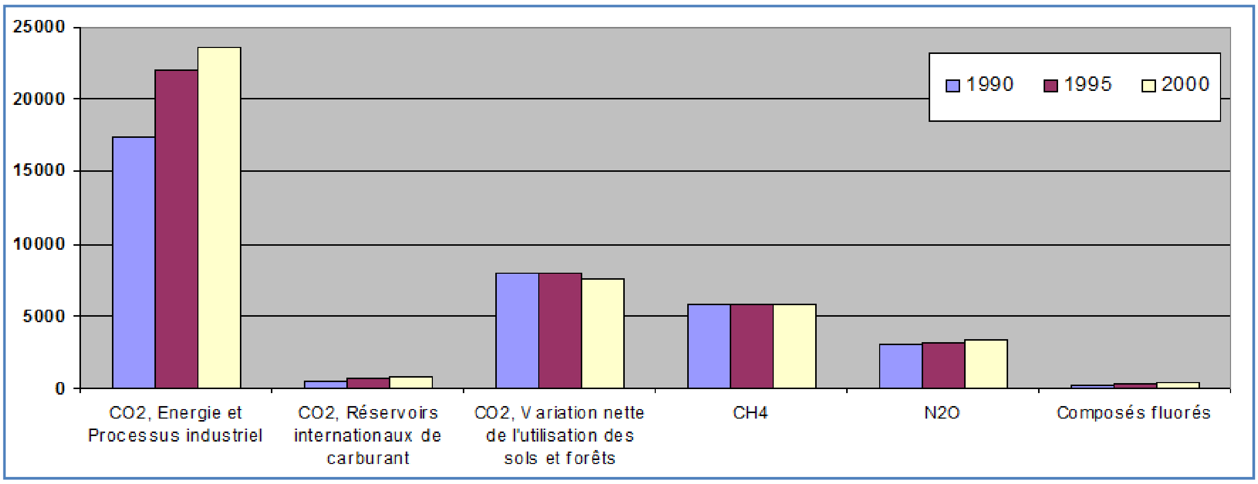
The evolutions observed for each gas are as follows:

- The CO_2 emissions related to energy use (including international fuel reservoirs) account[19] for 57%, 64% and 77% of GHG emissions in 2000 for the "world", SEMCs and NMCs zones, respectively.
- Carbon dioxide emissions related to energy use are increasing in all zones; however, this rise is more marked for the SEMCs and the world than it is for the Northern Mediterranean rim countries (NMCs). This growth is also observed for the particular sector of international fuel reservoirs. The latter reports a high rise in all the studied zones. This trend is influenced by the increase in international sea and air traffic. The share of this sector in the total gases remains highest in the Northern Mediterranean rim countries (NMCs).
- The carbon dioxide emissions generated by land use change and forestry (LUCF) are relatively stable over time. The estimate of the contribution of this sector to an evaluation of anthropogenic emissions is difficult to make.[20] However, it may be clearly observed that, while

15 This share is of 2.7% for 2005, cf. Table 1. The SEMCs scenario for the time frame is generated based on the MEO (2006); the baseline scenario for 2020 for the world is generated based on WEO (2007).
16 A gas bar chart for each zone is available for the years 1990, 1995, 2000, cf. Figures 3, 4, 5. Pie-charts are available in annex for the year 2000 and use a baseline method for the carbon dioxide related to energy use.
17 Only three years (1990, 1995, 2000) are available for non-CO2 gas emissions.
18 Houghton (2003). Cf Box 1.
19 These percentages are calculated using a baseline approach for CO2 energy which differs very little (in value) from the sectoral approach for this sector presented in the diagrams. These percentages are respectively 55%, 61% and 72% if international fuel reservoirs are excluded from the analysis. Zone-based diagrams are available in annex for the year 2000 with a baseline approach for each share representing a GHG.
20 The estimates are those obtained by Houghton (2003). Cf Box 1 for classification of the data according to their uncertainty.

this sector is a real challenge for the world in terms of global warming as a second net emitting "sector", this is not the case for the Mediterranean region. The estimate for the NMCs even reveals a low net storage originating from land use change and forestry (LUCF).

Figure 3 - Global GHG emissions in 1990, 1995 and 2000 as per gas, million TECO2.



Source: Plan Bleu computations and formatting after WRI CAIT data for 2000.
Notes: The 1990 estimate of the aggregate "CO2, Energy and Industrial Process" is skewed downwards due to missing countries. The sectoral approach adopted for the CO2 energy tends to slightly downplay its share in the breakdown of gases, but does not affect the dynamics compared. The non-CO2 gases are the "national totals" not derived from a sectoral summation, contrary to sub-Part 2.2. Anthropogenic GHG emissions standardised as CO2 equivalent (global warming power over 100 year, IPCC recommendations [1996]). Plan Bleu percentages and formatting based on data for 2000 provided by the on line WRI CAIT interface. The data sources used by the CAIT base are available in annex. Attention is called to the extent of uncertainty of the master data included in a box (cf. Box 1). Particular reserve needs to be made with regard to the sector "Land Use Change and Forestry – LUCF" (Houghton estimates, 2003) whose estimates are liable to differ. Besides, error margins are high. The sector "International fuel reservoirs" is included in the diagram for the sake of information only. This sector should appear separately as recommended by IPCC; its presence belongs here within a global and regional vision of GHG emissions. The data "CO2, Energy and Industrial Process" do not integrate this presentation of the international fuel reservoirs given on the right hand side.

Figure 4 - GHG emissions of the SEMCs in 1990, 1995 and 2000 as per gas, million TECO2.

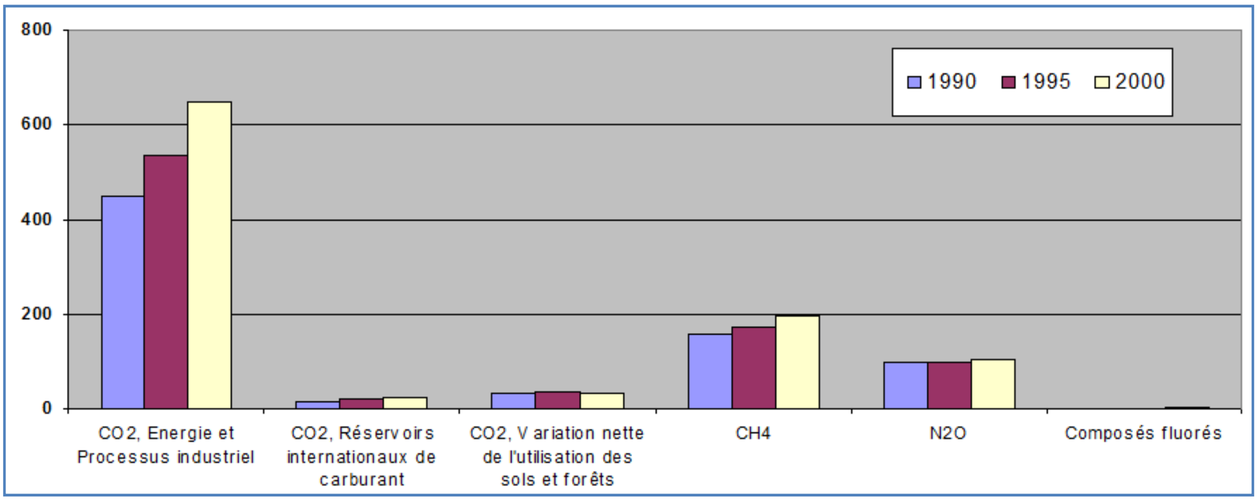
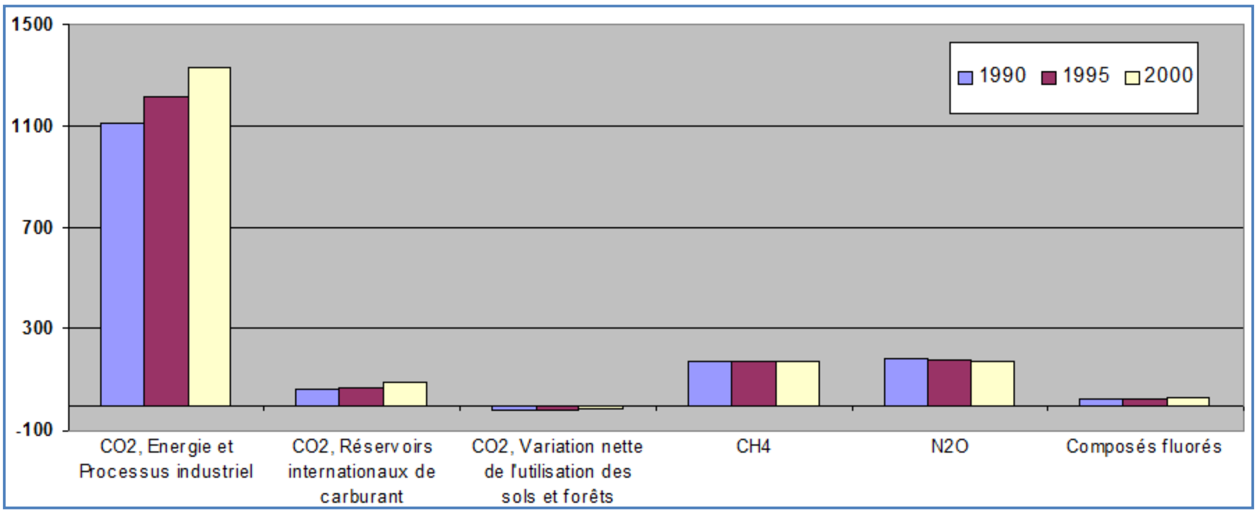


Figure 5 - GHG emissions of the NMCs in 1990, 1995 and 2000 as per gas, million TECO2.



Source and note : Cf. Figure 3. In 1990, the carbon dioxide due to energy is not available for Croatia, Bosnia-H. and Serbia-M. In 1995, these three countries accounted for 5% of the total carbon dioxide emissions due to energy use of the NMCs. The 1990 estimate of this aggregate is, therefore, skewed downwards.

- Methane emissions are constant for the five-year data of the 1990s for the world and the NMCs, while these data have significantly increased for the SEMCs. Nevertheless, the SEMCs share with the "world" a quantity of methane which ranks this gas as the second GHG of anthropogenic origin for these two zones.
- Nitrous oxide emissions remained stable during the baseline period. Only the NMCS reported a very slight decrease of these emissions. However, they still constitute the only zone among the three zones studied for which nitrous oxide is in 2000 the second source of GHG emissions.[21]
- Fluoride gases emissions [here, HFCs, PFCs and SF6] are significant in the NMCs, while they remain marginal in the global emissions and even more so in the SEMCs. However, these gases generated by industrial processes report significant growth in the world and the SEMCs. Overall, hydrofluorocarbons (HFCs) constitute the most dynamic share in the fluoride compounds, this observation rests particularly on the fact that HFCs constitute a substitute for CFCs and HCFCs.[22]

Box 1 - Information on the data

Sources, methodology, uncertainty, estimates and scenarios

Sources:

The data of this study relating to the period 1850-2003 are mainly mined in or derived from the quantified estimates provided by the World Resources Institute [WRI], and, in particular, its climate related tool entitled « Climate Analysis Indicator Tool » [CAIT]. The online version 4.0 of this tool is used for Part I (WRI, 2005b). Parts II and III rely, in their turn, on those of version 5.0 (WRI, 2007a ; WRI, 2007b) [http://cait.wri.org/], which allows a detailed analysis covering the year 2004. The "CAIT-Excel□" module is also used for the historical carbon dioxide emissions. The statistical modules compile non official sources of GHG emissions, which need to be distinguished from the inventories and communications prepared by the countries within the framework of the Kyoto Protocol. The compiled sources are international references, and a conciliation has been conducted by CAIT between geographical and time cover, as well as qualitative level of the data. The six sources used are the following: IEA [International Energy Agency], AEA [American Energy Agency], Houghton [Author of biomass derived estimates], CDIAC [Carbon Dioxide Information Analysis Center, USA, Tennessee], EDGAR [Emission Database for Global Atmospheric Research, The Netherlands] and EPA [American Environment Protection Agency]. Very few estimates have been conducted by the WRI itself. Each source covers particular gases and, sometimes, periods*.

[21] The two main components of GHG are in general CO2 energy and CO2 biomass or methane.
[22] Gases whose use was prohibited by the Montreal Protocol in 1987 owing to their effect on the ozone layer. The European legislation on the matter does not have an equivalent in the Southern and Eastern Mediterranean Countries (SEMCs).

Methodology:

The GHG emissions of Part I are analysed on a regional basis, with aggregates whose precise content is specified in annex. The main European aggregates are the EU-27, the EU-15 and the 12 new EU member countries since 2004. In the Mediterranean, the Northern Mediterranean Countries (NMCs) and the Southern and Eastern Mediterranean Countries (SEMCs) make up the whole "Mediterranean". A sub-regional and country-based analysis is included in Parts II and III of the study, with, in particular, the emergence of the FEMIP aggregate, and hence of Jordan.

The historical carbon dioxide emissions are estimated based on a baseline approach (the supply of commercial energies is weighted for each type of energy in order to obtain a corresponding total carbon dioxide emission). The carbon dioxide emissions of Part I in 1990, 1995 and 2000 included in the GHG analysis are approached from a sectoral point of view, especially in the part related to energy use. The historical time series of carbon dioxide emissions were initially expressed in carbon unit. They have been converted into carbon dioxide unit in order to ensure consistency of account units in this study (the conversion factor is 44/12). The CO2 emissions of Parts II and III rest on a sectoral approach.

Finally, the CAIT GHG emissions data are expressed in terms of carbon dioxide equivalent according to the global warming power of each gas for a duration of 100 years, in conformity with IPCC recommendations (1996).

Uncertainty and reliability:

CAIT provides indications with regard to the relative level of uncertainty of the data on GHG emissions. Thus, it is possible to deduce that the uncertainty of the data presented narrows down according to the following order: carbon dioxide emissions due to land use change and forestry (LUCF), nitrous oxide emissions, methane emissions and, finally, carbon dioxide emissions due to the sectors and related to energy use. Fluoride compounds** (HFCs, PFCs and SF6) are also inventoried and are presented under the same label. Geographic and time cover, as well as the quality of the data, are better in developed countries than those in developing countries. Particular care must be granted to perusing the nota and footnotes annexed to the figures, graphs, tables and diagrams (charts) so that the approaches to and content of the data presented should appear clearly to the reader.

Plan Bleu estimates and baseline scenarios:

In Part I of the study, the global and regional series related to the carbon dioxide emissions due to energy use have been estimated for the years 2004 and 2005, as well as complemented with their baseline scenarios where available. MEO [Mediterranean Energy Observatory, 2006] data have served as a basis for the Mediterranean regional data 2004 and 2005, as well as for this region's baseline scenarios. European Environment Agency (EEA) data are used for the 2004 and 2005 data of European zones. The World Energy Outlook 2006 and IEA [2007, "CO2 emissions due to energy combustion"] supply global data respectively for 2004 and 2005. The WEO 2006 source also allows an estimate of the baseline scenario 2015 for the EU-27. The estimates, as well as the baseline scenarios, have been incorporated in the master data based on the applied variations method.

* Cf. annexes for a precise distribution of the data according to their function and their source of origin. ** CAIT does not classify the degree of uncertainty and reliability related to these gases.

2. BREAKDOWN OF GLOBAL AND MEDITERRANEAN GHG EMISSIONS IN 2000

2.1. Geographical breakdown of global GHG and CO_2 emissions

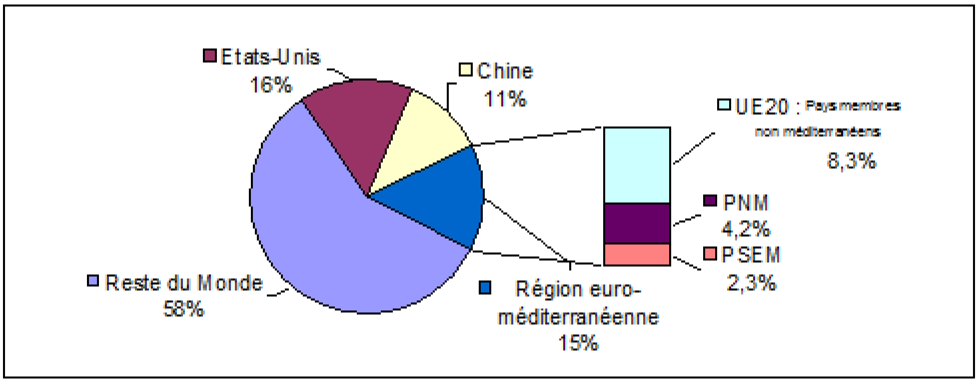
2.1.1. The Mediterranean emits 6.5% of the global GHG emissions

China and the USA accounted, together, for 27% of the global GHG emissions[23] in 2000[24] (cf. Figure 6). In the same year, the Euro-Mediterranean region, composed of the EU-27 and the remaining Mediterranean countries, accounted for 15% of GHG emissions. In terms of emissions,

[23] The global GHG emissions considered as the sum of carbon dioxide gases, methane, nitrous oxide and fluoride compounds are distributed geographically in the world and the Mediterranean as presented in Figure 6.
[24] Cf. notes of Figure 6 and Box 1 for further details on the data used.

this region is dominated by the non Mediterranean countries of the EU [EU-20] which, thus, accounted in 2000 for 8.3% of the world total, while this same share of emissions originating from Mediterranean countries, i.e. the NMCs and the SEMCs, stood at 6.5%.

Figure 6 - Global breakdown of anthropogenic GHG emissions, TECO2, year 2000. World total emissions of 42 billion TECO2

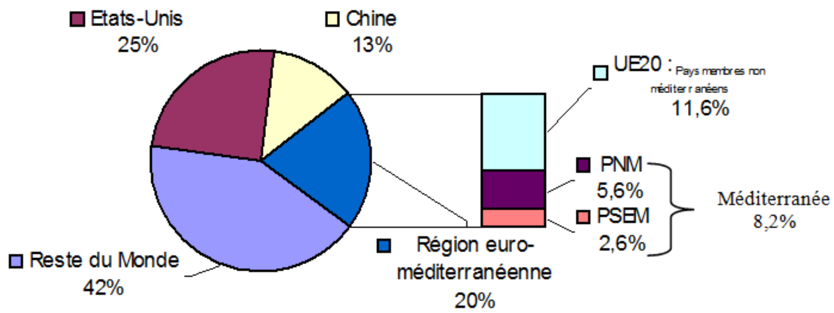


Source: Plan Bleu computations and formatting after WRI CAIT data for 2000.
Notes : Percentages related to anthropogenic GHG emissions standardised as CO2 equivalent (global warming power over 100 years, IPCC recommendations [1996]). Plan Bleu estimates based on aggregated data for 2000, as provided by the on line WRI CAIT interface. The data are derived based on a sectoral approach (particularly for non CO2 gases). Emissions due to land use change and forestry - LUCF (Houghton, 2003) are included, subject to reserve on estimate uncertainty. This sectoral approach tends to underestimate the total non CO2 gas emissions, particularly for the SEMCs. International fuel reservoirs are also incorporated in the data presented.

2.1.2. The Mediterranean accounts for 8.2% of the global CO_2 emissions due to energy use

Carbon dioxide, the main GHG, originates from the sector of energy use, industrial processes[25] and, finally, from land use change and forestry (LUCF).[26] The focus, here, will be exclusively on the "World" and "Mediterranean" breakdown of CO_2 emissions due to energy use.

Figure 7 - Global breakdown of CO2 emissions due to energy use, TECO2, year 2000. World total emissions of 23 billion TECO2.



Source : Plan Bleu computations and formatting after WRI CAIT data for 2000.
Notes : CO2 emissions due to energy use in 2000. Plan Bleu estimates based on CO2 emissions due to energy use (sectoral approach, also comprising gas flaring and venting) as provided by the on line WRI CAIT interface. International fuel reservoirs are excluded.

The geographical origin of the world carbon dioxide emissions due to energy use (cf Figure 7) is more concentrated than that of GHG emissions. Indeed, the triptych [USA - China27- Euro-

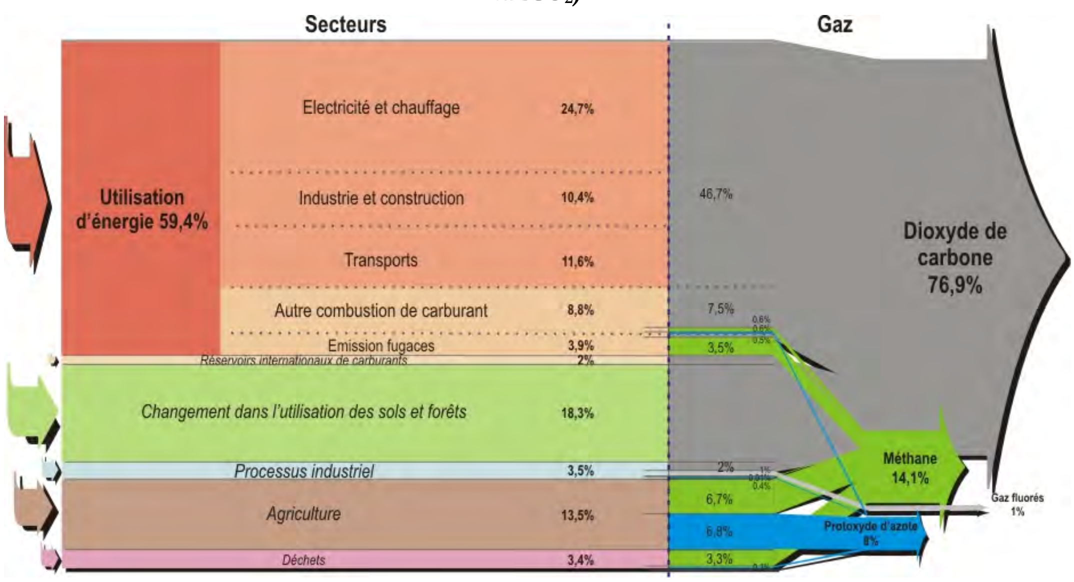
[25] The origin of carbon dioxide emissions in industrial processes here concerns only cement manufacturing.
[26] There may be added to this list the international fuel reservoirs which are often considered separately as recommended by IPCC.
[27] The case of China is to be taken with caution and, in particular, the global shares which are ascribed to this country. Indeed, the strong economic growth of this country and its type of energy supply cause its global share to report a quick rise. While its share in CO2 energy was slightly lower than 13% in 2000, in 2005 this global share is driven upwards to about 19% (IEA 2007, sectoral approach).

Mediterranean region] accounts for 58%[28] of the world total (as against 42% for GHG). This increase in their respective shares is due especially to the fact that these countries share the common characteristic of having very low carbon dioxide emissions originating from land use change and forestry (LUCF).[29] Thus, the share of the Euro-Mediterranean region as a whole is of 20% of the world total carbon dioxide emissions related to energy use (as against 15% for GHG). The share of the NMCs and the EU-20 is, therefore, of 17.2% in total, while the SEMCs accounted in 2000 for a mere 2.6% of the world total. Nevertheless, this low world share of the SEMCs must be seen in view of the key elements of the strong trend dynamics brought out in parts [1.2] and [1.3] for this zone.

2.2. Breakdown by sector and by gas of GHG emissions

The GHG emissions described in this chapter may be traced back to human action. The GHG emissions in the year 2000, latest year available, are given in this Part[30] according to their sector of origin. The sectors considered are energy, land use change and forestry (LUCF), agriculture, industrial processes and wastes. The sector related to land use change and forestry (LUCF) and that of international fuel reservoirs have only carbon dioxide emissions inventoried by CAIT. The other sectors have diversified gas emissions, with the extreme case in this regard being the industrial processes sector which by its nature and its diversity ends up emitting the four major gases inventoried: carbon dioxide, methane, nitrous oxide and fluoride gases [here, HFCs, PFCs and SF6].

Diagram 1 - Breakdown by sector and by gas27 of global GHG emissions in 2000, % of total emissions (41641 million TECO$_2$)



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[28] These CO2 emissions result from the aggregation of the sectoral approaches and can slightly differ from the estimates by the method of reference. The share in the world total of the United States also leaps owing to the fact that its non-CO2 emissions are low.
[29] Houghton estimates (2003).
[30] Cf. the various notes and Box 1 for details on the data and the approaches adopted.

Diagram 2 - Breakdown by sector and by gas27 of GHG emissions in the SEMCs in 2000, % of total emissions (941 million $TECO_2$)

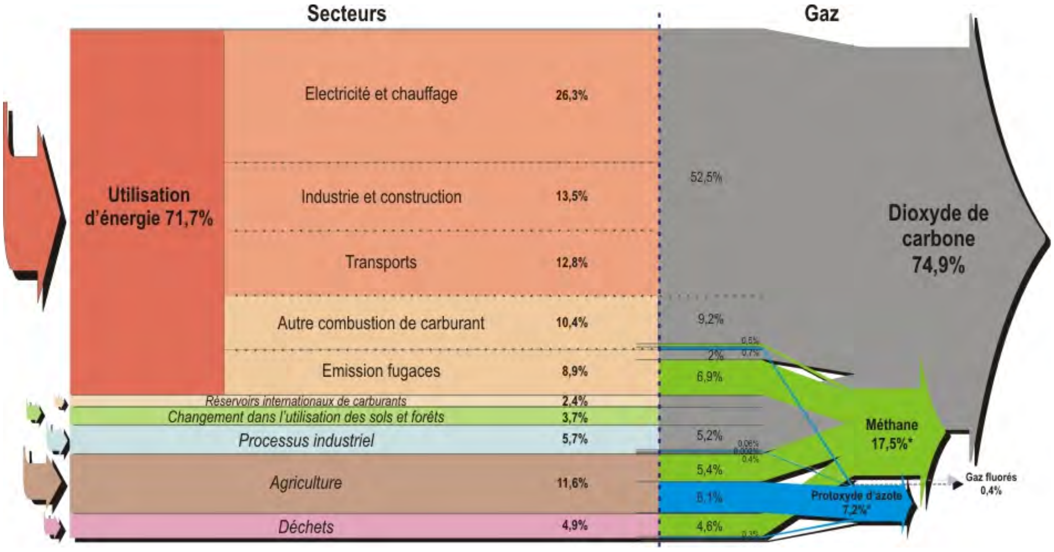
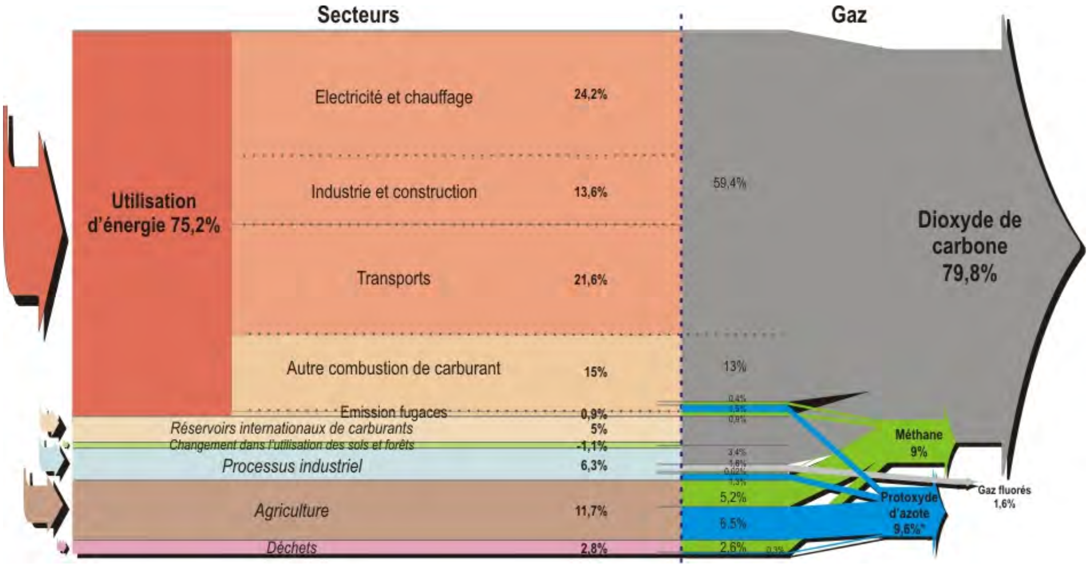


Diagram 3 - Breakdown by sector and by gas27 of GHG emissions in the NMCs in 2000, % of total emissions (1757 million $TECO_2$)



Source of diagrams 1, 2, 3 : Plan Bleu computations and formatting after WRI CAIT 4.0 data for 2000

Notes to diagrams 1, 2, 3 :

* Methane and nitrous oxide emissions are not available for the industrial processes and fugitive emissions sector for the SEMCs zone. This non availability tends to undervalue the share of these two gases in the total GHG. Based on a baseline method, the respective shares in 2000 of methane and nitrous oxide are, for the SEMCs, of 19% and 10%. The nitrous oxide generated by the sector of fugitive emissions is not available for the NMCs; this skew does not modify significantly the breakdown by gas of NMCs emissions. A breakdown by gas of the emissions based on a baseline methodology (useful for the SEMCs) is available in annex.

The percentages presented in the diagrams relate to anthropogenic GHG emissions standardized as CO2 equivalent (global warming power over 100 years, IPCC recommendations [1996]). Plan Bleu percentages and formatting based on data for the year 2000 provided by on line WRI CAIT 4.0 interface. The sectoral data sources used by the CAIT base are available in annex. Caution is called as to the degree of uncertainty of the master data to which a Box is dedicated. A particular reserve needs to be mentioned with regard to the sector "land use change and forestry – LUCF" (Houghton estimates, 2003) whose estimates may differ; besides, error margins are high. The "International fuel reservoirs" sector is included in the diagram for the sake of information only. This sector should appear separately, as IPCC recommends; its presence belongs here within a global and regional vision of GHG.

Based on the gas composition of the emissions of each sector, it is possible to deduce a global and regional breakdown by gas31 which is characterized as follows:

- Whether for the "world", the SEMCs or the NMCs, carbon dioxide represents over 70% of the total GHG emissions. It is the most significant GHG of anthropogenic origin. Methane is particularly present in the SEMCs; it is usually found in rather agricultural countries, and its emissions vary according to the type of agriculture.[32] Nitrous oxide is, in relative terms, strongly present in the NMCS, since it constitutes the second emitting gas in this zone before methane. It is produced during the use of fertiliser in agriculture and in cases of incomplete combustion.
- The SEMCs and the NMCs have GHG emissions that are more related to energy use. In proportion, they are more significant than the global baseline situation. This is partly due to the absence of anthropogenic emissions resulting from land use change and forestry in the Mediterranean.
- Industrial processes proportionally account for more emissions in the Mediterranean than in the rest of the world. This observation is mainly due to regional emissions generated by the industrial process of cement making (Cf. Box 2). Thus, in the SEMCs, the phenomenon of decarbonation inherent in the manufacture of cement accounted in 2000 for 5% of the total GHG emissions of this zone. These emissions in the SEMCs increased by 57%[33] between 1990 and 2000.
- Similarly, the transport sector in the Mediterranean is a highly CO2 emitting sector, with a particular large growth in the NMCs, caused primarily by the level and pattern of development of these countries. The NMCs also share a common characteristic: a "other fuel combustion"[34] sub-sector which is markedly more imposing than the “world” as a whole or even than that of the SEMCs.
- Within the framework of a brief analysis of the emissions related to energy use, it is also worth pointing out that fugitive emissions[35] in the SEMCs constitute a highly emitting sector. The fugitive emissions of this zone are dependent on the existence of energy producing, and sometimes exporting, countries.
- Besides, whatever the zone presented, the energy mix sector ("electricity and heating"), which emits only carbon dioxide, represents on its own a quarter of the GHG emissions in 2000.
- The SEMCs also have a relatively oversized wastes sector, with the methane emissions resulting therefrom. The latter are primarily due to unregulated burning and decomposition of wastes.

[31] Ibid.

[32] This gas is also present in the wastes sector, as well as in countries exporting products related to energy use, two highly emitting sectors in the SEMCs.

[33] This increase for the SEMCs between 1980 and 2003 is 204%. In the Mediterranean and in the year 2000, 45% of the CO2 emissions resulting from the phenomenon of decarbonation during cement making are generated by the SEMCs. The increase rate of the emissions of Egypt generated by this phenomenon is about 10% per year between 1980 and 2003. This growth rate is close to that reported by China over the same period. The production of cement also requires large quantities of energy. In 2000, Egypt and Turkey produced, each of them, more cement than France. China would produce, by 2010, half of the world cement. [Sources of the data: WRI CAIT and Mineral Commodity Summaries (u.s.g.s, various years)]. Cf. Box 2 for additional items on the issue of the emissions resulting from decarbonation ascribed to cement industries in the Mediterranean.

[34] This sector contains, in particular, part of the emissions of the residential sector and commercial and institutional activities. These three entities emit primarily CO2. For further details on the contents of the sectors, refer to Part III, as well as to the WRI CAIT document (2005).

[35] Fugitive emissions generated by oil and gas energy systems, of which technical flaring and venting of gases.

II. REGIONAL AND COUNTRY TRENDS: BREAKDOWN OF CO_2 EMISSIONS DUE TO ENERGY USE

This Part analyses the CO2 emissions due to energy use. The key elements of this analysis are as follows:

- With 1393 MTCO2 emitted in 2004, the NMCs reported an increase by 18% of their CO2 emissions due to energy use between 1990 and 2004.
- The SEMCs emissions reckoned in 2004 as amounting to 663 MTCO2 increased by 58% over the same period. This growth rate exceeds by twenty points the global growth rate.
- Per capita CO2 emissions in the Mediterranean (4.6 TCO2/inh) display a marked heterogeneity in their levels; accordingly, this indicator reveals ratios of over 2.5 between the NMCs indicator and that of the SEMCs. This ratio may be as high as 7 between two riparian countries. Overall, in the Mediterranean, per capita emissions reported a 10% growth between 1990 and 2004.
- The breakdown of carbon intensity of Mediterranean economies is more even than that of per capita emissions, and fairly little correlated with the economic development level. In 2004, the SEMCs emitted 464 TCO2 due to energy per million dollars of GDP (PPP, 2000), which represents a drop by 2% over the observed period. The SEMCs and the FEMIP countries, thus, reported a slight drop in their CI, which was, in addition, lower than that of the NMCs.
- The analysis proposed helps highlight the low relative impact, in the Mediterranean, of the energy intensity and fuel mix factors on the past variation of emissions. The latter results in the Mediterranean, and particularly in the NMCs, from an increase in per capita wealth. Population growth is also an overriding factor for the region as a whole, but more particularly in the SEMCs, where this factor holds dominant position. The SEMCs thus have a factor contribution profile contrary to that observed for the world as a whole.

1. TOTAL AND PER CAPITA CO_2 EMISSIONS DUE TO ENERGY USE

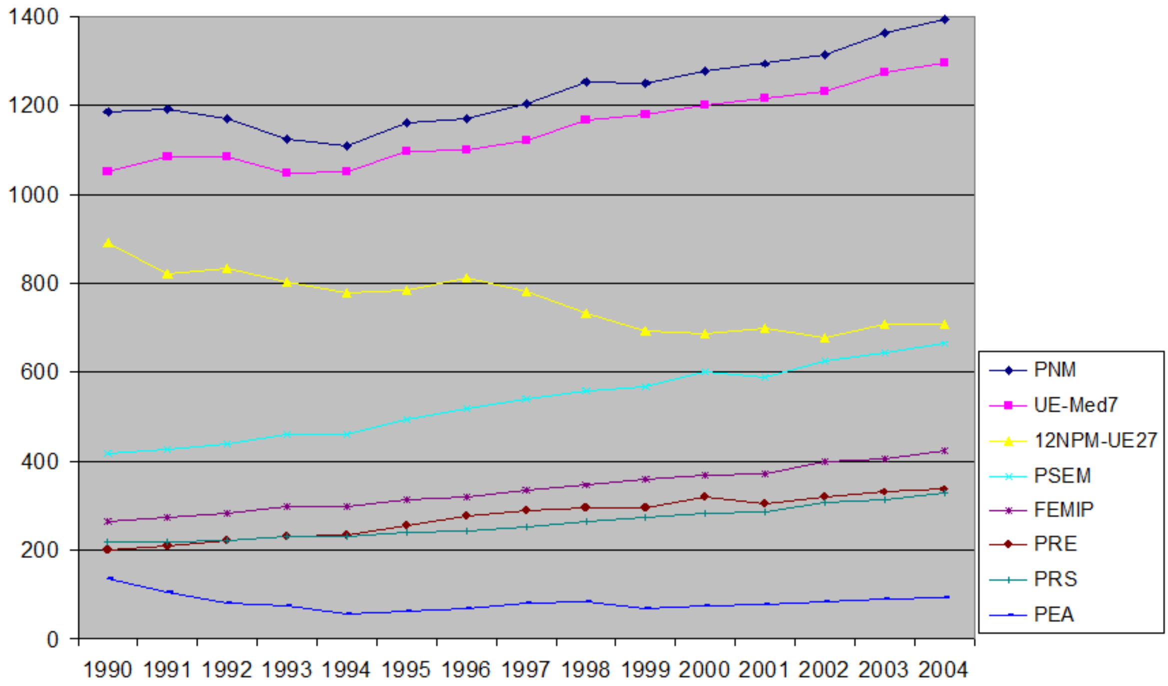
1.1. Total emissions: High increase in the SEMCs

The greenhouse gas (GHG) emissions presented in this Part are carbon dioxide emissions due to energy use. The analysis is focused on CO_2 emission levels in the Mediterranean basin and their variations between 1990 and 2004.

CO_2 emissions related to energy use in the Mediterranean reported, on the whole, an increase by 28% between 1990 and 2004 (Cf. Table 2). Such a high rise remains nevertheless lower than the global growth rate. This Mediterranean trend applies both to the NMCs and to the SEMCs. Nevertheless, while the two rims of this basin are net contributors to the rise, the SEMCs are characterized by a trend that is twenty points higher than the global growth rate of these emissions. In terms of absolute contribution to the rise, SEMCs have also exceeded the NMCs over the period observed (Cf. Figure 15). The SEMCs thus constitute one of the many regions of the world sustaining the global growth of CO_2 emissions due to energy. The year 2001 (economic recession year) was the only year of decrease in emissions for this region. The aggregate of the FEMIP countries is similar to that of the SEMCS over the studied period.

The NMCs emitted in 2004 about 1400 TCO_2 due to energy use, as against 663 TCO_2 ascribed to the SEMCs. The CO_2 emissions trend specific to the NMCS is less linear than that of the SEMCs. Nevertheless, the observable decrease over the period 1990-1994 is mainly due to the situation which then prevailed in the Eastern Adriatic Countries (EACs). Thus, the countries of the EU-Med7 reported a drop in their emissions only in 1993 (economic recession year). The twelve new EU member countries since 2004 have, in their turn, reported a drop in their total emissions over the period, even though this fall seems today to experience a stoppage. After a decade of structural changes that affected these countries, the latter emit today as much as the SEMCs as a whole.

Figure 8 - Regional trends in CO2 emissions due to energy, 1990-2004, million TCO2.



Source: Plan Bleu computations and formatting after WRI CAIT 5.0 data

The emissions growth dynamics is differentiated for the NMCs and the SEMCs. While the Mediterranean has, like the NMCs and the EU-Med7, reported a higher growth of these emissions between 1997 and 2004 than between 1990 and 1997, the opposite is obviously true for the SEMCs. The slackening of relative growth over the period is particularly marked for the Eastern Mediterranean rim countries (EMCs).[36]

Italy (22,5% of the total emissions of the region), France (19%) and Spain (16%) are, respectively, the major contributors to the CO_2 emissions resulting from energy use in the Mediterranean. The fourth emitting country, Turkey, is a SEMC with more than 10% of the emissions of the Mediterranean basin in 2004. Spain for the NMCs, the countries of Mashreq, together with Jordan, are the countries which reported a high growth of their emissions due to energy use. The EACs, France, Italy and Malta--for the NMCS—, and Algeria and Libya—for the SEMCs—are countries for which one observes either decreases (for the EACs) or fairly more moderate rises than the region as a whole.

[36] The annual growth of emissions for this zone is 5.3% between 1990 and 1997 and 2.2% between 1997 and 2004. These figures are, respectively, 0.9 % and 2.1% for the EU-Med7. These shifts are mainly due to a slackening of growth of the emissions of Turkey, for the EMCs, and an acceleration of growth of emissions in Italy, for the results relating to the EU-Med7.

Table 2 - Absolute emissions and per capita emissions of CO2 due to energy use by region and country, 2004 values and recent evolutions

Pays et Régions	émissions absolues				émissions par tête	
	2004, millions de tonnes de CO2	Taux de variation des émissions, 1997-2004, %	Taux de variation des émissions, 1990-2004, %	Emissions 2004, Méditerranée = 100	2004, tonnes de CO2 par habitant	Taux de variation des émissions par tête, 1990-2004, %
Albanie	5	234,5	-22,5	0,2	1,5	-18,1
Algérie	85	14,5	23,5	4,1	2,6	-3,5
Bosnie-Herzégovine	16	81,1	-50,8	0,8	4,2	-45,8
Chypre	7	26,0	79,1	0,3	9,3	40,4
Croatie*	21	18,4	30,0	1,0	4,6	31,9
Egypte	142	48,7	74,5	6,9	2,0	33,8
Espagne	330	35,7	59,0	16,0	7,7	44,6
France	387	6,3	8,9	18,8	6,4	2,1
Grèce	94	18,2	33,0	4,6	8,5	22,2
Israël	62	22,5	85,3	3,0	9,2	26,9
Italie	462	12,5	16,1	22,5	7,9	13,2
Jordanie	17	27,5	81,4	0,8	3,1	7,5
Liban	15	-1,9	139,5	0,7	4,3	85,5
Libye	45	11,8	23,7	2,2	7,9	-6,6
Malte	3	2,4	10,5	0,1	6,2	-0,9
Maroc	36	36,7	81,0	1,7	1,2	45,2
Serbia-Monténégro	53	-0,8	-32,1	2,6	6,6	-11,6
Slovenie	16	1,3	24,8	0,8	7,8	24,9
Syrie	48	16,1	51,5	2,3	2,6	4,7
Tunisie	21	24,9	70,1	1,0	2,1	39,7
Turquie	210	15,9	62,8	10,2	2,9	28,5
UE-Med7	1298	15,8	23,6	63,1	7,4	16,4
PEA**	95	16,5	-30,0	4,6	4,8	-18,0
PRE	335	16,1	67,2	16,3	3,4	27,7
PRS	328	30,0	50,3	15,9	2,2	17,3
FEMIP	425	27,7	61,9	20,7	2,4	23,4
PSEM	663	22,6	58,4	32,3	2,6	22,5
PNM	1393	15,9	17,5	67,7	7,1	13,3
Méditerranée	2056	18,0	28,2	100,0	4,6	9,9
12NPM-UE27	708	-9,5	-20,6	34,4	6,8	-18,0
UE27	4034	3,3	0,6	196,3	8,3	-2,8
Monde	28228	16	38,9	1373,3	4,4	14,8

Source : Plan Bleu computations and formatting after WRI CAIT 5.0 data
Notes : * CO2 emissions for 1991, not for 1990, are used for the computations related to Croatia. ** The EACs 1990 aggregate used in the computations has been estimated.

1.2. Per capita emissions three times higher in the NMCs than in the SEMCs

CO_2 emissions [due to energy use] per capita (i.e., per inhabitant) are an additional indicator allowing passage from gross aggregates of emissions per region or country to a demographic vision of these same emissions. The population level of the Mediterranean basin countries and zones varying widely[37], the large emitting countries per capita are not the large emitting countries in absolute value. Overall, the levels of per capita emissions are relatively dependent on the level of per capita income. Nevertheless, this relation is imperfect.

The per capita CO_2 emissions related to energy use are, in the Mediterranean (4.6 TCO_2/inhabitant), very close on average to those observed for the whole of the world. Per capita emissions are, in 2004, 2.7 times higher in the NMCs than in the SEMCs[38] and they are close in level in the NMCs

[37] Extreme examples in terms of population level of the sample of countries presented in Table 2 are Turkey, with 71 million inhabitants, and, conversely, Malta with 0.4 million inhabitants in 2004.

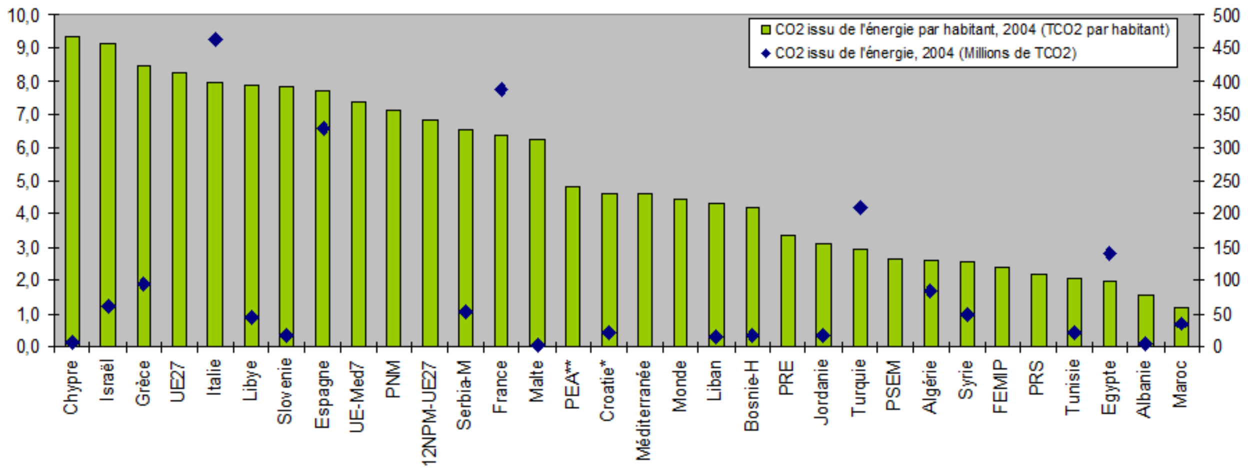
[38] Total GHG emissions per capita would lead to a slight rise of the SEMCs in the classification presented in Figure 9. Indeed, the SEMCs emit a larger share of non-CO2 gases than the NMCs (Cf Diagrams 2 and 3).

and in the "12NMCs-EU-27".[39] Israel and Libya are the only two SEMCs having per capita emissions higher than the NMCs average. Cyprus and Israel are the Mediterranean countries which emit most CO_2 per capita, while Albania and Morocco stand on the opposite end of the scale for these same emissions. A 7-point ratio separates the per capita emission values of these two types of emitting countries. The Eastern Adriatic Countries (EACs) constitute, in view of this indicator, an intermediate set between the countries of the EU-Med7 and the SEMCs. On sub-regional level, per capita emissions are higher in the Eastern Mediterranean Countries (EMCs) than in the Southern Mediterranean Countries (SMCs).

In dynamic terms, the rise in per capita emissions in the NMCs (13%) between 1990 and 2004 was lower than in the SEMCs. Nevertheless, the heterogeneity of the variations is high within the sub-regions themselves. Thus, the rise in per capita emissions in Spain (45%) stands at the extreme end of that observed in France (2%) and exceeds the growth observed in the large majority of the SEMCs. Conversely, the EACs (except for Croatia) reported a significant drop in their per capita emissions, like—but also to a larger extent—some SEMCs, such as Libya and Algeria.

All in all, the per capita emissions of the Mediterranean increased by 10% between 1990 and 2004. This increase is much higher than that of the EU-27 (-2.8%). Nevertheless, this growth is lower than that of its two sub-regions, the NMCs and SEMCs observed separately [40] and a little less constant than the global growth of this same indicator.

Figure 9 - Absolute emissions (right hand side scale) and per capita emissions (left hand side scale) of CO2 due to energy use by region and country in 2004.



Source : Plan Bleu computations and formatting after WRI CAIT 5.0 data

[39] The 12 New Member Countries of the EU-27 since 2004.

[40] This rather surprising feature is the result of a relatively modest increase in emissions in the North (with a mass of CO2 emissions mainly in the North) and of a relatively significant population growth in the South (with a balanced population mass between North and South in 1990). This result is possible because the per capita emissions of the Mediterranean are the result of a ratio made up of the countries of the North and of the South Mediterranean.

2. CARBON INTENSITY OF ECONOMIES, WEALTH AND DEMOGRAPHY: TRENDS AND RESPECTIVE RESPONSIBILITIES

2.1. Carbon intensity of the economies: Towards a decarbonisation?

Carbon intensity of economies is defined as the ratio between the CO_2 emissions of a country and its GDP. It measures the capacity of the countries to generate economic wealth in view of their CO_2 emissions due to energy use. In this study, the production of goods and services of the countries and regions is evaluated in purchasing power parity (PPP, international dollars 2000) in order to facilitate international comparisons.

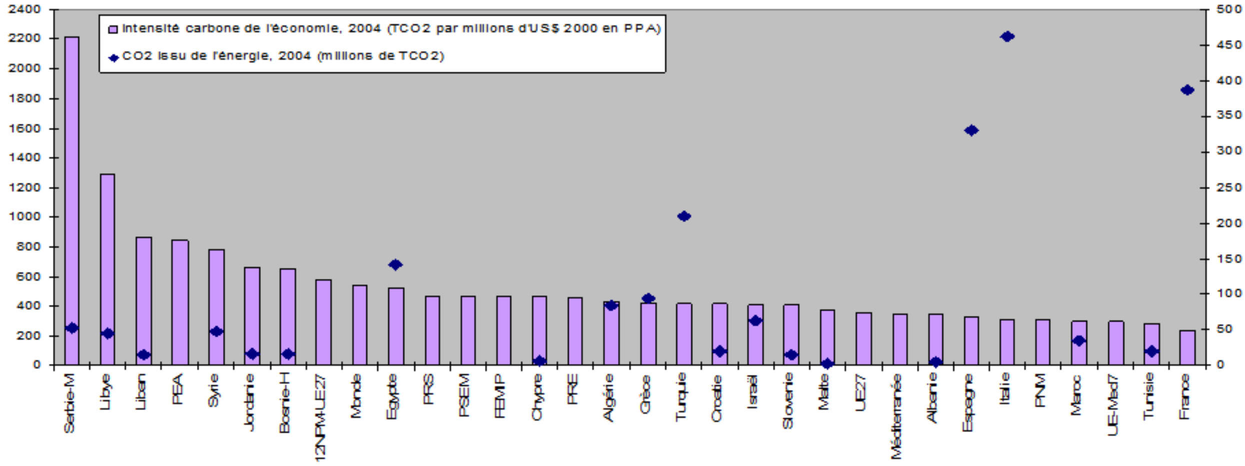
Several factors are likely to influence carbon intensity. The structure and the specialization of the economies, as well as the levels of energy efficiency, are the main elements which determine the primary energy consumption levels in relation to production levels. Besides, the carbon content of the energy sources used by the countries in order to meet their needs constitutes an explanatory factor of the observed level of carbon dioxide emissions due to energy use. In this chapter, we extend the term “fuel mix” to cover the resultant of the choices of primary energy supply in terms of CO_2. Indeed, the use of oil, natural gas, coal, nuclear power or renewable energies implies quite differentiated carbon emissions. The carbon intensity (CI) of economies, the energy intensity of economies (EI) and the "fuel mix” (FM) may be defined and structured as follows:

- $$\frac{CO2}{PIB} = \frac{Energie}{PIB} \times \frac{CO2}{Energie} \qquad (1)$$
  $$[IC = IE \times ME]$$

PIB = GDP; Energie = Energy; IC = Carbon intensity; IE = Energy intensity; ME = Fuel mix.

The carbon intensity of Mediterranean economies stands on average at a level much lower than the world situation. This observation is due at once to lower EI and FM (cf. Table 3). The level of carbon intensity of the NMCs (308 TCO_2/million \$ 2000 PPA) is lower than that observed for the SEMCs (464). This disparity is due at once to a differential in the composition of the “fuel mix” and in the levels of energy intensity.

Figure 10 - Absolute CO2 emissions due to energy use (right hand side scale) and carbon intensity of the economies (left hand side scale) by region and country in 2004.



Source : Plan Bleu computations and formatting after WRI CAIT 5.0 data

The carbon intensity of the economies seems, nevertheless, to be fairly little correlated with the level of economic wealth. The Mediterranean basin attests to it (cf Figure 10 and Table 3). The major NMCs are the countries having a carbon intensity among the lowest in the Mediterranean; on the other hand, countries like Morocco or Tunisia stand at their level. These two countries have low energy intensities of their economies, due in particular to the respective specialization of their economies, to a strong energy constraint (case of Tunisia) or to low levels of per capita consumption (case of Morocco).

The carbon intensity of the Mediterranean economies has decreased over the past fifteen years. This decrease (-6.8%) remains, however, less significant than the global or European reduction (-24.2%). Overall, the relative composition of the decrease is different in the Mediterranean. Indeed, the decrease in the Mediterranean of carbon intensity is mainly due to a less carbon intensity of the primary energy supply, while, for the EU-27, the variation of the EI and FM is equivalent. Overall, for the world, the drop in the energy intensity of the economy justifies the reduction in carbon intensity. The decrease in the value of the "fuel mix" in the Mediterranean is mainly due to the contribution of natural gas in the energy supply whose share passed from 15% to 24% between 1990 and 2004.[41]

On Mediterranean level, the NMCs and the SEMCs have, on the whole, reported over the period 1990-2004 a reduction in the three indicators observed (cf Table 3). The decrease in CI is higher in the NMCs than in the SEMCs. The NMCs display a constant fall of the "fuel mix" driven by France and Italy, while, on the contrary, Spain reported a significant positive movement affecting the two components of the CI. In the SEMCs, 20% CI rises (Morocco) stand alongside with decreases of the same magnitude (Syria). While EMCs and SMCs aggregates of CI are down by about 2%, the EMCs (in particular, Israel) present a dwindling FM (i.e., an increasing CI); on the other hand, for the SMCs, energy intensity (in particular, Morocco) increased between 1990 and 2004.[42]

[41] MEO data (2006).
[42] MEO data (2006).

The figures lead to the conclusion that decarbonisation of Mediterranean economies is in a embryonic stage. Differences, which are sometimes significant, remain between the economies of the same Mediterranean rim, thus revealing the countries' individual energy challenges, constraints and policies. Positive trend elements, such as natural gas penetration, must be accompanied by proactive economic and sectoral policies.

Table 3 - Absolute CO2 emissions due to energy and carbon intensity (CI) of the economies by region and country, 2004 values and recent trends

Pays et régions	Intensité énergétique (Energie/PIB)			"Mix énergétique" (CO2/Energie)			Intensité carbone (CO2/PIB)		
	2004, Kep par K$ 2000 en PPA	variation 1997-2004, %	variation 1990-2004, %	2004, KCO2 par Kep	variation 1997-2004, %	variation 1990-2004, %	2004, TCO2 par millions de $ 2000 en PPA	variation 1997-2004, %	variation 1990-2004, %
Albanie	169	46,9	-37,1	2,0	38,7	-12,8	342	103,8	-45,2
Algérie	168	-5,8	-3,4	2,6	-9,2	-10,4	431	-14,5	-13,5
Bosnie-Herz.*	188	16,5	-24,0	3,5	5,6	39,3	650	23,1	5,9
Chypre	175	-4,0	1,0	2,6	1,3	5,2	462	-2,7	6,3
Croatie*	178	-11,1	-11,4	2,3	5,7	2,4	417	-6,0	-9,3
Egypte	209	8,7	2,1	2,5	2,5	-2,1	522	11,4	-0,1
Espagne	140	1,6	5,0	2,3	2,9	1,8	325	4,5	6,8
France	169	-5,7	-6,8	1,4	-4,7	-10,1	238	-10,1	-16,2
Grèce	137	-9,0	-8,9	3,1	-2,8	-3,2	421	-11,5	-11,8
Israël	137	-1,8	-4,3	3,0	4,3	8,2	411	2,4	3,6
Italie	124	2,6	3,1	2,5	-0,8	-6,9	311	1,8	-4,0
Jordanie	260	-2,6	-10,2	2,6	-6,3	-2,6	665	-8,7	-12,6
Liban	307	-20,3	-2,2	2,8	-0,9	2,5	870	-21,0	0,2
Libye*	520	*20,0*	*20,0*	2,5	-1,5	-21,5	1289	*21,9*	*21,9*
Malte	135	-14,6	-26,3	2,8	7,3	-5,8	372	-8,4	-30,6
Maroc	95	-4,3	13,1	3,1	9,0	6,3	295	4,3	20,2
Serbie-M*	741	-4,5	4,4	3,0	-3,8	-5,3	2219	-8,1	-1,1
Slovenie*	188	-16,6	-9,6	2,2	-6,4	-5,4	409	-21,9	-14,5
Syrie	300	0,2	-16,7	2,6	-4,8	-4,1	785	-4,6	-20,1
Tunisie	121	-4,3	-17,1	2,4	-6,0	8,2	286	-10,1	-10,3
Turquie	163	-4,9	-5,5	2,6	0,4	5,3	417	-4,5	-0,4
UE-Med7	146	-1,9	-1,4	2,0	-0,6	-4,7	294	-2,4	-6,1
PEA*	299	-9,7	-8,8	2,8	-0,2	3,9	842	-9,9	-5,3
PRE	173	-4,4	-5,8	2,7	0,3	4,5	458	-4,1	-1,5
PRS	184	1,3	4,3	2,6	-1,6	-6,6	471	-0,3	-2,7
FEMIP	176	-0,3	-1,4	2,6	-1,7	-1,8	464	-2,0	-3,2
PSEM	178	-1,6	-0,9	2,6	-0,7	-1,3	464	-2,3	-2,2
PNM	150	-2,1	-3,0	2,1	-0,5	-7,8	308	-2,6	-10,5
Méditerranée	156	-1,8	-1,8	2,2	-0,3	-5,1	345	-2,1	-6,8
12NPM-UE27	219	-25,8	-28,8	2,6	-4,9	-13,8	577	-29,4	-38,6
UE27	159	-10,3	-15,5	2,2	-2,9	-10,4	354	-12,9	-24,2
Monde	212	-10,8	-20,2	2,6	-0,8	8,5	543	-11,5	-13,4

Source : Plan Bleu computations and formatting after WRI CAIT 5.0 data
* Notes : For the countries and regions of Bosnia-H., Croatia, Serbia-M, Slovenia and EACs, the baseline year for the "1990-2004" variations is 1994,1992, 1993,1992 and 1994, respectively. The baseline year for Libya is 2000 for energy intensity and carbon intensity, while it is 1990 for the "fuel mix".

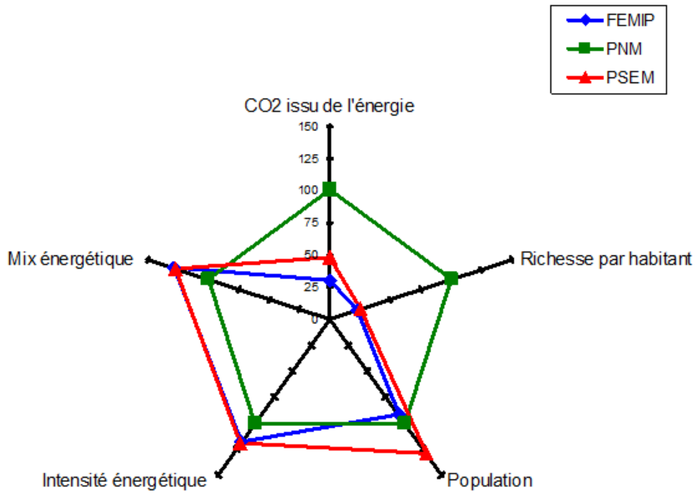
2.2. A ex-post breakdown of emission variations: The differentiated weights of per capita wealth and of demography

The increase in CO_2 emissions due to energy use is the result of the interaction of several factors and depends on the current, but also past, choices made by the players. This paragraph purports to put forward a breakdown of CO_2[43] such as to allow assignment of a relative importance to each

[43] This analysis of the rise of emissions in the Mediterranean is focused exclusively on the rise of the CO2 emissions due to energy use, leaving aside the non-CO2 GHG emissions and those due to LUCF CO2. The latter emissions are lower in the Mediterranean than in the rest of the world in general and increase less quickly than the CO2 emissions due to energy use.

economic, demographic, technical and energy factor to an observed variation of emissions. The exercise herein proposed rests, in particular, on part of the article by Ang and Liu (2001). The breakdown factors are in conformity with the stance elected by these authors with regard to the possible factorial development of CO_2 emissions, applied to the case in hand. The exercise bears similarity to the adaptation conducted by the WRI (2005).

Figure 11 - Relative levels (NMCs = 100) of CO2 emissions and of the breakdown factors for the NMCs, SEMCs and FEMIP regions, 2004.



Source : Plan Bleu computations and formatting after WRI CAIT 5.0 data

This is contingent upon an initial vision of the leading factors. The factors[44] at play, here, are per capita wealth (pcW), population (P), energy intensity (EI) of the economy and "fuel mix" (FM). Hypothetically, the results presented do not allow, for instance, a deduction of the impact of an anticipated increase of one of the factors on the others or on the CO_2 emissions due to energy use. The following formula sums up the ex-post development adopted with regard to the CO_2 emissions due to energy use:

- $$CO2 = \frac{PIB}{Population} \times Population \times \frac{Energie}{PIB} \times \frac{CO2}{Energie} \quad (2)$$
  $$[CO2 = Rh \times P \times IE \times ME]$$

PIB = GDP; Energie = Energy; Rh = Per capita wealth; IE = Energy intensity; ME = Fuel mix

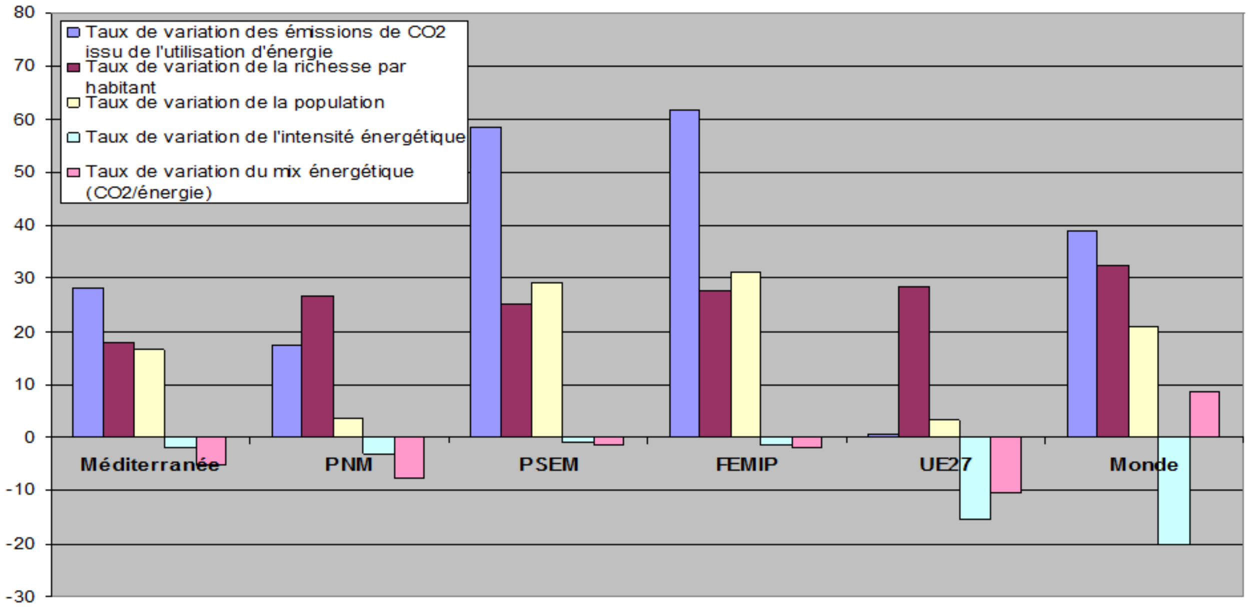
In formula (2), the structural changes of the economy, such as dis-industrialisation of the economy, a growth of the services sector or, again, increasing imports of carbon-rich manufactured goods (Cf the works of [Ahmad & Wyckoff] (2003)[45]) come to pass via the EI factor. Figure 11 recalls the levels of CO_2 emissions related to energy use, as well as the relative levels of the four factors of three Mediterranean zones. This reminder is useful, as the results presented here are focused exclusively on the variation, expressed in percentage, of the variables between 1990 and 2004 of the regions and countries studied.

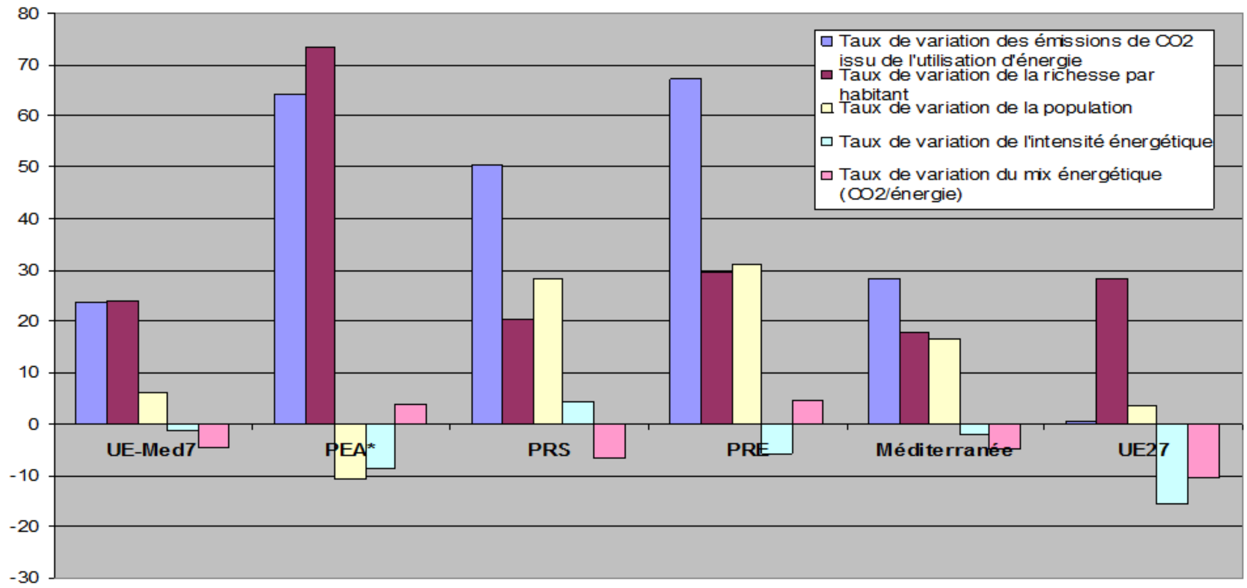
Figures 12 and 13 illustrate the fact that the Mediterranean and the SEMCs, as well as the FEMIP countries, do not report any factors presenting a high decrease over the period.

[44] Cf. WRI (2007a), for the secondary sources of the data used.
[45] The question at issue is that of the approach to CO 2 emissions (by the consumption of goods and services, or by the production of the latter) and of international trade. For instance, in 1995 in France, the emissions resulting from the consumption of manufactured goods were 15% higher than the emissions resulting from the production of this same type of goods [Ahmad &Wyckoff] (2003).

On the contrary, for the EU-27, the improvement of energy intensity (EI) and the evolution of the fuel mix (FM) help to completely mitigate the increase in per capita wealth (measured in PPP) and for the world as a whole; it is the decrease in energy intensity which reduces the potential increase in CO_2 emissions. The significant decrease in the world energy intensity is particularly accounted for by the high decrease of this factor for China.

Figure 12 et Figure 13 - Variation in % by region and sub-region of CO2 emissions due to energy use and of the factors issuing from the breakdown, variation 1990-2004.





Source : Plan Bleu computations and formatting after WRI CAIT 5.0 data
* Notes : For the EACs region, the baseline year for the variations is 1994, not 1990.

The profile of the variation of the factors for the SEMCs and the NMCs is rather different. The South/ North convergence of per capita wealth of the Mediterranean countries is little or negative according to the sub-regions compared. Nevertheless, the per capita wealth (pcW) of the SMCs did not converge towards that of the NMCs or even towards that of EU-Med7. The situation of the EMCs is different since these countries have, on the whole, reported a six-point higher per capita growth rate over the period 1990-2004 than that of the EU-Med7 countries. Table 4[46] reveals that the increase in per capita wealth is driven by Syria, Turkey and Lebanon in the EMCs, while in the SMCs the relatively low increase in pcW is dominated by the lower growth in Algeria. The pcW growth rate has, furthermore, increased in the NMCs over the period, while it has slackened in the SEMCs.

La croissance démographique en Méditerranée du Sud (PSEM et FEMIP) est globalement forte. Cette croissance a la particularité d'être plus soutenue que la croissance de la richesse par tête. Cette situation ne s'observe pas pour l'ensemble mondial. En Méditerranée, la croissance des émissions de CO_2 peut dans le cadre de cette décomposition être attribuée aussi bien à la hausse de la Rh qu'à l'augmentation de la population. L'effet population domine dans les PSEM, alors que dans le PNM, c'est l'effet richesse par habitant qui est supérieur à une croissance très limitée de la population. Cette dernière est la même sur l'ensemble de la période dans les PRE et les PRS. Les PEA ont quant à eux connu un recul de leur population au cours de la période 1990-2004. Du point de vue des pays, la croissance démographique a été très forte en Jordanie (+69%), en Israël ou en Syrie alors qu'elle a été quasi nulle en Italie et dans toute l'UE27. En termes dynamiques, la croissance démographique dans les PSEM a ralenti sur la période observée tout en restant à un niveau élevé, alors que la croissance de la population dans les PNM s'est légèrement accrue.

Les deux derniers facteurs, IE et ME, qui sont des facteurs techniques et énergétiques ont contribué au Nord et dans une certaine mesure au Sud de la Méditerranée à modérer faiblement la hausse des émissions de CO_2. Ces facteurs n'ont pas eu l'importance décisive en Méditerranée qu'ils ont eu dans les pays en transition d'Europe ou même aux Etats-Unis. L'intensité énergétique des économies de l'UE-Med7 a stagné alors qu'elle a largement régressé pour les pays de l'UE27. L'IE a même progressé pour l'Italie ou l'Espagne.

[46] The level variables of Table 4 are available for the year 2004 in Annex.

Table 4 - Variation in % by country and region of CO2 emissions due to energy, and of the factors issuing from the breakdown, variation 1990-2004.

Pays et régions	Emissions de CO2 liées à l'énergie, variation 1990-2004	Richesse (PPA) par habitant, variation 1990-2004	Population, variation 1990-2004	Intensité énergétique de l'économie, variation 1990-2004	Mix énergétique (CO2/E), variation 1990-2004
Albanie	-23	49	-5	-37	-13
Algérie	23	12	28	-3	-10
Bosnie-H (1994)*	342	277	11	-24	39
Chypre	79	32	28	1	5
Croatie (1992)*	34	49	-1	-11	2
Egypte	75	34	30	2	-2
Espagne	59	35	10	5	2
France	9	22	7	-7	-10
Grèce	33	39	9	-9	-3
Israël	85	23	46	-4	8
Italie	16	18	3	3	-7
Jordanie	81	23	69	-10	-3
Liban	139	85	29	-2	2
Libye (2000)*	*9*	*-18*	*8*	*20*	*2*
Malte	10	43	11	-26	-6
Maroc	81	21	25	13	6
Serbia-M (1993)*	32	73	-23	4	-5
Slovenie (1992)*	35	58	0	-10	-5
Syrie	52	31	45	-17	-4
Tunisie	70	56	22	-17	8
Turquie	63	29	27	-5	5
UE-Med7	24	24	6	-1	-5
PEA (1994)*	64	73	-11	-9	4
PRE	67	30	31	-6	5
PRS	50	20	28	4	-7
FEMIP	62	28	31	-1	-2
PSEM	58	25	29	-1	-1
PNM	17	27	4	-3	-8
Méditerranée	28	18	17	-2	-5
12NPM-UE27	-21	33	-3	-29	-14
UE27	1	28	3	-15	-10
Monde	39	33	21	-20	8

Source : Plan Bleu computations and formatting after WRI CAIT 5.0 data
* Notes : For the countries and regions of Libya, Bosnia-H., Croatia, Serbia-M, Slovenia and EACs, the baseline year for the variations is 2000, 1994,1992, 1993,1992 and 1994, respectively.

Rational energy use (REU) policies lead in particular to a reduction of the EI of the economies, while the development of non CO_2 emitting energies (REs or nuclear power) bring down the measured value of the "fuel mix". The result of the actions in both cases leads to a gradual decarbonisation of the economies. The preceding results may lead to the conclusion that the decarbonisation of certain Mediterranean economies starts, in particular, on the Northern rim, while in many countries of the Southern rim, it is less significant. It must be borne in mind, however, that these results do not mean that the energy development of one rim is more sustainable than on the other. On the Northern rim, which reports better performance in terms of evolution of CI, per capita emissions are still steadily on the increase. Moreover, the NMCs report lesser performance than EU countries as a whole. A sectoral analysis of CO_2 emissions thus proves to be necessary in order to complement the analysis of CO_2 emissions in the Mediterranean.

III. SECTORAL ANALYSIS OF CO_2 EMISSIONS DUE TO ENERGY USE

This Part presents the CO2 emissions due to energy use by sector. The key elements are the following:

- Emissions due to electricity and heating represent the chief CO2 emissions sector in the Mediterranean (37%). This sector is, in the SEMCs, the prime absolute contributor to the increase. The increase of these emissions (+92%) exceeds, in this region, the economic growth, though remaining less than the galloping pace of the growth in electricity production (+142%).
- The CO2 emissions ascribed to the transport sector are fairly strongly connected with the level of wealth by country. These emissions are thus particularly high in the NMCs and, more generally, in the EU-27. While these emissions rank second in terms of total emissions in these two zones (29% in the NMCs), they account for the major part for the rise in emissions between 1990 and 2004, with an extreme case for the EU-27. A linkage of these emissions with growth is reported neither in the SEMCSs(+55%) nor in the NMCs (+30%).
- The industry and construction sector accounted for 20% of CO2 emissions in the SEMCs in 2004. The growth in the direct emissions due to energy of this sector has been lower than in the preceding two: 11% in the NMCs and 46% in the SEMCs between 1990 and 2004. Emissions continue, nevertheless, to increase, while the EU-27 has reported a marked decrease in this type of emissions, which contributed to their global stabilisation between 1990 and 2004. Particular attention must, in addition, be granted to the issue of cement production in the SEMCs.
- The CO2 fugitive emissions due to gas flaring and venting during gas or oil production are on a steady decrease in the Mediterranean. These emissions are due to producing and exporting countries. Algeria accounts for over a half of these Mediterranean emissions. Concurrently, the methane emissions due to the same phenomenon reported a high increase between 1990 and 2004.
- The CO2 emissions due to "other fuel combustions" are mainly due to direct combustion of fossil energy by the residential and commercial sector. These emissions are, at 70%, originating from the NMCs and are fairly related to wealth level. The rise in these emissions is high in the SEMCs with, in particular, an increase by 71% in the SMCs between 1990 and 2004.

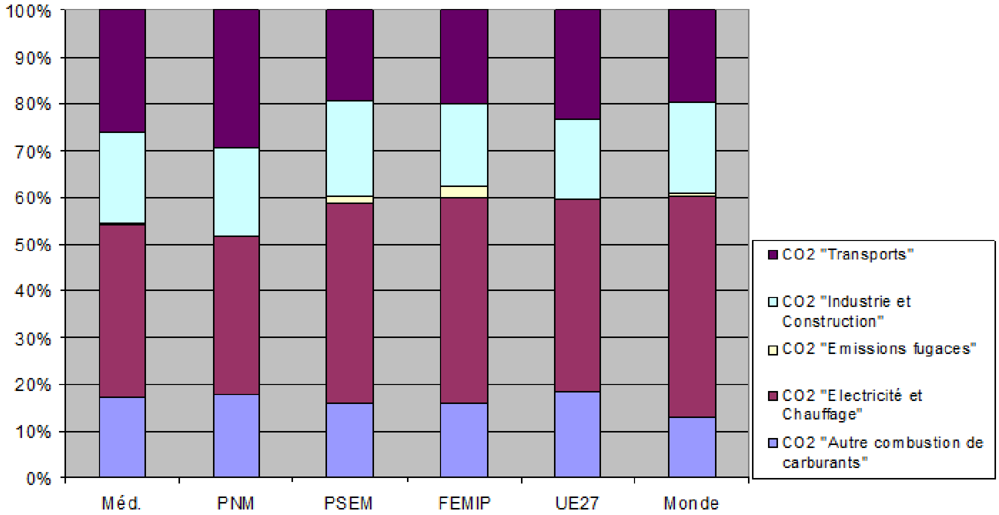
* Sectoral emissions according to level and variation are available for each country in annex.

1. CONTRIBUTION OF THE SECTORS TO EMISSIONS BY REGION: ELECTRICITY AND TRANSPORT, STAKE SECTORS

The CO_2 emissions due to energy use may be distributed into five major sectors within the framework of the emissions inventoried by WRI CAIT. These sectors are quite close to the classification of emissions proposed by the IPCC common notification framework of GHG emissions.[47] These five emitting sectors[48] are transport, industry and construction, fugitive emissions, electricity and heating, and finally other combustions of fuels. The contents of each sector and the relevant dynamics of emissions by region are specified in the following sections. Each region of the world is faced with a differentiated demand on energy for each of its sectors according to the specialisation of its economy, its development level, the natural conditions which it has to contend with (both in terms of exposure and in terms of allocations) or, again, the extent to which it has mainstreamed and implemented the question of rational energy use. The response to this energy need has a counterpart in terms of CO_2 emissions, and Figure 14 illustrates these relative emissions by sector in 2004.[49]

[47] A table summarizing the correspondence between the two systems for the whole emissions presented in this study is available in Annex.
[48] The emissions arising from international fuel reservoirs are not included in this part of the study.
[49] Cf. table in annex.

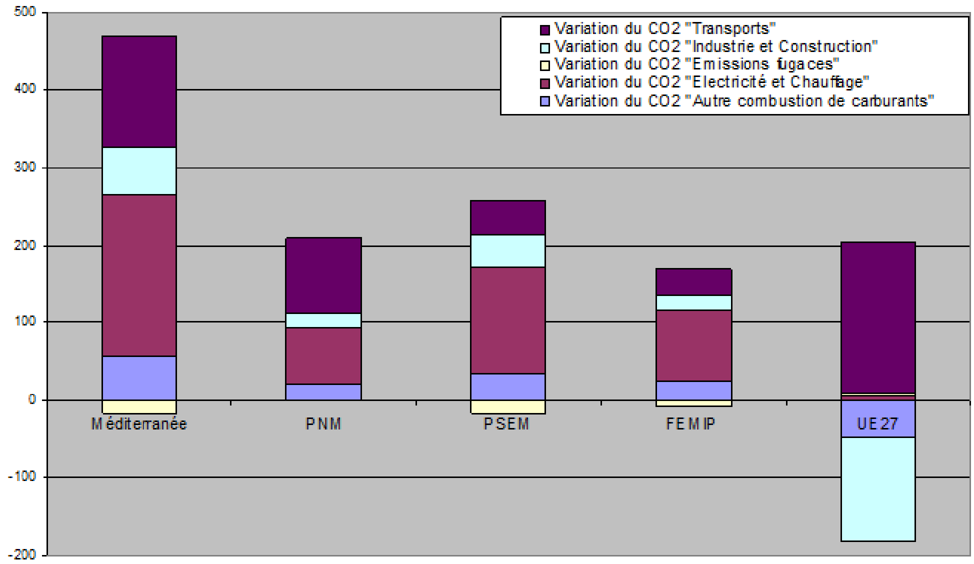
Figure 14 - Sectoral breakdown (%) of CO2 emissions due to energy use by region, 2004.



Source : Plan Bleu computations and formatting after WRI CAIT 5.0 data

Mediterranean emissions[50] are marked, as for all regions, by a dominant position held by emissions due to electricity, without, however, reaching the very high share (47% of the total) which it holds in the world situation among the emissions presented due to energy. The transport sector and that of the emissions generated by construction and industry hold an intermediate position in the emissions balance. The responsibility of the transport sector is more significant in regions whose per capita wealth is high, as in the NMCs (29% of total).

Figure 15 - Absolute sectoral contribution to absolute variation of CO2 emissions due to energy use by region, variation 1990-2004, million TCO2.



Source : Plan Bleu computations and formatting after WRI CAIT 5.0 data

The growth of CO_2 emissions can be considered based on the contribution of each sector to this same growth. This approach, materialized by Figure 15, gives the absolute variation of emissions by

[50] Sectoral emissions according to level and variation are available for each country in Annex.

sector and by region[51] between 1990 and 2004.[52] The SEMCs thus contributed more to the absolute rise of CO_2 emissions than the NMCs over the period observed.

In the SEMCs, the growth in emissions arises, for the major part, from the rise of electricity emissions, while in the NMCs it arises, above all, from an increase in the emissions due to transport. The increase in emissions in the EU-27 is exclusively due to the transport sector, while in the SEMCs, this sector ranks in third position in terms of absolute contribution to the rise.

The quasi-stagnation of the emissions of the EU-27 between 1990 and 2004 is mainly due to a significant drop in the emissions generated by industry and construction, while in the SEMCs this sector contributes to emissions more than the transport sector. The EU-27 and the SEMCs have, thus, experienced radically different changes in the structure of their emissions over the period 1990-2004.

2. ELECTRICITY AND HEATING

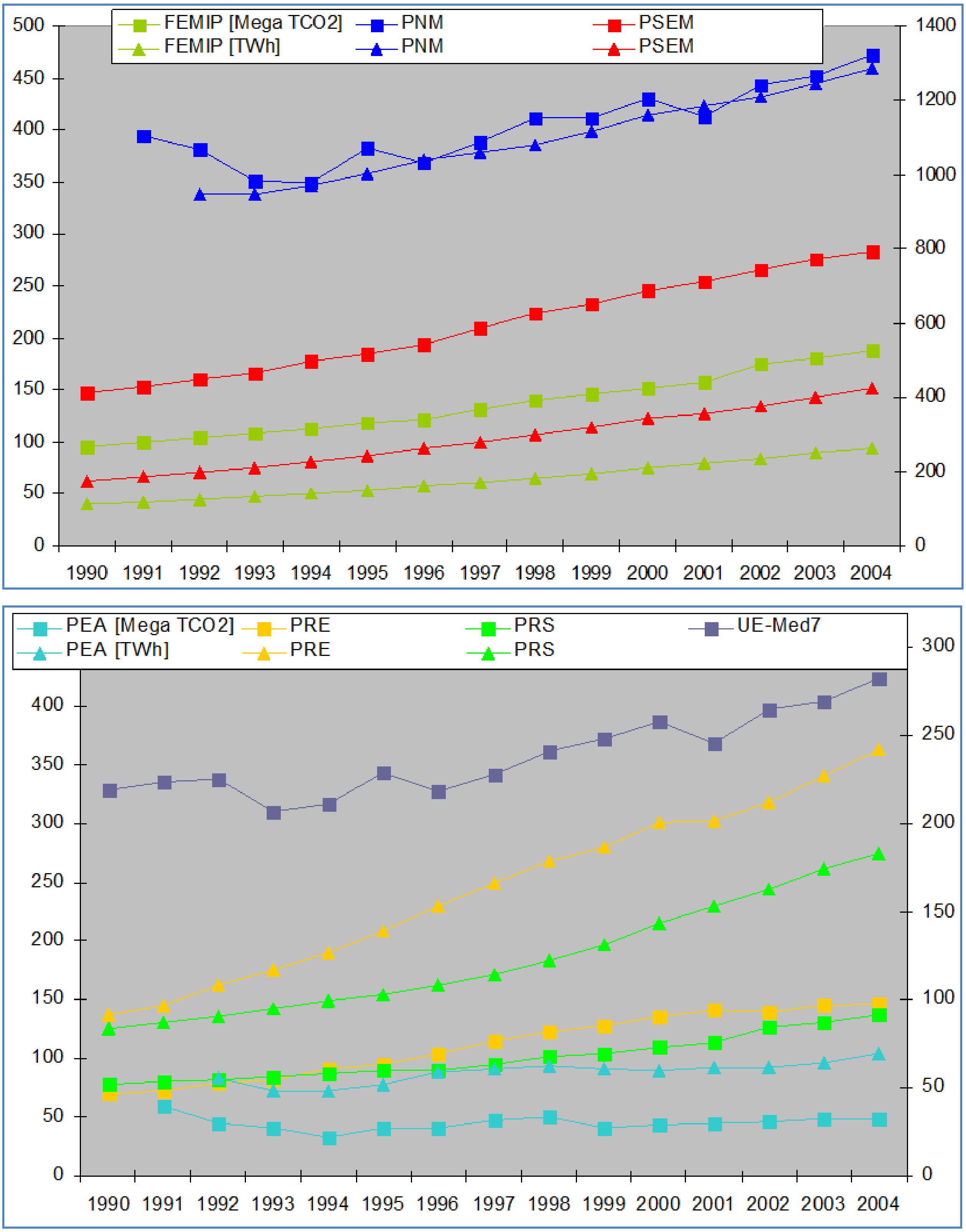
This section inventories the CO_2 emissions due to the production of electricity and heat either for commercial purposes or for self-use (or both), as well as the emissions resulting from the combustion of fossil energy by the other energy industries. These emissions are close to those of class "1A1" of IPCC.

In 2000, on a world level, the emissions due to the electricity and heating sector accounted for 25% of GHG emissions, that is the chief contribution to anthropogenic emissions (Diagram 1). In the NMCs and the SEMCs, this share was of 26% and 24%, respectively (Diagrams 2 and 3). In 2004, the share of these emissions within the CO_2 emissions due to energy stood at 34% for the NMCs and at 43% for the SEMCs.

[51] In Figure 15, certain flows are negative (such as the fall in the emissions resulting from industry for the whole world between 1990 and 2004); they need, therefore, to be subtracted from the positive flows in order to obtain the total absolute variation over the period.

[52] A table showing the flows of Figure 15 is available in Annex.

Figure 16 and Figure 17 - CO2 emissions due to electricity and heating (left hand side scale) and power production (right hand side scale) in the Mediterranean regions and sub-regions, 1990-2004.



Source : Plan Bleu computations and formatting after WRI CAIT 5.0 & IEA data

Electricity is a staple and strategic goods for the countries and their development. The demand on this not easily storable goods may arise primarily from industries or from the residential sector. Power production in the Mediterranean differs from the world situation in the sense that its production is much less met by coal as by nuclear energy (due to the weight of the French situation in the Mediterranean) and by natural gas. Thus, the carbon intensity of the production of electricity is lower in this region than in the world as a whole. Nevertheless, the rise in oil prices has induced a certain resistance to the use of coal for power production.

Table 5 - CO2 emissions due to electricity and heating by region, level in 2004 and variation over the period 1990-2004.

Région	2004, Millions de TCO2 issues du secteur "Electricité et chauffage"	Variation 1990-2004, %	2004, Production d'électricité, TWh	Variation 1990-2004, %
PRE	146	110	242	164
PRS	138	76	183	118
PEA*	49	-19	70	26
UE-Med7*	424	29	332	36
FEMIP	187	96	262	135
PSEM	284	92	424	142
PNM*	472	20	1288	36
UE27	1655	0		
Monde	13293	64	17373	47

Source : Plan Bleu computations and formatting after WRI CAIT 5.0 & IEA data
*Note : The baseline year for the rate of variation of emissions is 1991 for EACs and NMCs. The baseline year for the rate of variation of power production is 1992 for the EACs, NMCs and EU-Med7.

However, this region experiences a boom in demand on electricity (for example, for purposes of supply of new electrical appliances and a rise in standing), which is the most dynamic component of the rise in energy consumption and of the increase in CO_2 emissions. Thus, the growth in power production of the EMCs reported over 164% between 1990 and 2004, leading to an increase by more than 110% in the emissions due to the electricity and heating sector in this sub-region.

Certain SEMCs[53] then reported very big rises in these emissions, such as Syria (+157%) or Egypt (+123%). The growth of the emissions of the NMCs was more moderate, with countries such as France and Italy reporting only a slight increase in their emissions. Nevertheless, the growth of the NMCs (+ 20%) remains much higher than the stagnation of the emissions due to electricity and heating originating from the EU-27.

In terms of level of emissions of this sector, Italy, then Spain, are by far the largest emitters of the Mediterranean basin. Israel (66% of whose emissions originate from this sector) and Malta have, in terms of relative emissions, a very high share due to this sector, by contrast with Tunisia or Turkey (35% and 38%). Overall, the increase in demand on electricity is higher than economic growth.

Consequently, a reduction of the electrical intensity of growth (REU policies) and a decrease in the carbon intensity of power production (renewable energies) can contribute in curbing the increase in emissions due to consumption of this strategic goods.

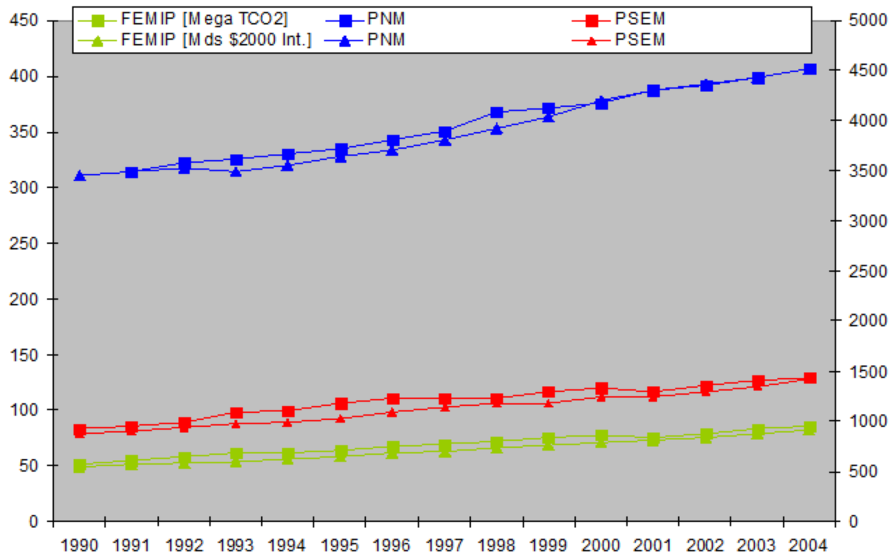
[53] The emissions and the growth of emissions by country of this sector are available in table format in Annex.

3. THE TRANSPORT SECTOR

CO_2 emissions due to energy use, such as those of the transport sector, comprise the emissions of domestic air transport (exclusive of international flights), land transport, railway, by pipeline, by intra-national navigation and other transport. The emissions generated by international fuel reservoirs intended for aviation and for the navy are excluded. These CO2 emissions correspond to the emissions of class "1A3" of IPCC.

The CO_2 emissions of this sector represented in 2000, for the world, the NMCs and the SEMCs 12%, 22% and 13 %, respectively, of the total of the emissions of anthropogenic GHG (Cf. Diagrams 1, 2, 3). In 2004, the share of this sector in the emissions presented in Part III is of 19% in the SEMCs and 29% in the NMCs. The share of the emissions of this sector in the Mediterranean originating from the NMCs is very high. Indeed, over three quarters of these Mediterranean emissions are the result of transport activities in the NMCs. The energy supply of this sector is quasi-exclusively provided by oil. On a global level, the emissions of this sector are largely dominated by the land transport component..

Figure 18 - CO2 emissions due to the transport sector (left hand side scale) and GDP (right hand side scale, PPP) in the Mediterranean regions, 1990-2004.



Source : Plan Bleu computations and formatting after WRI CAIT 5.0 data

The relatively low share of the emissions of the transport sector[54] in the SEMCs conceals a strong dynamics. Indeed, the growth of the emissions of the SEMCs in this sector reached 55% between 1990 and 2004, making of transport the second major contributor to the CO_2 emissions due to energy use in the SEMCs. The observation is the same for the aggregate of the FEMIP countries, as a whole, with however a higher growth and a bigger share of these emissions. In terms of emissions relating to the other sectors, transport accounts for 26% of the total in Jordan and in Lebanon, while it accounts for only 5% in Morocco. The high emitting countries[55] are France, Italy and Spain, in the North, and Turkey and Egypt, in the SEMCs. However, France and Malta reported "low" growths over the period, while Egypt and Lebanon saw their CO_2 emissions due to transport more than double between 1990 and 2004. Besides, the growth in the Mediterranean of the emissions of this sector was stronger in the SMCs than in all the other sub-regions. In spite of this North/South

[54] The sectoral emissions in level and variation are available for each country in Annex.
[55] The emissions and the growth of emissions by country of this sector are available in table format in Annex.

differential of growth of emissions, the level of per capita gross equipment in private car in the SEMCs is twelve times lower[56] than that of the economies of the EU-Med7 in 2002.

Table 6 - CO2 emissions due to the transport sector, level in 2004 and variation 1990-2004.

Région	2004, Millions de TCO2 issu du secteur "Transports"	Variation 1990-2004, %	Milliers de véhicules particuliers, 2002
PRE*	63,1	37	
PRS*	65,7	76	5460
PEA*	16,3	50	
UE-Med7	390,8	33	86649
FEMIP*	85,3	65	7642
PSEM*	128,8	55	
PNM*	407,1	30	
UE27*	947,6	26	209614
Monde	5589,3	44	

Source : Plan Bleu computations and formatting after WRI CAIT 5.0 & Eurostat/Medstat data
*Notes : The baseline year for the emissions variation is 1991 for the EACs and the NMCs. Number of private cars, excluding Libya and Lebanon, from the aggregates.

The emissions of the regions seem to be strongly connected with the level of production (in PPP). This linkage (Cf Figures 18) is a real challenge within the framework of a South/North convergence scenario of the levels of economic development. A disconnection economic growth/ transport emissions had not taken place yet in the NMCs at the turn of the century. The issue may, there again, be split into two sub-challenges: that of the countries' development pattern (space organization and place of transport at the heart of the growth mechanism and of society) and that of the carbon intensities of the means of transport (passenger and goods).

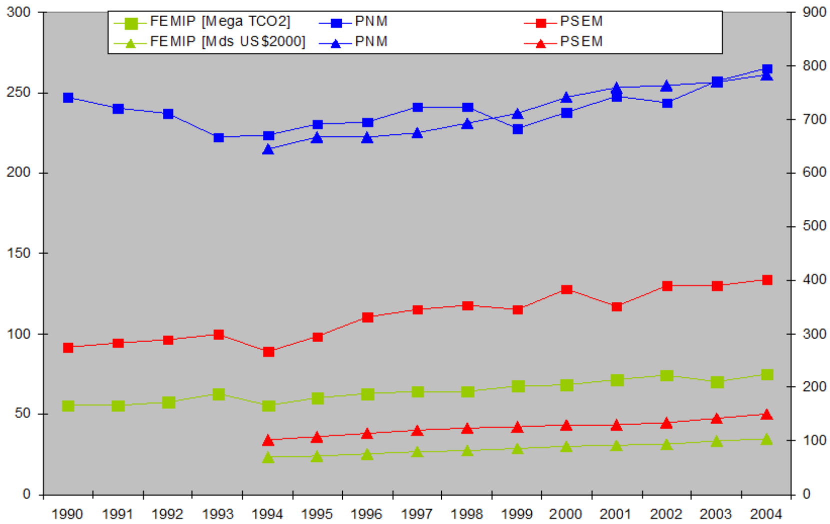
4. INDUSTRY AND CONSTRUCTION

The emissions of "industry and construction" comprise the direct CO_2 emissions due to the combustion of fossil energy. These CO_2 emissions have the same scope as those of class "1A2" of IPCC. However, the emissions due to electricity and heat self-production are excluded. The latter are included in the emissions of Section 2 of this Part, "Electricity and Heating".

The CO_2 emissions arising from energy use of the "industry and construction" sector accounted in 2000 for about 14% of GHG emissions in the NMCs and the SEMCs and a little more than 10% on global level (Cf Diagrams 1, 2, 3). This sector incorporates industries of very different nature. The main industries in terms of direct combustion of fossil energy are in particular those of chemistry and petro-chemistry, iron and steel, as well as those of cement (cf Box 2 for the CO_2 emissions arising from the cement industrial process). The share of emissions of these three industries due to direct combustion of fossil energy was, on a global level, respectively of 51%, 43% and 70% of their total GHG emissions in 2000.[57] According to production technologies, the level of energy efficiency and the carbon content of the energy used, the relative distribution and level of GHG emissions are likely to vary significantly from one region of the world to the other. Overall, the global industry and construction emissions due to energy combustion accounted, in 2000, for 49%[58] of the total GHG emissions of this same sector.

[56] Figure derived from Eurostat/ Medstat data, excluding Libya, Turkey and Lebanon. This ratio is not adjusted for the differential of size of the households and the larger population youth in the SEMCs.
[57] WRI (200ä).
[58] Ibid.

Figure 19 - CO2 emissions due to the industry and construction sector (left hand side scale) and Industry VA (right hand side scale, US$) in Mediterranean regions, 1990-2004.



Source : Plan Bleu computations and formatting after WRI CAIT 5.0 & WDI 2007 data
Notes : The Industry VA corresponds to the ISIC division 10-45 and comprises the ISIC division 15-37. The VA is not estimated in PPP, so there persist skews related to over-evaluated exchange rates in the series. Malta is absent in the whole series. Libya and Cyprus are absent in the Industry VA series. The NMCs series of Industry VA involves Serbia-M. only as from 2000.

Two thirds of the Mediterranean emissions of this sector[59] are due to NMCs in 2004; the remaining third is ascribed to the SEMCs. The growth of these emissions is steady in the SEMCs, while it is fairly low in the North. The emissions of the “industry and construction” sector have even dropped for the EU-27.60 This sectoral decrease in the EU has, to a large extent, led to a stagnation of the global CO_2 emissions due to energy. In France and in Italy, the emissions of this sector almost stagnated between 1990 and 2004 while they were strongly increasing in Spain.

Table 7 - CO2 emissions due to the industry and construction sector in the regions and sub-regions of the Mediterranean, 1990-2004.

Région	2004, Millions de TCO2 issu du secteur "Industrie et construction"	Variation 1990-2004, %	Variation VA Industrie (US$2000), 1994-2004, %
PRE	71,8	61	41
PRS*	61,9	32	51
PEA	16,9	-28	
UE-Med7*	248,4	11	21
FEMIP	75,1	35	50
PSEM*	133,7	46	46
PNM*	265,3	7	22
UE27	682,6	-16	
Monde	5499,3	14	

Source : Plan Bleu computations and formatting after WRI CAIT 5.0 & WDI 2007 data
Notes : The Industry VA corresponds to the ISIC division 10-45 and comprises the ISIC division 15-37. The VA is not estimated in PPP, so there persist skews related to over-evaluated exchange rates in the series. Malta is absent in the whole series. Libya and Cyprus are absent in the Industry VA. The NMCs series of Industry VA involves Serbia-M. only as from 2000, which slightly over-estimates the rise in VA..

Nevertheless, gains in terms of energy intensity of industries have brought in a contribution to this moderation. International industrial goods trade can, in addition, lead the countries to import more than they export carbon intensive manufactured products (cf. Ahmad, 2003). Jordan, Syria or Turkey have concurrently reported growth rates of over 60% in their emissions over the period

[59] Sectoral emissions in level and variation are available for each country in Annex.
[60] Industrial production in the Eastern countries of the EU-27 was drastically reduced in the early 1990s. This drop in production in the Eastern zone was coupled with dis-industrialisation phenomena in Western Europe.

observed. For Egypt, Cyprus or Turkey, industrial emissions account for over a quarter of the total CO_2 emissions due to energy, while this share is a mere 12% for Algeria in 2004. Emission levels are, particularly, influenced by the specialisation of the economies, production technology, type of industry (heavy or more labour intensive), level of energy efficiency and fuel mix of the industries.

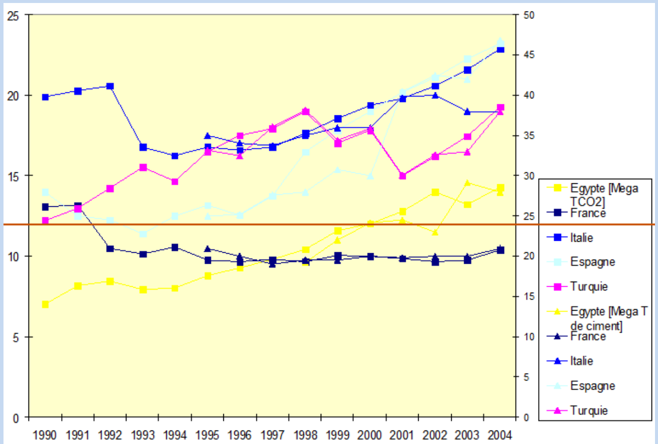
Box 2 - A few figures on CO_2 emissions in the Mediterranean and decarbonation in the cement industry

On global level, GHG emissions due to cement accounted for 3.8% of the total in 2000.* Emissions arising from cement industries are of three sources: there are those which arise from direct energy inputs (fossil energies), and from power consumption, and those inherent in the specificity of the industrial process, called “decarbonation”. Thus, on global level, the respective share of these three in total emissions of GHG cement stood, in 2000, at 43%, 5% and 52%.*

The emissions presented here are those clearly identified as arising from the decarbonation process operating during the production of clinker (intermediate product). These emissions have nothing in common, in terms of their nature, with the other presented in this Part III of the study; in other words, we are no talking of energy use. Decarbonation occurs during very high temperature firing of limestone which induces production of lime and of CO2. These CO2 emissions accounted—on global, NMCs and SEMCs level—for 2%, 4% and 5%, respectively, of the total GHG emissions in 2000 (cf. Diagrams 1, 2, 3)

Cement plant activity is strongly connected with the countries’ economic development and the construction of infrastructures. Henceforth, the additional demand on this goods issues mainly from developing countries, and certain Mediterranean countries have reported a very high production of this particular goods. The growth of this sector “fosters” and drives the rise in emissions related to energy by creating new structures that are potentially CO2 emitting (direct and induced emissions of buildings, emissions of the transport sector…). In this sense, this sector is a key sector. Besides, the WRI CAIT allows a clear differentiation of the emissions arising from decarbonation consisting in data provided by CDIAC and corresponding to the class of emissions “2A1” of IPCC.

Figure 20 and Table 8 - CO2 emissions due to decarbonation (left hand side scale) and cement production (right hand side scale) in the Mediterranean, 1990-2004.



Région	2004, Millions de TCO2 issu de la décarbonatation	Variation 1990-2004, %	Production de ciment, 2004, millions TCO2	Variation, 1995-2004, %
Italie	23	15	38	9
France	10	-21	21	0
Espagne	23	66	47	87
Turquie	19	58	38	15
Egypte	14	104	28	(1998-2004) 47
PRE	25	61		
PRS	29	92		
PEA	4	17		
UE-Med7	65	19		
FEMIP	36	93		
PSEM	55	76		
PNM	69	19		
UE27	120	1		
Monde	1092	90	2130	50

Source : Plan Bleu computations after WRI CAIT 5.0 & USDIGS data

In terms of level, these emissions** are still, for the major part, located in the NMCs, but the increase of these emissions in the Mediterranean originates from the SEMCs. This is mainly due to the fact that the NMCs are faced with a demand on cement for purposes consisting primarily in the renovation and maintenance of existing structures. However, the Spanish increase, accompanied by a housing estate boom, has led to a 66% rise in Spain’s emissions. The increase of these emissions in the South is particularly high in Lebanon, Morocco and Jordan, which have all reported a more than a twofold increase in these emissions within 15 years, that is a rate higher than global growth. Thus, the SMCs or FEMIP countries have reported trends close to the world situation, where exponential demand is mainly driven upwards by the major Asian countries. The relative CO2 emissions reveal that the phenomenon of decarbonation of cement industries alone accounts for over 15% of the scale of the CO2 emissions due to energy use in Tunisia or in Morocco.

The major cement producing countries in the Mediterranean are Spain, Turkey, Italy and Egypt. The Mediterranean basin represents a European hub of international trade in cement and clinker.*** Turkey is the top external world supplier of cement to the EU and, in particular, to Italy. The trade in the intermediate product, clinker, to the EU is claimed mainly by China and Egypt. Spain imports clinker from Egypt, which thus represents its second world supplier. However, international cement and clinker flows vary rapidly. This international trade constitutes a supply of carbon rich construction material from countries where production technologies, fuel mix and, especially, legislation on CO2 emissions are, sometimes, fairly different from those of the importing countries.

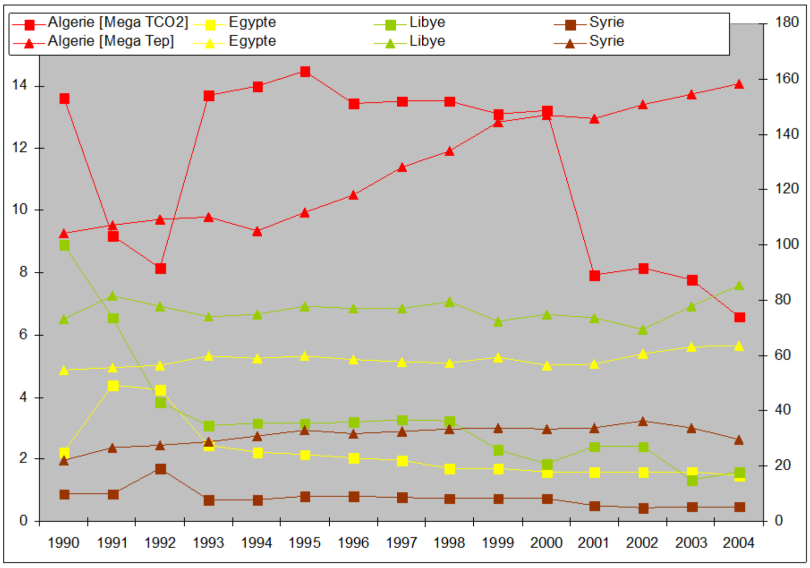
*WRI (2005a). **Sectoral emissions in level and in variation are available for each country in Annex. *** The descriptions of international flows are mainly derived from a presentation entitled “Emissions Trading and Cement: What does the empirical data suggest?” by N. Walker..

5. FUGITIVE EMISSIONS AND OTHER EMISSIONS

5.1. Fugitive emissions

"Fugitive" emissions are GHG emissions released deliberately or accidentally during human activities. These emissions may occur throughout the chain, right from the production up to energy use if these emissions do not sustain a productive activity. Total fugitive emissions (CO_2 and non-CO_2) accounted, in 2000, for 3.8 % of the global GHG emissions, 0.9% in the NMCs and 8.9% in the SEMCs (Diagrams 1, 2, 3). Methane emissions due to oil or gas energy systems, as well as to coal mines, are not included in the data presented below. The fugitive emissions studied in this section are those of CO_2 generated by flaring and venting of gas, particularly during energy production for safety or use reasons. These emissions correspond to the class "1B2c" within the framework of IPCC emissions notification. The data presented are derived from CAIT5.0; the secondary source being the IEA.

Figure 21 and Table 9 - CO2 emissions due to fugitive emissions (left hand side scale) and primary energy production (right hand side scale) for a few Mediterranean countries, 1990-2004.



Région	2004, Millions de TCO2 issu des "émissions fugaces"	Variation 1990-2004, %	Production d'énergie primaire, 2004, millions de tep.	Variation 1990-2004, %
Algerie	6,6	-52	158	51
Egypte	1,5	-33	63	16
Libye	1,6	-82	85	17
Syrie	0,5	-45	30	32
Tunisie*	0,8	0	7	12
Monde	161,8	-9	11171	27

Source : Plan Bleu computations and formatting after WRI CAIT 5.0 and IEA data
*Note : The baseline year for the variation of emissions for Tunisia is 1993..

Fugitive CO_2 emissions, such as defined above,[61] are in the Mediterranean due to a few gas and oil producing and exporting countries. These emissions reported, on the whole, a decrease between 1990 and 2004 even while energy production increased over the same period. In 2004 in the SMCs, these emissions accounted for 3.2% of the CO_2 emissions related to energy. The top contributor, in terms of level, to fugitive CO_2 emissions is Algeria. The emissions of this country represented over a half of the total Mediterranean emissions in 2004 in spite of a significant fall of these emissions in a context of a rise in its energy production over the period observed (cf Figure 2 1 and Table 9). In 2004, these fugitive emissions accounted for 8% of the total CO_2 emissions of Algeria. The other large emitters are Egypt and Libya. Tunisia is the only country to have maintained, on the same level, this type of emissions while the regional context is on the decrease.

The fugitive emissions of CO_2 due to energy use thus follow an encouraging downward trend in gas and oil producing Mediterranean countries. However, the 1990s reported a rise in fugitive methane

[61] Sectoral emissions in level and variation are available for each country in Annex.

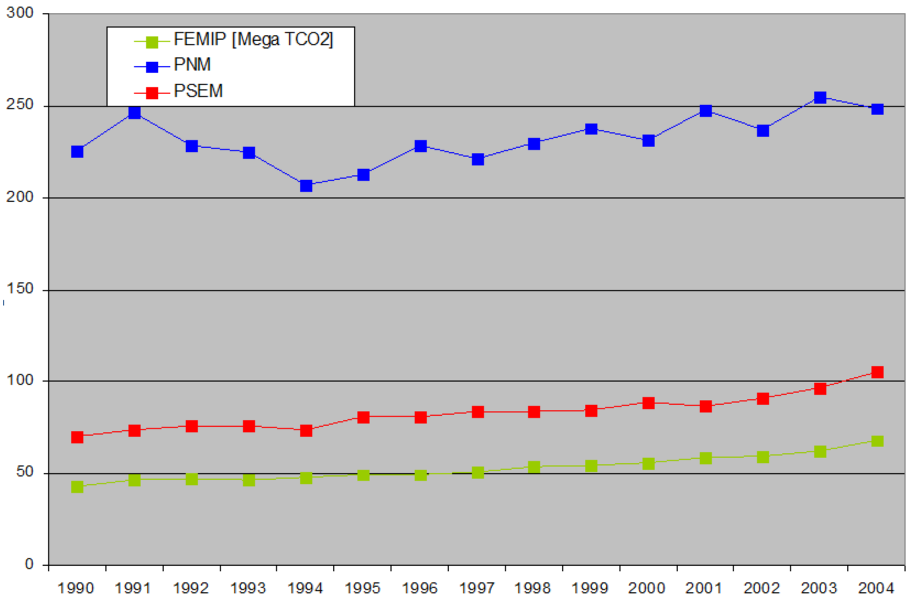
emissions arising from energy systems. These fugitive methane emissions in the SEMCs thus increased by more than 80% between 1990 and 2000. Additional efforts must also be exerted with regard to this precise type of emissions. Fugitive emissions could, in the case of export of gas and oil and within the "CO_2 consumption" logic, be at least in part ascribed to the importing countries of these energy raw materials.

5.2. Emissions due to other fuel combustions

The emissions of this sector are a heterogeneous grouping of the CO_2 emissions arising from sectors not covered above. These emissions are those resulting from individual direct combustion or in district of fossil energy arising from commercial and institutional activities, and the residential sector. This section also groups the emissions originating from the combustion of fossil energy by agricultural, fishery and forestry activities; "CAIT 5.0" does not allow a differentiation of these various components. These emissions correspond to the CO_2 emissions of class "1A4" of IPCC classification.

On a global level, the emissions of this heterogeneous aggregate originate mainly in the residential sector, then in the commercial sector and, finally, in the energy inputs of agricultural production. In 2000, the GHG emissions of this sector accounted for 9% of the world total, while this share was 10% and 15%, respectively, in the SEMCs and the NMCs. In 2004, the CO_2 emissions of this sector represented, for these same regions, 13%, 16% and 18% of their CO_2 emissions due to energy use.

Figure 22 - CO2 emissions due to other combustions of fuels in Mediterranean regions and sub-regions, 1990-2004



Source : Plan Bleu computations and formatting after WRI CAIT 5.0 data

The world emissions from the buildings of the residential sector amount to the double of those arising from commercial or institutional buildings.[62] Their nature and their use cause commercial and institutional buildings to emit, in proportion, more CO_2 in an indirect way through their power supply. These indirect emissions are not reckoned in this section. The relative weight of these two sectors (i.e., the residential and commercial sectors) cannot be known in the Mediterranean due to a CAIT aggregate. Nevertheless, the direct CO_2 emissions ascribed to this section[63] report in the Mediterranean a geographical distribution originating at 70% from the NMCs. These emissions arise

[62] WRI (2005a)
[63] The sectoral emissions in level and variation are available for each country in appendix.

from the heating and cooling of buildings or, again, kitchen activities. The share of these direct CO_2 emissions in the total CO_2 emissions related to energy use increases in proportion to the level of per capita wealth, but it also depends on the climate, as well as on integrating the aspect of energy efficiency in buildings.

Table 10 - CO2 emissions due to other combustions of fuels in the regions and sub-regions of the Mediterranean, 1990-2004

Région	2004, Millions de TCO2 issu des "Autres combustion de carburants"	Variation 1990-2004, %
PEA	13	-42
UE-Med7	235	16
PRE	54	36
PRS	52	71
FEMIP	68	58
PSEM	105	51
PNM	248	10
UE27	743	-6
Monde	3684	10

Source : Plan Bleu computations and formatting after WRI CAIT 5.0

The CO_2 emissions due to this sector reported a marked increase between 1990 and 2004 in the SEMCs (five times higher than the world rate), particularly in the SMCs, as in Morocco[64] (+108%) or in Libya (+102%). Algeria and Tunisia are, too, characterized by a strong growth of the emissions of this sector, to which there may be added a share that is henceforth ascribed at 20% of the total of their CO_2 emissions resulting from energy use. On the other hand, the increase remains moderate on average in the NMCs, with 16% of growth in the EU-Med7 countries. This low growth conceals the strong increase in emissions for Spain (+78%). This is partly due to a high level of new constructions in this country.

This sector of direct CO_2 emissions due to the energy arising from these other fuel combustions, and in particular from buildings, leaves ample room for legal regulation not only in terms of coupling constructions with capacity building in matter of production of renewable energies, but also in terms of energy quality of constructions. The existence and proper implementation of such legislations are all the more pressing as the useful life of this type of emission-generating asset is very long. Buildings thus leave a several decade mark on the energy quality of the housing stock. This fact pleads for a proactive move in the SEMCs, the cities and the coastline where the growth of the construction sector is strong. The buildings sector is characterised by being at the crossroads of combating GHG emissions and of adaptation to climate change.

[64] The following elements related to this sector in Morocco are observed in the national study on Morocco of UNEP/MAP/Plan Bleu (MTS N°167, 2007, page 506) "Absence of energy considerations in the design, construction, equipment and management of collective buildings; marked increase in energy expenditure owing to expectations of quality service and comfort on the part of users".

IV. CONCLUSION

The Mediterranean basin is characterized by anthropogenic GHG emissions that are quite substantially composed of CO_2 arising from the use of fossil energy. CO_2 emissions are, in the Mediterranean, quasi-exclusively due to the use of such energy as oil, gas or coal, which are naturally present on the Southern rim of this region.

On Mediterranean level, "land use change and forestry" (LUCF) generate little CO_2 emissions, contrary to the emissions balance of other African countries. Overall, the CO_2 emissions due to energy use accounted, in the SEMCs, for about 64% of GHG emissions in 2000; this share was of 77% in the NMCs and of only 57% on global level.

In the SEMCs, the high level of the emissions arising from wastes and cement industries constitutes two notable facts in view of the structure of global emissions or even of that of the emissions of the NMCs.

The aggregate CO_2 emissions arising from energy of the SEMCs since 1850 accounted for a mere 1.4% of the aggregate global emissions over the same period. In 2005, this zone emitted less than 3% of the global CO_2 emissions related to energy. The historical contribution to aggregate emissions is 6% for the NMCs, the latter emitting still about two thirds of Mediterranean emissions.

Without a behavioural change on the part of the players, the various emissions growth rates reported by both rims of the Mediterranean could bring the SEMCs to account for about a half of the Mediterranean emissions by 2020. The growth of the emissions of the SEMCs was already higher than global growth between 1990 and 2004.

The expected challenge in the SEMCs, related to demographic growth and to South/North economic convergence, lays a great responsibility on policies of anticipation and of control over GHG emissions in these countries. The NMCs are already addressing a legitimate need for immediate reduction of their emissions. The capacity to generate wealth via a controlled carbon intensity of the economies is one of the transmission channels at the heart of the GHG emissions.

From a sectoral point of view, the immediate challenge lies, in the NMCs, in the issue of the emissions resulting from transport whose disconnecting with economic growth appears to be a major point within the framework of mitigation of GHG emissions. This sector was, in the NMCs, the chief contributor in the rise of CO_2 emissions between 1990 and 2004.

The CO_2 emissions arising from the SEMCs and the FEMIP countries highlight the importance of the issue of the emissions due to power production. These countries are faced with a boom in demand on this goods, especially for use in the residential sector. Overall, the various emissions arising from buildings (construction, cement factories, electricity, direct energy combustion …) and, thus from the residential, commercial and institutional sectors, constitute today the major challenge in terms of control over GHG emissions. Buildings represent, henceforth, a strategic sector, all the more so as this sector is, by its very nature, sustained by long term investments, and lies at the crossroads of the twofold issue of control over GHG emissions and adaptation to climate change. The transport sector (passenger and goods) is, in its turn, a subject for concern in the countries of the Southern rim of the Mediterranean (SMCs) not only in view of the demographic pressure, but also of the demand on mobility which is likely to rise and impact the emissions of this sector.

Adequate physical and human investments and the implementation of legislation related to the multidimensional buildings sector, as well as that of transport, should strongly contribute in containing GHG emissions originating in the SEMCs and in the FEMIP countries for the decades to come.

ANNEXES

1. ANNEX I. COUNTRIES AND REGIONS USED AND REFERRED TO IN THE STUDY

Additional item 1 : List of countries, and geographical sub-regions and regions used

Countries and regions	Region 1	FEMIP	Region 2	Sub-Region	Number of countries
Spain	Med		PNM	UE-Med 7	1
France	Med		PNM	UE-Med 7	1
Italy	Med		PNM	UE-Med 7	1
Slovenia	Med		PNM	UE-Med 7	1
Greece	Med		PNM	UE-Med 7	1
Cyprus	Med		PNM	UE-Med 7	1
Malta	Med		PNM	UE-Med 7	1
Croatia	Med		PNM	PEA	1
Bosnia & Herzegovina	Med		PNM	PEA	1
Serbia & Montenegro	Med		PNM	PEA	1
Albania	Med		PNM	PEA	1
Morocco	Med	FEMIP	PSEM	PRS	1
Algeria	Med	FEMIP	PSEM	PRS	1
Tunisia	Med	FEMIP	PSEM	PRS	1
Libya	Med		PSEM	PRS	1
Egypt	Med	FEMIP	PSEM	PRS	1
Israel	Med	FEMIP	PSEM	PRE	1
Lebanon	Med	FEMIP	PSEM	PRE	1
Syria	Med	FEMIP	PSEM	PRE	1
Turkey	Med		PSEM	PRE	1
Jordan		FEMIP			1
PRS [Pays de la Rive Sud]	Med		PSEM	PRS	5
PRE [Pays de la Rive Est]	Med		PSEM	PRE	4
UE-Med7 [Pays de l'Union Européenne ayant une rive méditerranéenne]	Med		PNM	UE-Med7	7
PEA [Pays de l'Est Adriatique]	Med		PNM	PEA	4
FEMIP [Facilité euro méditerranéenne d'investissement et de partenariat, Turquie non comprise]		FEMIP			8
PSEM [Pays du Sud et de l'Est de la Méditerranée]	Med		PSEM		9
PNM [Pays du Nord de la Méditerranée]	Med		PNM		11
Méditerranée [Pays ayant une rive méditerranéenne et pour lesquels Cait fournis des données]	Med		Med		20
12NPM-UE27 [Les 12 Pays Membres de l'Union Européenne depuis 2004]	UE27		12NPM-UE27		10 [Bulgaria, Cyprus, the Czech Republic, Estonia, Hungary, Latvia, Lithuania, Malta, Poland, Romania, Slovakia, Slovenia]
UE27 [Union Européenne à 27 pays]	UE27		UE27		27
World	World				

Notes : Données Cait indisponibles pour l'Autorité Palestinienne et données Monaco incluses dans France

2. ANNEX II. DATA SOURCES

2.1. Part I

2.1.1. Cait "Excel 3.0"

http://cait.wri.org/

2.1.2. Cait 4.0

World Ressources Institute / Climate Analysis Indicator Tool

http://cait.wri.org/

WRI (2005), "CAIT: Greenhouse Gas Sources & Methods".

2.1.3. Secondary sources emisions data (used by Cait 4.0):

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EPA. 2004a. Personal communications based on "Global Non- CO_2 Greenhouse Gas Emissions: 1990 - 2020." (forthcoming 2005). Partial draft data available at: http://www.epa.gov/non CO_2/econ-inv/international.html.

Houghton Houghton, R.A. 2003. "Emissions (and Sinks) of Carbon from Land-Use Change." (Estimates of national sources and sinks of carbon resulting from changes in land use, 1950 to 2000). Report to the World Resources Institute from the Woods Hole Research Center. Available at: http://cait.wri.org.

IEA IEA. 2004. CO_2 Emissions from Fuel Combustion (2004 edition). Available online at: http://data.iea.org/ieastore/ CO_2_main.asp.

2.1.4. Additional sources

OME/Plan Bleu (2006).

IEA/WEO (2006).

Agence Européenne de l'Environnement [http://dataservice.eea.europa.eu/dataservice]

IEA (2007).

EIA/IEO (2007).

2.1.5. Sources for the baseline approach to GHG emissions and CO2 historical emissions as per Mediterranean country (CAIT Excel 3.0 and CAIT 4.0; Part I)

Additional item 2 : Sources for the baseline approach to GHG emissions and CO2 historical emissions as per Mediterranean country (CAIT Excel 3.0 and CAIT 4.0; Part I)

Country	CO_2 from fossil fuels	CO_2 from land Use Change & Forestry	Non-CO2 Gases (1990, 1995, 2000)	
			CH4 & N20	HFCs, PFCs, SF6
Albania	1933-1970 (CDIAC); 1971-2003 (IEA)	1950-2000 (Houghton)	EPA	EPA
Algeria	1916-1970 (CDIAC); 1971-2003 (IEA)	1950-2000 (Houghton)	EPA	EPA
Bosnia & Herzegovina	1916-1970 (CDIAC); 1971-2003 (IEA)	1990-2000 (Houghton)	EDGAR († 2000)	EPA
	Based on WRI estimates prior to 1992 (Yugoslavia).			
Cyprus	1950-1970 (CDIAC); 1971-2003 (IEA)	1950-2000 (Houghton)	EDGAR († 2000)	EPA
Croatia	1885-1970 (CDIAC); 1971-2003 (IEA)	1976-2000 (Houghton)	EPA	EPA
	Based on WRI estimates prior to 1991 (Yugoslavia).			
Egypt	1911-1970 (CDIAC); 1971-2003 (IEA)	1950-2000 (Houghton)	EPA	EPA
France	1850-1959 (CDIAC); 1960-2003 (IEA) Includes Monaco, and excludes overseas departments, including French Polynesia, Guadeloupe, Martinique, and La Réunion. (CDIAC and IEA).	1950-2000 (Houghton)	EPA Includes Monaco.	EPA
Greece	1867-1959 (CDIAC); 1960-2003 (IEA)	1950-2000 (Houghton)	EPA	EPA
Israel	1930-1970 (CDIAC); 1971-2003 (IEA)	1950-2000 (Houghton)	EPA	EPA
Italy	1860-1959 (CDIAC); 1960-2003 (IEA) Includes San Marino and the Vatican (CDIAC and IEA).	1950-2000 (Houghton)	EPA Includes San Marino.	EPA
Lebanon	1931-1970 (CDIAC); 1971-2003 (IEA)	1950-2000 (Houghton)	EDGAR († 2000)	EPA
Libya	1950-1970 (CDIAC); 1971-2003 (IEA)	1950-2000 (Houghton)	EDGAR († 2000)	EPA
Malta	1950-1970 (CDIAC); 1971-2003 (IEA)	1950-2000 (Houghton)	EDGAR († 2000)	EPA
Morocco	1928-1970 (CDIAC); 1971-2003 (IEA)	1950-2000 (Houghton)	EDGAR († 2000)	EPA
Serbia & Montenegro	1885-1970 (CDIAC); 1971-2003 (IEA) Formerly the "Federal Republic of Yugoslavia"; Based on WRI estimates prior to 1988 (Yugoslavia).	1976-2000 (Houghton)	EDGAR († 2000)	EPA
Slovenia	1885-1970 (CDIAC); 1971-2003 (IEA) Based on WRI estimates prior to 1980 (Yugoslavia).	1992-2000 (Houghton)	EPA	EPA
Spain	1850-1959 (CDIAC); 1960-2003 (IEA)	1950-2000 (Houghton)	EPA	EPA
	Includes the Canary Islands.			
Syria	1931-1970 (CDIAC); 1971-2003 (IEA)	1950-2000 (Houghton)	EDGAR († 2000)	EPA
Tunisia	1916-1970 (CDIAC); 1971-2003 (IEA)	1950-2000 (Houghton)	EDGAR († 2000)	EPA
Turkey	1865-1959 (CDIAC); 1960-2003 (IEA)	1950-2000 (Houghton)	EPA	EPA

Note : [†] WRI estimates

2.1.6. • Sectoral approach and sources of GHG emissions; [CAIT 4.0]

[WRI (2005b), p. 15]

Additional item 3 : Sectoral approach and sources of GHG emissions; [CAIT 4.0]

Table 3. Summary of CAIT Sector Data

CAIT Sector Category	CAIT Sector Contents	IPCC Category	Gas	Data Source (years)
Energy		1		
Electricity & Heat[1]	Electricity & heat plants (fossil fuels)			
	- Public plants (electricity, heat, CHP)	1 A 1 a	CO_2	IEA (1980 to 2002)
	- Autoproducers (electricity, heat, CHP)	1 A	CO_2	IEA (1980 to 2002)
	Other Energy Industries (fossil fuels)	1 A 1 b,c	CO_2	IEA (1980 to 2002)
Manufacturing & Const.	Manufacturing & Const. (fossil fuels)	1 A 2	CO_2	IEA (1980 to 2002)
Transportation	Transportation (fossil fuels)	1 A 3	CO_2	IEA (1980 to 2002)
Other Fuel Combustion[2]	Other Sectors (fossil fuels)	1 A 4	CO_2	IEA (1980 to 2002)
	Biomass Combustion	1 A 5	CH_4, N_2O	EPA (90, 95, 2000)
	Stationary and Mobile Sources	1 A 5	CH_4, N_2O	EPA (90, 95, 2000)
Fugitive Emissions	Gas Venting/Flaring	1 B 2c	CO_2	EIA (1980 to 2002)
	Oil & Natural Gas Systems	1 B 2	CH_4, N_2O	EPA (90, 95, 2000)
	Coal Mining	1 B 1	CH_4, N_2O	EPA (90, 95, 2000)
Industrial Processes	Cement	2 A 1	CO_2	CDIAC (1980 to 2002)
	Adipic and Nitric Acid Production	2 B 2,3	N_2O	EPA (90, 95, 2000)
	Other Industrial non-Agriculture	2	CH_4, N_2O	EPA (90, 95, 2000)
	All Fluorinated Gases	2	HFCs,PFCs,SF_6	EPA (90, 95, 2000)
Agriculture[3]	Enteric Fermentation (Livestock)	4 A	CH_4	EPA (90, 95, 2000)
	Livestock Manure Management	4 B	CH_4, N_2O	EPA (90, 95, 2000)
	Rice Cultivation	4 C	CH_4	EPA (90, 95, 2000)
	Agricultural Soils	4 D	N_2O	EPA (90, 95, 2000)
	Other Agricultural Sources	4	CH_4, N_2O	EPA (90, 95, 2000)
Land Use Change & Forestry	All	5	CO_2	Houghton (1950-2000)
Waste	Landfills (Solid Waste)	6 A	CH_4	EPA (90, 95, 2000)
	Wastewater Treatment	6 B	CH_4	EPA (90, 95, 2000)
	Human Sewage	6 B	N_2O	EPA (90, 95, 2000)
	Other	6 D	CH_4, N_2O	EPA (90, 95, 2000)
International Bunkers	Aviation Bunkers	1 A 3a*i*	CO_2	IEA (1980 to 2002)
	Marine Bunkers	1 A 3d*i*	CO_2	IEA (1980 to 2002)

Sources: IPCC, 1996b; IEA, 2004a; CAIT-UNFCCC. **Notes**:

[1] Refers mainly, but not exclusively to electricity and heat (including CHP) produced by entities whose primary activity is to supply the public. Here, this category also includes *autoproducers* and *other energy industries*. *Autoproducers* generate electricity, wholly or partly for their own use as an activity which supports their primary activity. They may be privately or publicly owned. Ideally these emissions should be allocated to the sector for which the electricity and/or heat was generated. CO_2 and energy statistics from the IEA do not allow for this. *Other energy industries* refer to emissions from fuel combusted in association with production and processing (for example, petroleum refineries) of fossil fuels, and is thus not strictly electricity or heat (IEA, 2004a).

[2] Emissions from fuel combustion in (1) commercial and institutional buildings, (2) residential buildings, (3) agriculture, forestry, or domestic inland, coastal and deep-sea fishing, and (4) remaining non-specified emissions (IEA, 2004a).

[3] Consistent with IPCC Source/Sink categories, CO_2 associated with fuel combustion in the agricultural sector is included under the Energy, not Agriculture Sector.

Note : The latest year available for CAIT 4.0 is 2003, though this table displays 2002.

2.2. Parts II and III

2.2.1. Cait 5.0

World Resources Institute / Climate Analysis Indicator Tool

http://cait.wri.org/

WRI (2007b), "CAIT: Greenhouse Gas Sources & Methods". Version 2007. Disponible à l'adresse Internet: http://cait.wri.org/downloads/cait_ghgs.pdf

2.2.2. Secondary sources emisions data (used by Cait 5.0 and in part II and III)

CDIAC Marland, G., T.A. Boden, and R. J. Andres. 2007. "Global, Regional, and National Fossil Fuel CO_2 Emissions." In Trends: A Compendium

EIA 2007. International Energy Annual 2005. Available online at: http://www.eia.doe.gov/iea/carbon.html.

IEA 2006. CO_2 Emissions from Fuel Combustion (2006 edition). Available online at: http://data.iea.org/ieastore/ CO_2_main.asp.

of Data on Global Change. Carbon Dioxide Information Analysis Center, Oak Ridge National Laboratory, U.S. Department of Energy, Oak Ridge, Tenn., U.S.A. Available online at: http://cdiac.esd.ornl.gov/trends/emis/meth_reg.htm.

2.2.3. Main data sources for informations not related to emisions and GHG contained in part II

WRI (2007a), “CAIT: Indicator Framework Paper.”

http://cait.wri.org/downloads/framework_paper.pdf

2.2.4. Other sources

USGS (2007). Available at : http://minerals.usgs.gov/minerals/pubs/mcs/

EUROSTAT Programme MEDSTAT II.

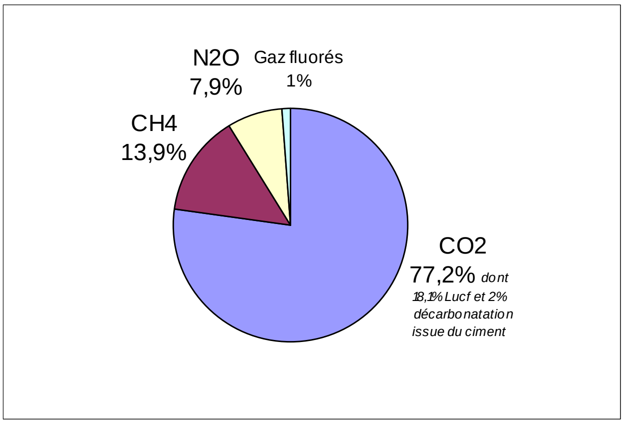
2.2.5. Sectoral approach and sources of GHG emissions and correspondence with the IPCC emissions frame; [Cait 5.0] (Additional element: 4)

WRI (2007b), “CAIT: Greenhouse Gas Sources & Methods”, p. 15.

http://cait.wri.org/downloads/cait_ghgs.pdf

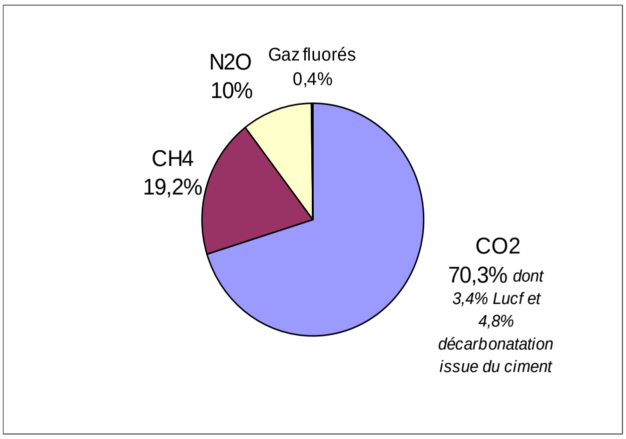
3. ANNEX III. BREAKDOWN BY GAS OF GHG EMISSIONS IN 2000, BASELINE APPROACH

Additional item 5 : Breakdown by gas of global GHG emissions in 2000, total 42 Billion TECO2



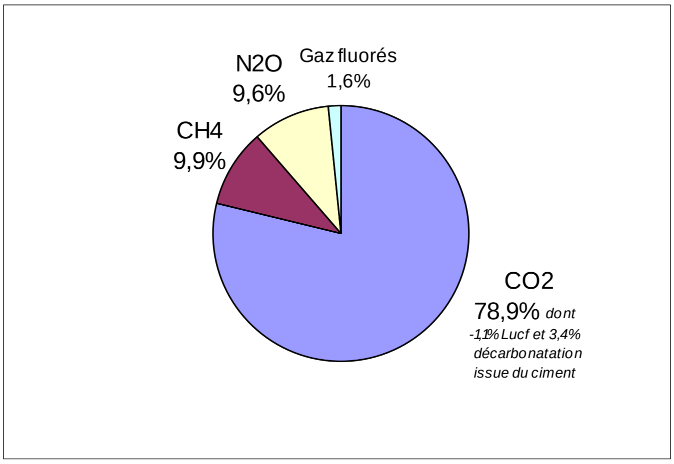
Source :Plan Bleu computations and formatting after WRI CAIT 4.0 data for the year 2000.
Notes : Percentages related to anthropogenic GHG emissions standardised as equivalent CO2 (global warming power over 100 years, IPCC recommendations [1996]). Plan Bleu estimates based on aggregated data for 2000 supplied by the on line WRI CAIT interface. The data are derived from a baseline approach (notably for non-CO2 gases). Emissions due to land use change and forestry – LUCF (Houghton, 2003) are included, subject to a reserve on estimate uncertainty. International fuel reservoirs are also incorporated in the data presented.

Additional item 5 : Breakdown by gas of the GHG emissions of the SEMCs in 2000, total 1.02 Billion TECO2



Source and notes : Same as for additional item 1

Additional item 7: Breakdown by gas of the GHG emissions of the NMCs in 2000, total 1.76 Billion $TECO_2$



Source and notes : Same as for additional item 1

4. ANNEX IV. LEVELS IN 2004 OF THE VARIABLES ISSUING FROM THE BREAKDOWN OF THE VARIATION OF EMISSIONS BY COUNTRIES AND REGIONS (PART II)

Additional item 8 : Level in 2004 of the variables issuing from the breakdown of the variations of the emissions (Part II), countries and regions.

Pays et régions	Emissions de CO2 liées à l'énergie en 2004, millions TCO2	Richesse par habitant (PPA) en 2004, K$ internationaux 2000	Population 2004, Khabitants	Intensité énergétique de l'économie en 2004, Kep par K$ 2000 en PPA	Mix énergétique (CO2/E) en 2004, KCO2 par Kep
Albanie	4,8	4,5	3112	169	2,0
Algérie	84,5	6,1	32358	168	2,6
Bosnie-Herzégo	16,3	6,4	3909	188	3,5
Chypre	6,9	20,2	740	175	2,6
Croatie	20,6	11,1	4443	178	2,3
Egypte	142,0	3,7	72642	209	2,5
Espagne	329,8	23,8	42692	140	2,3
France	386,9	26,9	60521	169	1,4
Grèce	93,9	20,1	11062	137	3,1
Israël	62,3	22,3	6804	137	3,0
Italie	462,3	25,6	58175	124	2,5
Jordanie	16,7	4,7	5350	260	2,6
Liban	15,3	5,0	3540	307	2,8
Libye	45,1	6,1	5740	520	2,5
Malte	2,5	16,8	401	135	2,8
Maroc	35,5	4,0	29824	95	3,1
Serbia-Monténé	53,0	3,0	8085	741	3,0
Slovenie	15,6	19,1	1997	188	2,2
Syrie	48,2	3,3	18582	300	2,6
Tunisie	20,5	7,2	9932	121	2,4
Turquie	209,5	7,1	71150	163	2,6
UE-Med7	1297,9	25,1	175588	146	2,0
PEA	94,7	5,8	19549	299	2,8
PRE	335,3	7,3	100076	173	2,7
PRS	327,6	4,6	150496	184	2,6
FEMIP	425,0	5,1	179032	176	2,6
PSEM	662,9	5,7	250572	178	2,6
PNM	1392,6	23,2	195137	150	2,1
Méditerranée	2055,5	13,4	445709	156	2,2
12NPM-UE27	707,8	11,8	103580	219	2,6
UE27	4034,0	23,3	487903	159	2,2
Monde	28227,5	8,2	6361888	212	2,6

Source : Plan Bleu computations and formatting after WRI CAIT 5.0

5. ANNEX V. SECTORAL CO2 EMISSIONS BY COUNTRY AND REGION IN 2004, LEVELS AND VARIATIONS 1990-2004 (PART III)

Additional item 9 : Sectoral CO_2 emissions (energy and cement) by country and region in 2004, levels and variations 1990-2004.

Pays et Régions	Emissions de CO2 issu de l'utilisation d'énergie										Complement sur les émissions de CO2 émises lors du processus industriel du ciment (décarbonatation), millions de TCO2 en 2004 et variation 1990-2004 [%]	
	Emissions du secteur électricité et chauffage en 2004 [millions de TCO2] et taux de variation 1990-2004 [%]		Emissions du secteur des transports en 2004 [millions de TCO2] et taux de variation 1990-2004 [%]		Emissions du secteur industrie et construction en 2004 [millions de TCO2] et taux de variation 1990-2004 [%]		Emissions du secteur "Autre combustion de carburant" en 2004 [millions de TCO2] et taux de variation 1990-2004 [%]		Emissions fugaces en 2004 [millions de TCO2] et taux de variation 1990-2004 [%]			
Albania	0,3	-61	2	228	0,8	-72	1,5	-29			0,3	-24
Algeria	34,1	40	16	39	10,2	31	17,1	59	6,6	-52	4,50	42
Bosnia & Herzegovina	8,6	-51	2	-50	2,2	-63	3,3	-40			0,50	268
Croatia	7,2	27 (1991)	6	82 (1991)	4,1	-6) (1991)	3,8	34 (1991)			1,90	35
Cyprus	3,2	86	2	44	1,8	129	0,2	33 (1991)			0,80	49 (1992)
Egypt	57,5	123	32	103	36,8	30	14,2	52	1,5	-33	14,30	104
France	68,3	7	136	19	83,1	4	99,8	3			10,40	-21
Greece	49,3	34	22	41	9,4	-10	13,5	66			7,50	11
Israel	41,2	111	10	48	1,9	-55	9,5	189			2,20	57
Italy	174,7	23	120	24	85,3	2	82,2	9			22,90	15
Jordan	6,7	90	4	63	2,6	97	3,1	81			1,90	114
Lebanon	5,7	108	4	114	3,4	966	2,2	50			1,50	246 (1991)
Libya	24,1	48	11	82	5,6	56	2,6	102	1,6	-82	1,80	34
Malta	1,9	8	1	13			0,1	44				
Morocco	14,9	89	2	54	5,2	30	13,7	108			5,50	162
Serbia & Montenegro	32,4	-33	6	-12	9,8	-7	4,4	-63			1,10	-17
Slovenia	6,1	15	4	54	2,7	-1	2,7	51			0,60	-14
Spain	120,0	56	107	67	66,1	45	36,8	78			23,20	66
Syria	20,0	157	13	37	10,9	70	3,9	-47	0,5	-45	2,40	35 (1991)
Tunisia	7,1	80	4	77	4,1	24	4,1	77	0,8	0 (1993)	3,20	93
Turkey	79,2	101	37	29	55,6	66	38,1	39			19,30	58
UE-Med7	423,5	29	391	33	248,4	11	235,3	16			65,40	19
PEA	48,5	(-19) (1991)	16	7	16,9	-28	13	-42			3,80	17
PRE	146,1	110	63	37	71,8	61	53,7	36	0,5	-45	25,40	61
PRS	137,7	76	66	76	61,9	32	51,7	71	10,5	-59	29,30	92
FEMIP	187,2	96	85	65	75,1	35	67,8	58	9,4	-46	35,50	93
PSEM	283,8	92	129	55	133,7	46	105,4	51	11	-58	54,70	76
PNM	472,0	20 (1991)	407	31	265,3	7	248,3	10			69,20	19
Med	755,8	38 (1991)	536	36	399	18	353,7	20	11	-58	123,90	39
NPM-UE	382,4	-19	102	61	120,3	-41	103,4	-31			17,80	-23
UE27	1654,8	0	948	26	682,6	-16	743,3	-6	5,7	1036	120,10	1
World	13293,0	64	5589	44	5499,3	14	3684,1	10	161,8	-9	1091,90	90

Source : Plan Bleu computations and formatting after WRI CAIT 5.0
Note : The baseline year for the variation rate is specified between parentheses in the corresponding box wherever this is not 1990.

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PART 2

MITIGATION OF CLIMATE CHANGE: TOWARD A LOW CARBON ENERGY SECTOR

INTRODUCTION

Part II objective is to identify and analyze options to shift towards a less emitting energy system.

Chapter 4 describes the Mediterranean energy system, past and possible future trends. Using data and indicator analysis, it attempts to answers the following question: are developments in the energy field compatible with sustainable energy targets and CO_2 emissions growth control?

Chapter 5 uses an economic approach to simulate strategies toward renewable energy (RE) and energy efficiency. Simulations for 3 countries shows the cost of inaction for the entire South and East Mediterranean Countries (PSEM) and assesses whether investing today in RE and EE yields economic returns up to 2015.

Chapter 6 reviews observed action and RE/EE development in the SEMC. Reviewing countries experiences, success stories and obstacles to the development of large scale EE/RE markets in the region?

The two case studies included in chapter 7, on Egypt and Tunisia, provide more precise information on RE/EE development in countries and identifies investments needed to generate an energy development path compatible with lower emissions and sustainable development targets.

Finally, chapter 8 provides a detailed review of the fossil fuel-based electricity sector and identifies and estimate cost of emission reduction options.

CHAPITRE 4
Energy in the Mediterranean: Situation and outlook

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KEY MESSAGES

The extension and updating of the Observatoir Méditerranéen de l'Energie (OME) trend scenario (2007), based on an aggregate of the evolutions estimated by the countries and the major energy companies, reveal that primary energy demand in the Mediterranean basin will be 1.5 times higher in 2025 compared to 2006. Over the same period, the Southern and Eastern Mediterranean Countries (SEMCs) could experience growth rates of their energy demand four times higher than those of the Northern Mediterranean Countries (NMCs). Between 2006 and 2025, primary energy demand in the SEMCs—which are in full development process and whose population is increasing significantly—could thus multiply by 2.2. The SEMCs would, then, account for 42% of the total energy demand of the Mediterranean basin, as against 29% in 2006, the remainder being claimed by the NMCs.

In 2006, Turkey claimed 34% of the primary energy consumption of the SEMCs, which makes of it the largest energy consumer of the sub-region. Egypt ranks second, accounting for 23% of the consumption of the SEMCs. For the time frame 2025, Turkey is likely to gather weight (thus ascending to the rank of the second largest consumer basin-wide), by claiming 43% of the primary energy demand of the SEMCs.

Energy demand is marked by an exponential growth of demand on electricity, at a pace much faster than that of GDP, of primary energy consumption and of population, particularly in the SEMCs. For this set of countries, the demand is likely to multiply by 2.6 between 2006 and 2025, mainly due to a tripling of the consumptions of Turkey, Tunisia and Algeria, and a doubling up of the consumptions of Egypt and Morocco. The expected development of the industrial sector, improved access to electricity, and higher standards of living (directly connected with the consumption of the residential sector) are the reason for these consumption upsurges.

In 2006, fossil energies (oil, gas, coal) accounted for as much as 80% of the energy supply of the Mediterranean countries as a whole and 94% for the SEMCs alone (75% for the NMCs). Four countries are hydrocarbon-exporting (Algeria, Libya, Egypt and Syria) and supplied in 2005 some 22% and 35% of the oil and gas imports of the whole Mediterranean basin. All the other countries are net energy importers. By 2025, according to the OME trend scenario, the weight of fossil energies is likely to stabilize at equivalent levels. Natural gas will increasingly gain in weight and will be available in all the countries by 2009; it is likely to account for 37% of the primary energy demand in 2025 in the SEMCs. Coal persists, particularly for electricity production. The share of renewable energies (biomass excluded) would remain thin, passing from 2.8% of primary energy to 3% in the SEMCs (3 to 4.2% in the NMCs).

Final demand per sector reveals that in the NMC transport had reported the highest consumption growth for 30 years, thus posting 32% in 2005. In the SEMC, all sectors are significantly increasing their consumption, with industry and the residential sector being the largest consumers in 2005 (36 and 27%).

Such a trend scenario foretells increased risks and impacts:

- The CO_2 emissions due to energy consumption are likely to increase, between 2006 and 2025 by 55% in the NMCs and by 119% in the SEMCs. All in all, by 2025, the SEMCs are likely to emit almost as much as the NMCs (47% of the basin-wide CO_2 emissions) in absolute value, as against 33% in 2006. They would be emitting, however, in ton/inh. 56% less than the NMCs by 2025;
- The energy dependence of the importing countries would increase significantly and more rapidly for the importing SEMCs (passing from 77% in 2006 to 88% in 2025) than for the NMCs (passing from 68% to 73% over the same period);
- The social and economic risks connected with the rise in supply costs and its repercussions on the energy bill of the countries, households and enterprises are already acutely felt in the current context of generalized rise of the price of hydrocarbons and of price volatility.

Awareness of the need to ease the energy constraints and of the obvious nexus between environment and development in the Mediterranean is on the increase. It has been given concrete expression in the North via the adoption of drastic measures geared towards the development of energy efficiency, promotion of renewable energies and reduction of GHG emissions. On regional scale, and on the political level, the adoption, in November 2005, of the "Mediterranean Strategy for Sustainable Development" (MSSD) by the 21 countries and territories signatory of the Barcelona Convention for the protection of the Mediterranean Sea, stands as a major sign. Similarly, several regional projects are underway in various fields (energy efficiency, renewable energies . . .). Besides, on national level, several SEMCs tend to espouse an increasingly sober energy vision.

Thus, several options are available for several simultaneous actions: reduce CO2 emissions, meet the services demand expected from energy, and secure supply.

These options, their feasibility in the SEMCs, their benefits and their costs are analyzed in Parts 2 and 3 of this report..

INTRODUCTION

Context and objectives

Globally, Southern and Eastern Countries (SEMCs) face a rapid demographic growth, combined with relatively low incomes, as well as a rapid urbanization rate with an important socio-economic development needs. This translates into a growing new demand for energy services and related infrastructures. Indeed, in all SEMCs, energy demand (electricity, in particular) is increasingly rising. In contrast, Northern Mediterranean Countries (NMCs) are characterized by more mature economies. This is illustrated by sectoral transformations of their economies towards the services sector and a saturation of certain energy demand and services.

Despite of being gathered around a commonly shared sea, Mediterranean countries are characterized by some major differences, both between the Northern and the Southern/Eastern shores. Four countries are exporter of hydrocarbon (Algeria, Egypt, Libya and Syria); all others are importer (including Tunisia, small producer). The Northern countries consume around two third of the basin energy use. They are seeking to diversify their energy supply while trying to reduce their environmental impact and achieve their Kyoto Protocol targets of GHG emission reduction. In the Southern countries, the main challenge is to answer the fast growing energy needs, while minimizing environmental impacts (global and local), gaining in competitivity, ensuring energy security in an acceptable macroeconomic and social point of view.

In this context, the objective of this study is to analyze the way in which the increasing demand in the Mediterranean region would be adressed, and to assess the impacts of such a development and to take stock of reflections / actions to improve the sustainability and the carbon intensity of the energy sector.

Sources of information

This chapter is based on an update and extension of the prospective study already performed by OME in 2005 and 2007 in collaboration with and in the framework of Plan Bleu activities. Additional information has been gathered from OME members, literature and international organisations. A questionnaire was circulated, through national companies (OME Members). The data from forecasts of the major energy companies in the region that OME collected through this questionnaire, are aggregated and supplied the inputs of this analysis of the so-called ‘’trend scenario”. It has to be noted that an extensive work is being performed by OME for the construction of a projection model for the Mediterranean region which will provide in-house scenarios.

About the chapter

The Mediterranean, as defined in this chapter, is divided into two sub-regions: the countries of the Southern and Eastern Mediterranean (SEMCs) and the countries of the Northern Mediterranean (NMCs). Countries of the Southern and Eastern Mediterranean Countries (SEMCs) includes - For the East - Turkey, Israel, Palestine, Syria and Lebanon and -For the South- Egypt, Libya, Tunisia, Algeria and Morocco. Countries of the Northern Mediterranean Countries (NMCs) includes Spain, France, Italy, Greece, Cyprus, Malta, Monaco, Albania, Slovenia, Croatia, Serbia, and Bosnia-Herzegovina (the last five forming the East Adriatic countries group).

The chapter includes three main parts:

- The first part deals with the major trends in energy demand in the Mediterranean region both primary energy demand, electricity and final energy demand
- The second part analyses some related challenges in regards with major trends, in particular dependency issues and CO_2 emissions.
- The last part reminds that options are available to avoid unsustainable trends and that several initiatives exist in that purpose.

I. MAJOR TRENDS IN ENERGY DEMAND

The Mediterranean region accounts for 7.2% of total world population, 9% of total primary energy supply (TPES), 10% of electricity consumption and 8% of CO_2 emissions. Per capita primary energy consumption in the Mediterranean is somewhat higher (+16%, 2100 against 1800 koe/cap) than the World's average, while per capita electricity consumption is 1.5 higher than the World's average (3900 kWh/cap against 2596 kWh/cap). Concerning CO_2 emissions parameters, Mediterranean countries have the same level as the World's average of CO_2 per capita and CO_2 per toe of primary energy consumption (4.6 t CO_2/cap against 4.2 CO_2/cap in the world; and 2.2 t CO_2/toe against 2.4 CO_2/toe in the world) (Table 1).

Compared to Industrialized countries (as OECD countries), the Mediterranean per capita energy consumption is about half of their levels (2.1 koe/cap against 4-4.7 toe/cap in OECD). The same proportion for per capita electricity consumption is valid (3900 kWh/cap against 8200 kWh/cap). Concerning the CO_2 emissions for primary energy consumption, the Mediterranean emits about the same level of CO_2 by toe (2.19 CO_2/toe against 2.34 CO_2/toe). The level of per capita CO_2 emissions, however, is lower (4.6 t CO_2/cap against 11.1 t CO_2/toe for OECD countries).

Table 1 - The Mediterranean over World

		MONDE	MED	% Med/Monde
Population	*million*	6432	461	7,2%
PIB	*Mds$2000*	36281	4269	11,8%
PIB (ppa)	*Mds$2000*	54618	6250	11,4%
Prod. Énerg.	*Mtep*	11468	643	5,6%
Importations nettes	*Mtep*	4476	576	12,9%
CEP	*Mtep*	11434	968	8,5%
Prod. Elec	*TWh*	18235	1816	10,0%
Cons. Elec	*TWh*	16695	1664	10,0%
Emissions CO2	*Mt CO2*	27136	2118	7,8%
CEP/pop	*tep/hab.*	1,778	2,1	118%
CEP/PIB	*Tep/1000$2000*	0,315	0,227	73%
Prod. Elec/pop	*kWh/hab.*	2835	3944	139%
Cons. Elec/pop	*kWh/hab.*	2596	3477	
CO2/CEP	*t CO2/tep*	2,373	2,188	93%
CO2/pop	*t CO2/hab.*	4,219	4,600	109%
CO2/PIB	*kg CO2/$2000*			
% Dépendance	*Import. nettes/TPES*		59%	

Infrastructure		MONDE	MED OME	% Med/Monde
Capacité installée	GW	3754	412	11,0%
Nbre de raffineries	Unité	661	89	13,5%
Capacité de raffinage	Mt/an	4362	496	11,4%
Nb d'usines GNL	Unité	18	7	39%
Nb de trains GNL	Unité	77	24	31%
Capacité GNL	Mt/an	186	37	20%
Réserves gaz.	x1000 bcm	181	8,1	4,4%
Réserves pétrol.	Gt	164	8,1	4,9%

Sources: WDI Indicators 2007 for 1971 to 2005, & Direct communication, OME.

Compared to the UE-25, the Mediterranean has currently the same population (about 460 Millions). The Mediterranean primary energy and electricity consumptions represent about half of the EU25 consumptions. Therefore, per capita consumption of primary energy and electricity in the Mediterranean are about half for the EU-25. Even though Mediterranean countries consume only half of the UE25 energy consumption, Mediterranean countries emit the same level of CO_2 by toe (about 2.2 t CO_2/toe).

The energy dependency on imports is much lower for Mediterranean countries (35%) compared to 55% in the UE25; this is mainly due to the important energy production coming from the SEMC exporter countries.

However, the Mediterranean situation hides significant disparities between the 2 areas of the region and between the countries themselves. Indeed, the largest share of energy is consumed by Northern Mediterranean Countries (72%) and the remaining 28% by the Southern and Eastern Mediterranean countries (14.7% for the SE &13.6% for the SW).

1. A FAST GROWING DEMAND, IN PARTICULAR IN THE SOUTH AND EASTERN COUNTRIES

Trends in primary energy consumption are illustrated in Figure 1. Total Mediterranean energy consumption increased from 402 Mtoe in 1971 to 968 Mtoe in 2006, growing at an average annual rate of 2.5% during this period. The Mediterranean region represents around 8.5% of world consumption. SEMCs energy consumption increased from 48 Mtoe in 1971 to 278 Mtoe in 2006, growing at an average annual rate of 5.1% while NMCs growth is slower at about 1.9% (354 to 691 Mtoe between 1971 and 2006).

In the future and according to forecasts issued by the main energy companies operating in the Mediterranean countries, the primary energy demand will continue to strongly increase: from 968 Mtoe in 2006, it should reach 1454 Mtoe by 2025 (Table 7.). One can notice that compared with the trend scenario published in 2005 by Plan Bleu , an acceleration of the demand growth is observed (the total primary energy consumption was forecasted at 1365 Mio tep in the 2005 scenario).

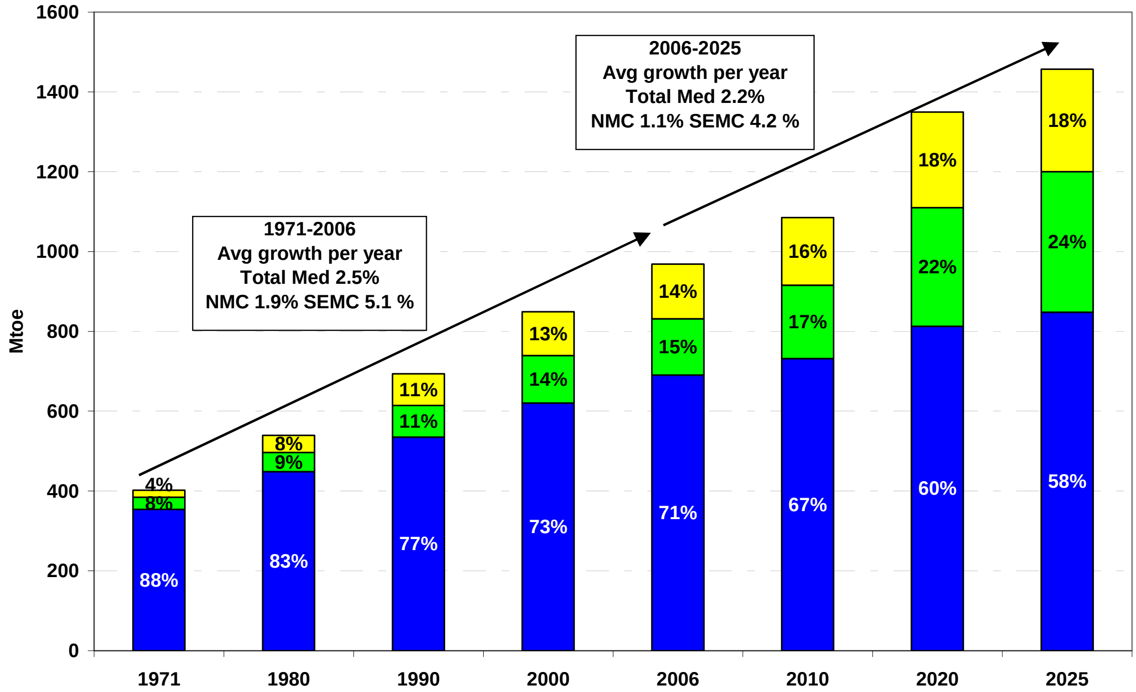
The fast increase of energy demand in the SEMC is first due to the trend in Turkey. Indeed, this country accounts in 2006 for 34% of the total demand in the SEMC. The same figure could be 43% in 2025 which would make Turkey the second largest consumer in the Mediterranean. Algeria and Egypt are also expected to be large consumers in 2025. The share of other countries is less important since they are smaller but some of them are expected to register the fastest growth rate in energy consumption (PNA., Tunisia and Syria first).

The share of SEMCs consumption in the global Mediterranean region has constantly been increasing from 12% in the early 1970s to 29% in 2006. This share is expected to reach 42% of the total in 2025.

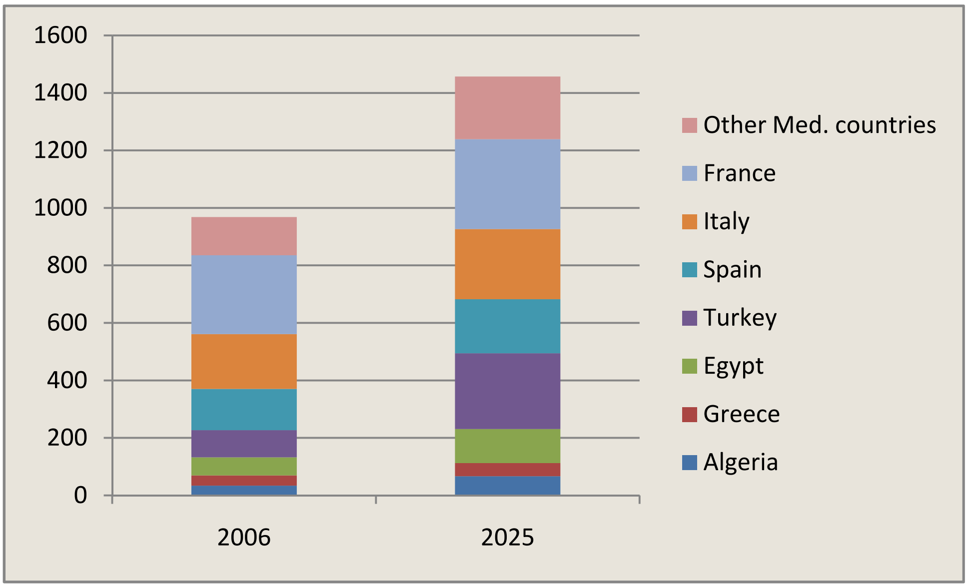
The growth of primary energy consumption per capita reached an average of 1.3% per year between 1971 and 2006 (Table 1.8). NMCs growth reached 1.6% whereas that of SEMCs 2.8%, thereby decreasing the gap between the two regions. In fact, SEMCs per capita consumption is currently one-third that of NMCs, compared to one-fifth in 1971. This measure should reach about one half by 2025.

Figure 1 - Primary energy demand

Trends in primary energy demand



The 7 main primary energy consumers countries in the Mediterranean (Mio toe)



Source: OME

Table 2 - Trends in primary energy consumption

	Primary Energy Consumption (in Mtoe)				Annual rate of growth (%)	
	1971	1990	2006	2025	1971-2006	2006-2020
North Med	354	535	691	848	1,9%	1,1%
SE Med	31	79	141	352	4,5%	4,9%
SW Med	18	80	137	257	6,0%	3,4%
SEMCs	48	159	278	609	5,1%	4,2%
TOTAL	402	694	968	1457	2,5%	2,2%
FEMIP	28	98	172	325	5,4%	3,4%

Source: OME

Table 3 - Per capita primary energy consumption (in koe/cap)

koe/cap	1971	1990	2000	2006	2025
Norh Med	2078	2843	3273	3483	4120
SE Med	631	1009	1227	1319	2671
SW Med	242	678	778	881	1320
SEMCs	397	810	961	1059	1866
TOTAL	1379	1807	1988	2103	2738
FEMIP	326	705	822	912	1369

Source: OME

2. DEMOGRAPHY AND ECONOMIC TRENDS: THE MAIN DRIVERS OF ENERGY DEMAND

The determinant factors of the energy demand evolution are demographic and economic trends.

Demographic trends: growth in the South and East, stabilisation in the North

The population of the Mediterranean amounts to 461 Million inhabitants in 2006, with that of SEMCs rapidly outpacing that of NMCs (Figure 1.1.). While the average annual population growth rate in SEMCs is expected to slow down to 1.2% (from 2.2% in the period 1971-2006), total SEMCs' population should reach 326 million by 2025. In contrast, population in NMCs has been stabilizing and should continue to grow at an average 0.2% per year until 2025, reaching 206 million inhabitants (see Erreur ! Source du renvoi introuvable.). It should also be noted that concerning SEMCs' population, the bulk of the population will be concentrated in Egypt, Turkey, Algeria and Morocco, which together will represent 80% of the total population in SEMCs.

Table 4 - Demographic trends in the Mediterranean countries (1971-2025)

	Population (in million inhabitants)				Annual rate of growth (%)	
	1971	1990	2006	2025	1971-2006	2006-2025
North Med	170	188	198	206	0,4%	0,2%
SE Med	48	78	107	132	2,3%	1,1%
SW Med	73	117	155	195	2,2%	1,2%
SEMCs	121	196	262	326	2,2%	1,2%
TOTAL	291	384	461	532	1,3%	0,8%
FEMIP	84	138	189	238	2,3%	1,2%

Sources: WDI Indicators 2007 for 1971 to 2005, & Direct communication with national institutions for 2006-2025 forecasts.

Economic Development: higher growth in the South and East

Economic growth is another essential determinant of energy consumption. Global Mediterranean economic growth has reached an average of 2.8% per year between the early 1970s and 2006. This growth has slightly slowed down in the past five years (2.0%). Economic growth in the SEMCs was twice that of the NMCs (4.0 and 1.6%, respectively) between 2000 and 2006 (Table 1.3.).

Table 5 - GDP growth rate (%)

	Annual rate of growth (%)	
	1971-2006	2006-2025
North Med	2,5%	2,0%
SE Med	4,2%	4,1%
SW Med	4,5%	3,4%
SEMCs	4,3%	3,8%
TOTAL	2,8%	2,4%
FEMIP	4,3%	3,4%

Sources: WDI Indicators 2007 for 1971 to 2005, & Direct communication with national institutions for forecasts..

Despite a more sustained overall economic growth in SEMCs, the gap of GDP per capita between the two regions remains considerable, reaching on average the order of 1 to 6.3 in 2005 (Table 1.4.). The disparity between the lowest and the highest GDP per capita in the Mediterranean is 1175 US$ in Syria, as compared to 23500 US$ in France. Indeed, SEMCs are confronted with relatively low incomes and fast growing populations. In addition, developing countries of the region face a rapid urbanization which translates into new needs for collective infrastructures, such as schools, hospitals and energy networks. According to several forecasts, this average disparity should slightly decrease (in the order of 1 to 5.3) by 2025 assuming a yearly average 3.9% economic growth rate in SEMCs.

Table 6 - GDP per capita in the Mediterranean countries (1971-2025)

	GDP/capita using exchange rates (billion $2000)				Annual rate of growth (%)	
	1971	1990	2006	2025	1971-2005	2005-2025
North Med	8557	13894	17621	25071	2,1%	1,8%
SE Med	2205	2902	4159	7278	1,8%	3,0%
SW Med	908	1286	2004	3022	2,3%	2,2%
SEMCs	1425	1933	2882	4741	2,0%	2,7%
TOTAL	5591	7798	9270	12601	1,5%	1,6%
FEMIP	1228	1757	2369	3631	2,0%	2,1%

Sources: Direct communication with national institutions.

3. ENERGY SUPPLY IN THE REGION

The availability of conventional energy resources is also an important factor in the structure of the energy demand in the region, which is globally more and more facing energy dependency challenges.

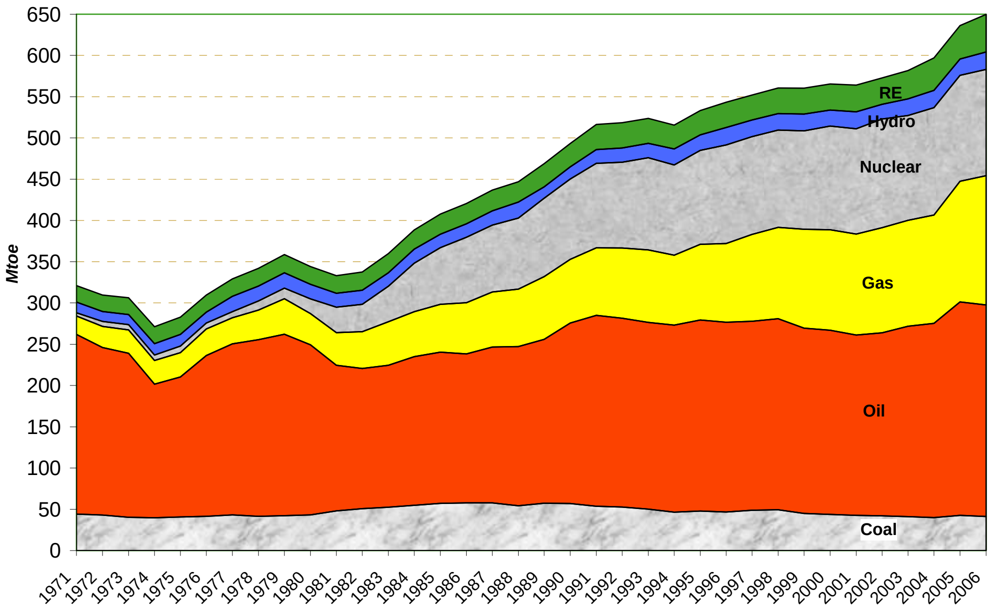
Indeed, the Mediterranean area is divided between energy importers and exporters. The Northern shore is exclusively net importer of fossil fuels while the SEMCs are further divided between exporters, (Algeria, Egypt, Libya, and Syria) with the remaining countries importing most of their energy needs.

In 2005, the Mediterranean's exporter countries supplied about 22% of imported Mediterranean's oil and 35% of imported Mediterranean's gas. This is due to a sustained oil and natural gas production in the SEMC export countries. In fact, primary energy production in SEMCs represented 1.4 times that of NMCs in the 1990s and 1.8 times in the early 2000s. This ratio is expected to increase by 2025 to reach 3 times the production of NMCs. In NMCs, the diminishing role of coal and oil shocks has left room for nuclear, hydro and renewable energies development. This has been mainly driven by diversification of supply purposes and technology development. In the meantime, the primary energy production in SEMC export countries is expected to grow very strongly (2.8% annually between 2006-2025 against 1.8% between 1971 and 2006). The SEMCs total energy production is expected to reach about 710 Mtoe against 420 Mtoe in 2006, including mainly natural gas and oil produced by a few exporter countries (as Algeria, Egypt, Libya, and Syria).

To contribute to these energy trades, important existing infrastructures exist in the region, such as oil refineries, oil loading harbors', LNG plants, LNG terminals, gas pipelines, electricity interconnexions, etc.). Both existing infrastructure and planned projects are detailed in annex of this report.

In 2006, Mediterranean countries imported a total amount of 576 Mtoe of fossil fuels, 468 Mtoe in NMCs and the remaining 108 Mtoe were imported by southern/eastern importer countries. Average import dependency in NMCs is 68% in 2006 (up from 65% in 2000) and is expected to increase constantly to reach 73% in 2025. Highest dependency levels concern oil and gas..

Figure 2 - Primary energy production (in Mtoe)



Source: OME

Table 7 - Net imports in the Mediterranean (in Mtoe)

	1971	1990	2000	2006	2020	2025
North Med Importers	257	325	397	468	585	614
SEMC Importers	10	47	85	108	247	311
TOTAL Importers	267	372	482	576	832	925
SEMC Exporters	- 188	- 176	- 206	- 251	- 406	- 410

Source: OME

Regarding SEMCs, energy import dependency is also high in most countries, with Morocco, Lebanon, Israel and Turkey ranking first. Tunisia has recently become a net importer and is expected to reach a much higher dependency level in the coming years (see 1.5 for more details).

Table 8 - Energy import dependency 2006 (in%)

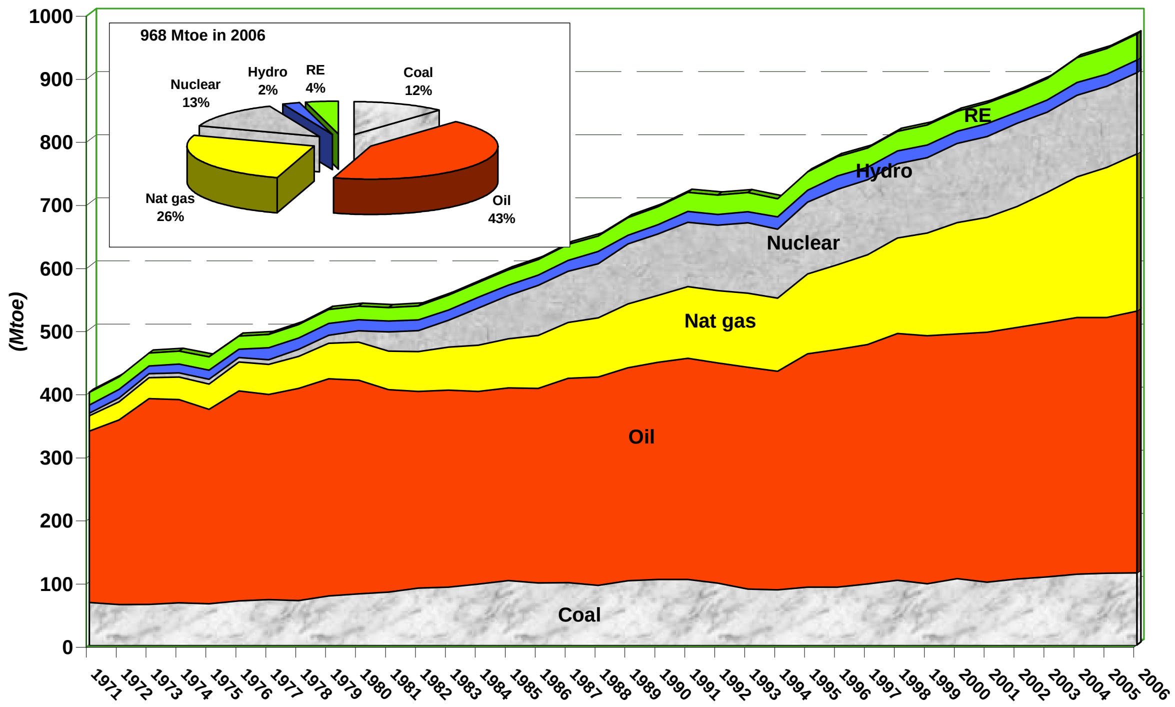
	All fuels 2006	All fuels 2005	Coal	Oil	Gas
Spain	78%	79%	71%	100%	100%
France	51%	51%	97%	99%	98%
Italy	87%	86%	100%	92%	86%
Greece	71%	67%	5%	99%	99%
Cyprus	100%	100%	100%	100%	-
Malta	100%	100%	100%	100%	-
Slovenia	50%	52%		100%	99%
Croatia	62%	63%	100%	74%	42%
Serbia & M.	35%	32%	6%	85%	90%
Bosnia-Herz.	36%	32%	4%	100%	100%
Albania	52%	52%	7%	75%	-
Turkey	74%	72%	46%	92%	97%
Israel	87%	90%	100%	100%	-
Jordan	96%	96%	-	100%	83%
Palestine	100%	100%	-	100%	-
Lebanon	97%	96%	100%	100%	-
Morocco	95%	95%	100%	100%	93%
Tunisia	23%	21%	100%	27%	31%
Syria					
Egypt			100%		
Libya					
Algeria			100%		
NMCs	68%	68%	62%	96%	92%
SEMCs importers	77%	76%	63%	91%	83%

Source: OME

4. PRIMARY ENERGY DEMAND BY SOURCE IN THE MEDITERRANEAN: DOMINANCE OF HYDROCARBONS AND PENETRATION OF GAS

Figure 3 - illustrates primary energy consumption between 1971 and 2006 by source for the whole Mediterranean region. Generally, trends show the increasing penetration of natural gas in the fuel mix, and the relative stability of coal and oil. The share of each fuel in 2006 is 44% for oil, followed by natural gas (25.7%), nuclear (13.3%), coal (11.8%), hydro and renewable together (6.3%).

Figure 3 - Trends in primary energy consumption in the Mediterranean (by source)



Source: OME

The following observations can be made for each energy source:

Coal is mostly used in the countries of the Northern shore of the Mediterranean and in Turkey, Israel and Morocco. Its consumption increased from 67 Mtoe in 1971 to about 114 Mtoe in 2006, an average yearly increase of 1.6%. The share of coal slightly decreased (from 16.7% in 1971 and 14.5% in 1990) and currently represents 11.8%.

Coal consumption in the region is expected to reach 190 Mtoe by 2025 (an annual average increase of 2.7%). This increase in coal consumption is mainly due to the projects of coal power stations in Turkey, Morocco and foreseen new development in Tunisia. The contribution of coal to the overall energy supply will remain stable at around 12% during the period under consideration, consumption in real terms progressing from 114 Mtoe in 2006 to 190 Mtoe in 2025.

The consumption of coal in the SEMCs is likely to increase from 41 to 115 Mtoe between 2006 and 2025, mainly due to the expected growth in Turkey but also in Israel, Morocco and Tunisia.

The NMCs' coal consumption should slightly increase, from 73 Mtoe in 2006 to 75 Mtoe in 2025, unless the recent commitments of the European Union to reduce its emissions of Carbon Dioxide bring further reductions in coal consumption.

The present estimates already show that coal is resisting the competition in the Mediterranean despite the increase in the use of natural gas. This is linked in particular to its integration in countries which are large producers as well as large consumers, such as Spain, Italy and France, and its use is maintained in countries such as Turkey, Israel and Morocco who see it as a means of diversification and a secure energy source.

Oil has constantly been the dominant fuel in the energy mix of Mediterranean countries. Its consumption had increased from 272 Mtoe in 1971 to 415 in 2006, with a yearly average increase of 1.3%. Its share, however, has been decreasing from 68% in 1971 to 49% in 1990 and 43% in 2006.

In the future, oil consumption is expected to reach 558 Mtoe (average annual growth of 1.8% until 2025) and its share should stabilize at about 38%. In fact, oil will preserve its leading position in the

Mediterranean and concentrate in those areas of use where no real alternative exists (typically motor fuel and lubrification oils). The relative regression for oil products is essentially explained by the competition from gas in the household and tertiary sectors, especially in the electricity sector (see chapter 2.).

Growth in oil consumption is expected to be higher in SEMCs (3.0%) than in NMCs (0.7%). The difference is being mainly explained by the fast growing demand in transportation sector. As such, oil consumption in SEMCs should increase from 125 in 2006 to 222 Mtoe in 2025 while that of NMCs from 290 to 336 Mtoe in the same period.

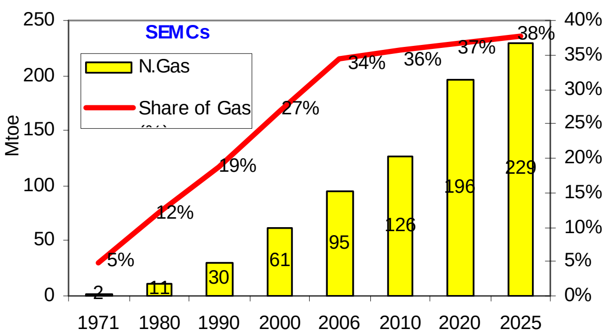
In sum, it can be noted that the substitution, notably from crude oil in its capacity as "fuel" to gas and electricity, and the widely increasing "transport" uses, should accelerate the retreat of crude oil to its noble uses - transport and petrochemicals - for which it appears difficult to find a substitute, particularly in the time-scale of this study.

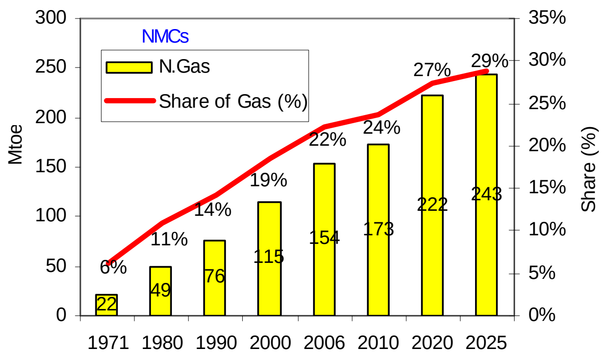
Gas - During the past decades, the average annual increase in the demand for natural gas was about 6.9% a year, increasing from 24 to 249 Mtoe – a ten-fold increase between 1971 and 2006 (increasing three times more rapidly than the total primary energy consumption). One of the key factors of this considerable growth of the overall energy and natural gas demand is the strong growth of gas-based electricity generation (due to the numerous power plant projects using natural gas, see chapter 2). The share of natural gas in the energy balance increased from 6% in 1971 to more than 26% in 2006. In 2025, it should reach a level of 33%, 472 Mtoe with a 3.5% average increase per year.

As we will see in chapter 2, 99 Mtoe of gas natural (40% of the total gas consumption) was burnt in gas power plants in 2006. By 2025, about 226 Mtoe (48% of the total gas consumption) is expected to be burnt in gas power plants by 2025.

In the early 1970s, only five Mediterranean countries used natural gas, whereas currently natural gas has a significant share in the energy balance of almost all Mediterranean countries[1] (except Cyprus, Malta, Lebanon and Palestine). It is also expected that all Mediterranean countries will increasingly consume natural gas and reach a share of 33% by 2025. (see. Figure 4)

Figure 4 - Penetration of natural gas in Mediterranean countries (Mtoe &%)





Source: OME

Favourite source of fuel for the new power stations in the North as in the South, natural gas will also see an increase by its penetration in the residential and tertiary markets of the SEMCs, boosted by the population growth and by the increased urbanization of coastal areas.

1 The last entrants were Portugal in 1997, Greece in 1999 (with Algerian LNG), Jordan in August 2003 (with Egyptian gas via the Arab Gasline), Israel since 2004 (with local off-shore production), and Morocco in January 2005 (with commissioning the first NGCC power plant at Tahadart supplied by Algerian GPDFgasline). With the extension of the Arab Gasline, Cyprus, Lebanon and Palestine will join the gas consumer countries.

The high natural gas consumption levels should easily be satisfied by the availability of the gas reserves (8500 bcm in SEMCs), but will of course require major investments in infrastructures to link production regions to consumption centres.

Nuclear Energy - After a period of rapid growth between the 1970s and 1990s, nuclear energy consumption has remained stable at around 126 to 129 Mtoe between 2000 and 2006. Its share in the energy mix has remained relatively stable at around 13-14% in the last 15 years and should be falling to less than 10% between 2006 and 2025. Its rapid development in the early named period was linked to the massive development of the French nuclear program that started in the 1970s. The growth of nuclear energy in NMCs slowed down following the Italian moratorium on this energy source and the Spanish decision to stop its further development.

Currently, nuclear energy is absent from SEMCs energy mix, even though several nuclear power stations had been announced. In particular, both Turkey and Egypt have recently called for a nuclear plan of action. Indeed, even their own national energy forecasts that nuclear power generation will represent 4 to 7% of total power production by 2015. In addition, Tunisia is planning to introduce nuclear in their energy mix (2000 MW by 2025). In case these projects come to completion, nuclear would represent a share of 2.2% in primary energy demand of SEMCs by 2025.

Renewable energy[2] (RE) (including hydro) - RE in the Mediterranean accounted for 36 Mtoe in 1971 and increased to 71 Mtoe in 2006, representing an annual average growth rate of 1.7%. They are expected to increase with an annual average level of 1.9% between 2006 and 2025 (from 71 Mtoe at present to 89 Mtoe in 2025[3]).

Table 9 - Primary Energy Consumption by Source & by Area

NMCs							TPES (Mtoe)
	Coal	Oil	Nat. Gas	Nuclear	Hydro	RE	Toal
1971	62	240	22	4	12	14	354
1980	73	279	49	18	15	14	448
1990	79	249	76	97	12	23	536
2000	70	269	115	126	15	27	622
2006	73	290	154	129	15	30	691
2010	66	310	173	131	16	32	728
2020	66	335	222	130	17	38	808
2025	75	336	243	130	17	43	844

SEMCs							TPES (Mtoe)
	Coal	Oil	Nat. Gas	Nuclear	Hydro	RE	Toal
1971	5	32	2	0	1	7	48
1980	8	60	11	0	2	10	91
1990	22	93	30	0	3	11	159
2000	34	118	61	0	4	11	228
2006	41	125	95	0	5	11	278
2010	50	158	126	0	7	12	353
2020	96	205	196	11	12	15	535
2025	115	222	229	14	12	16	608

[2] Detailed information about renewable energy are given in Part II, chapter 3.

[3] Corresponding for Hydro: from 20 Mtoe in 2006 to 30 Mtoe by 2025; and for renewable energies: from 41 to 59 Mtoe by 2025

Med							TPES (Mtoe)
	Coal	Oil	Nat. Gas	Nuclear	Hydro	RE	Toal
1971	67	272	24	4	13	22	402
1980	81	339	60	18	18	24	539
1990	101	342	106	97	15	34	695
2000	103	387	176	126	19	38	850
2006	114	415	249	129	20	41	969
2010	116	467	299	131	23	44	1081
2020	162	541	418	141	30	53	1343
2025	190	558	472	144	30	59	1452

Source: OME

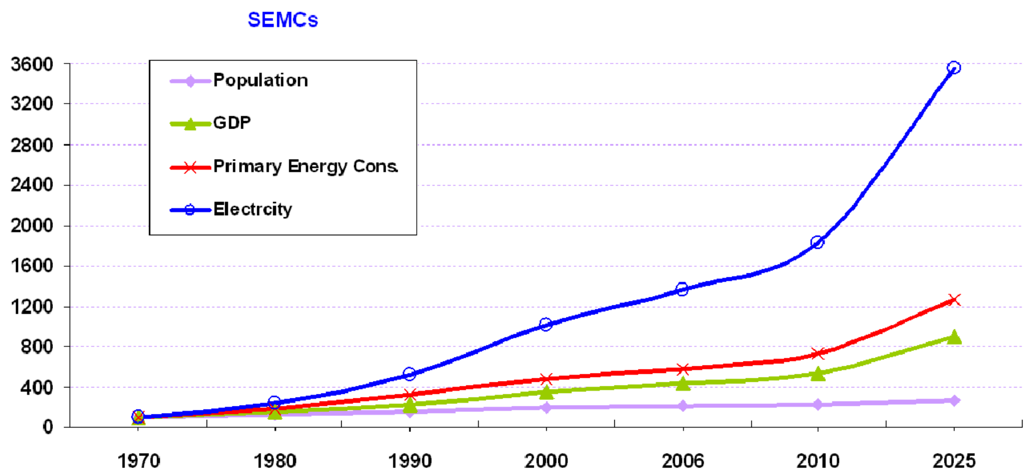
II. SPECTACULAR GROWTH IN ELECTRICITY DEMAND

The electricity sector in the Mediterranean region is developing fast and electricity growth in the Mediterranean is much higher than the economic, primary energy consumption and population growths. This is more specifically the case in SEMCs, where both electricity and primary energy consumption grow much faster than economic and demographic parameters. For this group of countries, the electricity demand could be multiplied by 2,6 between 2006 and 2025.

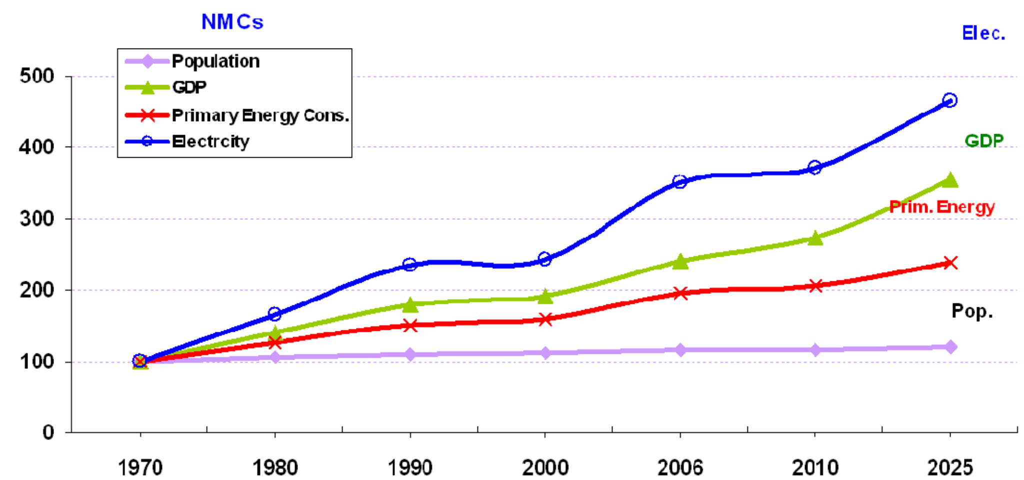
The developments in the industrial sector (for example new processes and automation) and improvements in living standards in the residential sector (for example appliances and air-conditioning) are the main factors explaining this fast trend.

Figure 5 - Mediterranean: Trends in selected parameters (1970 = index 100)

SEMC



NMC



Source: OME

Strong electricity demand is one of the main determinants of the important growth in primary energy consumption in the Mediterranean countries. In 2006, in the SEMC, fossil fuels used for power generation represents 34% of the total primary energy supply. Most striking in the electricity trends observed is the spectacular increase in the share of natural gas mainly in substitution of oil and the "resistance" of coal.

Electricity consumption in the Mediterranean countries is closely linked to the level of economic development. It can be noted that the per capita electricity consumption differs between the two shores of the Mediterranean, with an average of 6810 kWh/cap in NMCs as compared to 1780 kWh/cap in SEMCs. The ratio of per capita electricity consumption between SEMCs and NMCs has decreased from 1/8 in 1971 to 1/4.2 in 2006 and should reach 1/2.3 in 2025

Table 10 - Per capita electricity consumption (in kWh/cap)

	1971	1990	2000	2006	2020	2025
PNM	2259	4776	6119	6810	8205	8700
SE Med	417	1168	2074	2504	4975	5499
SO Med	191	715	1021	1278	2271	2504
PSEM	281	897	1451	1778	3364	3713
Méditerranée	1437	2799	3524	3944	5248	5641
FEMIP	284	513	1247	1504	2442	2722

Source: OME

III. TOTAL FINAL CONSUMPTION BY SECTOR: IMPORTANCE OF TRANSPORT IN THE NORTH AND RESIDENTIAL/INDUSTRY IN THE SOUTH

Trends in total final consumption (TFC) by sector in the Mediterranean are showing an average growth of 2.2% per year between 1971 and 2005. The average yearly growth by sector in the same period is 3.5% for the transport sector, followed by the residential & other sectors (2.7 and 2.7%, respectively) and the industrial sector (1.6%). The sectoral breakdown of TFC in 2005 is divided up between residential & others (23 and 14%, respectively), followed by industry (33%) and transport (30%). The shares of the transport sector (22 to 30%) and that of the residential sector (21 to 23%) have increased in the sectoral breakdown.

Concerning NMCs, trends in total final consumption (TFC) by sector recorded an average growth of 2.0% per year between 1971 and 2005. The average yearly growth in the same period is 3.2% for the transport sector, followed by the residential & other sectors (2.1 and 2.0%, respectively) and the industrial sector (1.1%).The sectoral breakdown of TFC in 2005 is divided up between residential & others (22 and 15%, respectively), followed by transport (32%) and industry (31%). The share of the transport sector in NMCs has considerably increased in the period under consideration (20 to 32%).

As far as SEMCs are concerned, trends in total final consumption (TFC) by sector recorded an average growth of 4.9% per year between 1971 and 2005. The average yearly growth by sector in the same period is 4.7% for the transport sector, followed by the residential & other sectors (4.1 and 6.1%, respectively) and the industrial sector (5.5%).The sectoral breakdown of TFC in 2005 is divided up between residential & others (26 and 11%, respectively), followed by industry (36%) and transport (25%). It should be noted that the share of industry in SEMCs has grown considerably between 1971 and 2005 (from 30 to 36%).

Figure 6 - NMCs total final consumption *(by sector)*

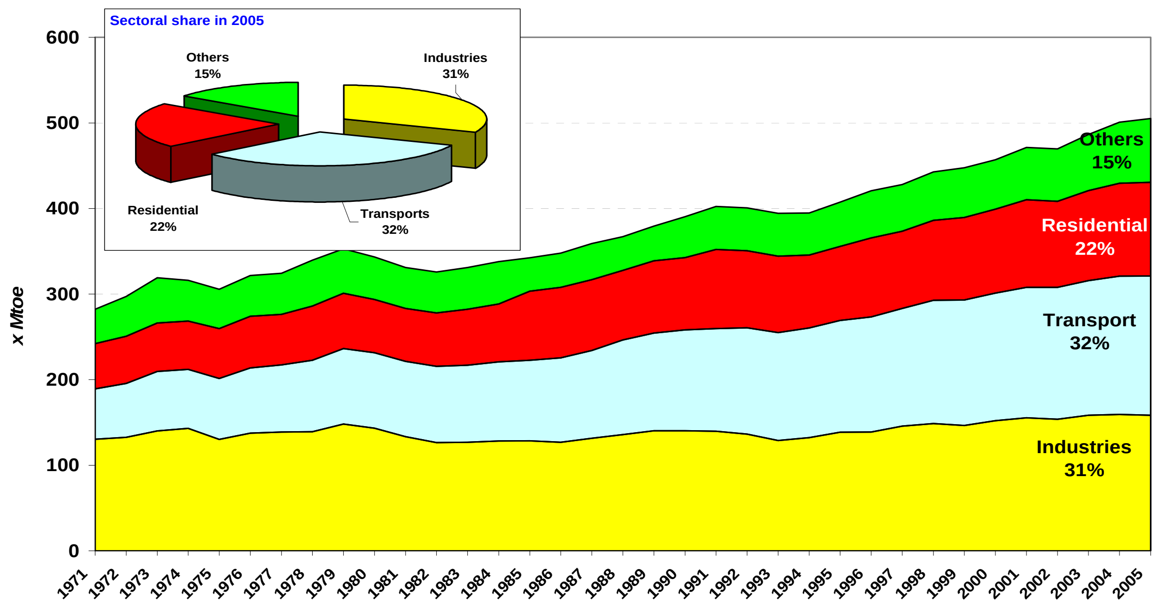
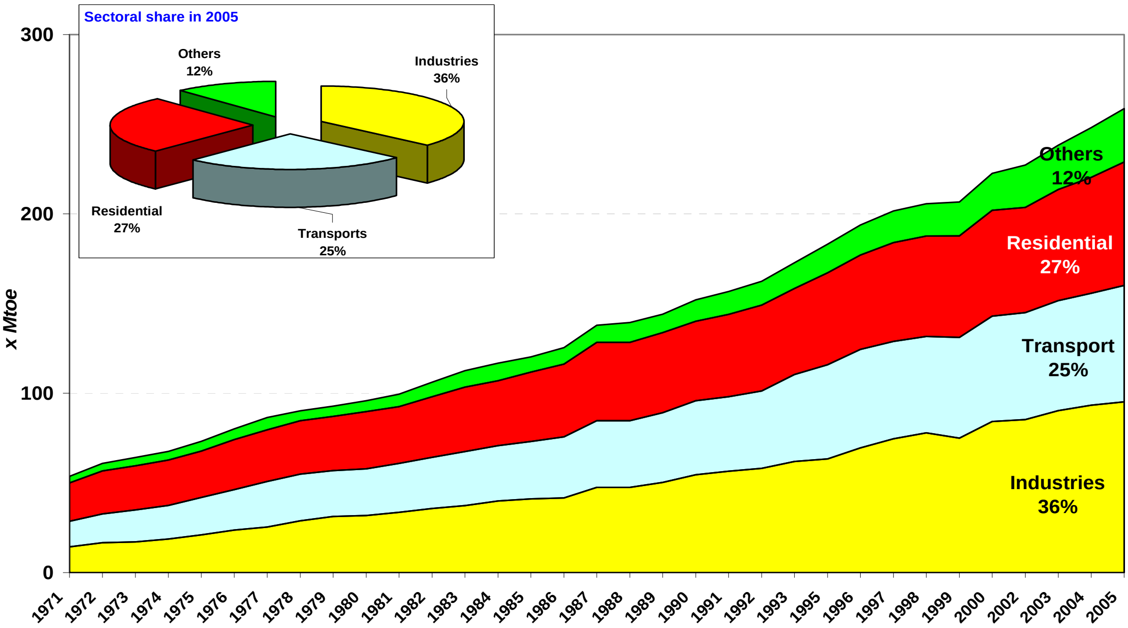


Figure 7 - NMCs total final consumption (by sector)



Source: International Energy Agency, Energy Balances for OECD and non-OECD countries, 2007..

IV. RISKS AND IMPACT OF THE ENERGY SYSTEM DEVELOPMENT

This paragraph highlights how and how much the situation and prospects for energy demand in the Mediterranean region will impact CO_2 emissions, dependency challenges as well as socio-economic development.

1. CO_2 EMISSIONS FROM ENERGY CONSUMPTION: BY 2025, TO MORE THAN DOUBLE AS COMPARED TO 1990

The CO_2 emissions from energy consumption are estimated from calculations based on energy balances of the Mediterranean countries. The methodology is similar to the sectoral approach used by the International Energy Agency (IEA), using IEA emission factors by energy source[4].

For the Mediterranean region, the CO_2 emissions from energy consumption has increased from 1547 Mt CO_2 in 1990 to 1837 Mt CO_2 in 2000 and continued to increase to 2118 Mt CO_2 in 2006. Emissions are expected to reach 3294 Mt CO_2 by 2025 and thus more than double as compared to their 1990 level (see Table11.).

For NMCs, the CO_2 emissions from energy consumption has increased from 1145 Mt CO_2 in 1990 to 1253 Mt CO_2 in 2000, and continued to increase to 1409 Mt CO_2 in 2006, which is 23% higher than the 1990 level. They are expected to reach 1740 Mt CO_2 by 2025. The growth rate was 1.35% from 1990 to 2006, and is expected to continue at a 1.14% annual growth rate up to 2025 in the baseline scenario. By 2025, to keep the NMCs CO_2 emission level equivalent to 1990 (1145 Mt CO_2) (the reference year for the Kyoto Protocol), the quantity to be saved will be 596 Mt CO_2, which corresponds to the CO_2 emissions of Italy, Greece, Croatia and Bosnia in 2006.

In SEMCs, CO_2 emissions from energy consumption have increased from 402 Mt CO_2 in 1990 to 583 Mt CO_2 in 2000 and continued to increase to 709 Mt CO_2 in 2006, which is 76% higher than the 1990 level. It is expected to double in 2025 (1553 Mt CO_2). The growth rate was 3.6% for the period 1990 to 2006 and is expected to reach 4.2% by 2025 in the baseline scenario.

In 2025, SEMC would then contribute to around half the emission of the whole basin (47%) ; but per capita they will emit around 1.8 times less than the NMC.

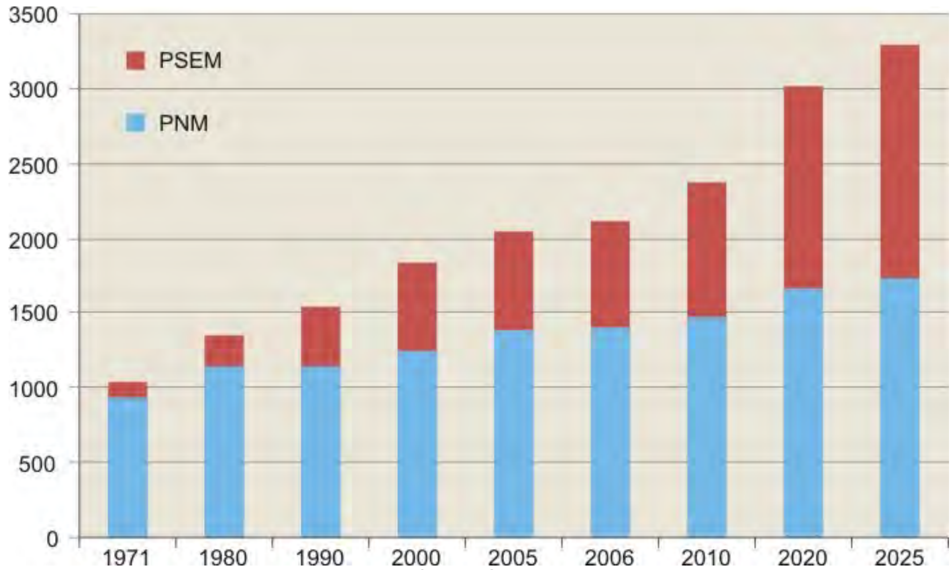
Indeed, CO_2 emissions per capita increased from 4000 kg CO_2 in 1990 to 4300 kg CO_2 in 2000 and continue to increase to 4600 kg CO_2 in 2006 in the region. It is expected to reach 6190 kg CO_2 by 2025 (see Table 12.). For NMCs, per capita CO_2 emissions from energy consumption increased from 6080 kg CO_2 in 1990 to 6600 kg CO_2 in 2000 and continued to increase to 7100 kg CO_2 in 2006, which is 17% higher than the 1990 level. It is expected to reach 8460 kg CO_2 by 2025. For SEMCs, the CO_2 emissions from energy consumption increased from 2053 kg CO_2 in 1990 to 2458 kg CO_2 in 2000 and continued to increase to 2705 kg CO_2 in 2006, 32% higher than the 1990 level. It is expected to reach 4758 kg CO_2 by 2025.

[4] The mean values of IEA factors used for these calculations are the following:

	Coal	Oil	N. Gas
t CO_2 by toe	3.80	2.70	2.26

Source: IEA

Figure 8 - CO_2 emissions activities, NMC-SEMC, trend scenario 1971-2025



Source: OME.

Table 11 - Total CO_2 emissions from energy consumption (in Mt CO_2)

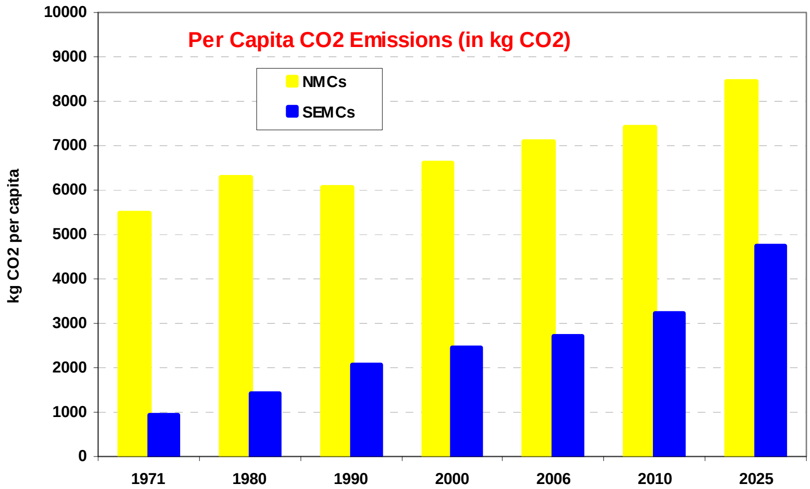
	1971	1980	1990	2000	2001	2002	2003	2004	2005	2006	2010	2020	2025
Spain	117	187	210	289	291	306	311	328	335	329	361	410	405
France	427	466	371	374	386	383	389	392	397	400	421	459	489
Italy	295	338	372	417	417	419	435	438	445	463	466	527	576
Greece	25	44	66	80	83	83	85	86	87	99	110	123	125
Cyprus	2	3	4	6	7	7	7	7	7	10	8	10	10
Malta	1	1	2	2	2	2	2	3	3	3	3	4	4
Ex-Yug	61	96	-	-	-	-	-	-	-	-	-	-	-
Slovenia	-	-	12	13	14	15	15	15	15	14	14	14	14
Croatia	-	-	21	17	18	19	20	20	20	20	24	32	35
Bosnia & H.	-	-	22	12	13	12	13	14	15	15	16	18	19
Serbia & M.	-	-	57	39	41	44	48	52	49	51	51	54	58
Albania	4	7	6	3	3	4	4	4	5	5	5	6	6
North Med	**932**	**1 141**	**1 145**	**1 253**	**1 276**	**1 293**	**1 329**	**1 359**	**1 378**	**1 409**	**1 478**	**1 656**	**1 741**
Turkey	41	69	134	200	180	190	201	209	218	246	326	582	715
Syria	7	14	30	44	43	45	45	45	45	47	58	88	97
Lebanon	5	6	6	13	14	14	16	14	15	15	21	25	27
Palestine	-	-	-	-	-	-	-	-	2	2	4	5	5
Israel	17	23	34	58	61	61	63	63	62	63	75	89	100
SE Med	**70**	**112**	**205**	**315**	**298**	**311**	**325**	**330**	**342**	**374**	**483**	**788**	**943**
Egypt	19	37	79	109	112	125	132	136	146	151	188	268	278
Libya	4	18	29	44	44	45	46	48	49	48	58	70	75
Tunisia	4	8	12	17	18	18	18	19	20	20	29	37	40
Algeria	10	30	59	71	71	76	81	82	79	82,4	97	147	159
Morocco	6	12	18	28	31	32	31	34	35	35	46	53	57
SW Med	**42**	**105**	**197**	**268**	**276**	**296**	**309**	**319**	**329**	**336**	**418**	**575**	**610**
SEMCs	**112**	**217**	**402**	**583**	**574**	**606**	**633**	**649**	**670**	**709**	**901**	**1 363**	**1 553**
TOTAL	**1 044**	**1 358**	**1 547**	**1 837**	**1 850**	**1 899**	**1 962**	**2 008**	**2 048**	**2 118**	**2 379**	**3 019**	**3 294**
FEMIP	**69**	**135**	**248**	**354**	**363**	**385**	**400**	**409**	**421**	**434**	**538**	**739**	**791**

Source: OME

Table 12 - Per capita CO_2 emissions (in kg CO_2/cap)

	1971	1980	1990	2000	2001	2002	2003	2004	2005	2006	2010	2020	2025
Spain	3 435	5 009	5 406	7 177	7 146	7 407	7 406	7 679	7 723	7 458	8 280	9 046	8 902
France	8 341	8 645	6 544	6 342	6 527	6 421	6 474	6 482	6 521	6 533	6 773	7 108	7 543
Italy	5 457	5 981	6 567	7 330	7 327	7 334	7 548	7 536	7 598	7 842	7 927	8 956	9 787
Greece	2 792	4 544	6 452	7 360	7 558	7 548	7 696	7 806	7 844	8 895	9 777	10 713	10 867
Cyprus	2 774	4 942	7 624	9 321	9 338	9 274	9 900	9 038	8 950	13 032	10 312	11 311	11 957
Malta	2 286	2 982	6 378	5 435	5 867	5 339	6 042	6 318	8 234	7 996	7 215	9 001	9 625
Slovenia	-	-	5 963	6 743	7 121	7 288	7 283	7 374	7 388	7 034	7 084	7 005	7 359
Croatia	-	-	4 422	3 818	4 026	4 263	4 573	4 502	4 490	4 408	5 324	6 862	7 463
Bosnia & H.	-	-	5 169	3 087	3 288	3 149	3 351	3 552	3 776	3 844	3 784	4 061	4 338
Serbia & M.	-	-	5 451	4 763	5 089	5 454	5 878	6 454	6 112	6 398	6 042	5 951	6 286
Albania	1 689	2 688	1 855	956	999	1 167	1 242	1 198	1 498	1 489	1 575	1 719	1 702
North Med	**5 475**	**6 300**	**6 080**	**6 607**	**6 698**	**6 745**	**6 871**	**6 962**	**7 006**	**7 108**	**7 418**	**8 070**	**8 461**
Turkey	1 132	1 549	2 394	2 959	2 633	2 732	2 844	2 931	3 022	3 370	4 199	6 701	8 145
Syria	1 111	1 541	2 358	2 646	2 492	2 555	2 480	2 423	2 359	2 426	2 712	3 439	3 703
Lebanon	1 995	2 341	2 131	3 830	4 102	4 036	4 436	3 966	4 091	4 249	5 511	5 893	6 165
Palestine			-	-	-	-	-	-	620	475	914	893	1 011
Israel	5 564	5 956	7 393	9 213	9 426	9 309	9 408	9 239	8 968	9 000	10 246	10 859	12 080
SE Med	**1 455**	**1 868**	**2 616**	**3 251**	**3 020**	**3 088**	**3 169**	**3 190**	**3 247**	**3 497**	**4 237**	**6 059**	**7 156**
Egypt	515	837	1 416	1 618	1 635	1 782	1 858	1 872	1 974	2 006	2 310	2 838	2 907
Libya	1 847	5 913	6 700	8 246	8 187	8 220	8 217	8 425	8 316	7 990	8 696	8 484	8 911
Tunisia	721	1 235	1 433	1 760	1 827	1 814	1 830	1 917	1 999	1 936	2 689	2 942	3 163
Algeria	673	1 596	2 337	2 333	2 310	2 425	2 538	2 523	2 404	2 469	2 757	3 677	3 935
Morocco	400	637	762	1 003	1 084	1 117	1 082	1 129	1 154	1 135	1 414	1 451	1 533
SW Med	**574**	**1 148**	**1 677**	**1 911**	**1 934**	**2 037**	**2 094**	**2 118**	**2 149**	**2 159**	**2 511**	**2 996**	**3 133**
SEMCs	**925**	**1 434**	**2 053**	**2 458**	**2 378**	**2 468**	**2 535**	**2 555**	**2 596**	**2 705**	**3 213**	**4 233**	**4 758**
TOTAL	**3 583**	**4 084**	**4 028**	**4 301**	**4 283**	**4 343**	**4 427**	**4 470**	**4 503**	**4 600**	**4 960**	**5 727**	**6 189**

Figure 9 - Per capita CO_2 emissions (in kg CO_2)



Source: OME

2. THE CONCERN OF ENERGY DEPENDENCY

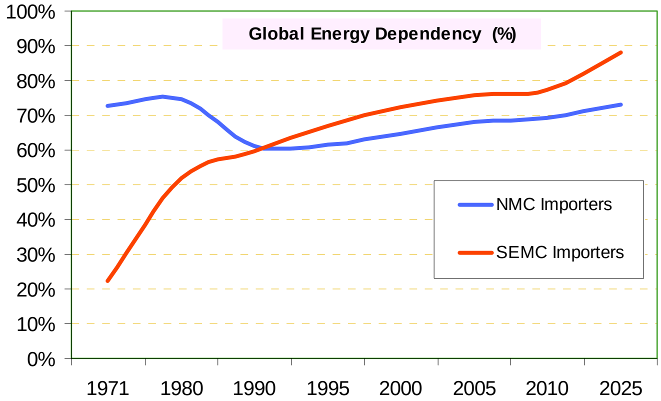
The energy dependency is calculated as the ratio of the net fuel imports over the total primary energy consumption. As mentioned previously, the Mediterranean countries are divided up into importer and exporter countries.

In the following, we consider three groups of countries:

- NMCs as a group of importer countries,
- Some net importer countries from SEMCs (Turkey, Israel, Palestine, Lebanon and Morocco) and
- Some exporter countries from SEMCs (Algeria, Libya, Egypt and Syria).

- For the first group (NMCs), the global energy dependency increases from 61% in 1990 to 65% in 2000 before reaching 68% in 2006, and will be increase to 73% by 2025.
- For the second group of SEMCs importer, one can note that they are increasingly dependent on energy import. In fact, their energy dependency increases quicker than that of NMCs. It goes up from 60% in 1990 to 72% in 2000, before reaching 77% in 2006, and is expected to increase to up to 88% by 2025.
- The third group of exporter from SEMCs exports about 185% to 200% of their primary energy consumption (it was 223% in 1990, 188% in 2000 and 187% in 2006 and expected to reach 161% by 2025).
- Global energy dependency for NMCs and SEMCs groups of importers is illustrated in Figure 1.3 where they follow similar trends and come close to the same rate of dependency by 2025; the SEMCs being in a more "critical" situation.

Figure 10 - Global energy dependency of Mediterranean importers



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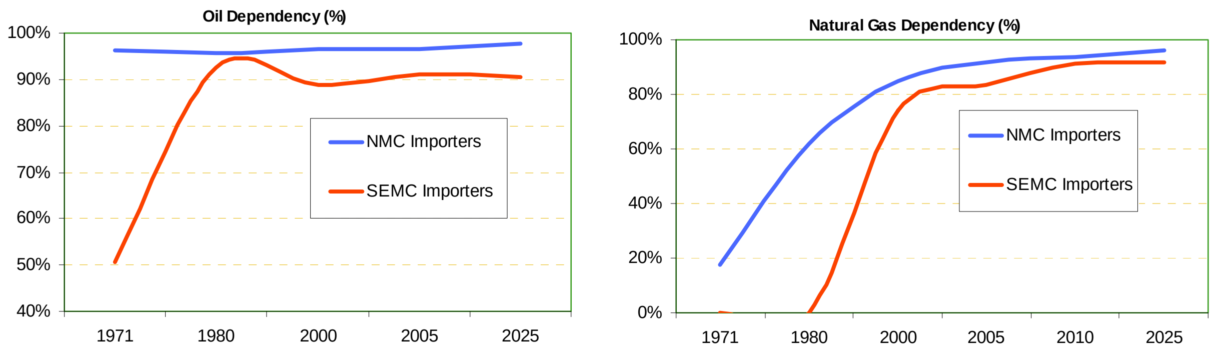
Source : OME.

- Both groups of importers are increasingly concerned by growing natural gas dependency while oil dependency has reached over 90% since the 1980s (Cf. Figure 11).

Figure 11 - Oil and natural gas dependency of Mediterranean importers



Source : OME.

- Concerning oil, Mediterranean countries are dependent on 26 export countries. The most important sources are Russia, Saudi Arabia, Libya, Iran, Norway, Algeria, UK and Nigeria. Mediterranean countries import 22% from the Mediterranean region itself (intra-trade Libya/Algeria accounting for 15%), followed by the FSU 20%, the Middle East 15% (Saudi Arabia 9%) and the Caspian 11% (Iran 8%), Europe 12% (5% & UK 4%; Netherlands 1%) and Africa 5% (Nigeria 3%).

Table 13 - Quantities of Oil imported by Origin in 2005 (Mt)

Importers	Port.	Spain	France	Italy	Greece	Malta	ex-Yug.	Turkey	Syria	Egypt	Libya	Algeria	Tunisia	Med	Russia	other CEI	M.East	Iran	Africa	Norway	UK	Other Eu	N.Am.	Lat. Am.	Asia	No spec.	Total
Portugal	0	875	217	171	10	0	0	0	0	0	1259	1804	0	4336	963	1598	1996	478	2278	594	1236	674	728	1688	0	1011	17580
Spain	421	0	830	4540	25	0	0	298	758	244	7744	4191	679	19730	11196	3169	12381	3479	11350	3727	2591	3980	11644	1526	95	25	84893
France	57	838	74	2649	41	14	0	141	1255	294	4244	6737	190	16534	18448	9603	17990	6381	6822	16027	11358	10674	1550	1170	748	324	117629
Italy	28	212	1446	0	197	425	191	965	2698	2962	25894	6046	405	41660	22379	4977	16321	9583	3583	3347	833	1138	2680	1418	494	0	108413
Greece	0	43	179	917	0	0	23	114	27	116	1452	0	0	2894	8614	673	7064	6592	68	0	48	651	241	369	228	0	27442
Cyprus	0	0	0	0	0	0	0	0	0	0	0	0	0	0			0	0	0	0	0	0	0	0	0	2411	2411
Malta	0	0	0	0	0	0	0	0	50	0	240	0	0	290			0	0	0	0	0	0	0	0	0	637	927
Slovenia	0	0	0	0	0	0	0	0	0	0	0	0	0	0			0	0	0	0	0	0	0	0	0	2721	2721
Croatia														0												5548	5548
Serbia														0												3810	3810
Bosnia & H.														0												1219	1219
Macedonia														0												1119	1119
Albania														0												1273	1273
Turkey		103	2	758	357				2200	99	4539	1381	43	9482	7169		5377	6937	48	415	63	460				4272	34223
Israel														0												14872	14872
PNA														0													0
Syria														0												1430	1430
Lebanon			379						800					1179												3850	5029
Jordan									200					200												5122	5322
Egypt														0												2818	2818
Libya														0												29	29
Tunisia			150						41		779			970												3278	4248
Algeria			402											402										240			642
Morocco			490									140		630			4000									3667	8297
Total	506	2071	4169	9035	630	439	214	1518	8029	3715	46151	20299	1317	98307	68769	20020	65129	33450	24149	24110	16129	17577	16843	6411	1565	59436	451895
Share by sour	0,1%	0,5%	0,9%	2,0%	0,1%	0,1%	0,05%	0,3%	1,8%	0,8%	10,2%	4,5%	0,3%	21,8%	15,2%	4,4%	14,4%	7,4%	5,3%	5,3%	3,6%	3,9%	3,7%	1,4%	0,3%	13,2%	100%

Source: IEA, CPDP, BP & OME

As for natural gas, Mediterranean countries are dependent on 14 exporter countries in 2006 of which the 3 most important sources are Russia, Algeria and Norway. They import 35% from the Mediterranean region itself (intra-trade with Algeria accounting for 27%), followed by Russia 28%, Norway 11%, Netherlands 9%, Nigeria 7%, the Middle East 6% and Iran 3%.

Table 14 - Quantities of Natural Gas imported by Origin in 2006 (in bcm)

Importers	Algeria	Egypt	Libya	Med	Norway	Russia	Nigeria	Oman	Qatar	Iran	T & T	Belgium	Germany	Netherl	UK	TOTAL
Portugal	2,10	-	-	2,10	-	-	1,97	-		-		-	-	-	-	4,1
Spain	11,42	4,8	0,72	16,94	2,12	-	7,10	1,0	5,00	-	3,00	-	-	-	-	35,2
France	7,35	2,30		9,65	14,50	9,50	4,23	-		-		1,90	0,10	9,50	0,20	49,6
Italy	27,46	0,10	7,69	35,25	7,20	22,92		-		-		-	2,50	8,70	0,80	77,4
Greece	0,45	0,04	-	0,49	-	2,40		-		-		-	-	-	-	2,9
Cyprus				0,00												0,0
Malta				0,00												0,0
Slovenia	0,44	-	-	0,44	-	0,56		-		-		-	-	-	-	1,0
Croatia				0,00		1,10										1,1
Serbia	-	-	-	0,00	-	2,15		-		-		-	-	-	-	2,2
Bosnia & H.				0,00		0,40										0,4
Macedonia				0,00		0,10										0,1
Albania				0,00												0,0
Turkey	4,60			4,60	-	19,65	1,12	-		5,69		-	-	-	-	31,1
Israel				0,00												0,0
PNA				0,00												0,0
Syria				0,00												0,0
Lebanon				0,00												0,0
Jordan	-	1,93	-	1,93	-	-		-		-			-	-	-	1,9
Egypt				0,00												0,0
Libya				0,00												0,0
Tunisia	1,30	-	-	1,30	-	-		-		-			-	-	-	1,3
Algeria				0,00												0,0
Morocco	0,50			0,50												0,5
Total to MED	55,6	9,2	8,4	73,2	23,8	58,8	14,4	1,0	5,0	5,7	3,0	1,9	2,6	18,2	1,0	209
Share by Source	27%	4,4%	4,0%	35%	11%	28%	7%	0,5%	2,4%	3%	1%	1%	1%	9%	0%	100%

Source: CEDIGAZ, BP & OME

The development of electrical interconnections has allowed for the increase in regional electricity trade. In this regard, trade between Mediterranean countries and their neighbours, volumes have reached 249 TWh (125 TWh exported and 124 TWh imported) in 2006. Of this total trade volume between Mediterranean countries and their neighbours (249 TWh), about 28% constitute intra-Mediterranean trade (70 TWh), only about 7 TWh (10%) of which are exchanged between SEMCs themselves. Intra-Mediterranean trade is illustrated in the table hereafter, clearly showing the dominance of electricity trade in France, Spain, Italy, Portugal, Slovenia and Croatia, and is including:

- 70 TWh exported from France (including 14.9 TWh to Italy and 5.9 TWh to Spain),
- 11.9 TWh exported by Spain (including 8.4 TWh to Portugal, 1.5 TWh to France and 1.9 TWh to Morocco),
- 7.5 TWh exported by Slovenia (including 5.4 TWh to Italy and 1 TWh to Croatia),
- 7.6 TWh exported by Croatia (including 6.9 TWh to Slovenia and 0.7 TWh to Bosnia-H.)

- 7.8 TWh from Serbia-M (including 2.1 TWh to Macedonia, 2.3 TWh to Bosnia-H and 0.3 TWh to Albania)
- 3.2 TWh exported by Portugal to Spain.

Only 10% of the total intra Mediterranean trade (70 TWh) concerns the trade between the Southern and Eastern Mediterranean Countries (SEMCs), including exchanges with Europe (Morocco-Spain). These small quantities are due to the limited capacity of existing power interconnections in the SEMCs.

The largest share of the 7 TWh exchanged between SEMCs took place mainly between Morocco and Spain, Morocco-Algeria-Tunisia as well as Libya-Egypt-Jordan-Syria-Lebanon, and a part between the Balkans and Greece.

Table 15 - Quantities of Electricity exchanged by interconnection in 2006 (GWh)

Electrical Interconnections	Exports	Imports	Total
Portugal-Spain	3183	8481	11664
France-Spain	5910	1479	7389
France-Italy	14891	726	15617
Italy-Greece	455	945	1400
Italy-Slovenia	12	5389	5401
Slovenia-Croatia	1036	6871	7907
Croatia-BiH	674	3647	4321
BiH-Serbia& M.	1476	2341	3817
Serbia& M.-Macedonia	2126		2126
Greece-Macedonia	12	1202	1214
Greece-Albania	979	26	1005
Albania- Serbia&M.	613	261	874
Spain-Morocco	1899	27	1926
Algeria-Spain			0
Algeria-Morocco	159	136	295
Algeria-Tunisia	141	135	276
Tunisia-Libya		0	0
Egypt-Libya	123	91	214
Egypt-Jordan	823	77	900
Syria-Jordan	42	2	44
Syria-Lebanon	1100	358	1458
Israel-PNA	1665		1665
TOTAL intra-Mediterranean	37319	32194	69513

Countries	Exports	Imports	Total
Portugal	3183	8481	11664
Spain	11859	9120	20979
France	69868	8079	77947
Italy	1618	46525	48143
Greece	1936	6151	8087
Slovenia	7487	7716	15203
Croatia	7577	13249	20826
Bosnia-H.	5123	3015	8138
Serbie & M.	7789	9739	17528
Macedonia	1202	2998	4200
Albania	639	1240	1879
Turkey	1800	600	2400
Syria	1142	360	1502
Lebanon	358	1100	1458
Israel	1665	0	1665
PNA	0	1665	1665
Jordan	79	865	944
Egypt	946	168	1114
Libya	91	123	214
Tunisia	135	141	276
Algeria	300	271	571
Morocco	163	2058	2221
TOTAL in Mediterr	124960	123664	248624

Source: UCTE; Eurelectric; UAPTDE; Comelec; Compagnies & OME

While still in a process of development, the completion and reinforcement of the Mediterranean ring (through future interconnection projects described in the following section) should further enhance regional trade and optimize the regional electrical park.

According to the estimations of the MedRing Study[5], power exchange should increase to a minimum of 75 TWh by 2010. Benefits resulting from the "closure" (completion) of the Ring are today expected to be significantly higher than the conservative figures announced in the MedRing study ($300 million per year) back in 2003.

[5] MedRing is the most complete study undertaken on the whole Mediterranean electric interconnections between 2001 & 2003. It was led by CESI (Italy) with partners EDF, REE, DESMIE, SONELGAZ, STEG, EEHC, NEPCO, PEEGT, TEIAS, ONE and GECOL The MedRing study identified the economic benefits of the Ring, detected operational difficulties and constraints, and defined solutions to address them. The study concluded that the Ring is viable, provided that the technical solutions proposed to overcome operational difficulties are adopted. The results of the study were presented at a conference organised by Eurelectric and Medelec, together with the OME and the UCTE on July 9th, 2003 in Rome.

3. AN INCREASE IN ENERGY VULNERABILITY AND SOCIO-ENVIRONMENTAL RISKS[6]

Given the current energy mix and its evolution, the high growth of energy demand entails an increase in dependence on fossil fuels. This situation gives rise to a greater energy vulnerability, which is to be connected not only with the inevitable depletion of hydrocarbons (estimated as within 30 to 50 years in the Mediterranean) but also with a volatile market and an unstable geopolitical context.

Besides, the management of the environmental impacts of this growth represents a major challenge of the coming years. Indeed, the CO2 emissions induced by an increasing consumption (these emissions are set to double between 1990 and 2020 in the Mediterranean basin) foster and exacerbate the current climate change which, in its turn, is likely to worsen pollutions. Indeed, a drop in rainfall and a decrease in nebulosity would give rise, during the summer, to an increase in polluting substances concentration, - such as ozone, for instance, which has impacts on human health, agricultural yields and natural ecosystems.[7]

In the long term, exposure to high levels of air pollution contributes to many diseases, such as respiratory diseases, throat cancers and heart attacks. World Bank estimates on the particle levels in a sample of cities indicate that the air pollution in Cairo, for instance, is one of the highest in the world[8] and that it is responsible for 20.000 premature deaths per year in Cairo and in Alexandria.[9] It is also observed that cities like Istanbul or Ankara (particularly, owing to a significant use of coal in collective heating) report higher levels of pollution than NMCs cities, which, themselves, are quite often situated beyond the recommended thresholds.[10]

The Intergovernmental Panel on Climate Change (IPCC) states, in its fourth report (AR4), that in the South of the Mediterranean basin "climate change is likely to make more difficult the weather conditions (high temperatures and dryness) in an area already vulnerable to climate variability, reduce water availability, hydroelectric energy, summer-season tourism, and the productivity of crop lands".

AR4 indicates that the most vulnerable Mediterranean regions are North Africa—adjacent to desert zones—, large deltas—such as the Nile—, coastal areas, as well as areas with high demographic growth and socially vulnerable (Southern and Eastern shores, dense cities and suburbs).

Plan Bleu baseline scenario indicates that, between 2000 and 2020, the number of inhabitants per km of coastline will triple on the Southern and Eastern shores. The number of power stations constructed along the coast will grow from 200 to 360, new refineries and desalinisation stations, new airports and housing quarters will be built. Yet, this coastal area is precisely the most vulnerable to climate change.

The current adaptation solutions are mainly based on high energy-consuming applications: mass displacement of population in response to water rise, air-conditioning in response to increase in temperatures, desalinisation and deep pumping in response to dryness. Thus, these "responses" to

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[6] & 3 and V drafted in cooperation with Stéphane QUEFELEC (Plan Bleu) and Stéphane POUFFARY (Ademe).
7 Filipo Giorgi, MCSD presentation, june 2007.
8 The practice of burning rice hay in preparation for the new crop in the Nile delta results in Cairo having levels of soot in ambient air 3 times above those of Beijing. It comes in addition to emissions from industries and transport activities. Source : http://www.enviro2b.com/environnement-actualite-developpement-durable/5998/article.html
9 Data from the World Bank in "Arab Republic of Egypt, Cost Assessment of Environmental Degradation", Sector note, 2002.
10 The EU Air Quality Directive (200/69/CE, of 16 Novembre 2000) sets recommended thresholds(Emission Limit Values (ELVs)for Member States. Notably: 20 µg/m3 on an annual basis for SO2, 40 µg/m3for PM10 and 50 µg/m3 for NO2. Those limit levels are based on scientific knowledges about negative impacts on health or/and the environment and should not been overpassed on a given period.

climate change would be the very factors furthering this change, which induces a gradual and inevitable acceleration of this major phenomenon and of the related impacts.

Lastly, this environmental impact entails, in its turn, impacts on the energy system. Thus, the high rise in energy demand at periods during which production capacities are reduced (heat wave periods or other extreme events) causes risks of 'black out', which should not be neglected. For example, the 2003 heat wave in France generated a rise in demand, with very high consumption peaks; but power production had been reduced owing to the rise in river water temperatures, which reduced the cooling efficiency of the stations (both conventional and nuclear). Had the heat wave continued, 30% of the power production would have been threatened.[11] The Mediterranean energy system, being quite centralized and little diversified, is all the more vulnerable to climate change impacts.

11 IPCC Report 2007, impact, adaptation and vulnerability.

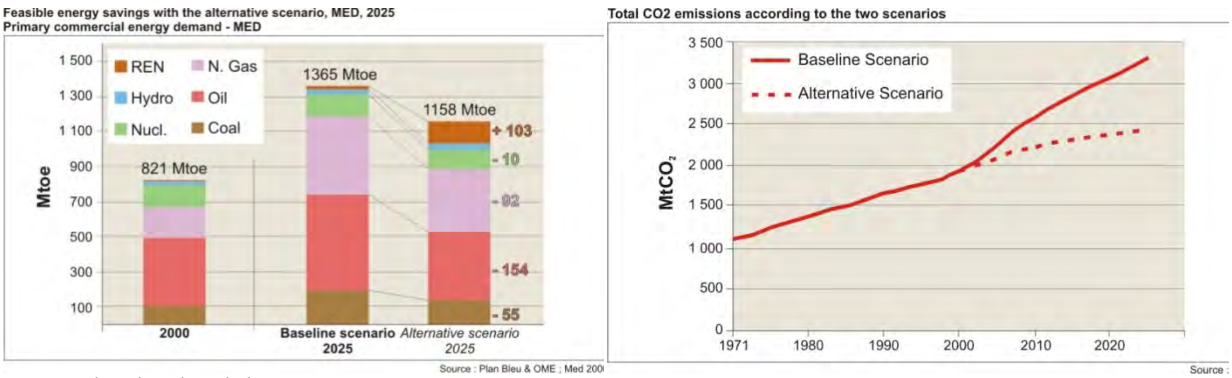
V. HOWEVER, A SUSTAINABLE MEDITERRANEAN ENERGY DEVELOPMENT AND LESS CARBON EMITTER IS STILL POSSIBLE

1. PLAN BLEU ALTERNATIVE SCENARIO

Plan Bleu published in 2005, an alternative scenario[12] for a sustainable energy development of the region which grants priority to a more rational energy use and a faster renewable energies development. Indeed, rational use of all energy products, in all activity sectors, is the only way to control, and even to structurally reduce, energy demand, while ensuring increase in the services provided and responding to economic development related needs.

If a vigorous policy of Rational Energy Use (REU) is conducted, the quantity of energy products necessary to produce the required services can be considerably reduced, and the share of renewable energies can reach 14% of the primary energy balance by 2025 (exclusive of biomass) instead of the 3% set in the baseline scenario.[13]

Figure 12 - Energy saving with the Plan Bleu alternative scenario, 2000-2025



REN : geothermic, solar, wind
Source : Plan Bleu, 2005, A Sustainable Future for the Mediterranean

Such a scenario helps reduce the energy vulnerability of the importing countries, maintain larger exportation capacities for the future in the exporting countries, as well as allows exportation of "green" energy, job creation, less environmental impacts, less—or deferred—investments needs, more competitive enterprises, and, finally, electrification of isolated areas at lower cost. Besides the alternative scenario quantifies, on Mediterranean basin scale, several of these advantages:

Significant energy savings: the energy intensity of the riparian countries would drop approximately twice more rapidly (-1.3% per year). The total energy savings likely to be achieved in the region would reach 208 Mtoe/year by 2025, which is about a half of the forecast increase in demand between 2000 and 2025. Approximately 60% of these savings would concern SEMCs, and 40% to NMCs. The demand on oil would stabilise in 2025 at its 2000 level, while the baseline scenario foresees an increase by 40% in demand between 2000 and 2025 (150 Mtoe). This evolution of demand would limit the necessary hydrocarbon imports and would reduce the energy dependence of

12 See the energy chapter in « A sustainable future for the Mediterranean » Plan Bleu, Guillaume Benoit and Aline Comeau (Dir.), Earthscan, oct. 2005. Scenari developed in partnership with OME.
13 The baseline scenario used here is the one proposed by Plan Bleu in 2005. It does not take into account 2008 update by the OME.

the importing countries. 208 Mtoe saved in 2025 is also providing substantial financial savings (2200 billion USD with a barrel price of 120 USD).

Mitigated environmental impacts: the construction of many energy infrastructures could be avoided (or deferred) and the attendant environmental impacts and risks mitigated. Thus, the construction of 154 power plants of 500 MW, mainly along the Mediterranean coastline, could be avoided into 2025, out of the 400 additional plants forecasted according to the baseline scenario. CO2 emissions would be cut down by 25% (-858 Mt) for the countries as a whole by 2025, which corresponds to 45% of current emissions. The contribution of Mediterranean countries to global CO2 emissions would be of 7% by 2025, instead of 9% according to the baseline scenario.

2. ACTIONS TO CHANGE SCENARIOS:

One major concrete expression of the increasing awareness in the Mediterranean is the adoption, in November 2005, of the "Mediterranean Strategy for Sustainable Development" (MSSD) by the 21 countries and territories signatory of the Barcelona Convention for the protection of the Mediterranean. The MSSD is a "framework strategy", in the sense that it can inspire the development of National Strategies for Sustainable Development (NSSD), each country being responsible of setting itself its own objectives. The 2nd priority topic of this Strategy is "a more rational energy management, increased use of renewable energy sources and adaptation—via mitigation—to the impacts of climate change".

The main energy objectives outlined are:

- to promote Rational Energy Use (REU);
- to optimise the Renewable Energies (RE) potential;
- to control, stabilise or reduce—according to each particular situation—greenhouse gas (GHG) emissions;

It puts forward quantified objectives, of which (i) to reduce by about 1 to 2% per year the energy intensity per GDP unit by 2015, and (ii) for renewable energies, to reach 7% of the total energy demand by 2015 (exclusive of CWR – Combustible Renewable and Waste).

It also suggests a set of actions and guidance of a qualitative nature, such as: (i) to promote energy savings policies as well as renewable and cleaner energies; (ii) to set global and sector-based objectives aimed at promoting REU and RE within the national and local sustainable development strategies,; (iii) to urge the economic players, local authorities and consumers to adopt sustainable behaviours through a pricing policy, targeted subsidies, tax incentives and public awareness-raising campaigns supported by NGOs; (iv) to promote economic mechanisms, such as renewable energy certificates, and regulations aimed at promoting renewable energies; and (v) to strengthen regional cooperation and support the implementation of the UNFCCC and the Kyoto Protocol.

Other initiatives also exist in the region in order to promote energy efficiency and renewable energy development in the region. Several organisations and institutions are devoting and or supporting important efforts in that purpose (European Commission, EIB, MEDENER, OME ...). OME is working on these issues in particular within its Renewable Energy and Sustainable Energy Committee.

VI. CONCLUSION

Trend scenario clearly shows that CO2 emissions from energy use are going to increase strongly in the near future. Up to 2025, the SEMC could CO2 emit as much as countries from the North of the basin.

Several options do exist, allowing satisfying energy needs while addressing security of supply concerns, reducing GHG emissions and climate change challenges:

- Exploitation of energy efficiency existing huge potential.
- Deployment of clean and efficient energy technologies for the electricity generation.
- Exploitation of local available renewable energy resources.
- Carbon capture and storage.
- Non technological solutions have also to be taken into account in particular in information, in urban development, tourism offer, transport or the water sector where change of behavior are directly linked with development option.

Those options, their cost and benefits,their advantages vis-à-vis climate change for the Southern Mediterranean countries are discussed all along the Part II and III of the study.

CHAPTER 5

Economic simulation of energy development strategies in the Southern countries of the Mediterranean: Egypt, Morocco, Tunisia

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Morocco, Tunisia), a rise by 52,6% of final consumption and by 76,7% of energy needs between 2005 and 2015, two types of scenarios based on the objectives of the MSSD are considered. A first series involves demand side actions of rational energy use. The second series is based on a greater recourse to renewable energies. The comparison between the trend-based evolution and the alternative scenarios helps evaluate the energy saving potential in terms of volume. This volume is, afterwards, appreciated in view of the evolution of the oil barrel price according to three assumptions: a falling trend causing the price per barrel to stand at 75$ by 2015; a stabilization trend with a price of 120$ by 2015; a continuous rising trend causing the price to reach 175$ by 2015.

The cost differential between the trend and the alternatives helps evaluate the cost of non action ("business as usual") during the coming decade. It also evaluates the financial room for manoeuvre available for the countries to deploy alternative actions.

Aggregated results for simulation carried out for Morocco, Tunisia and Egypt show:

- It emerges that the greatest potential lies on the demand side, via actions of rational energy use. Actions targeted at the non industrial sectors, resulting in a fall by 10% of the current level of energy intensity (energy consumption to produce one unit of GDP), would allow an average annual drop in energy needs in the three countries in 2015 equivalent to 11.1% of the final consumption for 2005. Similar actions targeted at industries hold a potential of annual savings equivalent to 5%.
- As regards the development of renewable energies (RE), a rather modest effort putting up the share of RE amounting to 1% of consumption would—nevertheless—allow a gain in volume in the order of 1.4% of the consumption for 2005. A more significant effort putting up RE to 3% of consumption would, in this case, help towards the saving of a volume equivalent to 4.1% of the consumption for 2005.
- By combining these types of action, and according to the extent of the effort in matter of RE, the annual rate of savings made in energy volume would range between 17.6% and 20.2% of the final consumption for 2005. These are annual volumes ranging between 10 and 12 million toe, that is about two years of final consumption for a country like Tunisia. As to the volumes saved over the 10-year period as a whole, they are in the range of 49 to 54 million toes.
- According to the oil price trend, these non saved volumes, if the alternative strategies were deployed, would have heavy financial implications. For the last three years of the simulation (2013-2015), the cost of non action would range from: (i) 14.4 to 16.2 billion dollars if the price per barrel fell to 75$ (about the total amount of Moroccan exports in 2005); (ii) 21.7 to 24.4 billion dollars if the price per barrel stabilized at 120$; and (iii) 30.3 to 34.1 billion dollars if the price per barrel were to steadily rise to 175$ (**about the amount of the aggregate exports of goods of Tunisia and Morocco in 2005**).

Lastly, the volumes likely to be saved based on the deployment of alternative actions will have an impact in terms of mitigation of climate change, via the CO_2 emissions avoided. Combining a rational energy use (REU) and a development of renewable energies (RE) in the three countries covered by this chapter would allow the avoidance, between 2006 and 2015, of the emissions of 190 to 209 million tons of CO_2 (that is the equivalent of the aggregate emissions of Egypt and Morocco for 2005). By 2015, the volume of emissions annually avoided would range between 39 and 46 million tons, that is between 17% and 19.8% of the emissions for 2005.

An extrapolation of the cumulated results for the 3 preceding countries shows that over the whole Southern rim, the aggregate for the whole actions would allow, as at 2015, an annual saving of 33.6 to 38.3 million toe and a decrease in CO_2 emissions in the range of 119 to 139 million tons. The annual return on the actions, as from 2015, would range, on regional level, from: (i) 18.5 to 21 billion dollars, with a barrel at 75$; (ii) 29.5 to 33.7 billion dollars, with a barrel at 120$; and (iii) 43.1 to 49.1 billion dollars, with a barrel at 175$.

It is worth recalling, for the sake of information, that Tunisia's nominal GDP stood at 28.7 billion dollars in 2005 and that its CO_2 emissions due to energy use stood at about 20 million tons.

INTRODUCTION

Context:

The Mediterranean is one of the world's regions which, irrespective of the global evolution, will see its climate evolve more rapidly and more drastically than the global average. Indeed, recent results of future climate modelling works concur towards affirming that the Mediterranean is a "hot spot" of climate change. The physical impacts of the change will further aggravate already alarming non sustainable trends.

For the Southern and Eastern Mediterranean Countries (SEMCs)—now reporting an energy upswing—, the stake rests, above all, in anticipation, so that the future development patterns (urbanization, way of life, energy systems) do not irremediably lead them to an environmental dead end, a greater vulnerability to climate change impacts, and a structural inability to adjust to a global economy which will most probably be, by 2050, very little CO_2 emitting and highly energy efficient.

The energy constraints and priorities of the countries of the region are varied. Yet, in its report, Plan Bleu identifies two main courses of action for which all the countries of the region have significant room for manoeuvre to meet the region's economic, environmental and social challenges: (i) Rational Energy Use (REU) (or energy efficiency); and (ii) diversification of the energy supply and promotion of "clean" or renewable energies (wind, solar, geothermal) (RE). In Mediterranean countries—where the consumption of commercial primary energy has more than doubled over the past 30 years, based at 87% on fossil energies—, it is estimated that, if the technologies already available were to be used, instead of letting the current trend towards a non rational use of energy develop without proactive adjustment, a potential saving of 20 to 25% of the total energy demand would be quite feasible by 2025. This saving on resources has a positive environmental impact, by reducing GHG emissions and, especially, CO_2 emissions (according to current trends, the CO_2 emissions of the Mediterranean would pass from 7% of the world total in 1992 to 9% by 2025). It also has a direct economic impact, by reducing an energy bill that weighs quite heavily on the countries of the Southern rim, with limited financing capacity owing to their economic and social development constraints. For the Southern Mediterranean Countries (SMCs), the major economic constraints are those related to employment (and, hence, to growth as a job-creation factor) and to external trade balance. They must be regarded as absolute from a sustainable development perspective, since they carry a heavy weight in the very short term on the social balance, and, consequently, of a priority order over any other agenda.

While a global awareness of the risks attendant upon the current trends of recourse to energy is an actual fact, we are still far from a consensual vision. Most often, one notices that the environmental and economic problems are presented separately and, what is more, in a concurrent way in terms of priorities.

There are, indeed, several fundamental contrasts: (i) first of all, between developed countries and developing countries, the latter suspecting that certain constraints related to environment protection imposed by the former stem more from a disguised protectionism than from a genuine concern for a "clean" development; (ii) secondly, between the "economists" themselves, in regard of priority stakes, with a hierarchisation of needs which assumes that when a major segment of the population seeks to meet vital basic needs, certain issues resting with the community are necessarily relegated to second order; (iii) finally, between "economists" and "environmentalists", even on ways of approaching the "environment" dimension—especially as regards the fact of including in the analysis of prices, costs and benefits certain aspects which are qualified by the latter as too commonplace to address a fundamental issue.

The first point will not be discussed; but it is fundamental, on the other hand, to further explore the point related to the priority character of various objectives. Herein lies, indeed, one of the main objections which some would level at environment protection strategies as follows: while there may be no doubt that it is relevant, it is not the top priority; actually, more "vital" actions need to be undertaken first in terms of human development, before thinking of the environment. A large debate around this tends to take place when groups of experts seek to agree, on the one hand, on the environmental impact of human activities such as they are conducted today and, on the other hand, on the existence of a more or less short time span to act before irreversible changes take place.

A way of reconciling such views is to recognize the need and the urgency of implementing far-reaching changes of energy strategies without underestimating the funding constraint, one of the commonly advanced impediments likely to delay a translation into facts of the awareness of environmental stakes. It is, indeed, certain that—no matter the level of this awareness—maintaining social cohesion remains a priority, and that short-term pragmatism will always override when it comes to trade-offs. In view of this, the approach developed here consists in quantifying in monetary terms the gains to be derived from a structural change of the energy strategies, in such a way as to estimate its short term economic advantages and, thus, evaluate its compatibility with the socio-economic priorities. This will help avoid an oversimplification of the issue opposing, to the urgency to act, the availability of limited financial means of action, thus implying that other problems must be addressed first.

Objectives of the chapter:

This chapter seeks to improve the state of knowledge about the short-term economic advantages—in financial and environmental terms—of the various possible energy strategies in the Southern Mediterranean Countries (SMCs), considering their own constraints in terms of economic and social development. More precisely, the task is to focus on the economic cost due to possible low energy efficiency and non use of renewable energies (RE) in the Mediterranean countries, a cost whose magnitude can encourage the countries to adjust their energy mix in favour of RE and to conduct energy efficiency actions. The chapter proposes a modelling activity which incorporates and complements the works of the prospective scenario developed in the Plan Bleu report. It thus allows a short/medium term (2015) economic quantification of the possible benefits generated by energy policy options geared towards achieving sustainable development objectives.

The analysis is based on 3 countries representative of the Southern Mediterranean Countries (SMCs): Egypt, Morocco and Tunisia, which form a sufficiently representative sample to evaluate the cost of non action ("business as usual") for the whole of the Southern rim. Being based itself on the differential of direct costs according to a trend scenario and alternative scenarios, the chapter purports to present in a fairly precise way the additional economic advantages likely to be expected from an alternative scenario—compared with a trend scenario—and to, thus, highlight the economic opportunity for the countries to engage in national strategies helping achieve the regional objectives of the MSSD.

These same alternative aspects also offer the possibility of evaluating the environmental benefits in terms of CO_2 emissions.

Information sources and methodology:

The analysis rests on a simulation approach that uses a model of economy in volume comprising its own energy balance. The macroeconomic data are derived from the IFS data base of the IMF, except for capital stock, which is recomputed after Vikram Nehru and Ashok Dhareshwar's "A New

Database on Physical Capital Stock: Sources, Methodology and Result", 1995. Data on energy balance are derived from MEO.

The equations making up the model are estimated by OLS (ordinary least squares) regressions over the period 1990-2005 for each country.

The reckoning of CO_2 emissions is based on an estimate of the Apparent Consumption according to the Final Consumption that is yielded by the simulation. A total emissions factor is calculated based on the composition in energy raw materials of the apparent consumption for 2005 (source MEO) by applying the principles identified in the IPCC "Guidelines for National Greenhouse Gas Inventories", 1996 (revised edition). This factor is possibly recomputed for each year between 2006 and 2015 in the scenarios integrating increased recourse to renewable energies.

The price of oil uses as reference the IMF estimates over the period 1990-2007 ("World Economic Outlook", October 2007; simple average of 3 spot prices (APSP): Dated Brent, West Texas Intermediate and Dubai Fateh). For the prospective period 2008-2015, three different resource price trends are assumed: falling trend (return to 75$), stability or continuation of the rising trend (up to to 175$).

The trend scenario represents pursuance of the trends for 1990-2005 over the period 2006-2015. It helps obtain the volumes of consumption and of CO_2 emissions, as well as the raw materials purchase costs, according to the three trends which will serve as reference. The alternative scenarios require structural changes in the Energy Production - Use relation and help obtain alternative volumes in Tons of Oil Equivalent (toe), in CO_2, as well as the cost in dollars according to oil price trend.

The benefits expected from of the alternatives (in terms of consumed volumes saved, emitted CO_2 volumes avoided, and purchase costs saved) are obtained by comparing the alternative values with the baseline trend values.

The approach adopted in this chapter evolves according to the following stages:

1) Representation of how the economy operates: identification of the current economic development model and its possible minimum growth level necessary according to the socio-economic constraints of the Southern Mediterranean Countries (SMCs). Three countries have been selected to measure the magnitude of the economic effects: Egypt, Morocco and Tunisia. Morocco had already formed the subject of a study in 2007 which is updated here;

2) Determination of the energy need for this model to operate: it is implicitly assumed that the production of goods and services—production based on which the economic development level is measured—uses a capital factor and a labour factor, with employment representing the constraint of social balance, and the use of a volume of energy ranging according to the level of production reached and to energy efficiency (the energy volume required by a commercial production plant);

3) Evaluation of the direct energy cost: The necessary energy volume has, on the one hand, a commercial purchase cost, which incurs a direct cost borne by the community and, on the other hand, an environmental, indirect, cost measured for example by the GHG emissions of the volume used. One, thus, evaluates the direct cost of the use of a given energy volume, according to the market price of the resources used. This cost is a reference value, the price of the national strategy adopted to provide to the socio-economic sphere the energy necessary for its operation. This stage is a crucial one, as the concept of price helps to make objective the relationship between the various aspects on a given date;

4) Taking into account the possibilities offered by the energy system, and this, via the part of the simulation which takes up the structure of an energy balance: the volume made available is

determined by: a) a local production which can be ensured by various sources; b) a distribution system whose efficiency is variable, part of the production likely to be "lost" before its marketing; c) an international energy exchange market, part of the local production likely to be "exported" (and, consequently, will not be consumed locally), and an energy volume which can be imported to meet domestic needs, at an internationally set price (the local country is supposed to be price- taker[1] , the energy price is thus exogenous);

5) The two processes (economic and energy) being calibrated in view of past trends, a continuation of the trends identified over a short period (within 10 years), during which most of the structural behaviours can be deemed as being stable without the assumption being too strong, helps evaluate the "trend cost". Obviously, this cost also depends on the evolution of energy prices, whose prediction is difficult, one must admit. In the present study, this trend cost is estimated in a range according to the evolution of the price of the oil barrel;

6) Evaluation of costs according to the various possible energy strategies: Various parameters of the energy system are changed in order to illustrate the national actions conducted for diversifying the energy supply (via renewable energies) or improving energy efficiency (via actions promoting rational energy use). The selected illustrations represent changes geared towards achieving the regional objectives of the Mediterranean Strategy for Sustainable Development (MSSD). Simulation helps obtain an alternative evaluation of the cost necessary to meet the new energy need according to the economic and social development. Comparing this alternative cost with the trend cost makes it easy to obtain a quantified evaluation of non action[2] and to elicit the financial room for manoeuvre thus available for a given objective, which it remains to compare with the costs of the measures to be deployed for achieving it. Consequently, it is possible to conduct a consideration in terms of a classical cost-benefit analysis: profitability and return time of the investments, sectors to be prioritised, impact of relative energy price (as the cost of non action varies according to oil prices, the benefit to be expected from the actions also depends on them, which "benefit" constitutes a "room for manoeuvre" to finance the cost of the actions), etc;

7) Assessment of environmental impacts according to the various strategies based on GHG emissions.

<u>Contents of the chapter:</u>

The reasoning adopted comprises 3 main aspects:

- gathering acquaintance with the cost mechanisms for the community, via a modelling which connects economic operation and the necessary energy needs to the current development pattern;
- financial evaluation for the time frames considered by the decision makers of the current strategy, and its short term trend according to the evolution of the international energy market;
- objective evaluation based on cost differential of the national measures taken with a view to: a) optimising energy use: that is, the volume necessary according to the objectives of the

1 The size of the country is not large enough as to influence prices on the international market.
2 In the models evaluating the economic and social impact of anthropogenic climate change, the evaluation and identification of the "cost of non action" are subject to several assumptions (Cf. Richard S.J. Tol et al.: "Methodological Aspects of Recent Climate Change Damage Cost Studies"). In the present analysis, the task is easier insofar as one is concerned only with the direct cost of goods having a market price: in the case in hand, the two systems yield, by extending the trends, the financial weight—within the time frame set—of the energy need, according to the international price. Non action is, here, defined by the continuation of the trends observed. Changing the various parameters translates certain actions and generates new values of this same financial weight. The comparison between the trend value and the alternative values is defined as the cost of non action.

economic development sought by the economy under consideration; b) diversifying the energy supply in order to mitigate national dependence—both in terms of resources and of cost—according to the fluctuation of relevant prices. This fluctuation is, in fact, represented implicitly, based on the evolution of oil prices, which actually minimises the assumptions to be considered: the reasoning proceeds in terms of profitability (return) threshold, insofar as the oil price rising, the direct savings generated by the use of alternative sources rise, too, thus increasing their relative interest.

The chapter is organised into 4 parts:

- a first part offers a brief overview of the particular economic and energy context of the countries of the Southern rim of the Mediterranean;
- a second part presents the macroeconomic and energy systems on which the simulation rests;
- a third part is dedicated to estimating the cost of non action in terms of volumes and value according to the trend of oil prices. It outlines various alternatives of rational energy use and recourse to renewable energies;
- a fourth, and last, section is dedicated to GHG emissions.

I. ECONOMIC AND ENERGY CONTEXT OF THE SOUTHERN MEDITERRANEAN COUNTRIES (SMCS)

1. ECONOMIC ASPECT: EMPLOYMENT, BALANCED GROWTH, CONVERGENCE

Three (3) economic requirements determine on the short term any sustainable development in the Mediterranean Countries (MCs) [3]:

- The employment exigency: with a young population and a working population steadily increasing, it is required to create at least 22 million jobs between 2005 and 2020 to stabilise the labour market situation, if not around 60 million in order not to swell the absolute ranks of the non working population;
- The growth exigency: these jobs must be created in a sustainable way and allow convergence of income levels between the two rims of the Mediterranean;
- The macro-economic constraints: development sustainability implies preservation of the achievements of the past 15 years and avoiding any crisis, by tending—especially for these developing countries—to a sound balance of payments, in a context of high trade deficit, as well as to budget balance.

Development sustainability rests, first and foremost, on conditions of maintaining social cohesion, a major cause for concern. As far as the countries of the Southern rim are concerned, the key aspect to take into consideration is the population structure.

The 10 MCs counted over 250 million people in 2005. A closer consideration of the demographic trends leads to the following main observations:

- The growth rates of the total population have markedly dropped, and forecasts for the time frame 2015 reveal a continued trend, especially due to a decrease in fertility;
- The number of young people is highly significant: over 80 million people are aged less than 15 years (2005) and will need employment within the coming 15 years, a number which exceeds the current level of the working population. Herein lies, indeed, the major constraint for Mediterranean societies.

It is obvious that MCs are well into their demographic transition. Consequently, all aspects concur to a quasi-stabilisation of the population growth of the MCs for the time frame of some twenty years. Yet, this incepted demographic transition does not preclude a continual marked increase of the working population over half a century on average (Cf. Graph below). The current population structure—which is marked by a working population (those having a job or those identifying themselves as unemployed) lower than that aged less than 15 years (that which will be in employment age by 2015)—will prevail over several years. Under these conditions, without a significant increase in the pace of economic growth, employment problems, too, will continue to prevail, with the whole host of social threats attendant upon them.

The crucial problem of the MCs today is, therefore, that of their youth and of the population in working age. To the former, there need to be offered prospects; to the latter, there needs to be

3 The 10 MCs are those of the MEDA: Algeria, Egypt, Israel, Jordan, Lebanon, Morocco, Palestine, Syria, Tunisia, Turkey.

offered employment, which—in addition—will confer credibility upon the prospects offered to youth. As shown by the experience of certain Asian countries, this demographic phase can be quite beneficial for the economy of the MCs. However, for this to obtain, the movement must evolve in an economy that is dynamic enough to offer the jobs necessary and that—moreover—the quality of these new jobs must allow a real wage increase, without it being a burden on the competitiveness of the economy. With regard to the issue under consideration, this has two implications:

- The first one is that the political agendas are entirely focused on the social priority of employment and that, consequently, and in view of a necessarily limited budget in the case of "developing" countries, all options must pass through the screen of trade-offs;
- The second relates to the scope of the task. According to FEMISE estimates (Presentation to the Euro-Mediterranean Seminar on employment by the Directorate General for Employment, December 2007, "The Employment Challenge in Mediterranean Countries"), for the whole Southern rim zone, by 2020, the MCs will have to create over 22 million new jobs for the sole purpose of not aggravating the current situation in terms of percentage, and up to 60 million to stabilise the absolute number of the unemployed.

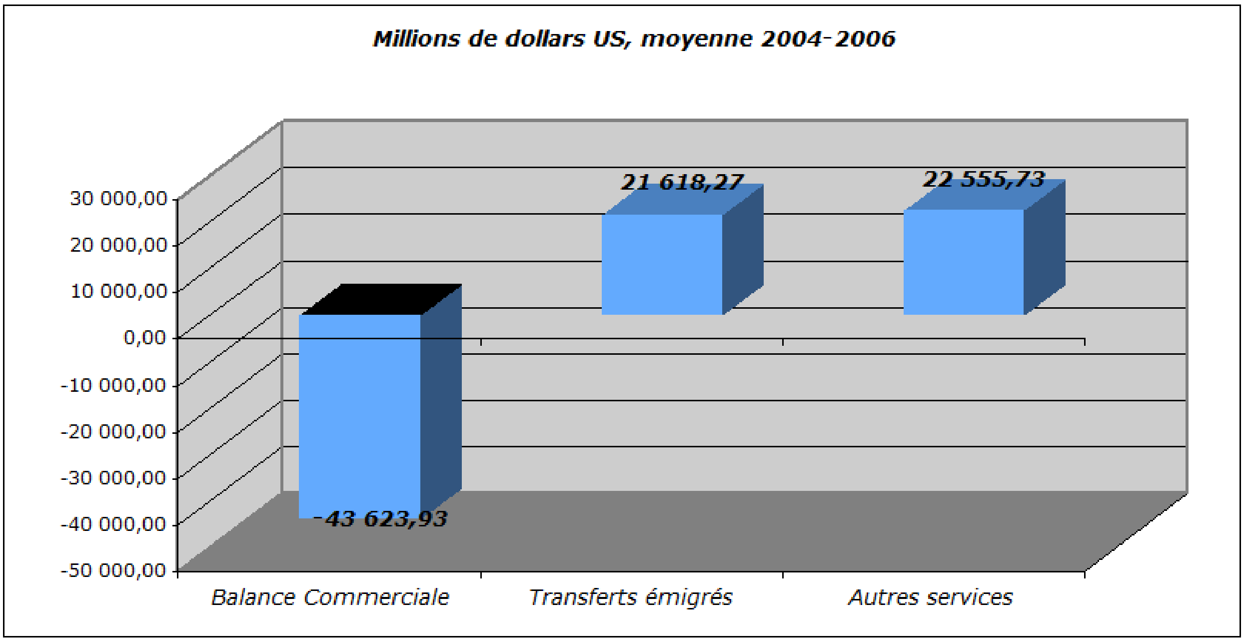
It is, therefore, a requirement of stepping up growth which the MCs have to meet, a quantitative and short-term requirement, above all, which relegates—as a matter of fact—such other aspects as the conservation of environmental resources to the position of issues of a second order. Growth will be sought whatever the "environmental cost", and—one must admit—this hierarchisation is perfectly rational.

All the more so that, if one were to look upon the situation from a Mediterranean-wide perspective, one would notice that, since 1990, the economic conditions have considerably changed in the countries of the Southern rim. A quite considerable effort has been made to improve the macroeconomic framework, with indisputable success. The significant performance in the macroeconomic management of the MCs has helped them avoid major crises (except for Turkey). However, the macroeconomic progress alone has not been enough to significantly mitigate their vulnerability in terms of exposure to external chocks (as evidenced by the case of Morocco with the impact of the drought on GDP growth) of unemployment and poverty.

Indeed, the progress reported over the past decade has not been able to muster a dynamics strong enough to trigger economic convergence between the two rims: there may now be observed in a glaring way a widening gap between the EU and the new members, on the one hand, and the MCs, on the other hand.

The fact that one needs only cross a strait to see such a gap in the standard of living and—more fundamental still—to lose/gain as many as 10 years of life expectancy, is hardly a stability factor and may warrant the fact that some should look upon environmental concerns as a "luxury" which one side of the strait seems no to have capacity enough to finance.

Graph 1 - Sustainability of the balance of payments current account of the 10 MCs



Source : Femise 2007, after EIU

The economic openness, in which the MCs as a whole have engaged since the early 1990s—with impetus by the Barcelona Agreements—, has altered the external constraint, but the economies remain exposed and the balance of payments remains often vulnerable. The trade exchanges with the EU evolve after a classical North-South model, according to which the MCs export raw materials and manufactured products that are intensive in labour of low qualifications, and that use low or average level technology. On the other hand, relations with the rest of the world give rise to higher level specialisation. Yet, in any case, the MCs are in a situation of major trade deficit. Exchanges in services seem to cover in part this deficit. But it seems that this is mainly due to earnings generated by tourism, while trade services remain lagging behind.

In terms of Foreign Direct Investments (FDIs), the situation gives cause for concern. Admittedly, the flows seem to be on the increase again over the past few years, but—over the whole period—the MCs have received a total volume that is far short of what would be necessary to observe an appreciable effect in terms of capital accumulation and increase in productivity. The MCs attracted 15.8% of the FDIs intended for developing countries in the 1980s, a share that—since the mid 1990s—has hardly exceeded 5% (3.5% on average).

In effect, for most Mediterranean countries, foreign balance obtains by compensating the significant trade deficit (especially vis-à-vis the EU) by tourism earnings and by immigrant workers' remittances.

box 1 - Theoretical transmission channels of energy cost changes to the economy, and estimate of recent impacts

"The impact of a rise in oil prices translates—above all—into a rise in the energy bill, accruing not only from the oil component, but also from the other raw materials whose prices are driven by oil prices (gas, in particular). The rise in the energy bill is passed on to the economy as a whole via two major channels. It induces a rise in the production costs of enterprises which, according to their margin behaviour, may pass totally or partly the rise in the cost of inputs on to the consumer prices. Inflation rises exert negative impacts on demand and supply of goods by distorting the cost of the factors, which leads to a fall in the country's income.

This, then, triggers a shrinkage in the consumers' purchasing power, the inflation translating into a dent in the real income available. The rise in energy prices leads to a reduction of the profit margin of enterprises, which causes the latter to revise downwards their investment and recruitment programmes. Nevertheless, this behaviour is far from being automatic, in view of the competitive context which prevents enterprises from fully passing on the rise in costs. (…) The IMF considered, in its estimates of September 2005, an average oil price of 54.2 $/b (for 2005) and of 61.8 $/b (for 2006). (…) According to IMF estimates, the current level of oil prices would incur 0.7 to 0.8 points to global growth in 2005-2006. However, the impacts would differ according to the extent of dependence vis-à-vis net oil imports, the energy intensity of growth and each economy's shock absorption capacity."

Source: Repercussions of the rise in oil prices on international and national economies (in French), Department of Studies and Forecasts – Ministry of Finance and Privatisation (Morocco), January 2006.

2. ENERGY BILL IN EGYPT, MOROCCO AND TUNISIA

In the MCs, primary energy consumption grew over fivefold between 1970 and 2005, reaching 265 million toe. According to MEO, assuming no change in the trend, demand would be in the range of 536 million toe by 2020. Population growth and economic development are the major drivers of the increase in energy consumption. At present, fossil energies (oil, coal, gas) account for over 95% of the energy supply of the MCs.[4]

In this context, the energy challenges for the MCs consist in the following actions at once:

- to meet the growth in demand;
- not to aggravate the impacts of the energy system on the local and global environment (GHG and climate change);
- to gain in competitiveness via control over consumption, energy efficiency and renewable energies, in an increasingly free, open and competitive Mediterranean market, and in an increasingly volatile and uncertain international energy context; and
- to step up energy security in order to ensure political, social and macroeconomic stability.

The simulation conducted in the present chapter will involve 3 out of the 10 countries of the Southern rim: Egypt, Morocco and Tunisia. The selected three countries alone account for over 40% of the population of the MCs. The economic weight, as measured by the GDP, is less significant, though they account for over a quarter of the gross domestic production of the region. However, exclusive of Turkey, the three countries account for 42.3% of the GDP. In terms of energy, the Egypt – Morocco - Tunisia group represents the third of the region's total energy production and final consumption. It is worth pointing out the lesser weight in terms of imports, about 20%, owing to the fact that Egypt and Tunisia are (modest) hydrocarbon "producers". Tunisia has only recently become a net importer, and Egypt is likely to soon follow suit. Their weight in regional exports (exclusive of Libya) is, obviously, much lower, standing at less than 10%. However, exclusive of Algeria, the set of the three countries accounts for 23.5% of the exports.

4 "The Mediterranean: Plan Bleu Environment and Development Outlook" .

Table 1 - Weight of the three countries under study among the countries of the Southern Mediterranean rim

	Source	Egypt	Morocco	Tunisia	Total MCs	In % of the 10 MCs
Total population 2005 (inh.)	FEMISE, ILO	74 032 884	31 478 460	10 102 467	260 410 199	44,4%
Active population 2005 (pers.)	FEMISE, ILO	20 359 300	11 139 725	3 413 100	79 377 844	44,0%
Unemployment 2005 (pers.)	FEMISE, ILO	2 240 700	1 226 429	486 400	9 331 997	42,4%
GDP 2005 in billion US$, 1996 prices	EIU	100	49	30	676	26,4%
Primary Energy Production 2005 (KTOE)	MEO*	71 754	615	6 571	310 715	25,4%
TPES 2005 (KTOE)	MEO*	60 691	12 190	8 950	246 029	33,3%
Energy imports in volume, 2004 (KTOE)	MEO*	4 008	12 039	6 052	116 576	19,0%
Energy exports in volume, 2004 (KTOE)	MEO*	-10 136	-1 441	-4 061	-171 075	9,1%
Final energy consumption in volume, 2004 (KTOE)	MEO*	40 125	9 248	6 417	167 569	33,3%

* Jordan non considered

In substance, it is to be noted that the three countries considered in the analysis account for 25% of the economic potential of the Southern rim, 33% of the energy balance, and 44% of the population. These figures should allow to rapidly extrapolate, on the level of the Southern rim as a whole, the evaluations concerning our sample.

Concerning now the direct amount of the energy bill, the MCs in general, of which the three countries selected, bring to play two combined movements which entail a high growth of the weight of energy in the national accounts: (i) a growth of demand under the effect of a strong population and production growth; and (ii) a recent trend of the price of hydrocarbons marked by a strong increase. For Morocco, a non producing country, for instance, energy imports accounted for 21.6% of the total imports in 2006 (as against 15.6% in 2003), claiming 40.2% of the export earnings (as against 25.3% in 2003). With regard to Egypt and Tunisia, which export oil products, the weight is less heavy but is growing significantly. In Egypt, energy imports accounted for 16.3% of the total imports in 2006 (as against 5.2% in 2003) and claimed 24.5% of exports (9.2% in 2003). In Tunisia, these exports of energy products accounted for 13.7% of the total imports in 2005 (as against 6.8% in 2003), claiming 17.1% of exports (as against 9.4% in 2003).

For these three countries, the energy bill in share of GDP reports a very strong growth and reaches significant percentages: 3.1% of GDP 2006 in Egypt (0.8% in 2003); 8.2% of GDP 2006 in Morocco (4.8% in 2003) and 6.3% of GDP 2005 in Tunisia (2.8% in 2003).

It is also worth highlighting that the prices of energy products enjoy public subsidy in most MCs. This indirect financial weight adds up to the direct cost (Cf., in Box 2, the example of the Moroccan Equalization Fund (CCM)).

box 2 - The Moroccan Equalisation Fund (CCM):

This body was created in 1941 to stabilize the prices of consumer goods. After Independence, Morocco maintained this institution, whose main resources are provided by taxation levied in the beneficiary sectors, the Fund's Board of Directors being vested with the authority to initiate a tax as it deems it fit. In 1975, a first imbalance arose: the Domestic Consumption Tax (TIC) on oil products was instated by the Moroccan government, but these some 12 billion dirhams per year are recovered directly by the State Budget, depriving the Fund of one of its most important sources of revenue. With the implementation of the "Structural Adjustment Plans", followed upon by the actions of liberalization of the Moroccan economy and the international trade agreements, the Fund's missions were revisited: as at the end of 1990, the Fund's subsidization list was narrowed down to sugar, edible oils, butane gas and oil products. In 1995, a new system came into force, the prices being pegged to the Rotterdam standard market quotations of oil products, with a view to a gradual liberalization of the economy and of the energy sector.

According to this reform, it is the consumer who bears (partially) the fluctuations of the international market for any rise or fall exceeding a certain threshold (2.5%). The pegging was introduced, but the system was suspended in August 1999 in view of the upsurge in barrel price. Again, the Equalization Fund covered the difference between the domestic prices set for revisable projections and international prices. The current mechanism is, roughly speaking, as follows: over a certain period, an average price of the oil barrel is projected. If the international price exceeds this estimated amount, the public price being not pegged (since 2001), the Fund must compensate the difference to professionals who operate "within the framework of controlled prices". The continuous rise of the prices of oil products (but also of the price of raw sugar) since the beginning of the decade have destabilized the system, which is now the subject of a wide debate not only by international bodies, such as the IMF, but also from a local point of view. This is due to an increasing burden on public finance: in 2005, the central rate was set at 47.8 $, and in fact, that led the Moroccan State to transfer19.2 dollars to the Equalization Fund for each imported barrel (which is equivalent to a drawing down of 600 million dirhams (DH) per month, that is—according to the foreign exchange rate provided by the Ministry of Economic and General Affairs of 1 $ = 9 DH—a monthly drawing down of 66 million $). The budget for 2006 thus provided an allocation of 7 billion DH (780 million dollars) for equalization (subsidy) of oil products (out of a total of 9 billion), to which there had to be added 12 billion in arrears (1 300 million dollars). To illustrate the weight on public finance, it may be recalled that, in 2005, according to IMF data, public consumption amounted to101.26 billion DH (implying that the Fund budget accounted for over 6% of it, and arrears for over 11%), public revenue amounted to 140.2 billion (the same shares of 5% and 8.6%, respectively), and GDP stood at 457.62 billion (the same shares of 1.5% and 2.6%, respectively).

Today, the Moroccan authorities do not wish to completely call the system into question, while putting a ceiling on the budget: "The Equalization Fund will still continue to support the prices of normal gas oil and of butane gas of up to 5.5 billion dirhams per year in order to sustain the citizen's purchasing power"*, that is, 610 million dollars or, again, according to the preceding figures for 2005: 5.5% of public consumption, 3.9% of public expenditure and 1.2% of GDP.

* Statement by the Deputy Minister in charge of Economic and General Affairs, Mr. Rachid Talbi El Alami, dated 13 January 2007.

II. METHODOLOGY: THE MACROECONOMIC CHANNEL AND ITS ENERGY COROLLARY

1. OVERALL LOGIC

The approach adopted is pragmatic. For developing countries, such as the Mediterranean Partners, economic development emergencies take precedence. This unquestionably partakes not so much of a choice as it is of a reality. Here, for a still large part of the population, it is the vital basic needs that need to be met, as a priority order, and which dictate conduct.

Technically speaking, in the simulation model which we propose to present, the economic dimension will take precedence over the energy dimension. The task is, first of all, to reconstruct the current operation of the economies, possibly by assuming that it tends towards a stabilization of the situation in such a way that the very foundations of society are not threatened. From this economic operation, we will deduce the energy aspects, in terms of "fuel" to the economic driving force. The outlook may appear mechanical, if not even caricatural, but it is undeniably the reconstruction of the current way of thinking, including in the developed countries. In almost the whole economies, alternative technical solutions are considered only as a last resort, according to their cost and to the possibility of introducing these techniques in an economically viable way.

In broad terms, the logic rests on the following:

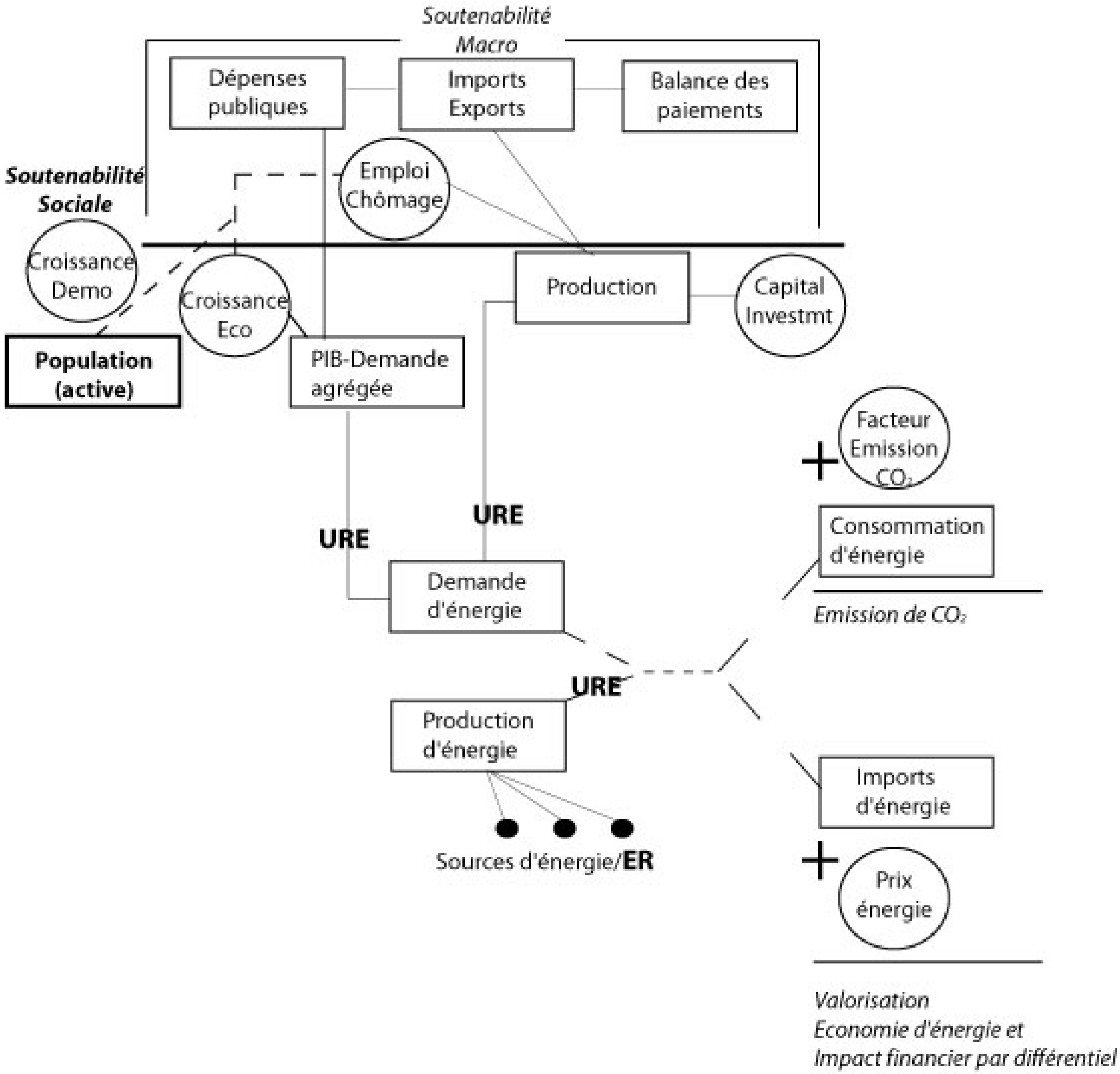
Operation of the economy (to absorb the growth of the working population)

=> energy need (energy balance)

=> cost (cost of the resources)

In more detail, the logic proceeds according to the following plan:

Graph 2 - Simulation logic-diagram



First of all, there is an upper part simulating the economic operation, with—as a main objective—the employment need and—as rigidities—the macroeconomic balance. This operation leads to an economic indicator which is GDP. To reach these GDP levels, people have energy needs: economic operation generates the total energy demand. Now, one gets to the low, left-hand side part: the energy part which must simulate the energy balance. To meet this presumably inelastic demand (except as, otherwise, questioning the economic foundations), it is necessary to produce energy, locally, and to import it. What is not produced locally, whatever the method, must be imported at a cost which depends: (i) on the volume necessary for the operation of the economy; and (ii) on the price of the energy raw materials.

There are in the energy part some action levers: (i) REU, or rational energy use: each volume of GDP requires the consumption of volumes of energy that the model works out as parameter, the variation of the parameter symbolizing an action lever; (ii) RE, or renewable energy: increasing the local production (in a "clean" way, by definition), which induces a fall in the volume that needs to be imported and, hence, of the collective cost; based on the differential between the cost without increase of energy production and the cost with increase, the expectancy of profit and, hence, of return on investment, can be evaluated under various assumptions of variations of energy prices.

2. ECONOMIC SIMULATION MODEL

2.1. Model core (economic process) used

The macroeconomic process used is a hybrid of a Keynesian and neo-classical approach. In terms of causality, production seems to be at the origin of the largest part of the national revenue available, which determines consumption, the trade balance and the various aggregates of the aggregate demand (exclusive of investment). But, an impact of demand on production level operates in feed-back by a law of Okun (Cf. Box 3): the variation of the unemployment rate is, indeed, a function of the growth of the aggregate demand, determining employment and, consequently, production, with investment being assumed, here, as exogenous (determined by a set rate of capital accumulation). This feed-back effect causes the model to diverge from the model of the traditional neo-classical approach, all the more so as the absence of the price loop allows a maximum production – aggregate demand variance. Thus, the reasoning focuses on the typical Keynesian loop of demand side flows.

box 3 - Law of Okun, relation between growth and employment

Formulated by Arthur Okun in 1962, it describes the linear relation between the production growth rate (GDP) and the variation of the unemployment rate. Generically, it is written as follows:

Ut-Ut-1 = -ß (gt-a), where U is the unemployment rate (in t and t-1), g the growth rate, and a et ß two parameters.

It stipulates, thus formulated, that the growth rate can have an impact on the variation of the unemployment rate starting from a certain threshold of growth equal to “a”. Below the threshold “a”, unemployment increases (owing to two factors: growth of the working population and growth of labour productivity); above the threshold, the unemployment rate decreases, with a constant elasticity ß: thus, each growth point above “a” entails a reduction of the unemployment rate by ß point.

“a” is a measurement of the “economy growth employment content” (variable over time and from one country to another). For Morocco, based on IMF data covering the period 1999-2005, the coefficient is estimated as 0.4.

Source: Blanchard, Cohen “Macroeconomics”, 2nd edition.

The starting point is the growth of the working population, which determines employment, according to the variation of the unemployment rate (resulting from the growth of past demand). The level of investment is adjusted to maintain a constant growth rate, compatible with the trend observed (1990-2005), according to IMF data.

The initial capital stock is reconstructed based on the Vikram Nehru and Ashok Dhareshwar series “A New Database on Physical Capital Stock: Sources, Methodology and Result”, 1995. It rests on the inventory method, with a 4-year lifecycle. The stock is denominated in local currency at 1990 prices.

The capital and employment determine the level of the Value Added, via a Cobb-Douglas standard production function, with constant return.

A “Total Productivity of the Factors” effect is introduced into the model by a time function coefficient increasing the level of production, in addition to the growth generated by increase in the capital and labour production factors.

The parameters of the Cobb-Douglas type production function for capital and labour are derived from A. Senhadji, “Sources of Economic Growth: An Extensive Growth Accounting Exercise”, IMF Staff Papers, vol. 47, n° 1 (2000). This paper provides for the three countries a range for the parameter related to capital. The simulation rests on a value comprised in this range, a value that is readjusted in order to work out the mean rate for the period 1990-2005.

The tax incomes are generated by the production at a marginal rate t. The Income available is thus obtained by the value of the production minus the tax levy, the capital downgraded, but increased by remittances (here “Workers Remittances” only, exogenous data, possibly increasing over time).

The fundamental equation of Consumption is a traditional Keynesian function, determining the level of consumption according to the income available and the propensity to consume.

Public expenditure is assumed to have to follow a constraint of a “Structural Adjustment Plan” type. The level of public procurement of Goods and Services composing the aggregate demand is a fixed fraction of the level of the Total Expenditures, which in their turn are determined according to the tax incomes.

$G = a \times \text{TOT EXP}; a<1$

$\text{TOT EXP} = a' \times \text{Tax} ; a'>1$

$\text{Tax} = a'' \times \text{Value Added}; a''<1$

It is, nevertheless, assumed over the period a certain “budgetary generosity”, the level of the total expenditure exceeding the tax incomes. The values selected for the three coefficients are derived from the IMF country reports and data for 2000-2005.

For the exchange cluster, the underlying assumption is that this is the case of “small countries”, which, therefore, do not have any impact on world prices. By applying a propensity to import on Consumption, the level of imports (in volume still) is reckoned. Under the assumption of “small country”, the absence of (global) imports price levels is no reason for concern (by definition, exogenous to the model).

The main question relates to the exports equation (and, consequently, the movements of the trade balance (X-M)). In general, such an equation would make exports depend on: i) a foreign demand indicator (in the context of the MCs, the volume of importation from the OECD or EU countries); ii) a competitiveness-price indicator for the products of the MCs on foreign markets—(or another possibility: i) an indicator of the role of the supply factors of the productions of the MCs and ii) the price ratio factor). This would assume, however, including an effect of foreign exchange rate, on which assumptions would need to be advanced as to its evolution between 2005 and 2015, in addition to the assumptions to make on the evolution of foreign demand. The risk is to multiply the economic assumptions not directly connected with the main issue, all of which are obviously debatable, which would conceal the results obtained.

Moreover, the very essence of the reflection lies in an evaluation of the volumes, be they of employment, or energy production or consumption. Indeed, it is the volumes that are relevant from a perspective of sustainability and environmental impacts, which implies that purely monetary effects are not desirable in this approach: they are likely, in fact, to conceal the evolution of actual volumes.

We will, then, have selected a simple equation of propensity to export dependent on the level of production.[5]

At this stage, all flows making up the aggregate demand have been identified. It is worth recalling, nevertheless, the growth-unemployment loop: the level of growth reached determines the variation of the unemployment rate, which—in view of the increase of the working population—determines the level of employment (and of production, etc).

5 This also offers the possibility of making the propensity to export—here assumed to be stable for the coming 10 years—dependent on the factors mentioned above if one were to make the model further sophisticated by integrating exchange effects.

2.2. Calibration process

The model is calibrated for each country separately. The procedure uses the IFS data of the IMF over the period 1990-2005. The parameters are estimated based on simple econometric relations, which are adjusted if necessary, in such a way that the simulated national accounts (exclusive of the shocks observed) reconstruct the trend 1990-2005.

The system of equations and the parameters estimated or observed are given, with a table presenting the values for the three countries under consideration:

$dPA/dt = a_1\%$	growth of the working population	(1)/*
$L = (1-u)\ PA$	employment level	(2)/**
$u_t - u_{t-1} = -a_2\ (dGDP/dt - b_2)$	unemployment rate	(3)/***
$dK/dt = I - 0{,}04\ K$	capital accumulation	(4)/****
$I = a_3\ K$	investment	(5)/****
$VA = a_4 * PGF_t * K^{\alpha} * L^{ß}$	production function	(6)/*
$T = a_5 * VA$	tax revenue	(7)/***
$REV = VA - T - 0{,}04K + WR$	incomes available	(8)/**
$C = c_0 + c_1\ REV$	consumption	(9)/***
$G = (a_6 * a_7) * T$	public expenditure	(10)/****
$M = a_8\ C + b_8$	imports of G & S	(11)/***
$X = a_9\ VA + b_9$	X exports of G & S	(12)/***
$GDP = C + I + G + X - M$	aggregate demand	(13)/**

* Data generated by third-party estimates
** Identities or mathematical calculations
*** Statistical estimates based on IMF or MEO data: OLS, out of 15 observations
**** Exogenous whose value is advanced
TFP =Total factor productivity ; WR = Workers Remittances
Values in local currency at 1990 prices

Table 2 - Simulation parameters for the 3 countries

	Egypt	Morocco	Tunisia
(1)	a_1=2,80%	a_1=3,00%	a_1=3,23%
(3)	-0,31 (dGDP/dt - 1,4)	-0,4 (dGDP/dt – 2,3)	-0,12 (dGDP/dt - 3,3)
(5)	I = 0,076 K	I = 0,074 K	I = 0,078 K
(6)	$VA = 0{,}895 * PGF * K^{0,7} * L^{0,3}$	$VA = 0{,}103 * PGF * K^{0,5} * L^{0,5}$	$VA = 0{,}717 * PGF * K^{0,7} * L^{0,3}$
	PGF=0,006t + 1	PGF=0,00001t + 1	PGF=0,009t + 1
(7)	T = 0,15*VA	T = 0,26*VA	T = 0,20*VA
(8)	REV = VA – T – 4%K + WR	REV = VA – T – 4%K + WR	REV = VA – T – 4%K + WR
	WR = 435t + 1440	WR = 45	WR = 46t + 310
(9)	C = 7200 + 0,93 REV	C = -10 + 0,87 REV	C = 160 + 0,90 REV
(10)	G = 0,66*1,3*T	G = 0,6*1,1*T	G = 0,66*1,3*T
(11)	M = 0,6 C - 31600	M = 0,82 C - 60	M = 0,834 C - 570
(12)	X = 0,50 VA - 35000	X = 0,46 VA - 63	X = 0,596 VA - 1745

Sur la base des trois estimations du circuit, on observera que les trois pays diffèrent essentiellement dans leur mode de croissance par le niveau de l'investissement (plus élevé en Tunisie et plus faible au Maroc), le poids de la main d'œuvre dans la fonction de production (plus élevé au Maroc) et surtout la croissance de la productivité globale des facteur (forte en Tunisie, quasi nulle au Maroc).

2.3. Results of the simulation

To evaluate the relevance of the macroeconomic simulation thus calibrated, we proceed to a comparison between the simulated data and the observed trends of 1990 to 2005.

One of the specificities of the countries of the Mediterranean rim, in general, and of Morocco, in particular—related to the intensiveness of the agricultural production, the importance of the tourism resources and the characteristics of their industries—is a strong exposure to exogenous shocks.

Morocco, in particular, is very sensitive to the droughts which struck hard there during the simulated decade.

Revisiting the data, exogenous shocks were introduced for the years concerned, by mere application of a coefficient lower than 1 to the simulated Value Added (1992, 1993, 1995, 1997, 1999, 2000 and 2005). Though to a lesser degree, Egypt and Tunisia, too, undergo this kind of shocks (especially, as regards these 2 countries, the impact on tourism earnings of the conflicts in Iraq and of attacks), and the same method is applied.

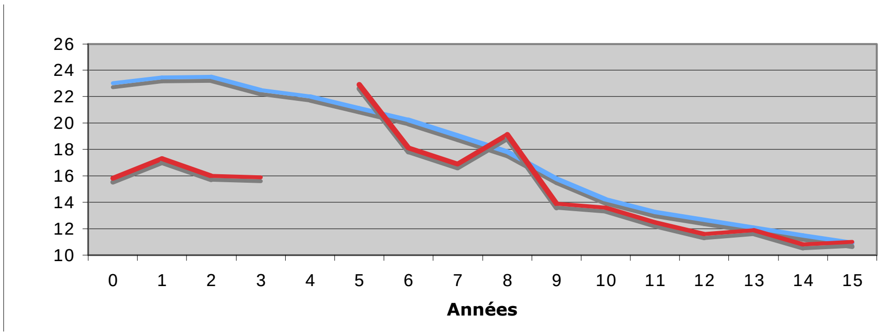
Hereafter are proposed the graphs comparing the values obtained by simulation integrating the shocks and the actual values (IFS data, IMF):

Graph 3 - Unemployment rate 1990-2005: Simulation – Observation comparison

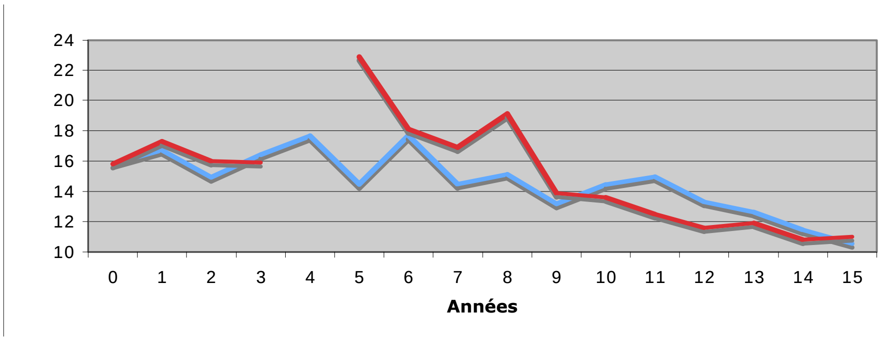
Blue curve : unemployment rate from the simulation

Red curve: observed unemployment rate

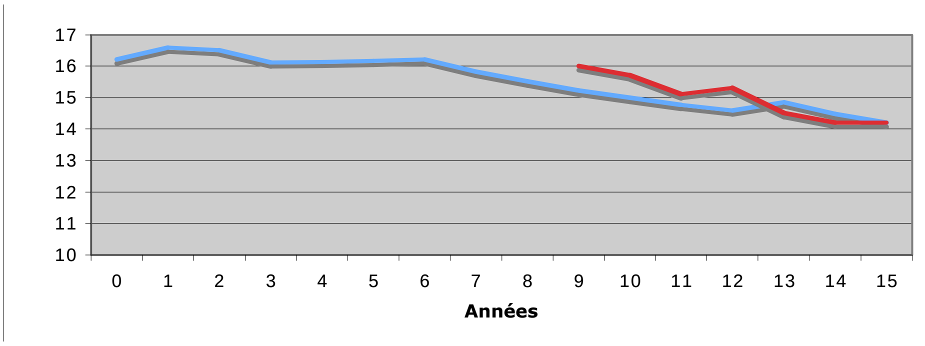
Egypt 1990-2005



Morocco 1990-2005



Tunisia 1990-2005

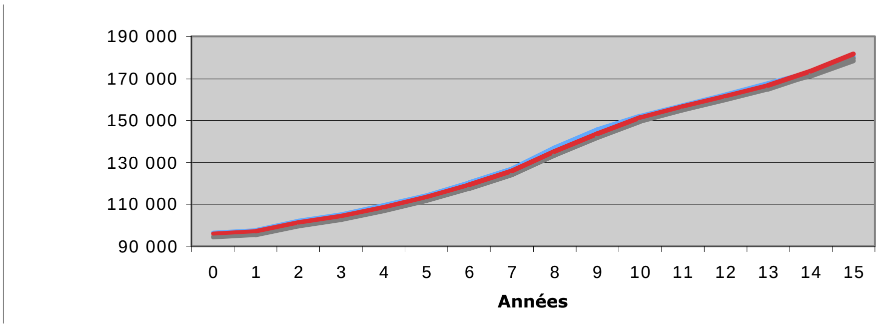


Graph 4 - GDP 1990-2005 (at 1990 prices, local currency): Simulation – Observation comparison

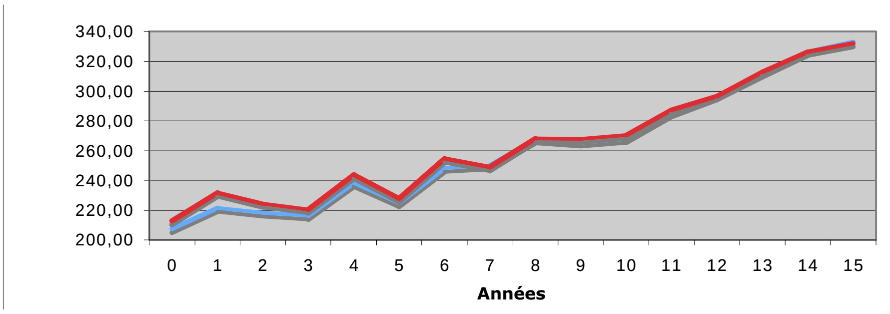
Blue curve : GDP from the simulation

Red curve: observed GDP

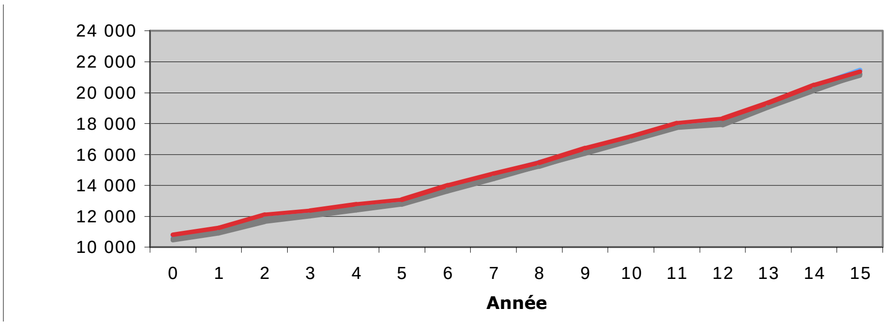
Egypt 1990-2005



Morocco 1990-2005



Tunisia 1990-2005



3. THE ENERGY CLUSTER

To connect the energy balance to the economy, it is assumed that the operation of the economy requires a consumption of energy, whatever its the form—at this point. To a certain extent, each GDP unit is thus obtained by consuming energy units. Each economy will choose a energy mix to provide its people with the total volume of energy necessary for a particular course of growth. It is based on this diagram that the simulation founds the relation economy-energy here: the operation of the economy involves a total energy consumption in volume which one finds in the energy balances (Total Final Consumption). In this version, two sectors only are singled out:

- the Industry sector, and
- other sectors, grouping the Residential (housing) sector and the Transport sector, in particular.

The logic consists in making the consumption in these two sectors depend on the levels of production and of the aggregate demand via a linear function.

TFC_industry = a VA + b	Final consumption of the industry sector	(15)***
TFC_house = a'GDP + b'	Final consumption of households, transport and other	(16)***
TFC= TFC_ind. + TFC_house	Reckoning the total volume necessary for the economy	(17)**

Equation 16 calls for some discussion: in it, the final consumption of households, composing the aggregate, depends on GDP. Indeed, we could have, alternatively, made the consumption of these sectors depend on the population or on employment. But this would have deprived us, in this case, of a simulation lever in terms of "rational energy use". The trend of the coefficient "a'" which we seek to simulate would have become, indeed, ambiguous. With the rise in the standard of living, the households will be able to access goods and services which they cannot currently finance. However, this social progress will mathematically increase the level of consumption per capita (coefficient "a'"), without this being an indication of a trend among the people to improve their use of energy. It would, then, be necessary to proceed in two stages: the first being a trend of convergence with the levels observed on the northern rim (a rise in "a'"); the second being an attempt to moderate this rise by a fall in the same coefficient, due to the initiatives taken towards improving energy use.

To avoid further complicating the analysis, while allowing for the use of the objective ratios of the MSSD, the explicative variable selected is, therefore, the aggregate demand, based on the following reasoning: with the rise in the standard of living—made possible by the fact of finding employment—, which depends on economic growth by assumption, people's residential energy needs increase, and this, due to more substantial equipment and newly possible consumption behaviours. This implies that for the residential sector, too, demand is also a function of GDP, as standard of living indicator, this time. However, the behaviour of households and the consumption of equipment can be "optimised" for better energy use, which results in a fall in coefficient "a'".

With respect to this energy need (TFC), and according to the energy balances model, the supply cluster is introduced. The volume of the energy necessary is, then, produced locally or imported. The function of domestic production is assumed to be exogenous, in order to constitute a true control lever, in particular as regards the production generated by renewable energies. It is also worth noticing the remarkable stability of the growth trend over 15 years, in view of the volatility of Moroccan growth and the volatility of oil prices, which stability further confirms the idea of independence of consumption of the variations of energy prices.

In order to estimate the benefit of investing in an increase in domestic production via the use of energy sources in line with sustainable development objectives, the model holds this variable for exogenous, that is constant, or following a time-bound trend.

Prod_domestic = aT + B	Domestic energy production	(18)***

Between the primary production and the actually distributed energy, there exist multiple sources of loss (and, consequently, of optimization), of indirect uses and of self-consumption (e.g. stock constitution, maritime storerooms, consumption of power production plants,…). Let us assume, for the time being, that production and distribution losses, self-consumption, storage, etc… are not distinguished. Again, this must be a control variable and the simulation thus assumes it to be exogenous. The simulation already giving the level of the TFC, the level of these "losses" is set in such a way that the TPES re-calculated by the simulation is adjusted to the level observed by MEO.

Losses = P	Losses and indirect uses of Domestic Production	(19)****

The energy balances also take into account the exportation of the energy produced locally, which—in a national model—must be subtracted from the supply available on the domestic market. This variable is considered, here, as exogenous, that is constant, or following a time-bound trend. It is interesting, from this standpoint, to note the example of Egypt, a producing country, whose exports follow a negative trend. For such a country, it may be worthwhile to consider the question of trade-offs between domestic use, and exportation—according to market price—of the resource (this being, accordingly, the case for Tunisia).

X_nrj = aT + b	Domestic energy exported	(20)***

We, thus, derive the gap between domestic demand and the supply available by domestic production, which will be assumed as being imported.

B_nrj=TFC-(pertes* Prod_domestic – Xnrj)	Energy volume to be imported for domestic needs	(21)**

Estimate of the coefficients per country:

TFC_industry = a VA + b	Final consumption of the industry sector	(15)***
TFC_house = a'GDP + b'	Final consumption of households, transport and other	(16)***
TFC= TFC_ind. + TFC_house	Reckoning the total volume necessary for the economy	(17)**
Prod_domestic = aT + B	Domestic energy production	(18)***
Losses = P	Losses and indirect uses of Domestic Production	(19)****
X_nrj = aT + b	Domestic energy exported	(20)***
B_nrj=TFC-(Losses * Prod_domestic – Xnrj)	volume of energy to be imported for domestic needs	(21)**

* Data generated by third-party estimates
** Identities or mathematical calculations
*** Statistical estimates based on IMF or MEO data and simulated values, out of 15 observations.
**** Exogenous whose value is advanced

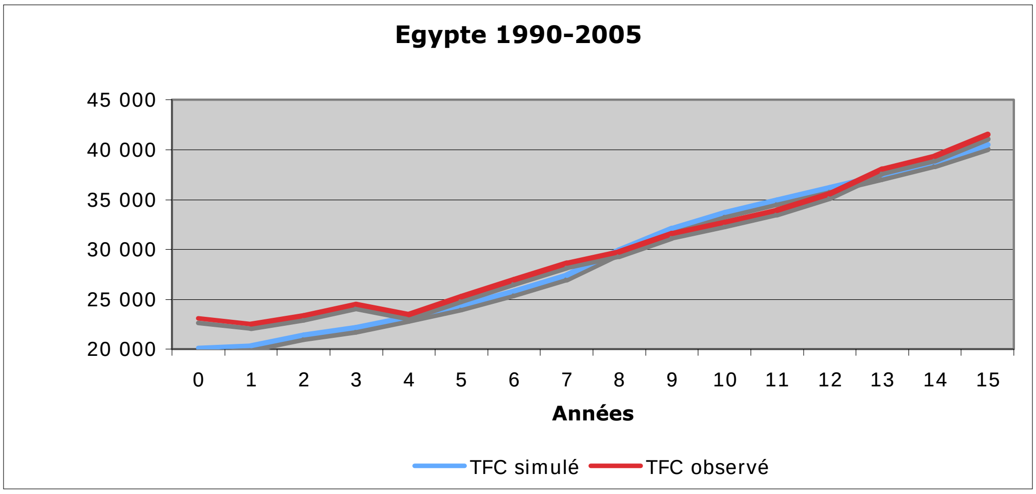
Table 3 - Simulation parameters for the 3 countries

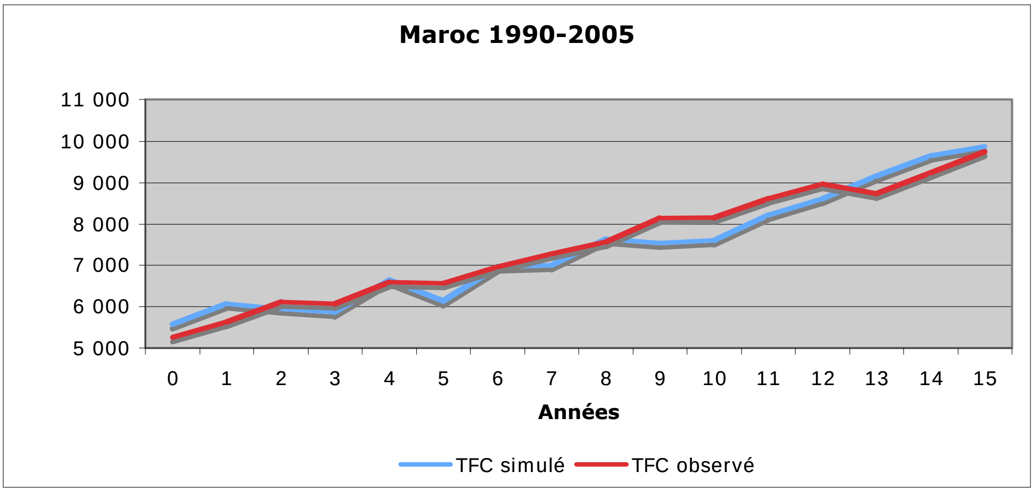
	Egypt	Morocco	Tunisia
(15)	0,095* VA - 1 260	8,23* VA - 163	0,051* VA + 690
(16)	0,158*GDP - 2 150	25,5*GDP – 1 348	0,262*GDP - 444
(18)	=740*t + 54 300	735 ; *trend non significatif*	6400 ; *trend non significatif*
(19)	Pertes = 0,78	Pertes = 0,84	Pertes = 0,84
(20)	=-600*t+24 750	X_nrj = -805 ; *trend non significatif*	X_nrj = -4210 ; *trend non significatif*

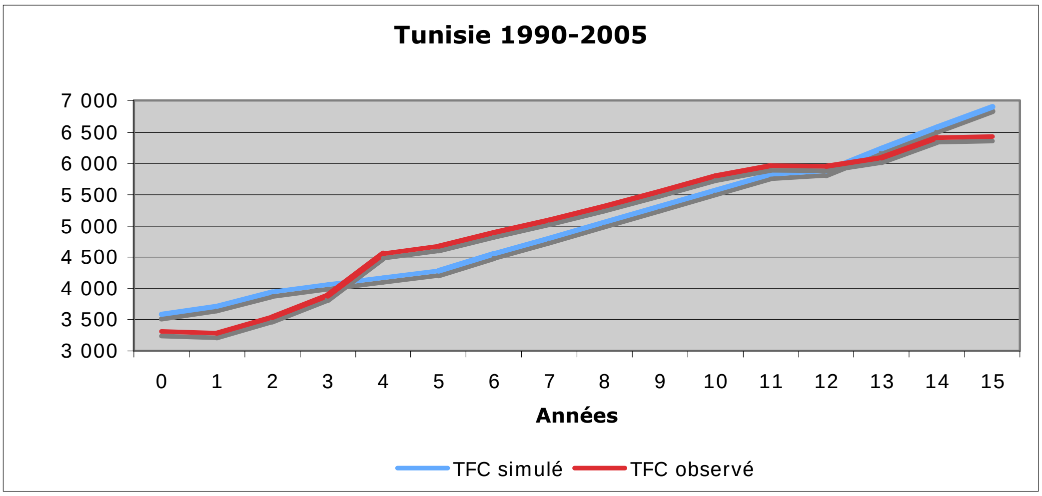
Few remarks can be directly made based on this table, the equations (15) and (16) being in local currency. It is worth noting, however, that Egypt posts a greater rate of "loss" than the other two countries. Concerning production, Egypt seems to still have some margin to increase its domestic production (or, at least, such was the case in the previous decade), but its exports follow a declining trend which can, in the long run, have a negative impact on the balance of payments. As regards Tunisia, the absence of a positive trend in terms of production during a period of a rise in the price of the resource tends to reveal a levelling off of the production.

The OLS estimate gives fairly significant results. By taking up again the economic simulation while integrating the shocks, it will be possible to compare below the total estimate between 1990 and 2005 of final consumption compared with the observed data provided by the Mediterranean Energy Observatory (MEO) for each of the countries studied:

Graph 5 - Total Final Consumption: Simulation – Observation comparison







At this stage, we obtain—with these two clusters—a simulation model that helps reconstruct the operation of the 3 economies and estimate, for each one of them, the energy need compatible with the trend economic operation, as well as the need for them to resort to importation to meet this need. It now remains to evaluate the relevant cost.

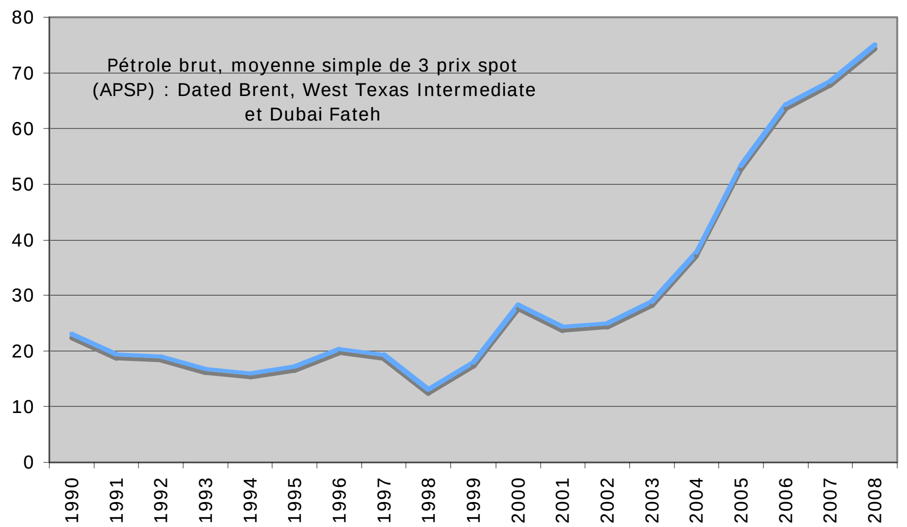
III. EVALUATION OF THE COSTS OF "NON ACTION" AND OF THE MARGINS OF FINANCIAL MANOEUVRE OFFERED BY THE VARIOUS STRATEGIES

1. ASSIGNING VALUE TO ENERGY VOLUMES

First of all, it is important to take a glance back at the estimate of energy volumes. Any monetary effect being eliminated from the model, by taking into account only variables in volumes, the issue of units is of secondary relevance. The task of the calibration was, accordingly, to estimate the functions of demand and supply based on a common volume unit, irrespective of the energy used. The logic was to choose the "ton of oil equivalent (toe)". The monetary evaluation was geared towards assigning a price to the TOE. The choice is quite simple. The price of the barrel converted into "ton of oil" gives the dollar value of the need to cover. Of course, the mix imported is not composed at 100% of oil, and a value-assignment assumption based exclusively on an average price of the barrel is a simplification. But, it will be assumed hereafter that the evolution of the oil price drives that of the price of other fuels, thus representing a good approximation.

The source used to estimate the price of the barrel is the series given by the IMF in its "World Economic Outlook" base, October 2007.

Graph 6 - Evolution of the oil price



Source FMI, WEO database, octobre 2007

2. LOGICS AND ALTERNATIVES

The trend analysis will, thus, yield a "total cost" in dollars of the currently adopted energy strategy, according to the recent economic trend. When this is extended to a more remote time frame, the dynamics of oil prices becomes a key element in the cost-benefit evaluation. While one will obtain directly only one cost, the logic adopted is to consider that—among several alternatives—the cost differentials obtained allow an identification of the room for manoeuvre available to finance the set up of new mechanisms.

As has already been pointed out, several elements of the simulation were regarded as "exogenous" or as "parameters", which confers upon them the status of an action lever and helps distinguish several types of public options.

This, then, leads to envisaging the following types of action:

1) 1. Actions fostering a more rational energy use and targeting households, transport and other non industrial sectors. Equation (16) is the simulation element: TFC_house = a*GDP +b (16). It is, indeed, assumed that the actions undertaken will help bring down the value of the consumption / GDP elasticity (coefficient "a") from the value 2005 to a target value 2015.

2) 2. Actions fostering a more rational use of energy in the industrial sectors. Equation (15) is the simulation element: TFC_industry = a'*VA +b' (15). It is, indeed, assumed that the actions undertaken will help bring down the value of the consumption / VA elasticity ("a'") from the value 2005 to a target value 2015.

3) 3. Actions sustaining a diversification of the domestic energy supply by a recourse to renewable energies. Equation (18) is put to service here: Prod_domestic = a"T+b" (18).

The value of the parameter in the standard model corresponds to the average production over the past few years, or to its time-bound trend, including the share of renewable energies. It will be assumed that the actions undertaken will help increase the share of RE in this total production, the remainder being assumed as constant (or pursuing the previous trend), the production level, thus, increasing gradually, which is simulated by adding, to the initially simulated value, the new RE production.

3. RESULTS

3.1. Trend evolution: Future cost according to three possible oil price trends

In this first section, the purpose is to observe the evolution between 1990 and 2005 for the three countries. Then, the simulation is extended over 10 years, in such a way as to obtain a forecast of all indicators for the time frame 2015 (2005 + 10 years), "All Other Things Being Equal". It is, thus, assumed that the economic process follows the operation highlighted over the past 15 years, during 10 years still, without structural change. The same assumption is made with regard to the energy process, which amounts to assuming that no action is undertaken to achieve the MSSD objectives.

Between 1990 and 2005, in an economic context of insufficient growth to absorb the significant unemployment reported by the three countries, the total energy consumption has followed a similar trend and almost doubled (+80% in Egypt, +86% in Morocco, +94% in Tunisia). The evolution of imports differs appreciably between the three countries. In Morocco and in Tunisia, the growth of imports has followed that of consumption (growing almost twofold), though slightly higher in Morocco (+95% in Morocco and +93% in Tunisia). On the other hand, the imported volume has been multiplied by 4.4 in Egypt.

At the same time (Cf. Graph on the evolution of the price of the barrel), the price of the resource has risen by a factor of 2.3 (1990-2005). But the combined effect of the increase in volume necessary and of the price of the resource implies that it is by a factor of 4.5 that the cost of energy has increased over the past 15 years in Morocco and in Tunisia. In Egypt, which has reported a high rise in imported volumes, the cost of energy has multiplied by 10.3 in 15 years. In monetary terms, combining MEO data on imports and IMF average barrel price, it is thus noted that the cost at international market price of the countries' energy imports has risen by a factor of 5.3, at a value of 1 895 million dollars in 1990 (283 million for Egypt, 1 110 million for Morocco and 502 million for Tunisia) and amounting to 10 181 million dollars in 2005 (2 917 million for Egypt, 5 011 million for Morocco and 2 253 million for Tunisia).

A continuation over 10 additional years (2006-2015) of these trends allows a preliminary evaluation of the energy need necessary for a mere continuation of the current dynamics, of which it must be said, however, that it is hardly sufficient to stabilize the unemployment rate, considering a steady growth of the working population. According to the process described, the energy need of the three countries is set to further grow by 76.7% by 2015 reaching 40 171 thousand toe (15 604 for Egypt, reporting a rise by 163%;15 075 for Morocco, reporting a rise by 41%; and 9 492 for Tunisia, reporting a rise by 56%).

To estimate the related cost, it would naturally be necessary to consider the evolution of the oil price over the same period. The position taken here is not to multiply assumptions, knowing that this price is fundamentally difficult to predict in the wake of geopolitical considerations combining with economic principles. In what follows, each monetary estimate will be conducted based on three trends:

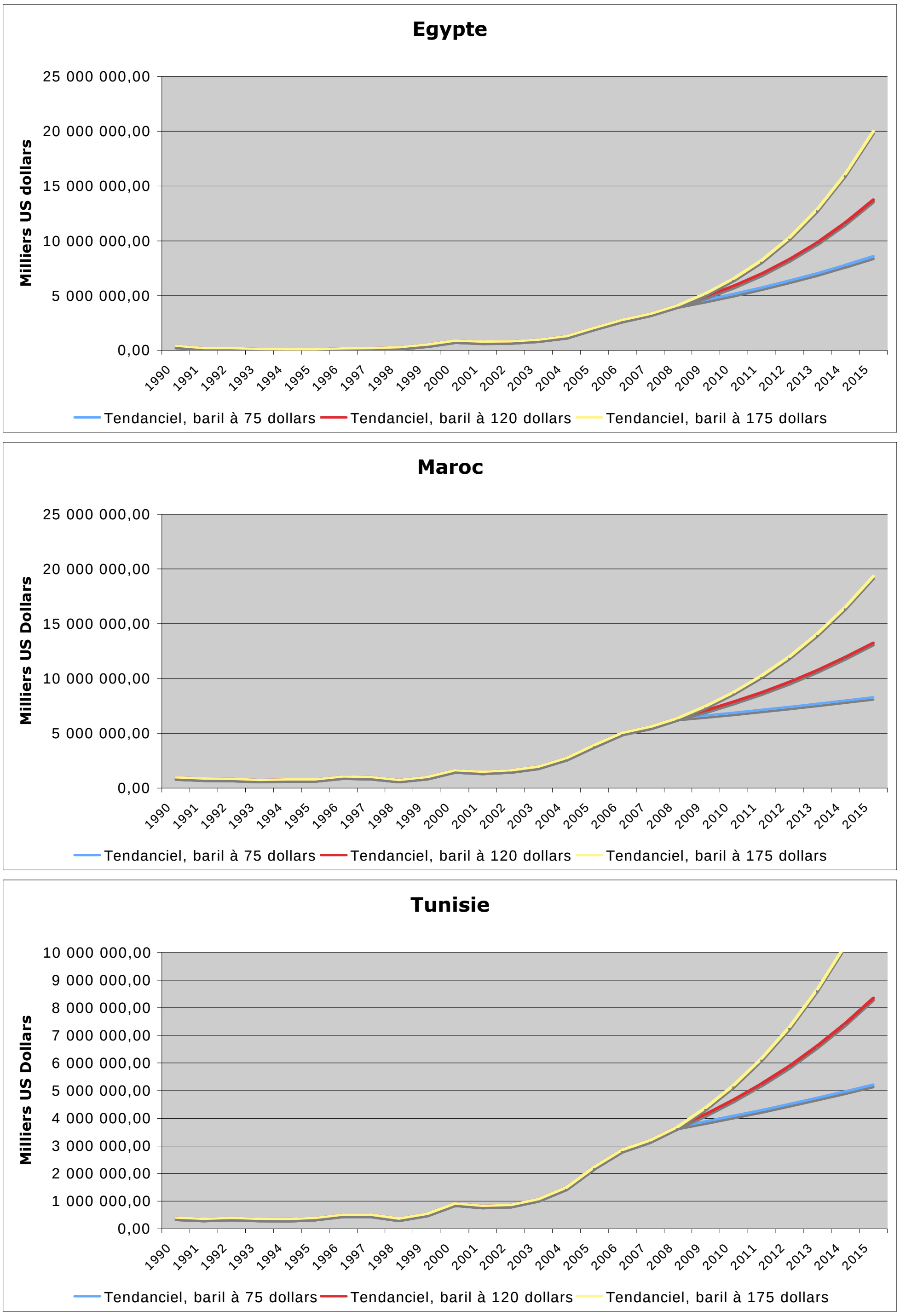
- The oil price falls again to lower levels, even though consumption increases. In this case, there will be assumed a price of 75$ per barrel in 2015, in a linear fall with respect to a level reached in 2008 (that is 120$).

  Under these conditions, the cost would pass from 10.2 in 2005 to 16.1 billion dollars in 2010, then would grow more slowly up to 22.1 billion in 2015, the rise in demand exceeding the fall in price of the resource. For Egypt, the amount would reach 5.2 billion in 2010 then 8.6 billion in 2015. In Morocco, the amounts in 2010 and 2015 would be of 6.9 billion and 8.3 billion, respectively; and, in Tunisia, of 4.1 billion and 5.2 billion.

- The price is maintained at 120 $ per barrel. In this case, for the three countries, the price to be paid would pass from 10.2 to 18.4 billion $ in 2010 (5.9 billion for Egypt, 7.9 billion for Morocco and 4.7 billion for Tunisia) and 35.3 billion in 2015 (13.7 billion for Egypt, 13.3 billion for Morocco and 8.3 billion for Tunisia).

- The price continues its trend rise to reach 175 $ per barrel (according to a linear growth). In this extreme scenario, the energy cost would reach 20.5 billion in 2010, then 51.5 billion in 2015. For Egypt, the bill would amount to 6.6 billion in 2010 and 20 billion 5 years later. For Morocco, these amounts would be of 8.8 and 19.3 billion, respectively; and, for Tunisia, they would be of 5.2 and 12.2 billion.

Graph 7 - Cost ranges of the trend scenario 1990-2015 according to the evolution of oil prices

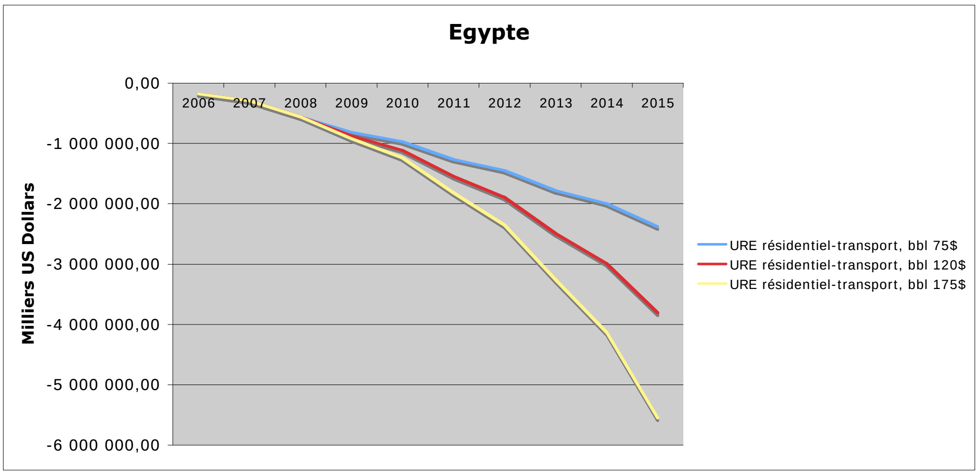


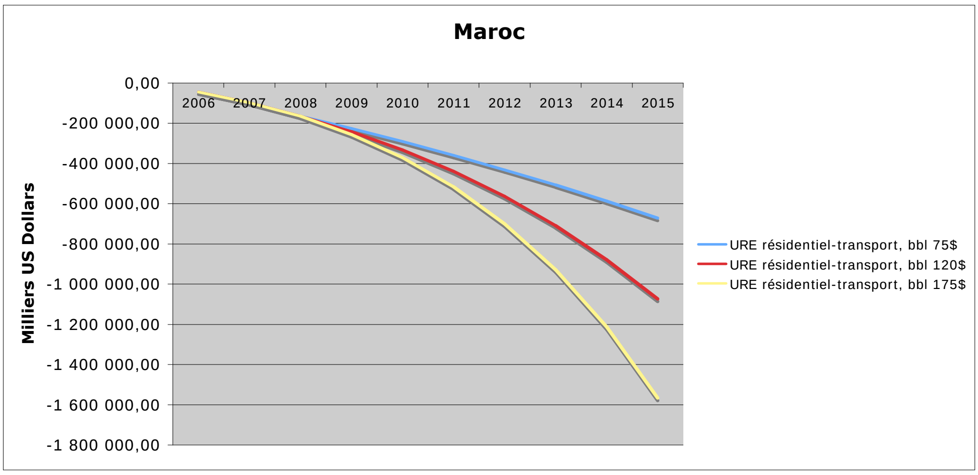
Having estimated the energy need trend, as well as its probable cost according to oil prices, we may now move on to deducing, by difference, the financial room for manoeuvre (if not of self-financing), and this based on comparing—to the baseline scenario described above—the various alternatives represented by the adjustment of certain parameters of the energy loop, which adjustments correspond to the previously described REU/RE actions. The differential is expressed, on the one hand, in terms of volume measured in thousand TOE, then in terms of value according to the three assumptions made on the price of the barrel between 2005 and 2015 (stable at 120 $ over 10 years; falling at 75 in 2015; rising to 175 $).

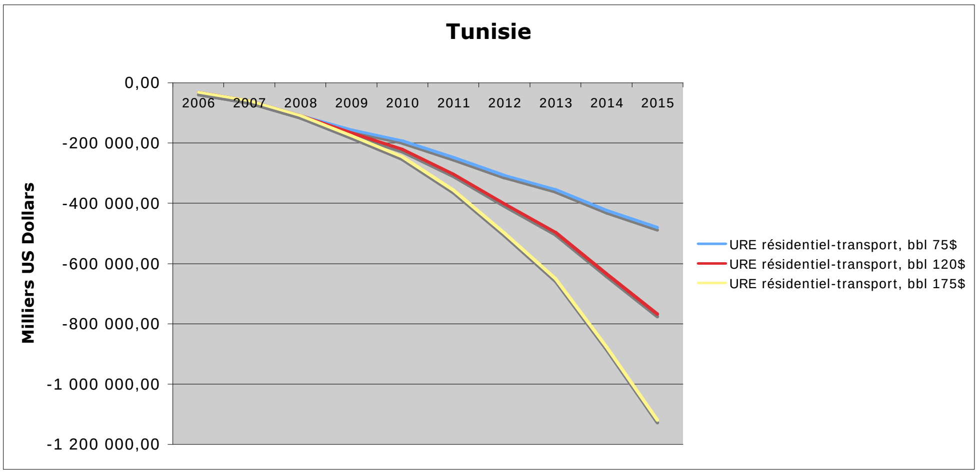
3.2. Rational energy use: Less energy for as much growth, the energy volume – GDP unit ratio

A first scenario illustrates the benefits to be expected from REU actions targeted at the demand of non industrial sectors (transport, residential, other). In the model used, the final consumption of these sectors depends on the level of the demand aggregated by an elasticity (the cost in TOE of a GDP unit). The assumption of the simulation is that the actions aimed at rationalizing energy use result in a decrease in the energy cost of the operation of the economy, i.e. less energy is needed to reach the same level of production (that is, reducing the elasticity). The illustrated case simulates a fall by 10% in 10 years of the simulated level 2005 (that is, slightly more than 1% per year, a figure selected since corresponding to the lower objective of the MSSD).

Graph 8 - Annual value in dollars of the savings made in view of the evolution of oil prices by REU actions targeted at non industrial sectors







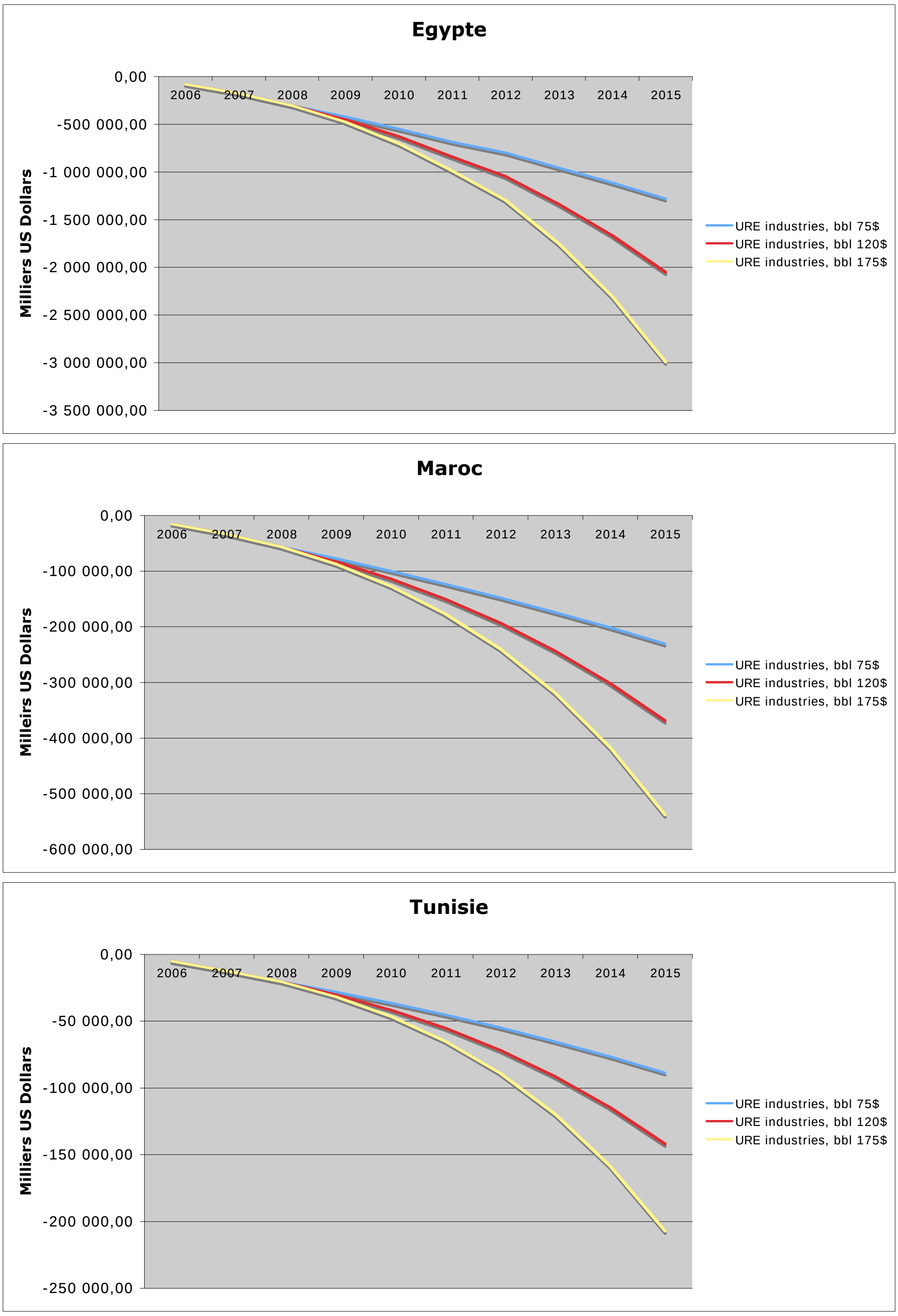
In this type of graph, it will be noted that the cost of non action is represented by the variance between the scenario curve and the axis of the abscissa.

The result derived from the model indicates an aggregate saving of 31.876 thousand toe within a period of 10 years for the three countries (of which 6 420 annually by the end of the period, that is 11.1% of the annual consumption 2005 of the three countries). The value of this saved consumption, aggregated over the last three years of the simulation, reaches 9.2 billion $ with a barrel at 75$. It would represent 13.9 billion dollars if the price of the barrel were to stabilize at 120 $. Lastly, with a barrel whose price would rise to 175 $ in 2015, the differential of the aggregated cost over the last three years would represent 19.3 billion dollars (for country details, cf. table 5 in section E).

It is worth recalling, with regard to each of these estimates in value (as well as with regard to the following ones), that they are obtained by difference between the trend costs estimated in a) according to a oil price in 2015 and the new costs obtained after a change in the parameters. This amounts to observing that "the actions to improve REU [by 10% in 10 years] allow a saving of X million $", a gain that can be compared with the costs of implementation of the measures to be taken for the achievement thereof.

Can the industrial sector be targeted by similar measures? Experts have a divided opinion about this, as well as about achievable objectives. One may, in fact, estimate that, as enterprises are subject to international competition, they cannot afford to be inefficient in the use of the energy resource at the risk of seeing themselves eliminated from the market. The competition mechanism involves an optimisation of the resources and, consequently, competition urges the use of best techniques. But, underlying these automatic mechanisms, one may argue for various approaches, particularly in terms of sectors subject or not to competition, margin behaviour or optimisation of inputs, etc, which leaves room for a general optimisation of the use of the energy resource. As an illustration, consumption is also connected with the VA of the economic model by a second elasticity. The simulated assumption is, here again, a linear fall by 10% of this elasticity in 10 years (i.e. consuming 10% less for the same level of production).

Graph 9 - Annual value in thousand dollars of the savings made, according to the evolution of oil prices, via REU actions targeted at industries



The result obtained is equivalent to a saving of 14.563 thousand toe in 10 years (of which 2 913 annually by the end of the period, or the equivalent of the annual imports of Tunisia in 1990). The value of this spared consumption amounts, for the last three years, to 4.2 billion $ with a barrel at 75$, 6.3 billion with a barrel at 120 $) and 8.8 billion dollars if the oil price were to reach 175 $ per barrel.

3.3. Diversify the local energy supply: Renewable energies

The Supply aspect should not be neglected. Part of the energy need can also be covered by domestic production. The question considered here is directly that of Renewable Energies (exclusive of biomass), the environment aspect underlying the whole study. Thus, the last effect evaluated is that of a policy of promotion of RE.

The renewable energies potential in the Mediterranean is considerable and largely under-tapped, according to the Plan Bleu report. The Mediterranean has a sunshine ranking among the highest worldwide (approximately 5 kWh/m²/day), sites favourable for aero-generators are multiple, geothermal resources are appreciable (as in Turkey), possibilities of development of small-scale hydropower are significant, and the use of biomass is an energy option for a good part of these territories.

In the simulation, it is obtained by increasing the level of the simulated production. The MSSD has set a regional target of 7% of domestic production. In view of the current situation in the three countries, this target seems to be very difficult to sustain for the time frame 2015. Morocco, the most advanced of the three in this regard, is at 1.35% (exclusive of biomass), while Egypt and Tunisia stand at 0.06%. All in all, in 2005, Renewable Energies, thus, accounted for a production of 201 thousand toe, that is 0.24% of the Apparent Consumption. Two scenarios are, hereafter, considered: a low hypothesis scenario and a more proactive scenario.

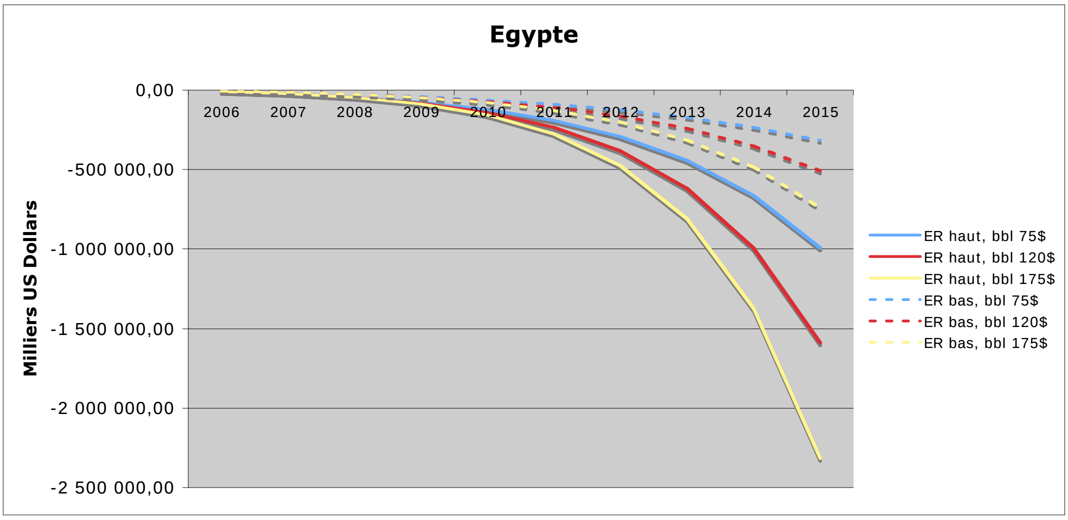
The first scenario rests on the following country assumptions. In Egypt, the low hypothesis is to reach 1% of the apparent consumption, that is a production totalling 938 thousand toe by 2015. In Morocco, the low hypothesis is to double up in 10 years the current RE (exclusive of biomass) production, which would pass from 150 thousand toe to 300 thousand toe. This will put up the share of RE in the Apparent Consumption from 1.35 to 1.7% by 2015. In Tunisia, the simulation assumption is, as in Egypt, to reach 1% of the Apparent Consumption, that is a production totalling 130 thousand toe by 2015 (almost the level of Morocco 2005). For the three countries as a whole, this scenario implies that the production would reach 1 368 thousand toe by 2015 (7 times the level of 2005), which would account for 1.1% of the Apparent Consumption.

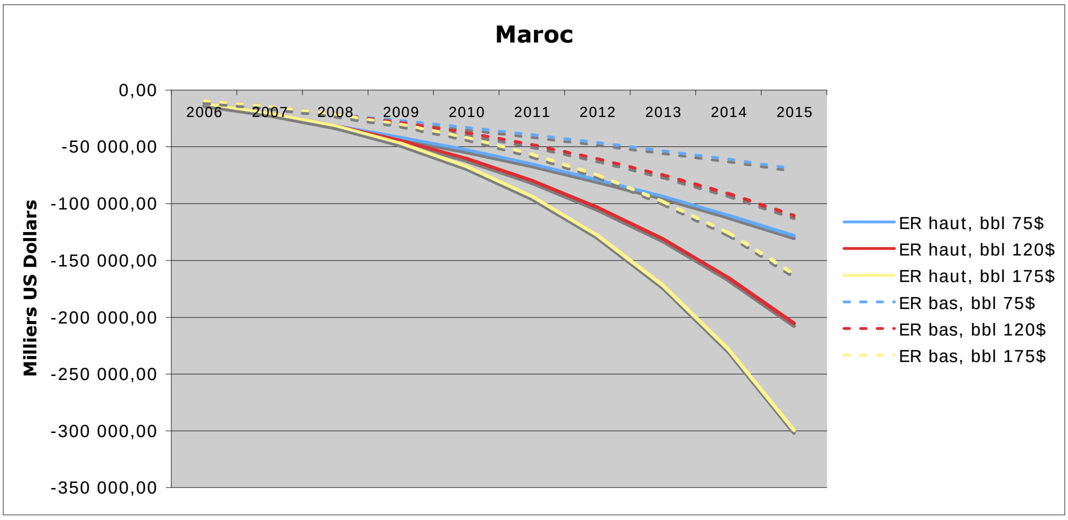
This first simulation yields a saving of 3 029 thousand toe in 10 years, of which 812 thousand the last year (1.3 times the total domestic production of Morocco in 2005). It is known that the play of the relative prices of energy sources is fundamental in the depreciation of the investments outlaid in infrastructure, which confirms the value assignment to these savings according to various evolutions of oil prices. The value of the spared consumption in the last three years amounts to 1 040 million $ with a barrel at 75$, 1 578 million with a barrel at 120 $ and 2.2 billion if the oil price were to reach 175 $/barrel (1.2 times of the total energy imports of Tunisia in 2005).

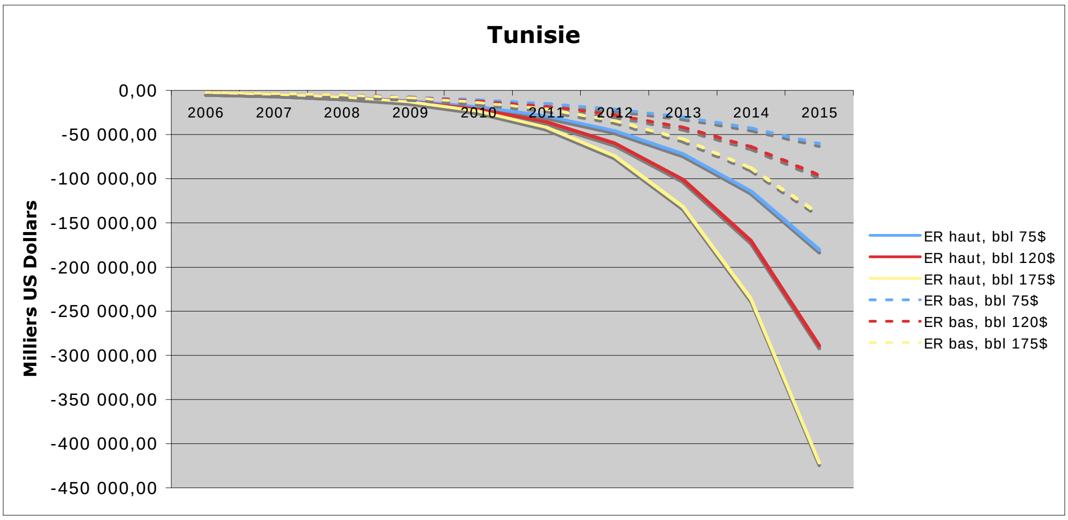
A second simulation was conducted with a more ambitious objective in terms of RE, although still lower than the regional objective. It is based on the assumption that, in the 3 countries, the production of RE would reach 3% of the Apparent Consumption (less than a half of the regional objective of the MSSD). In Egypt, the production ensured by RE (exclusive of biomass) would, thus, reach a level of 2.815 thousand toe. In Morocco, this amounts to increasing the level of the production to 534 thousand toe by 2015. And in Tunisia, the production would rise to 391 thousand toe. This would, therefore, amount to multiplying by 19 the 2005 level of RE production to reach 3 739 thousand toe.

This second simulation totals, over 10 years, a saving of 7 249 thousand toe (it's worth recalling that the total volume of the energy imported by Egypt in 2005 amounted to 7 460 thousand toe), of which 2 367 for the year 2015 alone (about 57% of the volume exported by Tunisia in 2005). The financial room for manoeuvre allowed by such an increase would represent, for the last three years, a value of 2.8 billion dollars with a barrel at 75 $, of 4.3 billion dollars with a barrel stabilized at 120 $, and would rise to as much as 6 billion with a barrel reaching 175 $ in 2015.

Graph 10 - Annual value in thousand dollars of the savings made, according to the evolution of oil prices, via increasing the share of RE







3.4. GHG emissions

The simulation has helped evaluate a “cost of non action/benefit of action” in terms of non used energy resources, which makes it possible to address issues directly connected with the environment. The task is, once having demonstrated the strictly economic benefit obtained, to also evaluate the direct environmental benefit on top of it. This chapter will, then, conclude by an evaluation of these costs/benefits in terms of CO_2 emissions.

By helping reconstruct the energy balance, the simulation used can address the issue of CO_2 emissions, based on the following assumptions:

The transition from power consumption to carbon dioxide is made according to the method of the “IPCC Guidelines for National Greenhouse Gas Inventories”, 1996 revised. The reckoning of the emissions is conducted, here, based on the carbon content of the fuels available in general for the country. It is organized in 6 stages: (i) Estimate of the apparent consumption (in toe); (ii) Conversion into an energy unit, the terajoule; (iii) Calculation of an aggregate emission factor which is the average of the emission factors per source of fuel weighted by the share of these sources in the total consumption. Use is made, here, of the breakdown of the balances derived from MEO for the latest year available, i.e. 2005. In view of the energy mixes of 2005, the total factors selected for the three countries for purposes of the simulation 2006-2015 in tons of carbon/terajoules are given in the following table; and (iv) Correction, to take into account incomplete combustion, then conversion of oxidized carbon into CO_2 emissions.

Table 4 - Apparent Consumption per type of fuel for the three countries:

Egypt 2005	Volume in TOE	Share in total	Carbon emission factor T of C per TJ)*
Apparent Consumption**	62 753	100,00%	17,741
of which			
Coal	894	1,42%	26
Crude oil	36 167	57,63%	20
Oil Prdts	- 4644	- 7,40%	20
Gas	27 765	44,24%	15
Hydro	1 087	1,73%	0
RE Biomass	1 437	2,29%	30
RE non Biomass	47	0,06%	0

Morocco 2004	Volume in TOE	Share in total	Carbon emission factor T of C per TJ)*
Apparent Consumption**	11 091	100,00%	21,731
of which			
Coal	3 628	32,71%	26
Crude oil	5 540	49,95%	20
Oil Prdts	1 316	11,87%	20lli
Gas	0	0,00%	15
Hydro	138	1,24%	0
RE Biomass	319	2,88%	30
RE non Biomass	150	1,35%	0

Tunisia 2005	Volume in TOE	Share in total	Carbon emission factor T of C per TJ)*
Apparent Consumption**	8 307	100,00%	19,450
of which			
Coal	0	0,00%	26
Crude oil	1 763	21,22%	20
Oil Prdts	2 316	27,88%	20
Gas	3 091	37,21%	15
Hydro	12	0,14%	0
RE Biomass	1 121	13,49%	30
RE non Biomass	4	0,06%	0

Source: MEO, * "IPCC Guidelines for National Greenhouse Gas Inventories", 1996 revised ** Defined in the IPCC Guidelines as Production + importations – exportations – International storerooms – variations of stock. In the simulation, the storerooms and stocks are not considered, for lack of data.

At this stage, it is assumed that—for the trend scenario and scenarios 1A, 1B—the share of fuels and, consequently, the emission factor, remains constant from 2006 to 2015. Conversely—for scenarios RE 3A and 3B—it is actually this total factor which changes due to a diversification of the energy mix. For purposes of the simulation, the assumption put forward is that the share of traditional fuels (non RE exclusive of biomass) in the apparent consumption "non RE exclusive of biomass" remains fixed, the total shares changing by the significance of "clean" RE in the production. The variation of CO_2 emission with respect to the trend scenario thus results from the improvement of the total emission factor related to an increase in the use of RE in the domestic production.

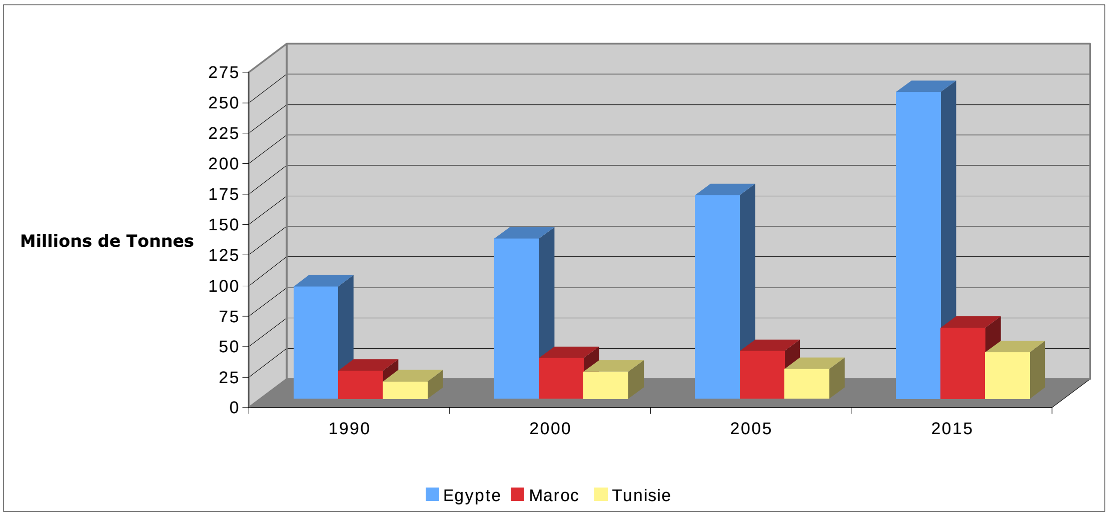
The last assumption relates to the estimate of the apparent consumption resulting from the simulation, with certain variables, such as storerooms or stock, not included. Besides, the simulation estimates the TFC rather than the TPES, since it deals mainly with the demand side. In fact, the simulation does not consider here the energy consumption of the energy sector itself, in particular for power production, which needs to be corrected in order to estimate the emissions. Also, the apparent consumption is calculated based on the TFC according to a relation between the estimate of the total apparent consumption defined by the IPCC, according to the detailed balance of MEO, and the TFC, as estimated by OLS:

App Consump = a TFC + b

Using the method which has just been described in the model, we obtain the following observations:

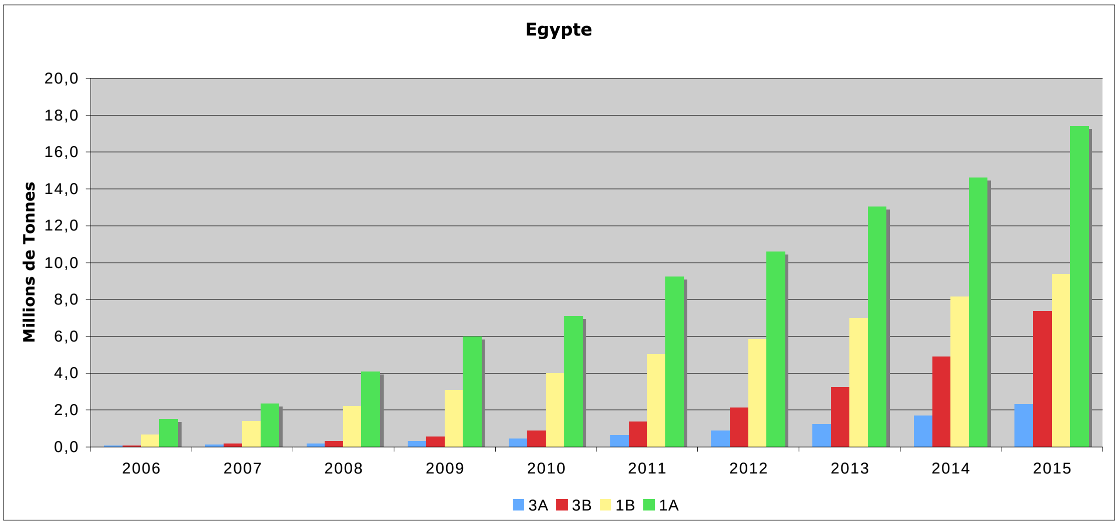
- The CO_2 emissions of the three countries due to energy consumption amounted to 130 million tons per year in 1990. They increased by 44% over the decade to reach 188 million tons in 2000, then 231 million tons in 2005. According to the trend scenario described in this study, the expected rise is of 51% between 2005 and 2015, year during which the three countries would emit 348 million tons of CO_2 due to their energy consumption. It is worth mentioning that these figures are all derived from the simulation, including those concerning the period 1990-2005 where we apply the method described in the IPCC guidelines to the figures provided by MEO. Between 2005 and 2015, Egypt would report an increase in its emissions by 50.7%, thus passing from 167 million tons to 252 million. The rise for Morocco would be hardly lower than 47.9%, the volume increasing from 405 to 58 million tons. The rise would be bigger for Tunisia (56.2%), the emissions growing from 25 to 38 million tons.

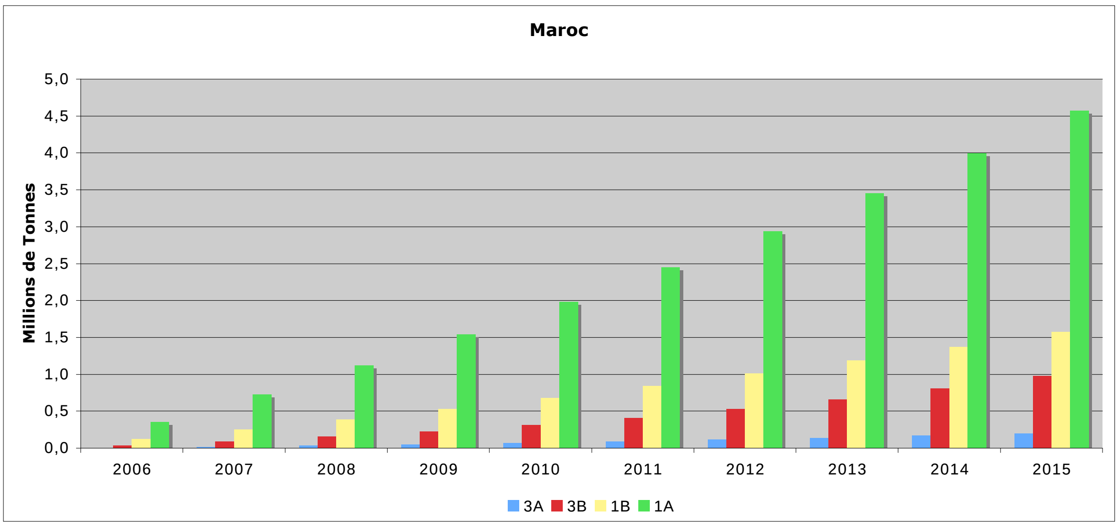
Graph 11 - CO_2 emissions: time series and trends

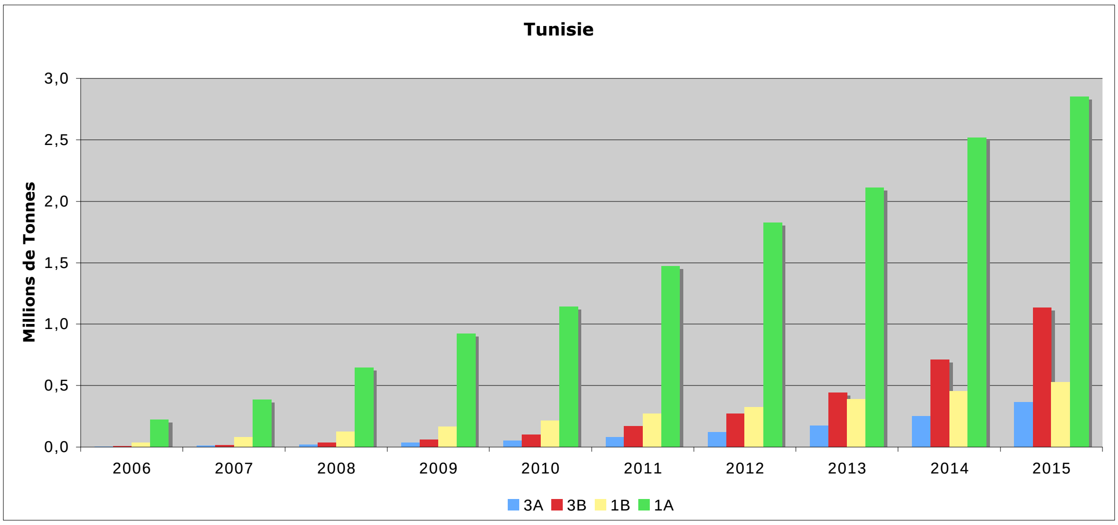


- The main scenarios studied are capable of moderating these emissions, by acting either on the apparent consumption, or on the emission factor via change of the energy mix used. The extent of the various effects per year can be seen in the following graphs:

Graph 12 - CO_2 emissions: differentials according to the scenarios







At the end of the simulation, the gain ranges from 2.9 million tons per year (3A), that is 1.3% of the level for 2005, to 24.8 million tons (1A), that is 10.7% of the total for 2005. The high RE scenario would generate a gain in 2015 of about 9.5 million tons, that is 4.1% of the level for 2005. The hierarchy is identical, on the whole, for each of the three countries, with scenario 1A generating the greatest gain in terms of emissions, the low RE scenario (3A) being the most modest. On the other hand, the variation between scenarios 1B (REU targeted at industries) and 3B (high RE) generates different gains according to the countries. In Morocco, the gain in 2015 generated by scenario 1B is 61% higher than that of 3B, when in Tunisia the latter posts gains that are twice higher.

- Thus, in 10 years (2006-2015), the aggregate gain in non emitted CO_2 totals 9.9 million tons in scenario 3A; 28.1 million in scenario 3B (that is, a little more than the annual level 2005 of emissions for Tunisia), and 57.4 million tons in scenario 1B (the annual level projected for the time frame 2015 for Morocco); the aggregate reaches 123.2 million tons in the case of scenario 1A (approximately the level reached by the emissions of Egypt in the early 2000s).

IV. SYNTHESIS TABLE & GRAPHS AND CONCLUSIONS

The objective of the study was to estimate the direct short-term economic cost of not engaging actions as described in the MSSD targeting the field of energy. The method used has consisted in coupling a standard economic channel in volume reconstructing the operating conditions of three countries from the Southern Mediterranean rim (accounting for nearly 45% of the population, a third of the energy consumption, and a quarter of the economic production) and an energy channel which estimates the volume of energy necessary to the operation of the economies. This simulation was, initially, calibrated in such a way as to reconstruct the trends of the 3 economies over the past 15 years. Then, the operation is extended until 2015, that is an extra 10 years. This extension describes a trend, baseline, scenario which stands for non action in terms of national energy strategy.

Four (4) alternative scenarios inspired from the objectives of the MSSD, standing each for a certain type of actions in favour of rational energy use (REU) or of development of renewable energies (RE) were compared to the baseline scenario in order to calculate the potential direct economic gains generated by these types of action. These possible gains are then interpreted:

- either in terms of "cost of non action", since the cost of energy in the baseline scenario is higher than the same cost in the identical economic context of the alternative scenario, but the latter taking into account the behavioural changes with respect to energy;
- or in terms of financial room for manoeuvre elicited mainly for the financing of the described actions, assuming that, with a expenditure budget maintained, the price differential obtained can be invested in the field of energy efficiency.

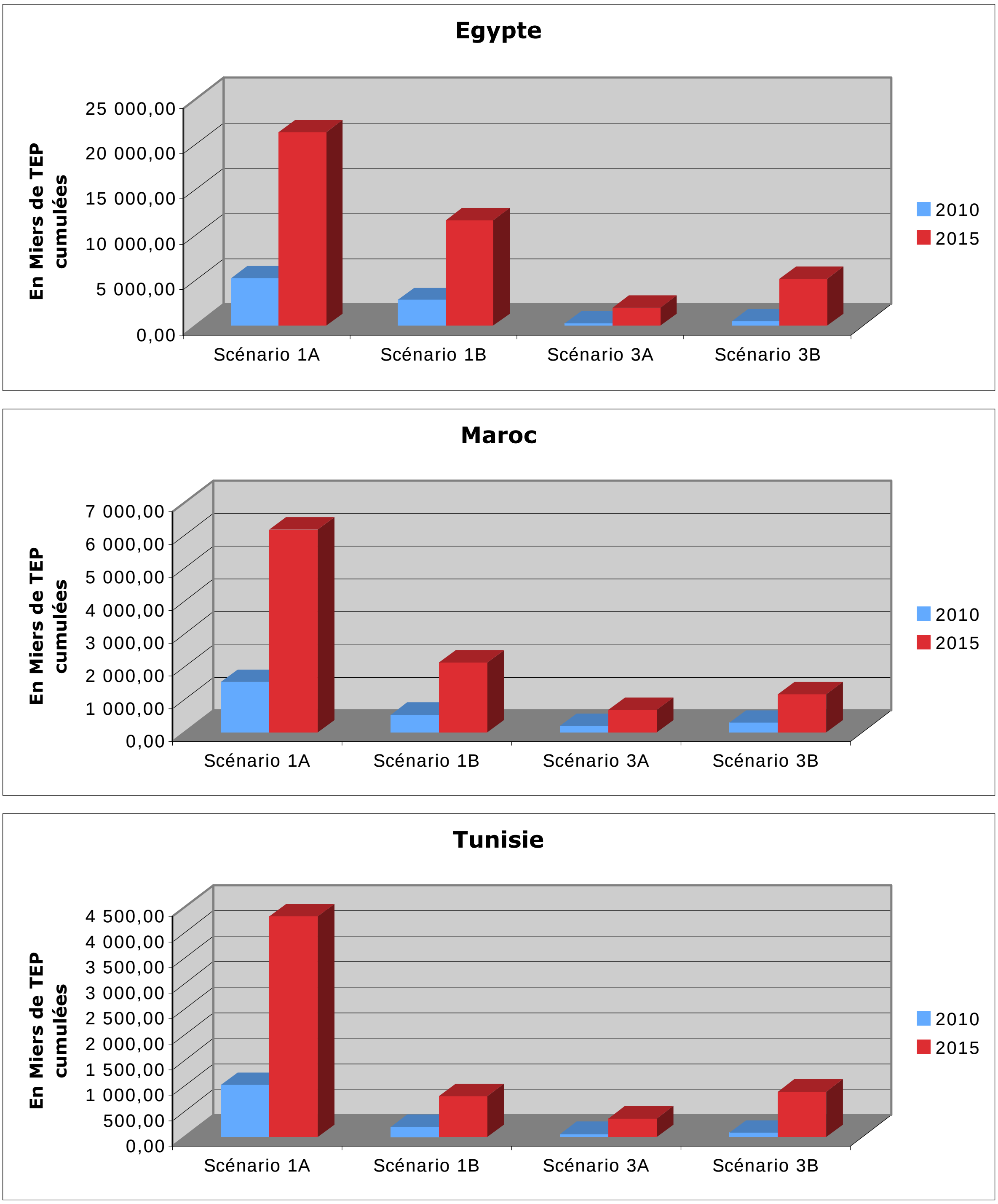
The quantified illustration in the case of the three countries is given in the following table:

Table 5 - Summary of the results

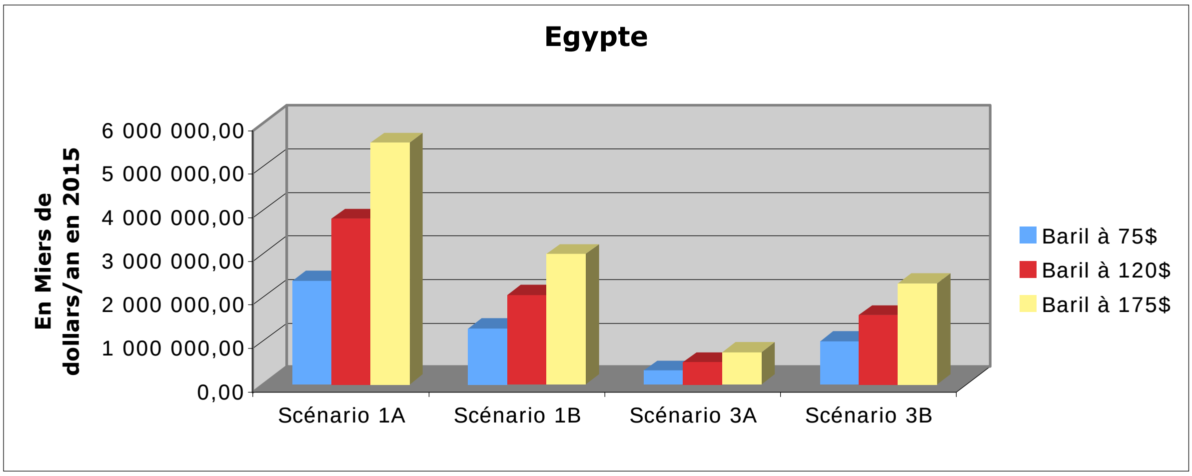
Alternative scenarios:	In volume (Thousand TOE)		Cost of "non action" Price of barrel in 2015 Million dollars Price of barrel in 2015		
		>	75	120	175
1A : Actions of Rational Energy Use targeted at households and transport (demand side) *Leading to a decrease by -10% in 10 years of the energy consumed per GDP unit*					
Egypt	-21 381		-6 161	-9 291	12 949
Morocco	-6 177		-1 765	-2 661	3708
Tunisia	-4 317		-1 259	-1 899	2647
1B : Actions of Rational Energy Use targeted at industrial sectors (demand side) *Leading to a decrease by -10% in 10 years of the energy consumed per GDP unit*					
Egypt	-11 650		-3 354	-5 058	7049
Morocco	-2 121		-606	-914	1274
Tunisia	-792		-231	-348	485
3A : Diversification of the domestic energy supply by promoting renewable energies exclusive of biomass *Low hypothesis:*					
Egypt *Increase domestic production to reach 1% of the App. Consumption in 10 years (from 47 to787 Ktoe)*	-1 984		-724	-1 099	1540
Morocco *Double up domestic production from 150 to300 Ktoe in 10 years (from 1.3 to 1.7% of the App. Consumption)*	-685		-184	-277	386
Tunisia *Increase domestic production to reach 1% of the App. Consumption in 10 years (from 4 to 130 Ktoe)*	-360		-133	-202	283
3B : Diversification of the domestic energy supply by promoting renewable energies exclusive of biomass *High hypothesis:*					
Egypt *Increase domestic production to reach 3.0% of the App. Consumption in 10 years (47 to 2 360 Ktoe)*	-5 203		-2 099	-3 200	4499
Morocco *Increase domestic production to reach 3.0% of the App. Consumption in 10 years (from 150 to 530 Ktoe)*	-1 161		-332	-502	699
Tunisia *Increase domestic production to reach 3.0% of the App. Consumption in 10 years (from 4 to 390 Ktoe)*	-885		-367	-560	789

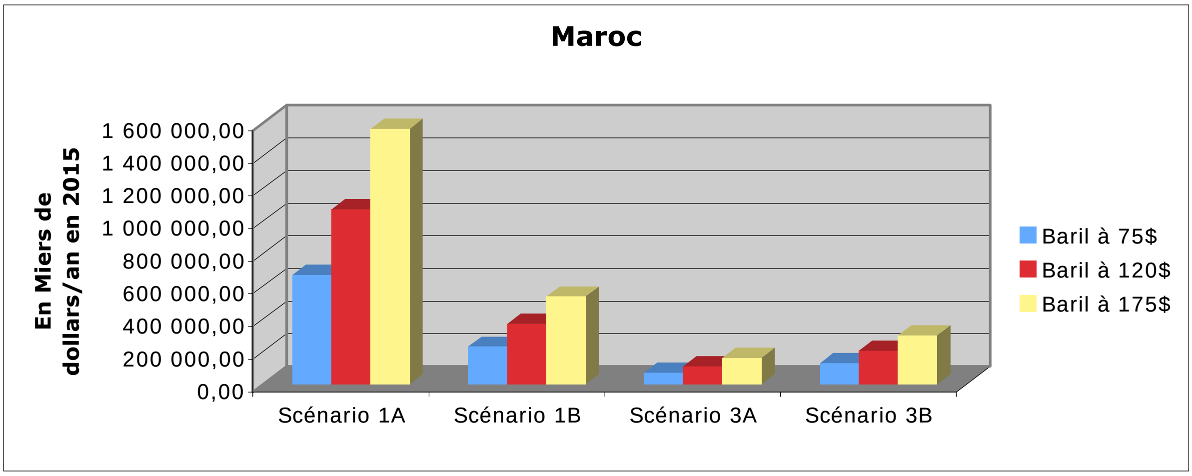
The quantified illustration tends to indicate that most of the possible actions generate an appreciable direct economic benefit under the form of non used and, hence, available resources for alternative uses. It helps visualize directly the strictly economic and immediate cost of not investing in a better energy management, which we called cost of non action (Cf. following graphs), which cost is broken down into used energy volume and into financial cost in the case of importing countries.

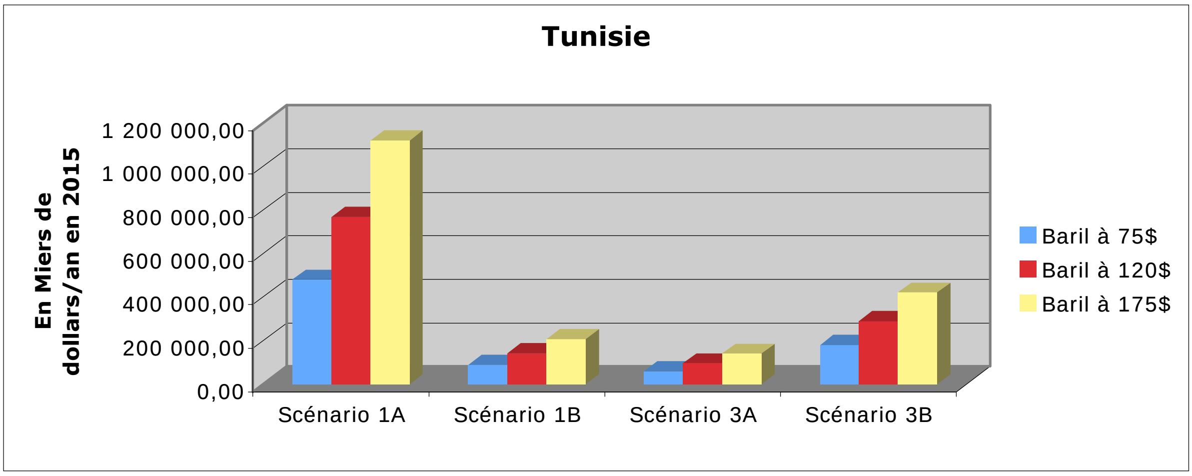
Graph 13 - Cost of non action in terms of resource saving



Graph 14 - Cost of non action in thousand dollars, according to oil price







In conclusion to this chapter, we will sum up the results by aggregating the potential gains for the three countries before extrapolating these figures on the level of the 10 MCs, which will help appreciate the extent of the stakes, both in economic terms and in environmental protection terms.

For the three countries of the analysis—Egypt, Morocco and Tunisia—, to take actions of rational energy use on the demand side aimed at cutting down by 10%, for the time frame 2015, the energy intensity of households and industries (scenarios 1A and 1B), while modestly developing renewable energies so that they account for 1% of consumption (scenario 3A), would lead to the saving of 49 468 thousand toe in 10 years, of which 10 146 thousand tons for the year 2015 alone, which accounts for 17.6% of the Final Consumption 2005. The cost thus avoided for the last three years (2013-2015) would amount to 14.4 billion dollars if the oil price were to drop back to 75 $, 21.7 billion if the price of the barrel were to stabilize at 120 $, or it would amount to as much as 30.3 billion dollars if the oil price were to rise to 175 $ by 2015 (that is, the aggregate total exports of goods of Tunisia and Morocco in 2005 i.e. 21.6 billion dollars). As regards the environment, these actions would help avoid the emission of 190 million tons of CO_2, of which 39 million tons for the year 2015 alone, that is 17.0% of the emissions reported in 2005.

By combining the actions of rational energy use (REU) with a more ambitious development of renewable energies (RE)—which would reach 3% of consumption (scenario 3B)—, the volume of energy saved would amount in 10 years to 53 688 thousand toe (almost the total final consumption (TFC) of the 3 countries in 2005 - 93%), of which 11 700 thousand toe for the year 2015 alone (20.2% of the consumption in 2005). That would generate, according to the evolution of oil prices, a saving in the range of 16.2 billion to 34.1 billion dollars. This would have helped avoid, over the same decade, the emission of 209 million tons of CO_2 (19.8% of the level of 2005, or again approximately the sum of the emissions of Egypt and Morocco in 2005).

Recalling the percentages represented by the 3 countries in the 10 MCs as a whole (Cf. Table 1), these results can be extrapolated to the whole of the Southern rim as follows:

1) According to a trend scenario, knowing that the three countries accounted in 2005 for 33% of the TFC of the MCs, the final consumption in 2015 in the 10 MCs would total 267 thousand toe. The estimated cost to meet these needs would then amount, for the region, to: 66.9 billion dollars for a barrel dropping to 75 $ (more than the GDP of Morocco in 2005: 55.6 billion dollars), 107.1 billion with a barrel price stabilizing at 120 $ and 156.1 billion in the event of a moderate rise of barrel price to 175 $ (exceeding the GDP of Egypt 2005:93.2 billion $);
2) In the case of scenario 1A, which simulates actions fostering rational energy use (REU) among households in the first place, the possible gain in energy volume would be about 96.593 thousand toe, of which about 19 455 thousand for the year 2015 alone. Here, the cost of non action extended to the Southern rim would range between 23 billion dollars for a barrel at 75 $, 27.8 billion for a barrel at 120 $, and up to 58.5 billion if the barrel were to reach 175 $. It is worth recalling that the nominal GDP of Tunisia stood at 28.7 billion dollars in 2005;
3) In the case of scenario 1B, which evaluates the impact of actions of rational energy use (REU) targeted at industries—and recalling that the 3 countries of the analysis account for 25% of the regional GDP—, the possible gain in volume would exceed 58 252 thousand toe, of which more than 11 652 thousand toe in the year 2015 alone. According to the price of the barrel, the value of these savings would amount to 16.8 billion dollars, 25.3 billion and up to 35.2 billion, respectively;
4) The recourse to renewable energies, were it to be as modest as in the case of scenario 3A, would help save—all the same—not less than 9 180 thousand toe, of which over 2 462 thousand in the year 2015 alone. The amounts which these potential savings represent (and which may be considered as investment potential) would amount to 3.2 billion dollars if the oil price were to drop to 75 $ per barrel, 4.8 billion if the price were to stabilize at 120 $, or 6.7 billion if the oil price were to rise to 175 dollars;
5) A stronger effort of recourse to renewable energies (RE), raising the share of the latter to 3% of consumption (scenario 3B)—which is slightly less than a half of the MSSD target—would generate a saving of about 21 966 thousand toe in 10 years, of which over 7 172 thousand per year in 2015 (it is worth recalling that total final consumption (TFC) of Tunisia in 2005 stood at

6 434 thousand tons). The value of the savings generated for the last three years would, then, be about 8 billion dollars with a barrel at 75 $, 12.9 billion with a barrel at 120 $ and 18.1 billion with a barrel at 175$;

6) In terms of CO_2 emissions—again, based on the fact that the 3 countries of the sample account for 33% of the regional TFC—the regional aggregate of the emissions avoided over the period 2005-2015 would amount to 30 million tons in the case of scenario 3A, 85 million tons in the case of scenario 3B, 174 million tons in the case of scenario 1B, and 373 million tons in the case of scenario 1A. By combining the actions of Rational Energy Use (REU) and a rise in the share of Renewable Energies (RE), the potential reduction of CO_2 emissions would range between some 577 million and some 632 million tons. In annual terms, in 2015, the region could avoid the emission of a volume ranging between 119 million to 139 million tons.

CHAPTER 6

Renewable energy and rational energy use in the South and East Mediterranean countries: current situation and outlook

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Thanks to their geographical location in one of the world sunniest place, many windy sites and considerable geothermal resources, Mediterranean countries from the South and East (SEMC) have huge potential for renewable energy. Additionally, estimates of potential energy saving is about 40%, which allow enormous progress in energy efficiency.

In order to use this potential, the 21 Mediterranean countries and territories adopted, late in 2005, the Mediterranean Strategy for Sustainable Development (MSSD) which, while being non binding, proposes guidance, actions and objectives in matter of RE and REU.

In the SEMCs, the analysis of recent trends compared with MSSD objectives reveals that, with very few exceptions, concrete implementation of RE is steadily increasing in scope, but that it remains limited. The share of RE in the primary energy supply was 2,5% in 2000 and reach 2,8% in 2006. This trend is not compatible with the MSSD objective of 7% by 2015. Energy intensity of the whole basin improved by 0,3% per year between 1992 and 2003, which is far from objectives of 1 to 2% improvement suggested by the MSSD. Besides, the use of REU potentials seems to be “neglected” by comparison with RES development.

Energy demand management options are then underexploited. Yet, the several projects implemented and the experiences of a few countries (Tunisia, Morocco, Egypt and Israel, for instance), reveal that RE and REU are credible, appropriate and advantageous. Thus, what is at stake today is to undertake a large-scale generalization of these experiences and to create a Mediterranean RE and REU market.

Significant progress has been reported in almost all SEMCs in the implementation of an institutional framework necessary for the development of a real energy efficiency market. However, the progress made remains often incomplete, scarcely visible and, sometimes, instable. Yet, as attested by the experience of the more advanced countries (Tunisia, for instance), the simultaneous presence of these three factors is decisive.

Two of the major weaknesses of the institutional and legal frameworks are in the SEMC are:

- The issue of the financial and administrative terms of connection to the power distribution network for independent RE producers, and
- The lack of institutional coordination or the absence of an institution in charge of energy efficiency.

The under-utilisation of the REU potential in the SEMCs also seems to result partly from a lack of information and of visibility concerning possible economic and financial gains. Besides, the exploitation of this potential is still hampered by economic impediments: subsidies to fossil fuel which results in relatively low final consumption prices, little efficiency of economic and financial incentives provided for RE and REU. The countries that have established incentives are facing, on the one hand, funding difficulties and, on the other hand, little efficiency due to incomplete/not implemented/non enforceable institutional and legal frameworks.

Within this perspective, the building/ residential/ tertiary sector emerges as a key sector, as it already accounts for about 40% of SEMCs energy consumption and, in view of the expected demographic growth and urban development, it may be a significant contributor to future CO2 emissions increases.

The solar sector is an opportunity for the future in the region since it can be integrated in buildings and in urban development which is presently and for coming years booming in the SEMC. The development of this sector is also an industrial opportunity for the SEMC. It could increase co-benefit in term of employment and development (industry and services) already proven, particularly in countries where adapted professionals trainings are set up (Tunisia, Morocco). To become reality, the large scale development of energy demand management needs technology transfers and know how (training) in RE and RUE from the Northern rim to the Southern one.

The climate/energy package of the EU could become a positive driver in the future for the SEMC if it exists an institutional and legal framework compatible with the one of the EU.

The Official Development Assistance (ODA) funds have participated to the promotion of RE and REU in the SEMCs and can have important leverage effects on private national invesment. Today, private international investment funds are available and the Clean Development Mechanism (CDM) plays a role of incentive, but SEMCs are lacking a sufficiently important number of project iniator — and attractive environment for foreign direct investment .

To finalise the construction of a complete and effective legal framework in the SEMC and allow a convergence of RE/RUE policies of the Mediterranean basin countries will be a determinant factor. If it succeeds, it could become realistic that the SEMC control there increase of CO2 emissions in one hand, and help the EU to achieve its objectives in term of climate and energy in the other hand, thanks to the exchange of green and sustainable energy produced in solar plant.

INTRODUCTION

Main issues and context

The energy supply, production, distribution and consumption system in the Mediterranean is characterized by: (i) its vulnerability, notably related to prices and supply; (ii) the inequality of natural provision, access and consumption of energy among the countries; and (iii) the damage—irreversible sometimes—which it causes to the environment and to human health. Such an energy development pattern shows its limits and its incompatibility with sustainable development objectives. It increasingly contributes, in particular, to global warming and highlights a certain vulnerability vis-à-vis the new regional climate context.

In spite of different situations and priorities, the Mediterranean countries have all room for manoeuvre to enhance rational energy use (REU). Besides, it is now generally admitted that renewable energies (RE) and energy efficiency are two factors that will play a significant role in addressing the need to secure energy supply, to avoid an aggravation of the impacts on the local environment (air pollution) and global environment (greenhouse gas (GHG) emissions), to gain in competitiveness, as well as to improve individual well-being in an increasingly free, open and competitive Mediterranean market and in an increasingly volatile and uncertain international energy context. It is in this context that the 21 Mediterranean countries and territories adopted in November 2005 the Mediterranean Strategy for Sustainable Development (MSSD), of which a Chapter is dedicated to energy issues.

Objectives

This chapter aims to present the national policies and actions implemented in order to promote RE and REU, the barriers to their development and the solutions to be undertaken in order to overcome them. The analysis refers systematically to the objectives and guidance set out in the "Energy" chapter of the MSSD.

While the Mediterranean basin constitutes the framework of this study, the latter is, above all, focused on the Southern and Eastern Mediterranean Countries (SEMCs) which group Algeria, Egypt, Israel, Lebanon, Libya, Morocco, the Palestinian Territories, Syria, Tunisia and Turkey.[1] It also includes information on Jordan.[2]

Information sources

This chapter is based, above all, upon a set of documents produced within the framework of the cooperation programme on the MSSD/energy monitoring,, coordinated and facilitated by Plan Bleu in 2006-2007. It refers to the national studies (in particular on Egypt, Israel, Libya, Morocco, Syria, Tunisia and Turkey), as well as the regional studies which were produced within the framework of this programme and discussed during a final workshop organized by Plan Bleu in March 2007 in Monaco.[3] The figures used are derived from these studies, as well as from international data bases (mainly the International Energy Agency (IEA), the World Bank (WB) and the World Resource Institute (WRI)). Additional information has been collected from documents of the Mediterranean

[1] Other Mediterranean countries are grouped under the denomination of Northern Mediterranean Countries (NMC) and include: Bosnia-Herzegovina, Cyprus, Croatia, Spain, France, Italia, Greece, Malta, Monaco, and Slovenia.
[2] Jordan is not bordering the Mediterranean Sea, hence non signatory of the Mediterranean Strategy for Sustainable Development, but is part of the euro-mediterranean partnership.
[3] All documents available at : www.planbleu.org

Energy Observatory (Observatoire Méditerranéen de l'Energie - OME), ADEME and Plan Bleu for the policies, the state of the RE fields and funding.

Content

The first part of this chapter presents an analysis of the energy development observed in the region over the past 30 years and projections on the horizon 2020. It underscores the recent awareness in the region vis-à-vis the challenges related to climate/ energy/ sustainable development and introduces the MSSD as a regional response to this new context.

The MSSD guidance and objectives are used as a starting point for the second part which aims to present the countries positioning vis-à-vis the MSSD recommendations, both from a qualitative standpoint (policies) and from a quantitative perspective (quantified objectives).

The various barriers to a large-scale RE and REU development are then analysed in a third part and possible solution paths (adopted by certain countries) to overcome them are proposed.

I. ANALYSIS OF THE CURRENT RENEWABLE ENERGY AND ENERGY EFFICIENCY SITUATIONS IN VIEW OF MEDITERRANEAN STRATEGY FOR SUSTAINABLE DEVELOPMENT (MSSD) OBJECTIVES

This first part analyses the energy evolutions observed in the region and possible future outlooks. The alternative scenario of Plan Bleu, as well as the MSSD objectives, will be presented as a reminder.

1. RE AND REU POTENTIAL IN THE SEMC AND OBJECTIVE OF THE MSSD

SEMC have a very large renewable energy potential thanks to a large amount of sunshine, the numerous regular windy sites and geothermal possibilities.

Energy efficiency potential is also very large. Depending on countries, it can represent 15 to 40% of the consumption.

The report published by Plan Bleu in 2005 shows the huge potential and benefit in case those options are exploited, in particular, possible CO2 emission reduction from energy use up to 2025 (25% of emission could be avoided).

One major materialisation of the increasing awareness in the Mediterranean is the adoption, in November 2005, of the "Mediterranean Strategy for Sustainable Development" (MSSD) by the 21 countries and territories signatory of the Barcelona Convention for the protection of the Mediterranean. The MSSD is a "framework strategy", in the sense that it can inspire the development of National Strategies for Sustainable Development (NSSD), it being understood that it is up to each country to set itself its own objectives. The 2nd priority topic of this Strategy is "a more rational energy management, increased use of renewable energy sources and adaptation—via mitigation—to the impacts of climate change".

The main energy objectives outlined are:

- to promote Rational Energy Use (REU);
- to optimise the Renewable Energies (RE) potential;
- to control, stabilise or reduce—according to the case in hand—greenhouse gas (GHG) emissions;
- to increase access to electricity in the rural areas concerned.

It puts forward quantified objectives, of which (i) to reduce by about 1 to 2% per year of energy intensity per GDP unit by 2015, and (ii) to reach, for renewable energies, 7% of the total energy demand by 2015 (exclusive of CWR).

It also puts forward a set of actions and guidance of a qualitative nature, such as: (i) to promote policies of energy saving, and renewable and cleaner energies; (ii) to mainstream, within the national and local sustainable development strategies, cross-cutting and sector-based objectives aimed at promoting REU and RE; (iii) to urge the economic players, local authorities and consumers to adopt sustainable behaviours, and this, based on a pricing policy, targeted subsidies, tax incentives and public awareness-raising campaigns supported by NGOs; (iv) to promote economic mechanisms, such as renewable energy certifications, and regulations aimed at promoting renewable energies; and (v) to strengthen regional cooperation and support the implementation of the UNFCCC and the Kyoto Protocol.

The following part seeks, in view of the objectives and the guidance of the MSSD, to offer an overview of the political measures implemented and the quantified evolutions observed in matter of RE and REU in the SEMCs.

2. NATIONAL RE AND REU PROMOTION POLICIES IN SLOW PROGRESS

Table 1 sum up the measures implemented or being discussed in order to promote RE and REU in the SEMCs[4]. Three groups may be distinguished among the SEMCs:

- Countries having adopted, or set to adopt, strong measures in favour of energy efficiency (Morocco and Tunisia);
- Countries where energy is cheap (producer countries generally), for which the adoption of energy efficiency measures was done only in a very belated manner and/or is undertaken in a less proactive way (Algeria, Egypt, Libya and Syria);
- Countries halfway between the two preceding groups: Israel, Jordan, Lebanon, the Palestinian Territories and Turkey.

The national measures outlined further down in this chapter do not intend to be exhaustive; rather, they are meant to evoke certain emblematic mechanisms set up in the SEMCs.

[4] Informations included in this table were collected through national studies carried out for Plan Bleu in 2007, documents from OME, informations from ADEME and are complemented in some cases by additional information provided by experts. This table is not exhaustive (very recent measures might not be included). Also, some of the measures indicated may not be applied due to a lack of means for there implementations. Nevertheless, the table provides a good picture of the present situation which is its first objective.

Table 1 - Policies, legal and institutional support to RE and RUE in the SEMC

	Groupe 1		Groupe 2				Groupe 3				
EnR	Maroc	Tunisie	Algérie	Egypte	Lybie	Syrie	Israel	Jordanie	Liban	Territoires Palestiniens	Turquie
Politiques Nationales et Institutions											
Existance d'objectifs chiffrés	O	O	O	O	O	O	O	O	R		O
Existance d'études nationales de potentiel	O	O	O	O	O	O	O	O	O		O
Existance d'une loi cadre nationale	O	O	O	E	R	E	O	O			O
Existance d'une agence nationale	O	O	O	O		O		O		O	O
Autres actions de soutien											
Actions de communication / information du grand public	O	O		O	R	E					
Existance de formations professionelles (seminaires/ateliers/universités,,,)	O	O	O	O	R	E		O	O		
Existance d'une politique de développement de la qualité des équipement	O	O		R	R						
Mesures EnR batiments publics (Obligation d'installation chauffe-eau solaire, PV,,,)	E	O				E					
Obligation d'intégration de chauffe eau solaire dans les bâtiments neufs						E	O				
URE	Maroc	Tunisie	Algérie	Egypte	Lybie	Syrie	Israel	Jordanie	Liban	Territoires Palestiniens	Turquie
Politiques Nationales et Institutions											
Existance d'objectifs chiffrés		O		E		E		O			
Existance d'études nationales de potentiel	O	O		O	O	E	O	O			R
Existance d'une loi cadre nationale	E	O	O	R	R	E	O	E			
Existance d'une agence nationale	E	O	O	R	R	O		O		O	
Autres actions de soutien											
Existance de formations professionelles (seminaires/ateliers/universités,,,)	E	O	R	R	R	R		E			
Reglementation / Labellisation de l'efficacité énergétique des équipements	E	O	O	O		E	O	E		O	
Obligation d'études d'URE (ex: audits)	E	O	O		R	E	O				E
Reglementations thermiques des bâtiments	E	E	E	E	R	O[1]		E	E		E
Mesures d'URE des services publics	E	O			R	E					

Légende:	
O	: mesure actuellement en application
E	: mesure en discussion / en cours d'adoption mais encore à definir exactement
R	: mesure dont le manque est clairement identifié
	: mesure non mise en œuvre ou information non disponible

[1] Mise en application en janvier 2008.

Note: Informations included in this table were collected through national studies carried out for Plan Bleu in 2007, documents from OME, informations from ADEME and are complemented in some cases by additional information provided by experts. This table is not exhaustive (very recent measures might not be included). Also, some of the measures indicated may not be applied due to a lack of means for there implementations. Nevertheless, the table provides a good picture of the present situation which is its first objective.

2.1. Morocco and Tunisia: Very active countries

From the beginning of the 1980s, these two countries adopted a policy aimed at developing RE and energy efficiency. For doing so, national agencies were created and placed under the authority of the ministry of energy and strong and proactive strategies were adopted.

In Morocco, a country which imports 96% of its energy, RE and REU have been granted the status of a fully-fledged sector, alongside with oil products and electricity. At the end of 2006, the public authorities announced that, by 2012, RE would contribute as much as for 20% to power production and amount to 10% of the national energy mix.

As early as 1982, Morocco set up the Renewable Energies Development Centre (CDER). A new Framework Law on REU and RE is currently being laid down and provides for a reorganisation of the CDER into an Operational Agency in charge of the implementation of the said framework law. The latter belongs in a comprehensive programme of reform of the energy sector, supported by the World Bank and the European Investment Bank (EIB). The German Technical Cooperation Agency (GTZ) also assists in this process and intervenes in supporting the development of legal implementation mechanisms (study of RE potential, wind energy development, socio-economic impacts, promotion action, awareness-raising among potential independent producers, etc).

Concerning REU, energy intensity has been stable for over 30 years now and, therefore, significant effort remains necessary. The World Bank scenario[5] foresees a potential of energy savings of 13% by 2010 and 23% by 2020. The industrial sector is the first to be targeted, and the Framework Law will contain an energy audit obligation above a certain consumption threshold. Besides, the State exemplary conduct as regards REU in public buildings is put to the fore: the Framework Law aims at a generalisation of Low Consumption Lamps, solar water heaters or, mainstreaming REU in construction standards. Street lighting and transport optimisation in the local communities or, again, thermal regulation of buildings (the latter being implemented with support by GEF, UNDP and the Italian Government) are other components of these new regulations.

In Tunisia, also a net importer, while gas prices are subsidised, much effort has been made to promote RE and REU, with in particular a comprehensive, dedicated and promising legal framework.

Tunisia set up a National Agency for Energy Efficiency (ANME) as early as 1985. In 2004, the government strengthened the legal framework by extending the mandate of the ANME, clarifying the concept of energy efficiency and raising the subsidies dedicated to energy efficiency actions. In 2005, the subsidies to investment in REU actions were raised from 5% to 20%, and a 20% allowance towards the purchase of a Solar Water Heater was instated. Finally, RE equipment is exempted from VAT and customs duties are reduced for imported products.

A National Energy Efficiency Fund (FNME) was set up, and the National Agency for Energy Efficiency (ANME) has a dedicated task force focusing mainly on the industrial sector. This team is provided with human and financial resources and provides proximity coaching and technical expertise to enterprises. Energy audits are partially financed. Relay experts have been established in order to identify the necessary actions, to develop and monitor projects. Lastly, REU best practices workshops (comprising training, consultations and exchanges) are regularly organized by industrial sector.

2.2. Algeria, Egypt, Libya and Syria: Abundant fossil resources, but a non exploited significant RE and REU potential

Being hydrocarbon-rich, these four countries share the characteristic of having a highly subsidized and low price energy (one electric kWh costs to the residential consumer 0.005€ in Syria, 0.01€ in Egypt and 0.02€ in Algeria). This context, though quite obviously unfavourable to RE and REU, must not be considered as inevitable. Thus, Algeria and Egypt have clearly shown their will to develop these issues, and a political framework is underway.

Algeria, which holds over 53% of the SEMCs gas reserves[6], has a remarkable potential of development of renewable energies and, in particular, of solar energy. Algeria expressed its interest in the development of RE as early as in 1962 when it set up the Institute of Solar Energy, which was to become the Renewable Energies Development Centre (CDER) in 1988. It is in charge of research and development related to solar, wind, geothermal and biomass sectors. In the meanwhile, the Agency for the Promotion and Rationalization of Energy Use (APRUE) was established, in 1985, in order to address the significant increase in domestic demand. A National Energy Efficiency Programme (PNME) was set up through a Cross-sector Committee on Energy Efficiency (CIME) and is economically supported in its actions by a National Energy Efficiency Fund (FNME).

[5] Policy, program, and tools for a National Plan in energy efficiency, , World Bank, ICE, Burgeap, december 2006.
[6] Source: OME, BP Statistical Review & CEDIGAZ

The promotion of RE is supported by several measures: the law on research (1998) which makes RE a national priority of R&D, the decree on energy diversification (2004) which introduces feed-in tariffs for the electricity produced by RE, the law on RE (2004) which sets concrete objectives of RE penetration in the national energy mix and establishes incentive measures (green certificates and carbon credits). The latter law—a crucial framework for a real penetration of RE—needs, however, to be followed by implementation decrees in order to be effective.

Highly subsidized hydrocarbons and a only recent legislation framework have not been favourable to REU. Nevertheless, a series of successive decrees were promulgated on the energy efficiency of new buildings (2000) and on energy regulation of large energy consuming equipment and establishments (2005). A downward trend in energy intensity can be observed since the implementation of these measures, but substantial efforts can still be made.

In Egypt, energy efficiency is a key component of the National Strategy for Sustainable Development (NSSD) being currently developed by the Ministry for the Environment. As a reminder, as early as 1982, Egypt set up a Supreme Council for Energy & Renewable Energy and, in 1983, it created the Organization for Energy Planning (OEP) in charge of coordination, evaluation and dissemination of the corresponding policies.

Egypt has a significant wind resource on the western bank of the Suez Canal and benefits from an excellent sunshine over the whole country. This potential attracts foreign investors (German, Spanish, Japanese…). In 2000, the government announced that, by 2010, 3% of electricity would be produced based on wind energy. Subject to an adequate policy, these objectives can be hold. For the time frame 2021, the objectives are quite ambitious, with 7% wind power and 7% hydropower.

To sustain this policy, the New and Renewable Energy Authority (NREA), a centre specifically dedicated to RE, was set up in Cairo (1986). A platform for experimentation was also established there, with support by the European Commission (EC). Information seminars, as well as summer courses (draining technicians and engineers from other Arab and African countries), are regularly organised at the centre. More recently, a wind energy technological development, certification and training centre was set up Hurghada, with support by the EC and the Italian government (1994).

And yet, the total energy intensity quasi-constant value over the period 1981-2005 shows that considerable efforts are still to be made in terms of REU. In 2003, the national strategy aimed, by 2010, to achieve a 10% to 20% reduction of energy intensity on the production side (electricity and hydrocarbons), as well as on the demand side (industry and residential), particularly by boosting communication and information, research and development, training of the staff in charge of energy consumption in the industry and services sectors, participation by NGOs in the environmental debates related to REU and, finally, participation by local government in projects related to street lighting.

Libya is a sparsely populated country (5.8 million inhabitants) which holds 67% of the SEMCs crude oil reserves[7] and considerable natural gas reserves. Oil exports contribute for over 90% to the country earnings for a GNP/inhab. among the highest of the continent. Hydrocarbon abundance and the very low price of energy on the domestic market explain why REU is not a national priority, in spite of a potential estimated as 20% of the total consumed energy.[8] Unlike Algeria and Egypt, Libya did not implement real measures for the promotion of RE and REU.

RE consist, for the major part, of photovoltaics, used since 1976 for purposes of decentralised electrification (communication, cathode protection, rural electrification, pumping). The most

[7] Source: OME, BP Statistical Review & CEDIGAZ

[8] Source: Study of Dr. Abdullah Ballut, Dr. Mohamed Ekhlat "The Potential Impact Of Improved Energy. Future Utilization Efficiency One The Energy Demand In Libya Up To The Year 2020"17th World Energy Congress, the USA, 1998.

promising projects are: a sea water desalinisation station, irrigation pumping, with 100 sites planned, and finally a solar power plant of 1MWp.

Syria was late to engage in REU and RE, but plans to take significant measures. A first national strategy for energy efficiency, the Energy Conservation Law (ECL), comprising the establishment of a REU and RE dedicated legislative framework, incentive measures and an action plan, is under development. Although a notable project, co-financed by UNDP, GEF and OPEC led to the creation of the National Energy Research Centre (NERC) in 2003, this agency has not yet been provided with significant means of action. However, this situation should, change, as the NERC was entrusted with implementing the REU and RE measures envisioned under the ECL 2006-2010.

In terms of REU promotion,, three new laws should be promulgated, as well as a thermal regulation for buildings and standards related to electric appliances. REU actions concerning energy production (electricity) will also be implemented in order to enhance the reliability of the whole production/ transmission/ distribution chain.

As for RE, even though such actions have been undertaken since 1998 by various government agencies, the absence of coordination and of a comprehensive policy did not allow a real development of these sectors. However, solar thermal potential is significant: individual solar water heaters are relatively widespread and the ECL envisions to fully develop this market, in view of its positive impact, not only in terms of energy, but also of job creation. The photovoltaic is also present in the national strategy, even though it relates mainly to rural decentralized electrification and pumping in isolated zones.

2.3. Israel, Jordan, Lebanon, the Palestinian Territories and Turkey: Recent policies and promising prospects

Although having little or no privileged access to fossil fuel, and despite a significant RE and REU potential, the countries of this group have adopted only very recently measures aimed at energy efficiency.

In Turkey, the Electrical Power Resources Survey and Development Administration (EIE) is entrusted with the implementation of RE and REU measures. In 2003, EIE participated in drafting the Electricity Market Law in order to take into account RE issue and production targets. In 2005, the "Law on Renewable Energy" was promulgated, assigning objectives by sector, feed-in tariffs and guarantees, granting subsidy to land used for RE production, and setting criteria for guaranteeing production origin. However, these measures are not sufficient (too low feed-in tariffs, absence of cross-sector coordination, etc.), and the share of RE in the total energy mix has been on the decrease since 1990 owing to gradual rarefaction of biomass.

The global energy efficiency of the country has almost stabilised since 1990 and, according to Ministry of Energy estimates, the total potential of the country was already in 1998 of 12-14 Mtoe/year, that is 15 to 20% of final energy consumption. This potential covers in particular energy production (mainly electricity), with the installation of combine cycle power plants (a policy already underway), strong actions on demand, and 20 to 40% of achievable energy saving in industry.[9]

Israel set itself, in 2003, rather modest objectives for promoting RE in power production: 2% by 2007 and 5% by 2016. In 2004, the Minister of National Infrastructures (MNI) set out more proactive measures for the promotion of RE (feed-in tariffs and procedures, code of conduct for

[9] Data from the Turkish Ministry of Energy and Natural Ressources .

producers…). In spite of this, the responsiveness of investors was rather low, and less than 100 MW have received conditional authorisations.

In Israel, 20% of the total energy consumed could be saved.[10] Since 1989, the Government has established energy efficiency standards including energy labelling for national products and inspections of major commercial and industrial installations. These standards have, unfortunately, not produced real effects as such owing to a lack of available resources. However, due to the high energy price, the interest for REU has been growing since 2002. The development, over the past few years, of energy services companies (ESCOs) is likely to boost this dynamics.

Jordan issued in July 2007 its Energy Master Plan which is an ambitious energy efficiency plan that envisions to reach, by 2020, 10% of RE in the national energy mix, as well as to achieve 15 to 20% of energy saving with respect to the baseline scenario. It also provides the setting up of a National Renewable Energy Fund by the end of 2007. However, presently, even if the RE potential is identified and considerable, the associated fields are not developing, due to the low price of electricity and the absence of incentive economic measures.

The Energy Master Plan sets the objective of a 3%/year growth in REU. The measures planned to achieve this ambitious goal are: a reduction of energy subsidies, the adoption of tax incentives and thermal regulations for equipment and buildings, an awareness-raising/ training campaign and the creation of a dedicated investment fund. There is, however, no law for the promotion of REU to date, and even though several international cooperation projects have been conducted in order to foster REU (KfW, Higher Council for Science & Technology, EU, USAID, UNDP, GEF), the absence of a dedicated political framework has not helped achieve sustainable effects.

In Lebanon, the Lebanese Association for Energy Efficiency and the Environment (ALMEE), which is an associative body operating is close cooperation with the public authorities, has been involved for over ten years in RE and REU issues.

Lebanon imports 97% of its primary energy at international prices,[11] transmission losses of the electricity supply network are significant[12] and the energy sold on the national market is highly subsidised. Yet, RE production in Lebanon is quite low, and this, in spite of a clearly recognised potential in the solar sector, for instance. Due to very low electricity prices (0.02 €/kWh for small residential consumers), solar water heaters do not report a growth, and estimates for 2002 stood at less than 1% of hot water produced by solar energy.[13] As for the photovoltaic, it is regarded as 'non competitive' with respect to the national grid. Moreover, given the high rate of access to the grid, DRE by photovoltaic systems cannot have a real impact on the national energy mix.

In addition to a high potential for REU in electricity production and transmission, a significant potential exists in the building sector which accounts for over 30% of the primary energy consumed. A project, conducted by ALMEE in cooperation with ADEME and AFD between 2000 and 2005, sought to identify and lay down energy efficiency standards in the building sector, through pilot projects. Late 2005, the first thermal regulations for buildings were discussed by the Lebanese government[14], but have not been actually implemented to date.

The Palestinian Territories (PT) have established a framework favourable to energy efficiency within a market dynamics where conventional energy is rare and expensive. Indeed, in spite of very

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[10] Source: National study carried out for Plan Bleu in 2007.

[11] Source: IEA (International Energy Agency), 2003 IEA (International Energy Agency), 2003. Paris, France (accessed at left angle brackethttp://www.iea.orgright-pointing angle bracket).

[12]Graph 7 is based on data from the World Bank and shows losses of about 15%. Other estimates are higher and can reach 45%, see as exemple *Electric Energy & Energy Policy in Lebanon*, By Chafic Abi Said, Consultant and Former Director Planning and Studies at EDL, march 2005.

[13] Source: Chedid, 2002. A survey on more than 500 families living in urban area showed that 2,8% of them were equiped with hot water solar themal whereas 82% of them were using standard electric water heater (Houri et Korfali, 2003).

14 Source: AFD (Agence Française de Développement), Division Evaluation and Capitalisation, R&D Department, Lettre n°01-2007

limited financial means, the Palestinian Energy & Environment Research Centre (PEC) was set up in 1993 to conduct R&D and to foster RE and REU economic development.

The development of the solar sector, which today accounts for 19% of the national energy mix, is nonetheless to be linked to an energy context characterized by very high energy prices (in particular, electricity) rather than to any particular support. Other RE projects are under study, such as the construction of the first share of a concentration-based solar power station of 3MW (to ultimately reach 100MW),[15] and the construction of a seawater desalination station powered by solar energy. As regards REU, there are only scanty data.

3. QUANTIFIED INDICATORS: SOME PROGRESS, BUT CURRENT TRENDS FAR FROM HEADING TOWARDS MSSD OBJECTIVES

The Mediterranean Strategy for Sustainable Development (MSSD) puts forward quantified objectives for 2015 in matter of RE and REU, and monitoring indicators have been identified. These include, among others, total energy intensity and the share of RE and REU in the energy mix. Additional indicators, more refined, may nevertheless prove to be necessary in order to detect significant progress in certain countries, sectors or branches.

3.1. Energy intensity: rather insignificant progress

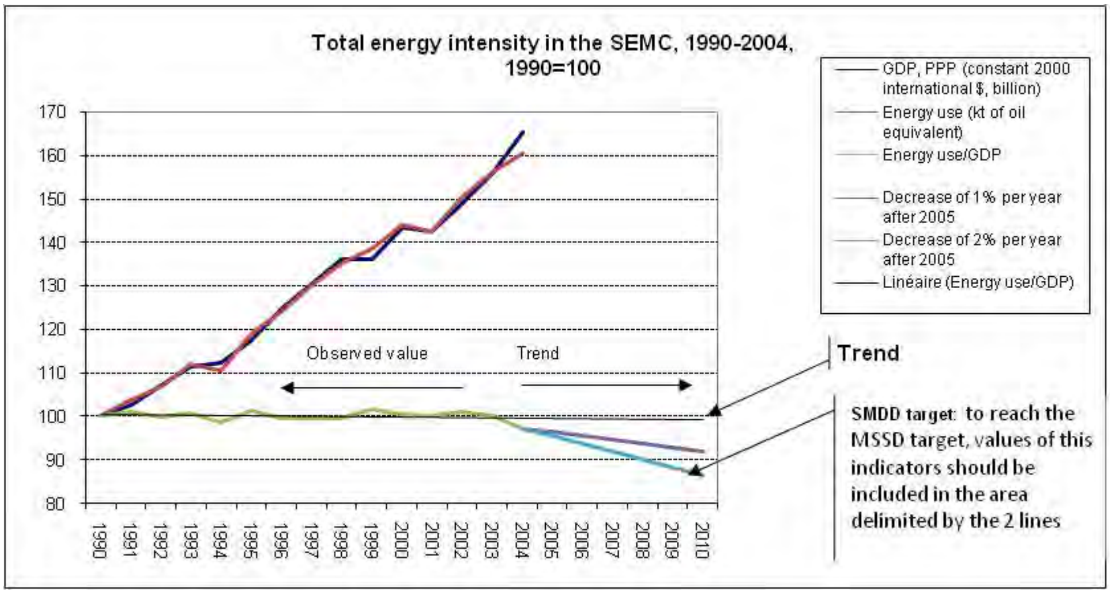
3.1.1. Total energy intensity: Tunisia stands out

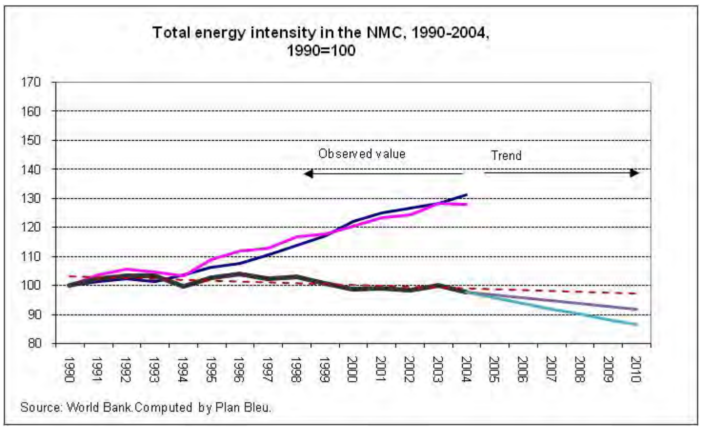
Despite a downward trend of total energy intensity in the Mediterranean Basin (-0.3% per year between 1992 and 2003), the objectives of reduction in the range of 1 to 2% per year, such as set by the MSSD, are unlikely to be reached (Graph 5). This general downward trend is often explained by a transition towards economies where the added value of services is growing, as well as by underlying technological developments[16]. On the other hand, the absence of proactive policies explains the slow improvements. Great disparities exist. Above all, the SEMCs report a slower improvement trend than the NMCs. Also, among the SEMCs themselves, the results are more or less encouraging, and three groups clearly stand out: Lebanon, Syria and Jordan report the lowest performance; Egypt, Algeria and Turkey constitute an intermediate group; Israel and Tunisia (the only country of the region to have decreased its energy intensity by more than 1% per year on average between 1992 and 2003) report better performance than the preceding countries. Lastly, Morocco is a particular case, as it has the most favourable indicator, but it must be underlined that it is also the country where consumption per capita is by far the lowest of the region. Compared with the global trend (-1.6% per year between 1992 and 2003), the Mediterranean reports a relatively slow progress, but it also reports lower energy intensity: in 2003, in the Mediterranean, 151 Mtoe were needed to produce 1 million USD of GDP, as against 212 on world level.

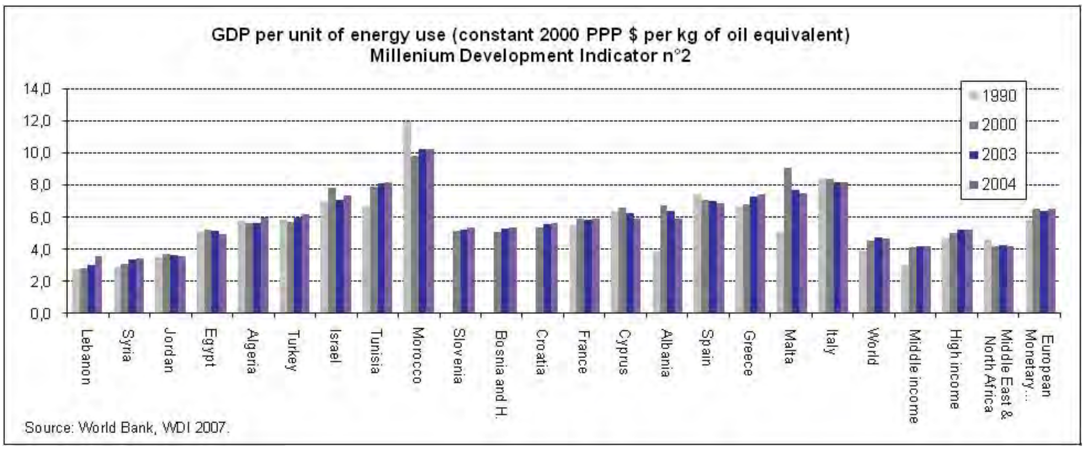
[15] Source : PEC web site: http://www.perc.ps/index.htm

[16] This indicator should be interpreted with a degree of caution: The evolution of the aggregated energy intensity of a country can be influenced by changes in the structure of the economy, climate (extremes in temperature) and geographical conditions, as well as by concerted efforts towards energy saving. For example, economies dependent on exploitation of primary resources (heavy industries), use more energy than countries which import such products. Geographically large countries tend to have higher transport costs due to longer distances that commodities have to travel, while countries in cooler climates have to foot a higher energy bill due to demand for heat..

Graph 1 – Total energy intensity in the Mediterranean and Mediterranean Strategy for Sustainable Development objective







Source : Computed by Plan Bleu using data from World Bank.

3.1.2. Energy intensity by sector: an under-exploited potential in all countries and all sectors

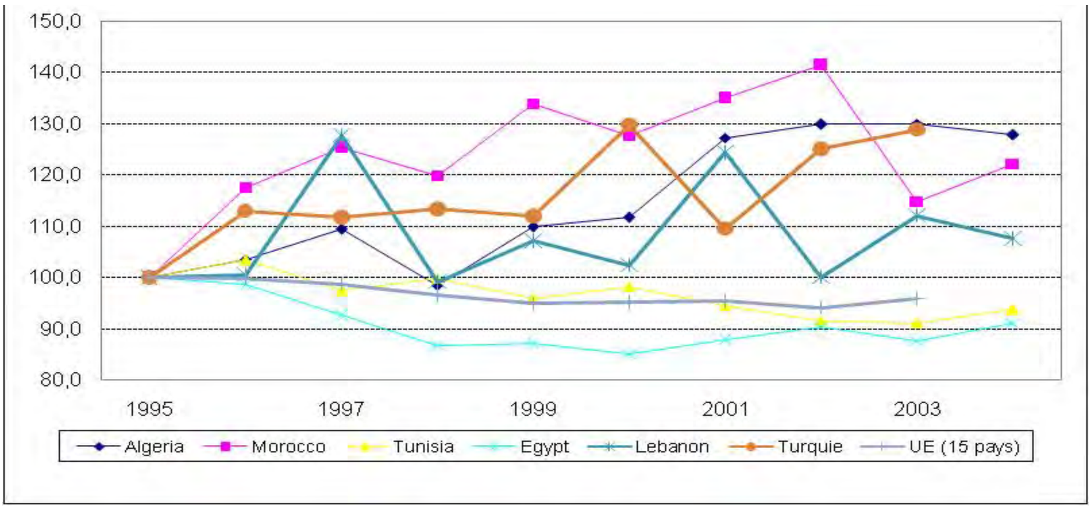
The economic energy potential is, on the whole, very significant in the SEMCs. It accounts, according to the countries, for between 15 and 40% of consumption,17 with a variable distribution between industries, the energy sector, the residential one and services (buildings).[18]

a. The industry and the energy production sectors: A potential often highly profitable from an economic point of view

Since 1995, out of all the countries for which data are available, only Tunisia and Egypt have seen the energy efficiency of their industry improve. In this sector, which accounts nearly for 40% of energy consumption in the SEMCs, gains in efficiency are, however, a priori easier to obtain in an "autonomous" way, because of the budget, competitiveness and competition constraints which companies have to address. However, the chief condition to exploit this potential is information of decision makers;[19] this is why many countries are today promoting audits in industry, especially for large energy consumers, which are not always aware of the existing savings potential.[20] In Morocco, the dissemination of enhanced wood-fired boilers for the production of hot water in hammams has allowed a reduction by 50% in wood consumption in the establishments equipped. Similarly, the good results obtained by Tunisia certainly reflect in part the efforts made by the dedicated Task force mentioned above.

As regards the energy sector, it reports significant losses during the transport and distribution of electricity. Apart from a few exceptions (Libya and Syria, where the losses are particularly significant and, on the opposite, Israel), these figures are close to those of the NMCs (between 10 and 15%). They are at the same time technical and commercial losses (illegal connections, deficient meters).

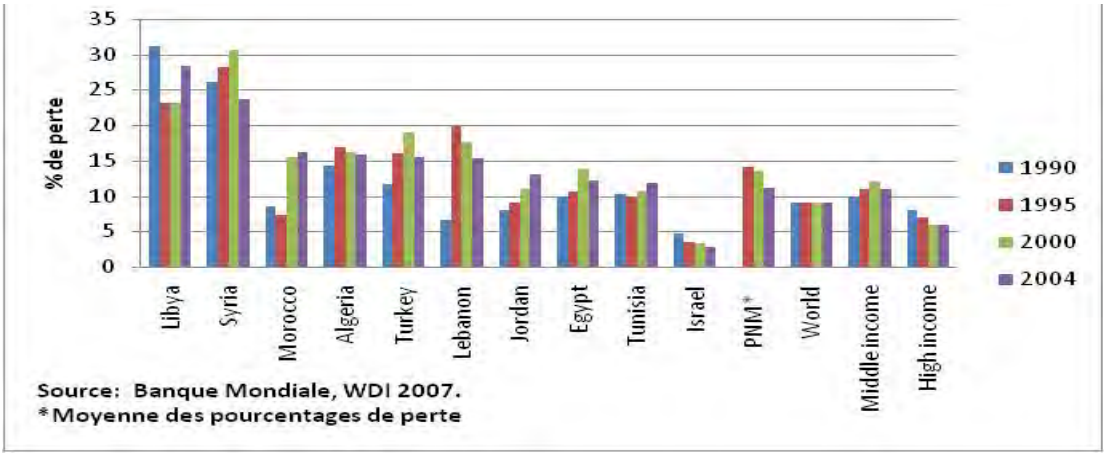
Graph 2 – Energy efficiency in the industry in a few SEMC (Toe consumed per USD of value added in the industry) 1995=100



[17] National studies carried out for Plan Bleu include the following estimate of potential saving : 20 to 40% of the primary energy consumption in Egypt, 15 to 20% of the total energy consumption in Turkey in 1998, 16% of the total demand in Syria and 15% in Morocco.
[18] Transport sector is not included in this study but is also with high potential of energy saving.

[20] XIth Euromediterranean Conference on the Economic Transition, June 2007, Presentation of V. Alzina, Directrice CAR PP/PAM/PNUE. see also paragraphe 3.4.1.

Graph 3 – Efficiency of electricity transportation and distribution (% of electricity production loss)



Source : World Bank, WDI.

b. The residential sector: A strategic stake for the region

In the SEMCs, energy consumption in buildings increased by over 40% between 1990 and 2004, and accounted then for about 40% of total consumption. Yet, savings potentials are very significant there. Thus, in Israel, an improved insulation, more efficient heating and air-conditioning systems, and the use of passive solar energy would represent a saving potential in the range of 25 to 40%.

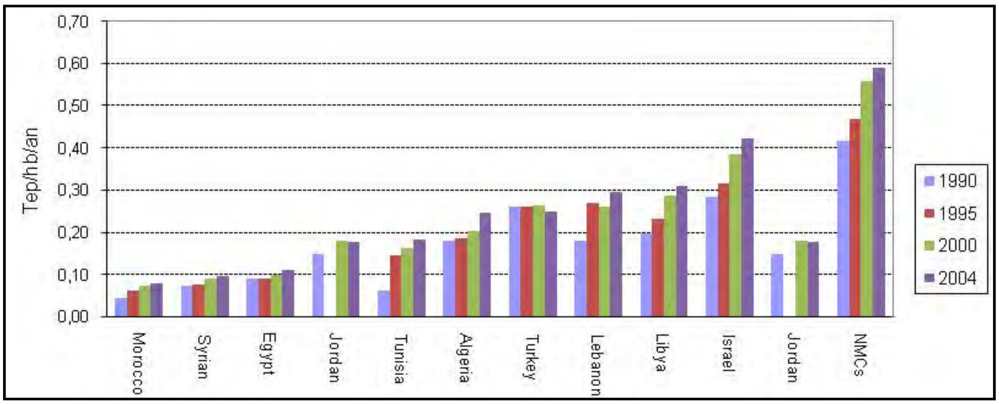
Although it does not take into account demographic growth, the per capita consumption of the residential sector is often used as an indicator of energy efficiency for this sector. Generally speaking, in the SEMCs, the quantity of energy consumption per capita increases, which is a relatively foreseeable result, insofar as the standard of living progresses, thus allowing access to new products and services. In Tunisia, for instance, the consumption of electricity by dwelling passed from approximately 1000 kWh in 1990 to 1500 kWh in 2003.[21] This increase is to be connected, in order of importance, with a rise in power consumption for heating (about 1/3), cooking uses (about 1/5), water heating (partly mitigated by the installation of solar water heaters), electric household appliances (refrigerators and television sets), lighting and also with the emergence of air-conditioning, which is set to increase significantly in the near future, in part because of climate change.

For the SEMCs residential sector, the challenge, thus, lies in anticipating the rise of consumption in a context of demographic growth. Everywhere, new dwellings, districts and cities are or will be in construction in the coming years,[22] and urban planning rules, construction standards and architectural techniques in the building sector will determine the energy consumption and the emissions (CO_2 and air pollution) of this sector for the years ahead. Besides, access to more and more numerous electric household appliances is likely to spread. Accordingly, some countries have already implemented labelling programmes and consumption standards, such as Egypt, Tunisia or the Palestinian Authority, for instance, which have standards and labels for refrigerators, ventilation systems and washing-machines.

[21] Source : ADEME and ANME

[22] Up to 2025, the total population of the SEMCS could increase by 96 millions with 74% of the population living in cities (64% in 2000) (Source: Plan Bleu 2005).

Graph 4 – Energy efficiency in the residential sector (consumption of the residential sector, in tep per inhabitant)



Source : World Bank, OME, WRI and Plan Bleu calculations

3.2. Renewable energies: A timid breakthrough, but promising experiences

Despite a rise in the quantity of the renewable energies produced in absolute value (from 23.1 to 25.3 between 2000 and 2006 according to OME), considering the simultaneous increase in demand, their share in the energy balance of the Mediterranean basin remains stable, if not on the decrease. They accounted for 2.9% in 2006, all types considered (apart for biomass), which is far from the objective of 7% set for 2015 by the MSSD.

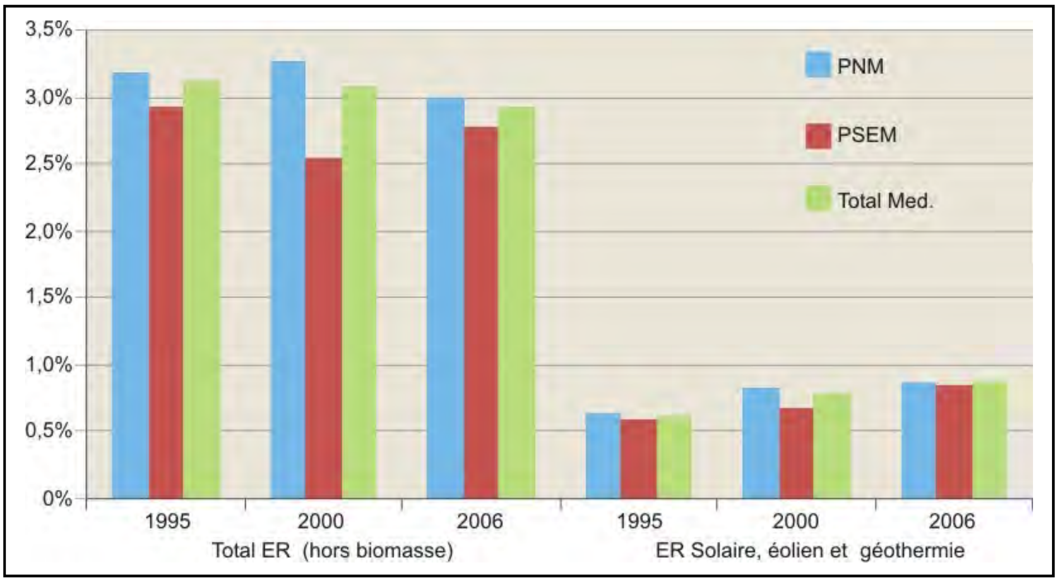
In the Mediterranean countries, the most utilised renewable energies are hydropower and biomass (Table 2). The other renewable energies (wind, solar, geothermal) targeted by the MSSD are still little developed even though the region, and especially the SEMCs, have a huge natural potential, in particular in solar and wind. Nevertheless, the still recent development of certain sectors in the SEMCs seems promising (Table 3).

Table 2 - Part Share of renewable energy in the total primary energy supply

	Total RE			Total RE excluding Hydro			Total RE excluding CWR**			RE Solar, Wind & Geo		
	1995	2000	2006	1995	2000	2006	1995	2000	2006	1995	2000	2006
Albania	51.1%	36.0%	30.0%	23.8%	14.2%	11.3%	27.3%	21.8%	20.8%	0.0%	0.1%	2.1%
Bosnia & H.	30.4%	15.4%	13.7%	10.1%	4.5%	3.6%	20.3%	10.9%	10.1%	0.0%	0.0%	0.0%
Slovenia	9.1%	12.2%	14.9%	4.4%	7.1%	10.6%	4.7%	5.1%	8.1%	0.0%	0.0%	3.8%
Croatia	10.1%	11.3%	10.9%	3.7%	4.8%	4.1%	6.4%	6.5%	6.9%	0.0%	0.0%	0.0%
Serbia & M.	13.1%	13.7%	10.4%	5.4%	6.0%	4.6%	7.7%	7.7%	5.8%	0.0%	0.0%	0.0%
Spain	5.6%	5.7%	6.9%	3.6%	3.7%	5.3%	2.0%	2.4%	3.3%	0.1%	0.4%	1.8%
Italy	4.9%	6.0%	5.3%	2.9%	3.8%	3.4%	4.0%	4.7%	3.2%	2.0%	2.5%	1.2%
France	7.6%	7.0%	6.5%	5.0%	4.8%	4.6%	2.7%	2.3%	2.1%	0.1%	0.1%	0.2%
Greece	5.6%	5.3%	4.7%	4.4%	4.1%	3.2%	1.7%	1.6%	1.8%	0.4%	0.5%	0.4%
Cyprus	2.2%	1.9%	1.6%	2.2%	1.9%	1.6%	1.5%	1.4%	1.6%	1.5%	1.4%	1.6%
Malta	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
NPM	6.7%	6.7%	6.5%	4.2%	4.3%	4.4%	3.2%	3.3%	3.0%	0.6%	0.8%	0.9%
Turkey	17.4%	13.1%	11.2%	12.5%	9.7%	7.2%	6.0%	4.7%	5.5%	1.1%	1.2%	1.5%
Israel	2.9%	3.2%	3.5%	2.9%	3.1%	3.5%	2.8%	3.1%	3.4%	2.8%	3.1%	3.4%
Syria	1.6%	1.6%	1.9%	0.0%	0.0%	0.0%	1.5%	1.6%	1.8%	0.0%	0.0%	0.0%
Egypt	6.1%	5.5%	4.2%	3.4%	2.9%	2.5%	2.8%	2.6%	1.8%	0.0%	0.0%	0.1%
Lebanon	4.1%	3.4%	3.3%	2.7%	2.6%	2.3%	1.5%	0.9%	1.2%	0.1%	0.1%	0.2%
Morocco	5.4%	5.1%	4.5%	4.8%	4.4%	3.8%	0.6%	0.7%	0.8%	0.0%	0.1%	0.1%
Tunisia	12.4%	12.4%	11.4%	12.4%	12.3%	11.3%	0.0%	0.1%	0.1%	0.0%	0.0%	0.0%
Algeria	0.3%	0.3%	0.3%	0.2%	0.3%	0.2%	0.1%	0.0%	0.1%	0.0%	0.0%	0.0%
Libya	0.8%	0.8%	0.9%	0.8%	0.8%	0.9%	0.0%	0.0%	0.1%	0.0%	0.0%	0.1%
SEMC	8.1%	6.7%	5.9%	5.7%	4.9%	4.0%	2.9%	2.5%	2.8%	0.6%	0.7%	0.8%
TOTAL Med.	7.0%	6.7%	6.3%	4.6%	4.5%	4.3%	3.1%	3.1%	2.9%	0.6%	0.8%	0.9%
FEMIP Countries	3.8%	3.7%	3.4%	2.6%	2.6%	2.4%	1.6%	1.6%	1.5%	0.5%	0.5%	0.6%
JORDAN	1.4%	1.4%	1.0%	1.3%	1.3%	1.0%	1.3%	1.3%	1.0%	1.3%	1.3%	0.9%

* MSSD indicator - NPM: Northern Mediterranean Countries - SEMC: South and Eastern Mediterranean Countries - FEMIP Countries: SEMC plus Jordan less Turkey and Libya - CWR: Combustible and Waste renewable (biomass): solid biomass, gas/liquid from biomass, Municipal and industrial waste - RE: Renewable energy - Total RE: hydro. Biomass (CWR), solar, wind, geothermal energy.
Source: OME 2008.

Graph 5 – RE share in the total primary energy consumption (%)



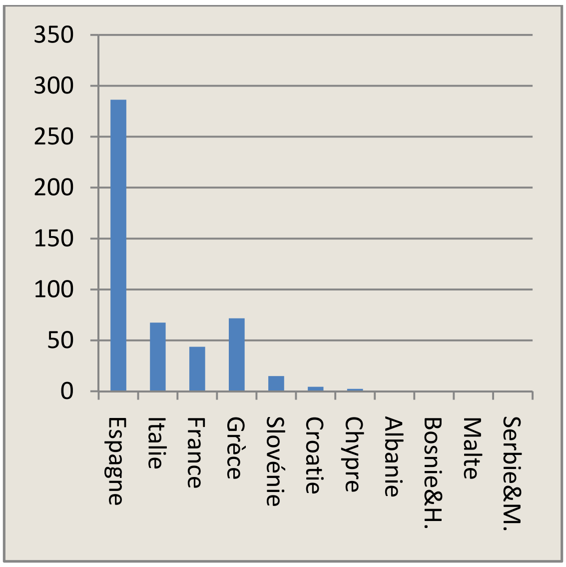
Source : Observatoire Méditerranéen de l'Energie/ Plan Bleu

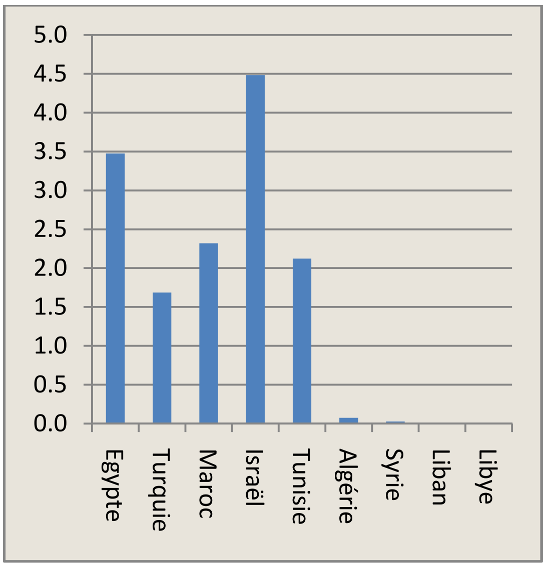
Table 3 - Renewable energy installed capacity in 2006 (in MW)

	2006 Mega Watt		
Pays	Hydro-électr.	Autres ER* (hors biomasse)	Total
Espagne	18477	12426	30903
Italie	21070	3951	25021
France	25287	2660	27947
Grèce	3460	795	4255
Slovénie	920	30	950
Croatie	2060	20	2080
Chypre	0	2	2
Albanie	500	0	500
Bosnie&H.	2064	0	2064
Malte	0	0	0
Serbie&M.	3497	0	3497
PNM	77335	19884	97219
Egypte	2783	253	3037
Turquie	13216	123	13339
Maroc	1729	71	1800
Israël	0	30	30
Tunisie	66	21	87
Algérie	275	2	277
Syrie	1528	1	1529
Liban	276	0	276
Libye	0	0	0
PSEM	19873	501	20375
Total Med.	97208	20385	117594
Pays FEMIP	6669	380	7050
Jordanie	12	2	14

Source : OME, Plan Bleu

Graph 6 - Renewable energy installed capacity in 2006 (in MW per inahbitant)



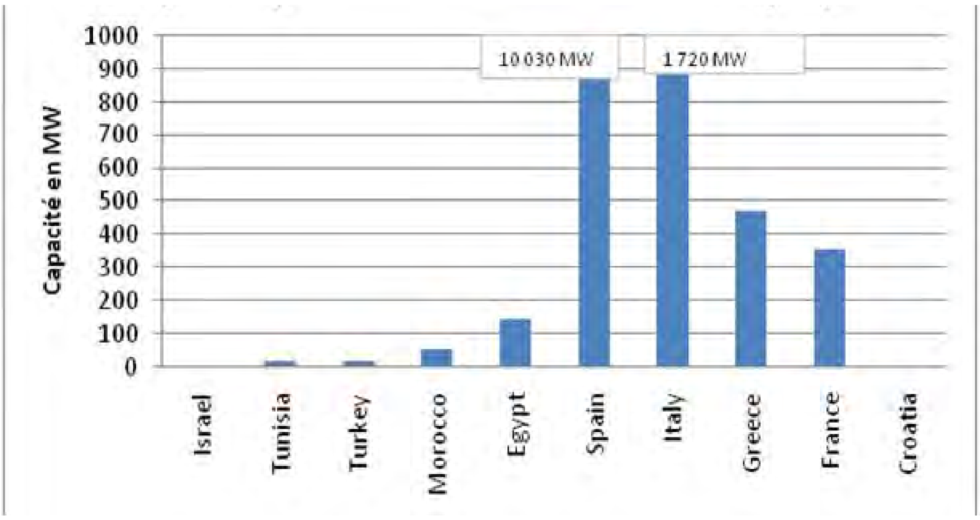


3.2.1. Wind energy: Egypt, a proven leader

Around the Mediterranean, the leader in wind energy is unquestionably Spain, which reported in 2005 the third largest production capacity (about 10 000 MW) after Germany and the USA.[23] In certain SEMCs, the technical wind potential is also particularly significant and, for instance, the OME estimates it as 28 000 MW for Egypt, Tunisia and Morocco taken together.[24]

Yet, in 2007, these three countries totalled an installed capacity of 365 MW and, thus, exploited a mere 1.3% of this potential. In Egypt, there is currently an installed capacity of 230 MW, which makes it the largest producer of wind-generated electricity in Africa and the Middle-East, and the objective for 2010 is 850 MW, that is about 3% of the electricity demand. In Morocco, the wind parks projects—both developed and underway—reveal a quite diversified portfolio (power plants integrated in the production park of the National Electricity Utility (ONE), self-production projects of private industrials or systems of power supply to seawater desalination stations). On the whole, the installed capacity in Morocco stood at 120 MW in 2007. The Moroccan Government has set the target of stepping up the contribution of RE to 20% in the national power balance, and decided in October 2006 to launch the "1000 MW" initiative which envisions the construction, between 2008 and 2012, of several new wind farms (200 to 300 MW in Tarfaya, 240 MW in Laâyoune and 200 MW in Foum El Oued—for the South of the country—, 100 MW in Touahar Taza—in the Centre—, and 60 MW in Tanger Sendouk). In Tunisia, the potential is still little exploited, but the sector is developing, and it is envisioned to achieve an installed capacity of 155 MW under the national programme 2007-2011 (the capacity in 2005 was of 20 MW). In Syria, the utilisation of wind energy has not started yet (only one wind mill is under operation as a demonstration project). The capacity of the country was estimated as 140 MW and a first tender is scheduled for 2007 for the construction of a 6MW farm. Finally, Israel offers a limited potential of 600 MW but has a capacity installed of only 6 MW.[25]

Graph 7 – Production capacity in wind energy in 2005, MW



Source: OME, Plan Bleu, Global Renewable status.
Note : For Spain and Italy, the values are given in the boxes since they are much bigger than for other countries. Data are for 2005, the value for Spain in 2006 is 1,6GW (Source : Renewable Global Status Report.).

[23] Renewable Global Status Report 2006, REN21.
[24] Source : OME, GEM, n°1, juin 2007.
[25] Source : études nationales réalisées pour le Plan Bleu, 2007 et dires d'experts.

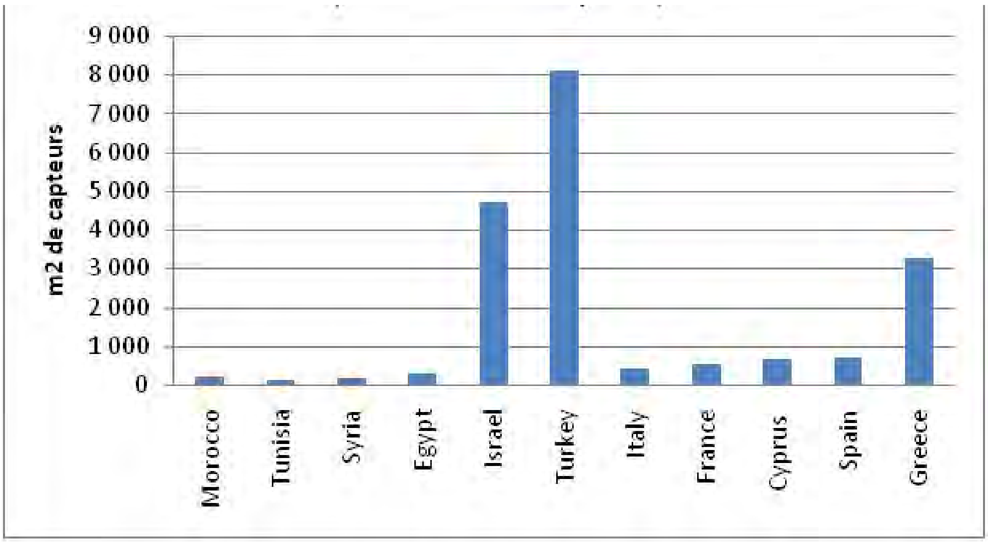
3.2.2. Solar thermal energy: Turkey and Israel among the world leaders; Tunisia as a best practice example

Contrary to the wind potential which varies according to the countries, the solar potential is considerable throughout the SEMCs. It is, therefore, the national context (price of energy, legal framework and financial support) which, above all, explains the disparities.

In Turkey, in Israel and in the Palestinian Territories, where energy prices are high, the individual solar water heaters market has reported a large-scale increase, without a real need for specific support mechanisms.[26] These countries belong in the group of world countries where the area of installed collectors for hot water production and for heating is the largest: Turkey ranks 3rd, after China and the European Union (as a whole), and Israel ranks 5th after Japan.[27] The Palestinian Territories now hold the 3rd ranking solar thermal market per capita in the world, with 350 m² per 1000 inhabitants,28 after Cyprus and Israel (420 m² per 1 000 inhabitants, which represents, according to the government, a drop by 8% of the country's electricity consumption[29]).

Nevertheless, the Tunisian and Moroccan experiences would prove that a sustainable market can develop in countries where power prices are, a priori, less favourable to solar water heaters. In Tunisia, the PROSOL-Residential project allowed the installation of 23 000m² of additional collectors in 2005, 35 000m² in 2006, and the objective is to operate a change of scale to reach an additional installation capacity of 150 000m² by 2011, which would raise the total installed area in Tunisia to about 740 000m² by end of 2011.[30]

Graph 8 – Solar water heater in a few mediterranean countries: 1000 of m2 installed in 2005



Sources: OME, Plan Bleu, Renewable Global Status report

This change of scale is based on several best practices implemented jointly and creating a mutual spill-over impact. Thus, on the financial level, a tripartite agreement was signed between the Tunisian State, which finances 20% of the equipment, STEG (Tunisian Electricity and Gas Utility), which ensures, via its electricity bills, a recovery of the loans granted to purchase the equipment, and commercial banks which, being assured of efficient recovery, grant loans more easily. Moreover, in order to ensure the market takeoff phase, UNEP subsidised—under the MEDREP programme—

[26] In Israel, in the early 80s a regulatory solar obligation targetted new, primarily residential buildings. This measure is largely outdated as 90% of new installations of this kind occur beyond the scope of the regulation. (existing buildinds or exceeding the regulatory target). Solar energy is now the norm for the production of hot water.
[27] Source REN 21, *Global Status Report,* 2007.
[28] Source : The Current Status of the Energy Sector in Palestine, with a Special Focus on the Electricity Sector, Ayman Abu Alkhair, Universtité de Genève, Centre universitaire d'étude des problèmes de l'énergie, 2006
[29] Source : ESTIF
[30] Conference acts : financing and energy management , , Hammaet Tunisie, avril 2007.

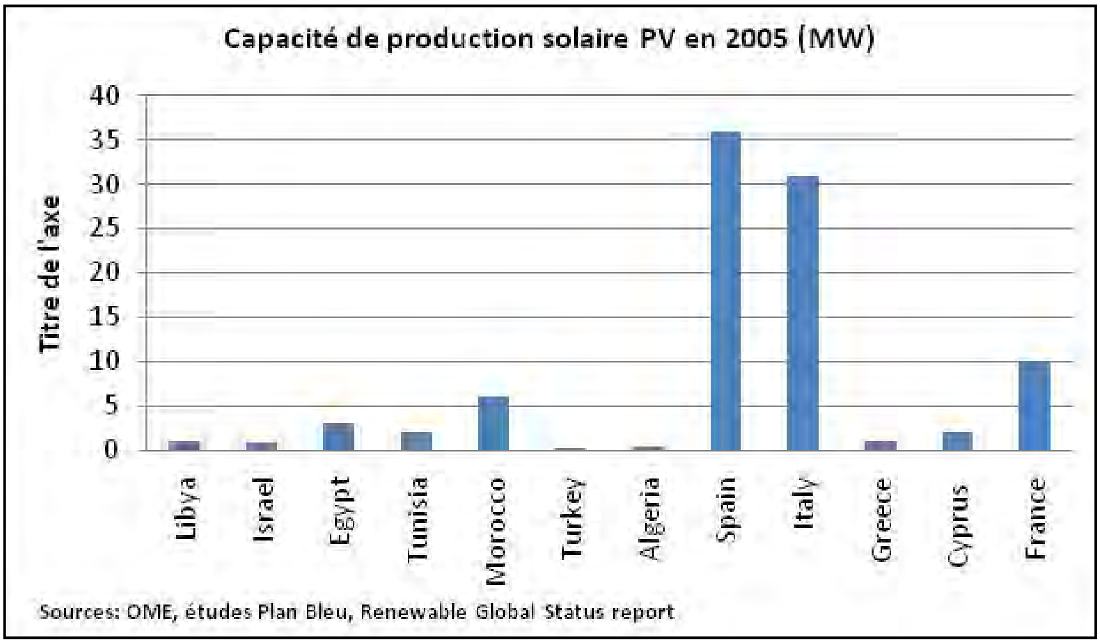
interest rates to 7% for the first 22 000m². Besides this innovative set-up, the Tunisian State seeks to sustainably organise this professional sector by establishing quality control of the equipment, training of professionals and the mandatory implementation of a Guarantee of Solar Results (GRS) contract for collective installations (as recommended within the framework of the MEDA project AESTBM[31]).

In the case of PROMASOL in Morocco, the programme comprises—in addition to measures concerning equipment quality, training of professionals and investment subsidies—financial mechanisms aimed at facilitating the development of national operators. Thus, the Prospecting-Sale Insurance (Assurance Prospection-Vente/APV) is targeted at solar water heaters suppliers (producers or importers) in order to facilitate the development of sales for industrial and commercial establishments and enterprises. This insurance covers up to 70% of the prospecting costs related to the hiring of commercial personnel, the development of catalogues, the conducting of preliminary studies… with a view to promoting sales in these sectors. PROMASOL encourages the development of solar water heaters and helps the current market develop quite rapidly (30 000 m² of additional collectors in 2006).

3.2.3. Solar photovoltaic energy: Decentralised Rural Electrification (DRE) mainly

To date, this sector is quantitatively little developed, but is steadily growing and plays a decisive role in access to energy in the more isolated areas.

Graph 9 – Solar photovoltaïc capacity in 2005 (MW)



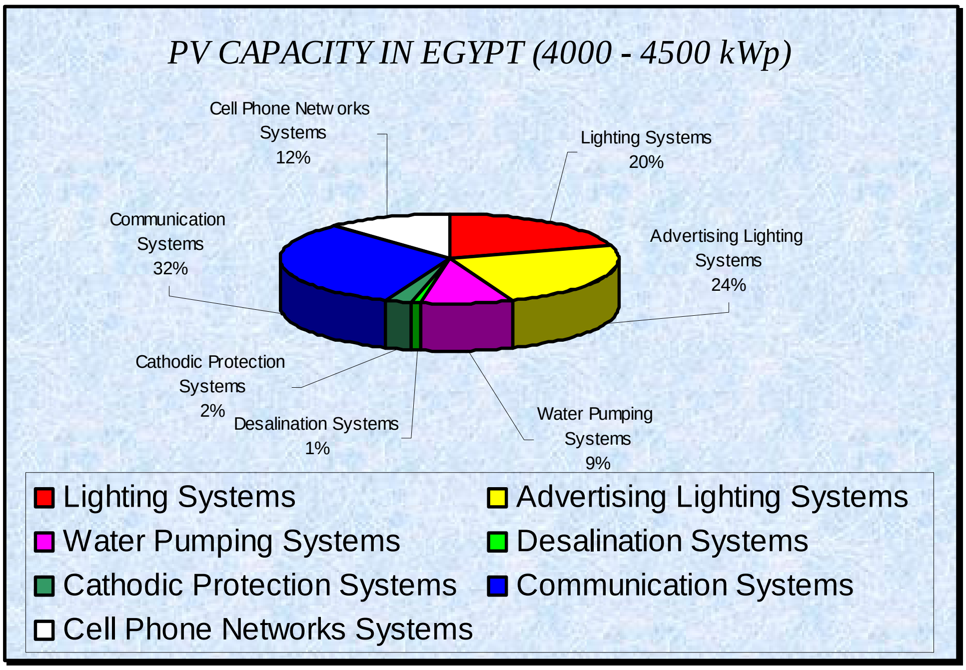
DRE: A successful Moroccan experience

Photovoltaic may prove in some cases to be more profitable than national grid extension or the use of diesel generators. Decentralized applications are numerous: water pumping in the Libyan desert, telecommunication relay stations in Egypt (Graph 13), etc. But it is in Morocco that decentralised

[31] MEDA Project- Appying thermal solar energyin the Mediterranean basin (AESTBM), 2001-2004. Suggested reading for a summary of the project, Stéphane Pouffary, Thermal solar energy in the Mediterranean : challenges and perspectives in an energy market in full transformation (in French : *Le solaire thermique en Méditerranée : enjeux et perspectives dans un marché énergétique en pleine transformation*, MEDENERGIE, issue n° 14, October 2004.

photovoltaic power is the most developed, and this, for two main reasons: the country's electrification rate is fairly low compared to that of the other SEMCs,[32] and the government, via the National Electricity Utility (ONE), has implemented a dynamic Global Rural Electrification Programme (PERG) including a decentralized component based on a cost-benefit analysis. Late 2007, 3.057 Moroccan villages were equipped with photovoltaic systems, which corresponds to 43.300 households, and the total potential would be of 150 000 households. In the SEMCs as a whole, 9 million people still did not have access to electricity in 2005.

Graph 10 - Share by area of activity of the the installelled solar photovoltaic capacity in Egypt, 2006



Source : R.Y Georgy, A. Soliman, national study carried out for Plan Bleu, 2007.

Grid connected photovoltaics: Relatively few experiences yet

There is, however, increasing interest and, subject to setting up a favourable and stable legal framework, several projects could emerge in the coming years, either under the form of photovoltaic farms or building integrated.

3.2.4. Solar thermodynamic: A potential for the near future?

Solar thermodynamic consists in concentrating solar energy in cylindrical-parabolic collectors or on towers in order to heat a fluid up to vapour state. This vapour runs power turbines and generators.

In this sector, certain technologies may be regarded as mature. The electricity costs proposed are already economically enticing (about 100€ MWh) and, from now, ambitious deployment plans could be set out. Concerning the less mature technologies, significant research programmes are underway on international level and require direct support, as well as for the implementation of pilot projects.

These technologies are particularly interesting for the SEMCs because, in addition to their requiring considerable sunshine, they present features particularly suited to the regional context:

- They can be combined with fossil fuel, such as natural gas, or be coupled with heat storage systems, thus reducing recourse to fossil fuels;

[32] The level of electricity coverage in 2006 was 98,1% in Algeria, 99,1% in Egypt, 99,4% in Tunisia and 88% in Moroccono twithstanding the results of the (data WEA)

- They are suitable for areas with unsecured access to natural gas or electricity, such as seaside resorts;
- The power plant needing a cooling system, sea water can be used for this purpose. The vapour forming at contact with the hot pipes allows, by condensing, to obtain very pure water in significant volume and, hence, to partly meet the seawater desalination needs reported by several countries;
- Lastly, according to the technologies used, land coverage is more or less significant, but these power plants may be installed on semi-desert grounds.

These technologies enjoy significant support from the USA, Spain, Israel, Japan, Germany and, to a lesser extent, France. International cooperation is very dynamic. The German initiative DESERTEC and the Trans-Mediterranean Renewable Energy Cooperation (TREC) are campaigning towards awareness raising regarding the potential of this technology and the installation of solar power stations on the Southern and Eastern rims of the Mediterranean to supply in electricity North Africa, the Middle-East, and even Europe. It is indeed, in the long term, quite realistic to envision the installation of solar power stations in the SEMCs to supply Europe with clean and sustainable energy (Box 1).

Several projects of solar/gas hybrid power stations are under study or construction in the SEMCs. Algeria has identified a projects portfolio likely to be in operation by 2015. A first project of 150 MW is due to be operating in 2010. Morocco and Egypt have each a project in construction process likely to be operating in 2009.

It should be noted that these projects are conducted by national and international consortiums of public and private investors. The Global Environment Facility (GEF) of the World Bank has been very active in this field (50 million dollars in Morocco and 40 million in the power station under construction in Egypt). These projects, in view of their size and the financial sums mobilised, are in addition particularly suitable for the implementation of the Clean Development Mechanism (CDM) of the Kyoto Protocol.[33] While ensuring that the share of solar power is significant in the eligible projects, this should foster foreign investments in this type of applications. In view of the significant potential, but also of the significant investments, it is thus advisable to best organise the sector in order to develop a veritable industrial network. In due time, the equipment could be produced locally, thus allowing the creation of high value added jobs, while contributing towards energy independence and the production of fresh water in significant volume.

[33] CDM are treated in detail in Chapter 3.4.6.

Box 1 - Towards a power interconnections loop in the Mediterranean basin: An opportunity for renewable energies deployment in the region

The recent issues of security of supply, integration of electricity markets and economic cooperation in the Mediterranean region have focused reflection on HVDC[34] connection type between North and South (Spain/ Italy and Northern African countries). The feasibility studies were launched in the early 2000s in order to appreciate the economic viability and technical feasibility of sub-marine corridors. It was particularly under Algeria's and Libya's impetus that these studies were initiated, owing to their interest in exports to Europe. European operators, too, were favourably disposed to the interconnection projects: the Spanish Transport Network Manager (GRT), as well as its Italian counterpart, have encouraged the feasibility studies related to various hypotheses and consequences on networks.

At present, the only interconnection existing between the North and the South of the Mediterranean is the one located at the straight of Gibraltar. Thanks to these cables, and to the existing six interconnections—plus two under construction—between Morocco, Algeria and Tunisia, this part of North Africa is connected to UCTE (Union for the Coordination of Transmission of Electricity).

Great efforts are made in order to boost electricity interconnections in the Mediterranean. However, apart from the exchanges between Morocco and Spain, those of a South-South type are quite low. In addition to the North Africa-Southern Europe connection projects, the passage of South-South 400 kV networks is under realisation.

It is hoped that the "Priority Action Programme for Euro-Mediterranean Cooperation on Energy" will help improving the extension of infrastructures and boost financial investments, thus inducing an increase in future power exchanges. The latter will impact the economic development of Mediterranean countries, as well as cooperation, not only among these very same countries, but also with the countries of the European Union. All parties involved will, undoubtedly, reap significant benefits from this. Besides, the said exchanges constitute a prerequisite for the creation of a Euro-Mediterranean electricity market.

Furthermore, an inter-connected Euro-Mediterranean electricity network is likely to offer a significant opportunity in favour of "green" power exchanges and, consequently, of the development of renewable energies in the Mediterranean region. Indeed, the renewable energies potential—being high in the Southern and Eastern Mediterranean zones—could be exploited under centralised form for purposes of "green" power exportation from the South to the North. There are already several projects in the pipeline in various countries, of which in particular Concentration Solar Plants (CSP) and wind power farms.

Source: OME, février 2008.

4. CONCLUSION

The materialisation of an alternative scenario such as that presented previously in the Mediterranean requires a drastic industrial and organisational revolution. It involves a shift from a system that is generally still little diversified and quite centralized to a system where a large number of stakeholders will have a role to play, where new, cleaner technologies will develop on a large scale, where production on consumption site will be frequent, where energy exchanges between companies and/or individuals located in the vicinity of each other will be possible, where the issue of energy efficiency will be an integral part of energy policies and where the overall organization of societies will lead the consumers to an in-depth behavioural change.

There are today incentive policies, legislation and tools being established throughout the SEMCs in favour of RE and REU. These institutional and legal frameworks are more or less complete according to the countries: they are already fairly advanced in Morocco and Tunisia, slower to get established in fossil fuels producing countries (Algeria, Egypt, Libya and Syria) and still recent (dating back to the 2000s) in Israel, Jordan, Lebanon, the Palestinian Territories and Turkey. It is also worth pointing out the relative weakness of the energy efficiency component with respect to that of renewable energies, Morocco and Tunisia being rather an exception.

In spite of these advances and a significant potential, the area quantified indicators do not show, to date, any substantial progress towards an improvement of REU, nor do they reveal a significant

[34] HTCC : high tension continuous current

penetration of RE in the energy mix. The development of RE and REU in the SEMCs is, for the major part, based on pilot projects, and the legal and institutional framework underway is at pains to yield significant concrete results, especially in matter of REU. Even though there appear to be interesting prospects for the future, the SEMCs thus belong rather in the baseline scenario issued by Plan Bleu in 2005 and the current trends will not help achieve the regional objectives of the MSSD.

While today the prevailing discourse of the countries of the region as whole is convergent, it must be noted that the actual actions and wills are not homogeneous and that the performance reported can diverge significantly from one country to the other. The MSSD must, from now on, overstep the field of prospective strategy and become an operational document. For so doing, there remain many barriers yet to overcome but solutions do exist.

II. BARRIERS STILL TO OVERCOME

In spite of the progress reported in matter of institutional and legal framework, the indicators analysis reveals that the RE and REU market is still limited in the SEMCs, which reflects the several barriers that are still to be overcome in order to achieve a real change of scale in these fields. This chapter aims at addressing four major types of barriers: (i) institutional and organisational barriers; (ii) technical and technological barriers; (iii) social and psychological acceptance related barriers; and finally (iv) economic and financial barriers.[35]

1. INSTITUTIONAL AND LEGAL BARRIERS

In many cases, the institutional, legal and information frameworks are favourable to conventional energies. This is particularly due to the fact that coordination in matter of RE and REU is recent (hardly a few years at best), if not inexistent.

Absence of, or fragmented, responsibilities and lack of institutional coordination

This barrier affects not only the RE sector, but also—and more considerably—the REU sector which often represents a negligible part of energy planning.

In Egypt, for instance, two Ministries are responsible for energy, which adds complexity to the integrated planning of RE, REU and conventional energies development. In Israel, there is no central authority in charge of energy efficiency, which affects negatively the coordination with the other actions in the field of energy. In Morocco, the reform of CDER to turn it into an operational agency dedicated at the same time to the REU and RE should help improve the situation.

To date, Tunisia is the country in which the body of legal texts is the most comprehensive with regard to REU: creation of innovative financial mechanisms, set up of dedicated human resources, creation of networks of experts for local training, conducting of communication actions, training and dialogue (it is also the only country where energy intensity has improved since 1992).

It, thus, appears clearly that this type of barrier is directly connected with countries' political will.

Inexistence and partial or difficult implementation of the legislations

While almost all SEMCs put forward future quantified objectives for RE production, very few of them engage in concrete objectives for REU measures implementation. Moreover, these objectives cannot be credible without the establishment of an appropriate institutional and legal framework. Lastly, even when legislations are established, their enforcement can be partial or difficult. Thus, in Egypt, a solar obligation related to new cities was set in the mid-1990s. However, low energy prices non conducive to investment, combined with a glaring lack of controls, have quickly made this law non effective.

The case of RE electricity is also eloquent: apart from the simple fact of being able to produce, it is also necessary to be able to optimise electricity by having the possibility of selling the production. This is a sine qua non condition for the development of renewable electricity, all the more that RE producers are often small size ones because of the concerned technologies. However, procedures of access to the grid, when they exist, are often time consuming, difficult and costly, which discourages

[35] The examples referred to in this chapter are drawn from national studies performed for the Plan Bleu in 2007 and are not intended to be exhaustive.

and hampers the steps taken in this regard. A dedicated legislative framework allowing easy access to the grid, as well as an incentive financial framework, would help provide attractive conditions.

This type of barrier is strong today in the Mediterranean, and the support measures for the various sectors, not resting on a stable legal framework, are too often limited to stop and go measures which cannot have a multiplier effect on the market.

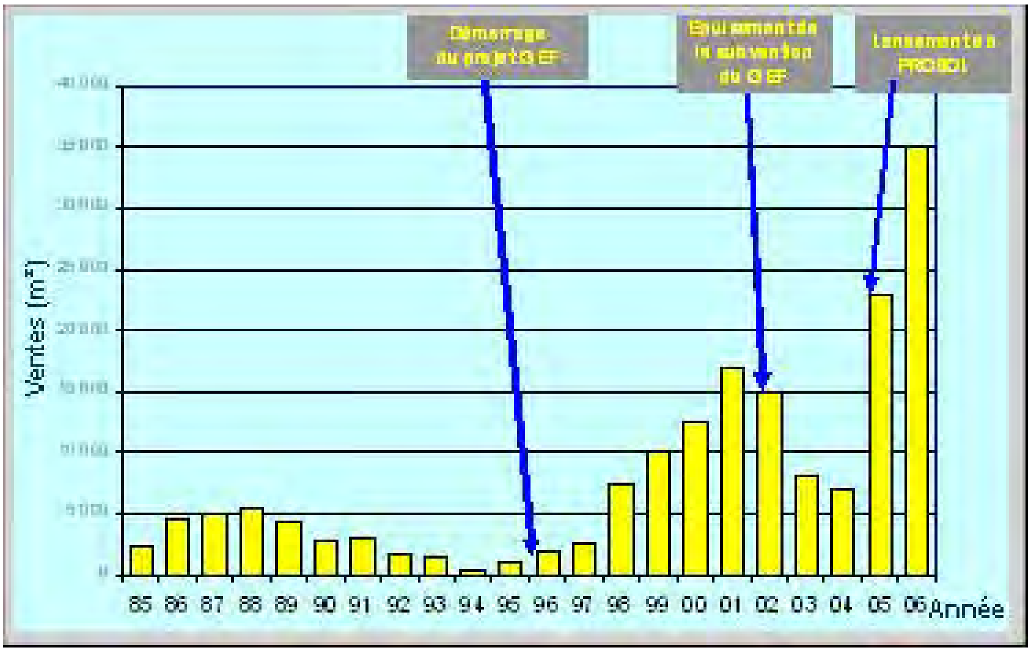
"Stop and go" actions and the instability of measures

The fact that the measures taken are insufficiently coordinated and/or planned over time does not help engage the fields in the expected virtuous circles. Examples of best practices, such as the PROSOL programme (solar thermal) in Tunisia and PERG in Morocco, seem, however, to prove that ways of action exist in order to overcome this barrier.

The example of the solar thermal sector in Tunisia is particularly eloquent. Its development fluctuated according to the various promotion programmes (Graph 14) leading today to the establishment of mechanisms likely to help ensure sustainability of the field and change of scale. Thus, between 1982 and 1994, the dissemination of solar water heaters (CES) was incepted thanks to a partnership between the public company SEN (SEREPT Energie Nouvelle), which manufactured the CES, and STEG (the Tunisian Electricity and Gas Utility), which recovered—via the electricity and gas bill— the consumer credits granted towards the purchase of the CES equipment. However, the capacity installed annually, after having reached a peak of about 5 000 m² in the late 1980s, subsequently decreased due to a lack of control over the technology. In order to give a fresh impetus to the sector, the government launched an ambitious programme financed by GEF in 1995. This programme is, then, mainly based on a purchase subsidy of 35%, as well as, in view of the lessons learnt, on setting up quality controls. This project helped restore consumer confidence and the emergence of national private operators as well as a network of installation professionals. The annual installed capacity reached 18 000 m² in 2001, but the fund financing the subsidy having run out, the year 2004 reported a modest 8 000 m² additional installed area. It was then that the PROSOL programme, already mentioned (cf. 2.3.2), was established. The preliminary results of PROSOL are promising, since the annual area installed is higher than that during the GEF project and that new national operators are emerging, with certain manufacturers taking even a regional scope, reaching out from the Tunisian market. This programme thus helped create a competitive market for solar water heaters (CES), get the banks to develop a “CES credits” quality portfolio (thanks to a secure recovery via the STEG electricity bill), and even reduce public budget deficit since the subsidy granted is about 9 times less expensive for the State than subsidising energy over the installations life time. The PROSOL programme, by setting up a win-win public-private partnership (PPP), seems able to ensure sustainability of the sector.[36]

[36] The history of the thermal solar energy in Tunisia and the first return on experience of the PRSOSOL project are drawn from the article of Rafik MISSAOUI, Solar water heaters: the PROSOL programme (available in French “Chauffe-eau solaires en Tunisie: le programme PROSOL”),Liaison Energie-Francophonie, N°23, avril 2007, pp. 67-74.

Graph 11 – Solar water heater market in Tunisia



Source : S. Amouss, communication Plan Bleu worshop, march 2007.

Similarly in Morocco: at the time of the Pilot Programme of Rural Electrification (PPER), conducted between 1985 and 1995, the crucial question of the maintenance of the installations arose. This is why, within the framework of the PERG, the National Electricity Utility (ONE) gradually set up partnerships with decentralised services companies, of which the major one is TEMASOL, for the installation and maintenance of the solar home systems, as well as the recovery of the monthly user fees. This is likely to ensure monitoring of the installations beyond the PERG itself. Besides, the PERG, having been planned on a national scale, helps ensure a (current and potential) activity volume sufficient enough for the entry of private operators on the market.

2. TECHNICAL AND TECHNOLOGICAL BARRIERS

RE and REU technologies are fairly recent, which gives rise to several difficulties: lack of technical knowledge about the various fields, little quality approach—if any—, lack of research and development.

A deficit of total quality approach. Such an approach is a key component of the sustainability of these sectors. Indeed, as RE call upon technologies which are economically amortised in the range of 10 to 25 years on average, it is essential that the installations should operate problem free throughout this time-period. Moreover, bad quality is doubly prejudicial: the projects in progress are not profitable, but it is also a whole field, often in development process and, hence, vulnerable, that suffers of such a bad image.

The quality requirement, to structure a field, must encompass the whole execution chain: proper design of the installation, quality equipment, proper assemblage and fixing of the provided equipment, regular maintenance throughout the life of the system by trained professionals. With regard to the latter point, the emergence of RE and REU sectors being recent, few professionals are versed in the related specialities. A major challenge thus lies in the development of training campaigns for the professionals of the field. Such campaigns have been established in Morocco, Tunisia and Egypt, for instance.

Insufficient Research and Development (R&D) effort. The R&D is too often neglected, it being regarded as not directly economically profitable. And yet, it is fundamental in the field of RE and REU, as these are two sectors still fairly recent where the technological improvement potential is still high, but also because the equipment must be adapted to the local context. R&D is crucial in ensuring an innovative and quality national technological offer. However, the financial amounts allocated to RE and REU are significantly lower than those dedicated to other sectors. It is worth pointing out that none of the SEMCs has, or envisions, a R&D policy in the field of REU.

3. BARRIERS RELATED TO SOCIAL AND PSYCHOLOGICAL ACCEPTABILITY

Lack of awareness-raising in civil society: Civil society plays a major in the implementation of RE and REU. This is particularly true for all measures related to the residential sector, since the owners are then direct players as potential buyers of individual solar water heaters and insulation materials, for instance. The reputation of the equipment and related services is essential because lack of knowledge about the technologies creates psychological reserve toward purchase. This factor also influences investment decision. While this obstacle concerns to date rather the NMCs, it is also likely to apply more and more to the SEMCs as in most countries where such markets have been set up.

Proper public information is, thus, necessary for the development of the fields, as well as for fostering a national awareness about energy issues. A public opinion poll on the environment in Arab countries[37] concludes that 60% of the persons interviewed believe that environmental conditions have deteriorated in their country, but inefficient energy use is regarded as a minor problem. Israel, Jordan, Morocco, Syria and Turkey point out a big deficiency in communication on national level, and this, in spite of major actions, sometimes, as in Tunisia where an annual "National Energy Efficiency Day" offers the opportunity for several communication actions.

This barrier has, however, become less arduous over the past few years (the Mediterranean Strategy for Sustainable Development adoption in 2005 is one evidence of this), and certain countries, such as Israel, have included these topics in school curricula, which helps towards achieving an appreciable enhancement of awareness.

[37] Arab Public Opinion and the Environment, 18 countries survey, June 2006.

The NIMBY syndrome: "Not In My Backyard"; Social acceptability of RE does not always obtain, and—as regards wind energy in the NMCs, for instance—it is even a major obstacle to overcome. In the SEMCs, it is not rare to meet with similar dynamics.

In Tunisia, for example, during the construction of the wind power park of Sidi Daoud, several actions were necessary to raise the confidence of the farmers and stockbreeders local populations and to ensure their adhesion to the project: an information and consultation campaign, compensation on losses of agricultural earnings during the assembly of the park and, whenever possible, participation in the works.

4. ECONOMIC AND FINANCIAL BARRIERS: REALITY OR PERCEPTION?

4.1. The issue of information in economic decision: Lack of visibility on real costs and benefits

It is commonly held that renewable energies "are more expensive" than conventional energies, or that energy saving is based on high initial investment. Is this true, or is it a mere assumption? The issue of costs and prices is at the heart of the stakes related to the development of RE and REU, but available information for economic decision is also equally decisive.

A whole range of factors may cause comparisons to be misleading (subsidised conventional energies, high capital cost, failure to take into consideration fluctuation risks of fossil fuels prices, as well as the advantages related to the use of RE and REU, technological damage, high transaction costs, etc). These elements are likely to make the market little accommodating of RE and REU penetration.

Nevertheless, renewable energies (RE) are already "profitable" under certain conditions; it is an element which has encouraged Morocco, for instance, to use solar photovoltaic power for rural electrification (cf. 2.3.3). For REU, generally speaking, direct profitability of the actions is hardly known. SMEs/ SMIs scarcely know the potential of the REU measures applicable to their production processes, while the financial and environmental benefits are considerable and constitute a major pillar for actions aimed at enhancing energy intensity (and related economic competitiveness). This is, indeed, one of the conclusions of the analysis of a 100 case studies, conducted by RAC/CP in Mediterranean enterprises, reviewing eco-efficiency actions and their degree of profitability (Box 2).

The following examples are derived from the said case studies:[38]

- In Egypt, a leading can producer has conducted a "Clean Production" audit. In this case, an initial investment of 141 436€ enabled the producer to achieve an annual energy saving of 167 863€ and to reduce CO_2 emissions by 17 036 tons per year, with a return on investment within not more than 9 months;
- An Egyptian edible oil producer conducted several process changes and took measures aimed at updating the hydraulic circuit, reducing hot water and steam losses and setting up various optimisation processes. The total investment, of 13 500€, helped obtain an annual energy saving of 174 888€, with a return on investment achieved within less than one month! The corresponding value in terms of generation of CO_2 is a reduction by 5 346 tons per year.

[38] Source : RAC/CP (fiche Med Clean, with practical advice and returns on investment. Available on theweb site of CAR/PP : http://www.cprac.org)

- A Turkish textile company specialized in dyeing achieved an annual energy saving of 29 576 773 MJ (276 229€) with a return on investment within about 20 months. The avoided CO_2 emissions amounted to 3 651 tons.

Insufficiently visible quantified objectives. The setting of quantified objectives in the medium term both for RE and for REU is also part of sending out a clear signal to the field investors and actors concerning the will of the public authorities to implement lasting actions aimed at massive utilisation of existing potentials. It also acts as lever in "arousing" interest among economic players in this subject. However, in most of the Mediterranean countries, when such objectives exist, they are little visible or insufficiently matched to actual commitments, which reduces their credibility.[39]

[39] See also paragraphe 3.1.

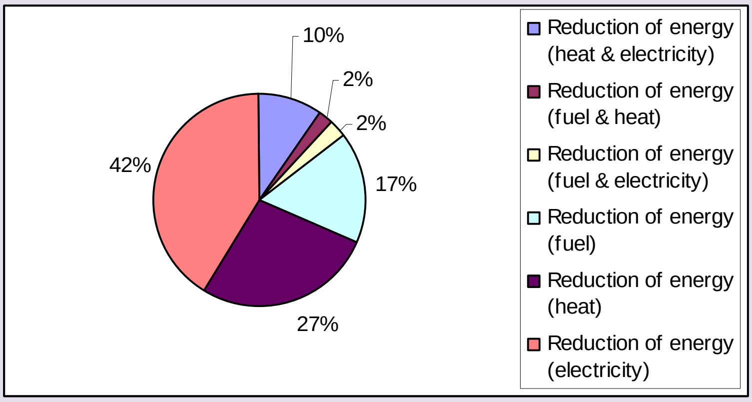
Box 2 - MED CLEAN: Practical cases of the Regional Activities Centre for Clean Production/ Mediterranean Action Plan/ UNEP

Energy efficiency in Mediterranean enterprises

On regional level, the Regional Activities Centre for Clean Production (RAC/CP), of the Mediterranean Action Plan (MAP), has endeavoured for over 12 years to enhance the ecological and economic efficiency of Mediterranean enterprises. The RAC/CP has compiled 100 practical cases of Mediterranean enterprises having conducted specific actions in such fields as reduction of waste generation, water and natural resources saving, and energy efficiency.

An examination of these 100 case studies has highlighted that Mediterranean enterprises often had no idea—prior to their implementation—of the possible savings potential based on the application of more eco-efficient techniques. The RAC/CP has recently conducted an analysis of the results of these 100 practical cases in order to better call awareness of the private sector as to the untapped potential and facilitate exchanges of experiences having led to significant energy savings, CO2 reductions and short-term economic gains.

In the said analysis, the RAC/CP has identified 34 cases of enterprises which implemented actions specifically reducing energy wastage. These cases obtain in enterprises from ten Mediterranean countries, not only from the Northern rim but also from the Southern and Eastern rims. In total, these actions conducted in the 34 enterprises have helped avoid emissions of 56.459 tons of CO2, and the economic gains derived from the actions of energy wastage reduction have been of 2.018.421€! And this, with an investment paying-off within one year only, on average. The improvement potential existing in the region is, therefore, tremendous, both with regard to reduction of CO2 emissions, and in terms of economic gains for the enterprises.



Source : RAC/CP[40]

The graph shows that, in the 34 enterprises considered, over 40% of the energy savings are obtained from savings on electricity, about 30% from savings on heating, 17% from savings on fuel, and the remainder is linked to savings on fuel or electricity for heating. These energy saving measures were conducted in several sectors: most in the food sector (29%), textiles (21%) metallurgy (18%), and electronics (6%). The remainder (29%) corresponds to several sectors (machinery, automobile, ceramics, etc.).

Source : UNEP/MAP/Regional Activities Centre-Clean Production, February 2008.

[40] The Med Clean fact sheets, with practical advice and returns on investment. Available on theweb site of CAR/PP : http://www.cprac.org

Table 4 : Financial support mechanism to RE and RUE in the SEMC

	Groupe 1		Groupe 2				Groupe 3				
EnR	**Maroc**	**Tunisie**	**Algérie**	**Egypte**	**Lybie**	**Syrie**	**Israel**	**Jordanie**	**Liban**	**Territoires Palestinie**	**Turquie**
Politiques Nationales de Soutien Economique											
Tarfis de rachat	E	E[4]	O	O		E	O				O
Subvention à l'investissement	E	O		O	R	O					E
Réduction des taxes (TVA, droits de douane...)	O	O	R			E					
Fond de Garantie des Investissements	O					E					
Fond National dédié au développement des EnR		O	O			R		E			
Financement sur le prix des hydrocarbures exportés car remplacés par des EnR [1]				O							
Réduction des subventions aux energies fossiles [2]	O	O		R		E		E			
Financements internationaux											
Actions de promotion des investissements nationaux et internationaux	O	O		O	R			O			O
APD et Projets Internationaux[6] (en cours et terminés)	O	O	O	O	O	R	O	O	O	O	O
Existance de MDP EnR [3]	O	O[5]	E	O		E	O				
URE	**Maroc**	**Tunisie**	**Algérie**	**Egypte**	**Lybie**	**Syrie**	**Israel**	**Jordanie**	**Liban**	**Territoires Palestinie**	**Turquie**
Politiques Nationales de Soutien Economique											
Subventions des audits URE	E	O	O		R	R		E			E
Réduction des taxes (TVA, droits de douane...)		O				E		E			
Fond National dédié au développement de l'URE	E	O	O			E		E			
Tarification de l'énergie et/ou réduction des subventions aux energies fossiles [2]	E	O		R		E					
Financements internationaux											
APD et Projets Internationaux[6] (en cours et terminés)	O	O	O	O	R	R	O	O	O	O	
Existance de MDP URE [3]	O	O[5]	E			E	O				

Légende:		
	O	: mécanisme actuellement en application
	E	: mécanisme en discussion / en cours d'adoption mais encore à definir exactement
	R	: mécanisme dont le manque est clairement identifié
		: mécanisme non mis en œuvre ou information non disponible

[1] Mécanisme s'appliquant aux pays exportateurs d'énergie, qui permet d'alimenter un fond de financement des EnR par les gains réalisés lors de la vente des hydrocarbures sur le marché international (qui sans EnR aurait été vendu sur le marché national subventionné donc moins cher)

[2] La réduction des subvention aux énergies fossiles permet non seulement de rendre plus concurrentielles les EnR sur le marché de l'énergie, mais aussi de diminuer la charge budgétaire liée aux subventions; Ces gains pouvant être utilisés pour financer directement des projets EnR.

[3] Projets MDP au stade d'enregistrement ou de validation, source UNEP RISOE Center, Mars 2007.

[4] Le tarif de rachat pour l'éolien et le PV devrait être mis en application très prochainement.

[5] Deux projets de torchage de Gaz de décharges sont déjà enregistrés. Le programme PROSOl de diffusion de chauffe-eau solaire est en cours de validation. Il a été développé selon l'approche programmatique.

[6] Les actions APD concernant l'URE sont beaucoup moins importantes, en termes financiers, que les actions APD concernant les EnR.

Note : Informations included in this table were collected through national studies carried out for Plan Bleu in 2007, documents from OME, informations from ADEME and are complemented in some cases by additional information provided by experts. This table is not exhaustive (very recent measures might not be included). Also, some of the measures indicated may not be applied due to a lack of means for there implementations. Nevertheless, the table provides a good picture of the present situation which is its first objective.

4.2. Financial and economic barriers to the development of a RE and REU market

All the SEMCs present this issue as the main barrier to the development of RE and REU. The table above shows that mechanisms are being set up in order to address these identified economic and financial barriers. They will, therefore, be analysed while highlighting a certain number of policies dedicated to mitigating them and to attracting investments in the fields of RE and REU.

4.2.1. 2.4.2.1 Ensure return on investment: The case of feed-in tariffs

For photovoltaic and wind-based power production, most NMCs have established a feed-in tariffs system for the electricity produced (specific to each production technology), guaranteed over a period compatible with the nature of the investment. This policy which was adopted by Algeria, Egypt, Israel and Turkey presents the advantage of subjecting the subsidy to proper operation of the equipment throughout the latter's lifetime. Besides, this tariff helps towards engaging in a win-win dynamics, both for the public authority and for private investors: the State pays only the kWh actually produced and has no treasury advance allocations to make, and the investor sees the economic return of his project guaranteed by the State over the whole useful life of the investment. This measure is all the more important as the OME estimates that, in the SEMCs, up to 70% of the projects in the electricity field will be of the IPP (Independent Power Production) type, financed by private funds.

However, the feed-in tariff incentive is efficient only when it is high enough to ensure return on the project and when the grid are really open to private producers. Yet, the management of the gird in the SEMCs is still largely monopolistic and the sale of the energy produced on the grid, when possible, is quite often preceded by lengthy and difficult procedures generating high transaction costs.

Best practices do, nevertheless, exist. Thus, Egypt offers connection to the national HV grid when establishing wind power farms, and Algeria offers renewable feed-in tariffs which vary according to the RE type (up to three times the purchase price of conventional energies).

4.2.2. The structure of energy prices: A complex barrier that is socially hard to overcome

The profitability of RE and of REU actions is directly determined by energy pricing. In many SEMCs, high electricity subsidies artificially hamper investment opportunities, as energy improvements result non competitive.

Pricing adjustments may, however, prove to be incentive. Thus, in Lebanon and in Morocco, for instance, a specific pricing is adopted during high demand time slots. This time-differentiated pricing may lead facilities where consumptions are hardly flexible—such as hospitals, hotels or industry—to implement energy efficiency measures.

Broadly speaking, it is obvious that a context of expensive energy is likely to foster the development and penetration of energy efficiency practices. As we have already seen, the development of solar water heaters in Israel, in the Palestinian Territories and in Turkey has taken place without large-scale public incentives. It is in this spirit that several countries, of which Morocco and Tunisia, where subsidies for fossil fuels incur heavy charges to the national budget, clearly manifest a will to move towards “true” energy prices.

It is worth underscoring, however, that price adjustments, and more particularly increasing rates, must be approached with great caution. Indeed, while these rates preclude access to RE and REU for a whole segment of the population, they also clearly include a social objective of access to energy. Accordingly, a non planned, abrupt rise, without an alternative solution for consumers, may lead to contrary results to those expected. In Syria, for instance, the increase in electricity prices in the early 2000s, immediately gave rise to line losses due to illegal connections in the poorest areas.

An energy price rise, in order to be socially acceptable, must therefore be accompanied by REU measures allowing the national industrial sector to remain competitive or ensuring that the end-user’s bill should not rise to unacceptable proportions. The Tunisian system for the funding of solar water heaters somewhat integrates this dimension. Indeed, the reduction in the consumption of grid supplied electricity and, hence, the related financial savings (cf. the substitution of electric water heaters by solar ones) allows reimbursement of the consumer loan necessary for the purchase of the equipment.

Energy prices that are often artificially low are a major impediment to the development of RE and REU in the SEMCs; and yet, such a RE and REU development is a necessary corollary to a return to “true” energy price.

An initial over-cost requiring appropriate financing mechanisms

RE and REU projects are characterised by a profitability linked to the fact that the RE ones do not require fossil fuels, and that REU ones allows energy savings. Yet, in both cases, the initial investment is still relatively high.[41] For this reason, "traditional" solutions are often chosen, even though they may be more costly upon utilisation. It is precisely because of this initial over-cost that it is important to accompany as upstream as possible the decision-making process. Several measures may be undertaken to address this barrier, such as direct subsidy, adjustment of tax burden, or loan subsidisation.

Direct purchase subsidy: A cornerstone for a market change of scale

In the countries that are more advanced in the development of RE and REU, direct subsidy emerges as a key factor in this change of scale.[42] By cutting down the initial investment in a visible way (direct visibility being one of the strong points of this strategy), it helps not only to shorten the return on investment time-period but also to mitigate risk perception. In the SEMCs, Egypt and Tunisia have already set up RE subsidy mechanisms, Algeria and Tunisia provide subsidies towards REU studies, while Jordan, Morocco, Syria and Turkey are considering the implementation of such measures.

Acting on the tax burden: Tax credit and VAT exemption

The initial cost of RE and REU may also be subsidised indirectly via various tax reduction policies. Thus, tax credit consists in deducting the equivalent of a portion of the equipment value from the tax due for payment in the following year. This measure has been applied both to individuals and to corporate entities. Today, in France, 50% of the amount of certain RE and REU equipments (solar, wood-fired boilers) for individual use is reimbursed under the form of an income tax credit, provided they reach a certain performance level. Another, more easily applicable measure (implemented in Morocco, Syria and Tunisia) is VAT exemption which may be quite high in certain countries (20% in Morocco and 17% in Algeria, for instance).

Leveraging the banking sector to mobilise capital: Subsidised loans

Loans for RE projects and REU actions are generally granted by commercial banks at interest rates over 1% higher compared to those granted to other sectors. This is mainly due to a wrong perception of the associated risks to these "new" technologies that classical finance is hardly familiar with. For this reason, many countries grant a subsidy to bring interest rates lower than those of the market. The funding of this subsidy may originate from multiple sources: a new budget line, funding by the regions and/or local government, "revolving" funds supplied by earnings accruing from savings on the operation costs of installed equipments, "overcharge" funds supplied by taxes on other products (oil products, for instance), "system benefit" funds supplied by the co-benefits generated (reduction of installed capacity, non extension of the network,…), or by "penalty funds" supplied by most polluting activities. The related loans not only help mobilise more capital than a mere State subsidy, but also gradually lead the classical banking sector to develop a RE and REU projects portfolio. Ultimately, it is important that the banking sector should realise that RE and REU projects are reliable and viable, the idea being to succeed in creating an autonomous market mobilising private funds without State intervention or allowing the latter to focus on other assistance mechanisms.

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[41] See Chapter 2 Part 1.

[42] Some examples of national incentive programs : 1991 in Germany, 60% of installation costs in the « 1000 Solar Roofs » programme ; Japan 1994, 5 UDS/Wp in the Japan's Sunshine Program ; USA, in certain states, up to 50% in the "million solar roof", and 70% in the state of New York .

Guarantee funds: Mitigating project risk

The State may directly intervene in the guarantee of risk taking. In Morocco, the Central Guarantee Fund (Caisse Centrale de Garantie - CCG) has set up the FOGAME (Guarantee Fund for the Upgrading of Enterprises). It secures credits, which thus may be more easily granted by banks, dedicated to enhance the efficiency of the SMIs/SMEs production processes.[43] This type of initiative can perfectly be envisaged in the other SEMCs and benefit from the expertise available in the National Agencies in charge of RE and REU issues. This scheme presents the advantage of not imposing a too significant financial burden on State budget.

Public Private Partnership (PPP) and specialised services companies: A better risk-sharing

A specificity of investments in the field of REU is that it is still difficult to persuade the classical banking sector to take into account, in the projects financing schemes, the benefits expected on the energy savings to be obtained. It is in order to bypass this barrier that specific partnerships with the State, of the Public Private Partnership (PPP) type, and that Energy Services Companies (SSE, or ESCOs), have developed.

Within a risk and benefit sharing perspective, PPPs allow a division of responsibility between private operators and public authorities, while benefiting from a State guarantee. They also present the major advantage of mobilising significant capital without being a burden on public budgets. These financing schemes, already developed in Egypt and Turkey for the construction of power plants, for instance, apply rather to large investments and could, thus, be envisaged for the financing of wind power farms, district heating or solar power stations.

Another possibility to mitigate project risk and better share the investment over time is to scale up the offer of Energy Services Companies (ESCOs). These companies make available to the customer an expertise specialised in RE and REU systems, help mitigate risk by sharing the capital invested, facilitate the engagement of initial investment and guarantee return on the project by ensuring optimal follow-up of the installed technologies. As for the companies, they earn incomes according to the energy performance of the solutions implemented and, hence, the energy savings made. A few ESCOs may be found in Israel, in Jordan, in Lebanon and in Tunisia, for instance.

4.3. National public financial means: Often too limited to support incentive measures

4.3.1. Context

In the economic context of the SEMCs, taxation levels are rather low with respect to public revenue. State revenue does not, generally, exceed 20% of GDP, even though oil products incomes increase this rate for producing countries. Indeed, the income tax level, both for individuals and companies, is fairly low. Moreover, individual wealth and private companies often do not pay tax either because of tax evasion or because they benefit from several investment codes de-taxing their profits. State budget balance is, therefore, vulnerable and often in deficit, and the SEMCs generally have relatively weak means of action.

Moreover, and in spite of this situation, it is worth pointing out that the subsidies granted to oil or gas exploration remain high and little questioned. This creates a strong competition between the various claims on public funds. In this context, resource allocation to the development of RE and

[43] This fund operates on the same principles as the French guarantee fund for investments in energy management (FOGIME (Fonds de Garantie des Investissements en Maîtrise de l'Energie) launched by ADEME in 2001.

REU is fairly often considered as non priority, and this, even while everybody agrees on its strategic importance.

In the absence of additional means, the challenge rests, therefore, in re-channelling part of the financial flows usually used to sustain fossil fuels to the funding of RE and energy demand management.

4.3.2. From national initiatives to international funding: Ensuring dedicated funds

On national level: RE and REU dedicated funds

The existence of such funds can help tailor the necessary budgets and ensure visibility on their use. In Algeria, for instance, the National Fund for Energy Efficiency (FNME) is dedicated to financing the actions and programmes listed in the energy efficiency programme. This fund is supplied, in particular, by State allocations, by tax on national energy consumption, by tax on high energy-consuming appliances or by the fines stipulated by the law on energy efficiency. Still in Algeria, the Finance Law 2002 stipulated a tax on the storage of dangerous wastes and atmospheric pollutants whose revenue would help implement tax incentives for, among others, the establishment of local enterprises and services companies for the promotion of REU in underprivileged zones or for developing investment in industries related to equipment and components in the REU field.

More generally, two types of taxes may be considered: on the one hand, fixed taxes that can be easily collected on polluting activities (incoming ships, car imports, tourist entries, etc) and, on the other hand, "polluter pays" type taxes, varying according to the level of pollution generated. The latter are more efficient, but also more difficult to implement as they require precise monitoring of each polluting activity.

Recourse to external funding

As it has already been mentioned, SEMCs national financial means dedicated to implement the expected policies are often too small to foster a real change of scale of the market. That is why the recourse to external funding is an important, if not often indispensable, alternative. This may be under the form of Official Development Assistance (ODA) or of Foreign Direct Investments (FDIs), the latter being likely to benefit from additional financing mechanisms, such as the Clean Development Mechanism (CDM).

North/South cooperation, and more particularly Euro-Mediterranean cooperation, is essential, as it helps to sustain projects that do not meet mere economic criteria and whose short or medium term profitability would have been insufficient to "entice" classical financial channels. Finally, climate change issue is receiving fresh attention and the energy efficiency question is often at the heart of the concerns of international donors.

4.4. International cooperation: An indispensable source of funding for RE and REU

The funds made available by international donors may be of various types: they are ranging from grants, through financial support mechanisms, to concessional loans.[44] The donors involved in the region are numerous an it is not possible, within the scope of this study, to describe all their actions

[44] A concessional loan is a loan where interest rates lie below the market rate constituting a « gift » which on the duration of the contract can ammount to 25% of the nominal value of the loan.

in detail.[45] As an example, the Global Environment Facility (GEF) is particularly active in the SEMCs: REU financing in the Algerian industrial sector, REU financing in all sectors and in concentration-based solar power in Egypt, solar photovoltaic power in Morocco, or solar thermal in Tunisia. Besides, almost in all SEMCs, GEF co-finances national programmes for enhancing the energy performance of buildings with the objective of furthering the establishment of thermal regulations in this sector.

Beyond the various donors, the Euro-Mediterranean Partnership—which, in the framework of the Barcelona Process, seeks to make of the Mediterranean Basin a privileged European Union cooperation zone—remains one of the most promising cooperation frameworks for the region. In the field of energy, the investments generated are often more related to the liberalisation of traditional markets than to a real reflection on RE and REU alternatives. The share of RE and REU projects in the MEDA programme, which had remained until the past few years the financial instrument of Euro-Mediterranean cooperation,[46] is however significant since it accounts for about 35% of the total support extended to the energy sector, which is much higher than the 10% support, on average, extended to these issues under the ODA. Besides, the Facility for Euro-Mediterranean Investment and Partnership (FEMIP) was created in October 2002, as a EIB initiative, to provide technical assistance, risk capital and interest subsidy to projects aimed at environment protection and private sector development. Lastly, the Mediterranean Renewable Energies Programme (MEDREP), initiated by the Italian Ministry of the Environment, ambitions to increase the access to RE and REU, in particular for rural populations.

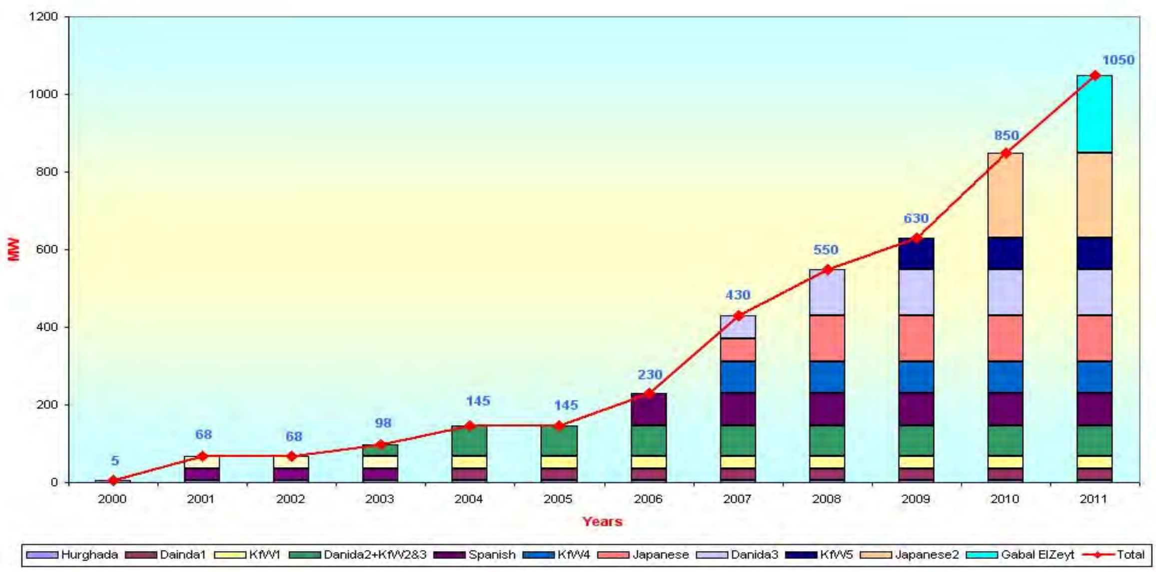
International cooperation may be mobilised for two major purposes. It can participate in financing the establishment of dedicated institutional frameworks, national institutional capacity building, or conducting preliminary studies; it is under these forms that it can obtain the most powerful lever effect. The example of the project currently conducted in Morocco by GEF and the EIB, with GTZ assistance (Gesellschaft für Technische Zusammenarbeit/ German Technical Cooperation Agency) fully belongs in this logic. International cooperation can also operate through the form of investments in projects implementation. Thus, the various stages of the wind energy farm of Zafarana in Egypt, for example, benefited from a variety of funds (loans and/or grants) by the German development bank (Kreditanstalt für Wiederaufbau (KfW)), the Danish International Development Agency (DANIDA) and the Spanish cooperation. In this country, several donors envision to invest in wind energy (Graph 16).

Eventually, another significant aspect of international cooperation is the dissemination and exchange of best practices which help replicate the result of the projects implemented in various countries and extend their outcome on a regional scale.

45 For more information, see national studies carried out for Plan Bleu in 2007 at : http://www.planbleu.org/themes/atelier_energie_monaco.html and the regional study : « Énergies Renouvelables, Utilisation Rationnelle de l'Énergie et Aide au Développement en Méditerranée », Plan Bleu, 2007.

46 The cooperation between the European Union and the SEMCS is now under the umbrella of the European Neighbourhood Policy. This new framework cooperation includes former MEDA programs for the SEMC and TACIS for east European countries.

Graph 12 – Installed wind power plants capacity present and planned until 2010 distributed according to cooperating countries in Egypt



Source : R.Y Georgy, A. Soliman, national study carried out for Plan Bleu, 2007.

4.5. International private funding: A relatively low attractiveness of the SEMCs

Foreign Direct Investments (FDIs) present the advantage of helping implement RE and REU projects without impacting the levels of public debt. They also contribute to job creation, technology transfer, training of human resources, promotion of new sectors, etc. However, FDIs are also likely to disrupt the country's trade balance, all the more as the equipment is most often imported and that the profits are, for the major part, repatriated. On the whole, the SEMCs are rather poorly evaluated in terms of perceived risks, and their attractiveness is relatively low. According to OECD rating for 2006—with rank 7 standing as maximum risk—, Lebanon and Syria are rated 7, Libya 6, Egypt 4, the other countries are rated 3, while the Palestinian Territories are assigned no rate. For instance, in 2003 and according to OME, the risk related over-cost could represent 17% of the total investment in Egypt.

However, FDIs in the conventional energy sector are rapidly increasing, with 83 projects inventoried in 2005, as against 39 in 2004 and 9 in 2003. These projects are mainly related to heavy infrastructures in the field of gas and oil (refineries, gas pipelines) or concessions acquisition. The only registered project concerning RE is the construction of a wind farm by the Lafarge group for its Tétouan factory (an already profitable project which, in addition, has benefited from the Clean Development Mechanism - CDM).

4.6. Mobilizing the flexibility mechanisms of the Kyoto Protocol: Still few projects under the Clean Development Mechanism (CDM)

The Clean Development Mechanism (CDM) is a financial incentive tool which can be used jointly with DFIs and which is particularly suitable for RE and REU projects. However, it must be pointed out that there are still few CDM projects in the region. All the SEMCs are non Annex B countries, and the majority have ratified the Kyoto Protocol,[47] which makes them eligible for proposing CDM projects in the fields relevant here. Yet, in early March 2008, out of over 3 150 validated CDM projects or projects in process of validation, only 44 were related to the SEMCs, while the major beneficiaries (China and India) claimed, alone, some 1 943 projects. Among the projects (validated or submitted) concerning the SEMCs, there were wind farms in Egypt, Morocco and Israel, the decentralized component of PERG in Morocco, energy efficiency measures in industry in Morocco and in Israel or biogas energy production projects also in Israel.[48]

Some impediments to the use of the CDM have been identified:[49] the CDM is not integrated to national policies, expertise in setting up carbon finance projects is lacking in the SEMCs, institutional coordination is insufficient (Designated National Authority (DNA), Department of the Environment and private sector are compartmentalised), there is little involvement of national banks and the private sector.

By their very nature, RE and REU projects are less attractive than others, such as carbon capture and industrial gases reduction for example, as they often are of small size, which implies higher transaction costs for lower benefits in terms of carbon credit. Finally, and this remains true in a good number of REU projects, identifying the baseline situation is delicate, which adds complexity to evaluating the emissions avoided. Uncertainty as to the price of a ton of carbon is an additional barrier for investors potentially attracted by this financial mechanism.

The success of the CDM in the SEMCs will depend on their capacity to attract projects and, in particular, to take advantage of their closeness and their special ties with the European Union. In Tunisia, a "task force" was set up in order to identify CDM projects likely to have an impact on the energy balance, to sustain priority projects and, more generally, to position Tunisia on the CDM world market. In Morocco, a list of some fourty projects likely to be eligible for the CDM (related, inter alia, to decentralised electrification, solar pre-heating, wind farms, equipment of cities or quarters with low consumption lamps) was established to mobilise funds more easilty. Besides, bilateral Spain/Morocco memoranda were signed within a win-win perspective: Morocco committed itself to facilitating the participation of Spanish operators in the implementation of the CDM; on its part, Spain committed itself to contributing in a rapid implementation of CDM projects in Morocco by supporting the participation of Spanish economic operators and extending aid and technical assistance to project bearers.

More generally, the Mediterranean region has to make profitable use of a major asset: it groups both Annex B and non Annex B countries around a mutual interest zone. In this regard, a Mediterranean carbon fund could be set up with the purpose of grouping all CDM eligible initiatives. Such a fund would also help organise the demand and offer of carbon emissions credits. Another major asset of this fund would be to serve as a single reference framework for CDM in the region, which would ensure procedures simplification and a better visibility of funding opportunities.

47UNFCC web site (http://unfccc.int) provides information about Kyoto Protocol and countries together with Designated National Authorities.
48 Source UNEP-RISØ (data available at : www. Cd4cdm.org)
49 Those information are results of the workshop organized by Plan Bleu in 2006 : « CDM and Southern Mediterranean Countries, The Clean Development Mechanism in the Southern Mediterranean countries, advantages and weakness, challenges and opportunities – linkages with energy efficiency project and renewable energy", full report available at www.planbleu.org. .

In the Northern Mediterranean Countries (NMCs), investors and private banks having created investment funds in the fields of RE and REU are now numerous. However, while this capital is available, it is essential to bear in mind that investors systematically consider available incentive measures (such as feed-in tariffs) in their project and business plan analyses. The attractiveness of the countries for foreign investors (as for national investors) thus depends also directly on the legal and incentive framework.

III. RE AND REU: MANY ADVANTAGES, PARTICULARLY IN THE FIELD OF EMPLOYMENT

1. OBVIOUS STRATEGIC, ENVIRONMENTAL AND FINANCIAL BENEFITS

RE and REU contribute to diversify the energy mix, reduce energy dependence, improve security of supply (fossil fuels non producing countries) or secure exportation benefits for the future (exporting countries), gain better control over costs of energy services, optimise power load curve, reduce peaks of power demand on the grid. From a financial point of view, the most obvious benefits are generated by a reduction of the energy bill.50 The benefits on local air pollutions and, hence, on human health are also significant. Lastly, with respect to climate change, in many cases the actions of CO2 emissions reduction thanks to RE and REU are also actions of adaptation to climate change allowing a reduction of the vulnerability of the energy system vis-à-vis its impacts (Table 5).

Table 5 - Examples of synergy between adaptation measures and mitigation one in the energy sector of the Mediterranean

	Bénéfice de réduction d'émissions de CO_2	Bénéfice d'adaptation	Co-bénéfices
Utilisation rationnelle de l'énergie / gestion de la demande			
Efficacité énergétique en général	Réduction de l'utilisation d'énergie	Meilleure fiabilité du réseau	Limitation des coûts liés à l'interruption d'activités économiques
Ventilation naturelle des bâtiments, isolation, fenêtres efficaces	Réduction de l'énergie utilisée pour chauffer et/ou refroidir les bâtiments (climatisation).	Meilleures capacité des bâtiments lors de canicules ou d'évènements extrêmes	Dépenses de santé diminuées, mortalité diminuée, confort amélioré, productivité maintenue dans les bâtiments à usage professionnel
Production d'énergie/offre			
Energies renouvelables individuelles non connecté réseau (ex. : solaire PV, thermique)	Réduction de l'utilisation d'énergie en provenance du réseau ; et production d'énergie sans émission de CO_2.	Réseau moins sollicité ; économie des moyens de production, réseau globalement moins vulnérable car décentralisé et diversifié.	Diversification des risques de dégradation des infrastructures ; diminution des coupures d'électricité ; confort individuel
Biomasse/bois de feu	La gestion des forêts permet un stockage de CO_2	Gestion des bassins versant (forêt utilisée comme réservoir d'eau)	Réduction des inondations, glissement de terrain ; Bénéfice sur les dépenses de santé et mortalité
Barrages hydroélectriques	Energie sans émission de CO_2	Gestion des crues et des inondations ; réserve d'eau pour les périodes de sécheresse	Limitation des pertes matérielles et humaines en cas d'événement pluvieux extrême

Source : Plan Bleu, inspired from Evan Mills, Synergisms between climate change mitigation and adaptation : an insurance perspective, Berkeley, 2006

2. AN OPPORTUNITY TO SUBSTITUTE EMPLOYMENT FOR FOSSIL FUELS IMPORTS

RE and REU may contribute in generating economic growth allowing job creation, which are the two priorities on the political agendas of the SEMCs. According to FEMISE estimates, the SEMCs as a whole will have to create more than 22 million new jobs by 2020 just to prevent a deterioration of the current situation (unemployment in the SEMCs—particularly that of youth—is, at present, among the highest in the world). Studies of RE and REU impact on the labour market concur that

[50] Example of similar benefits are provided in other parts of the report : see for example Chapter 2 and 4 of Part II.

the adoption of a scenario based on energy efficiency is synonymous with job creation: more jobs are necessary to produce/save the same quantity of energy by using RE and REU sectors as by using conventional sectors.[51]

On the Northern rim, the countries massively engaged in RE sectors already report significant job creations. Thus, 35 000 jobs were created in the wind sector in Spain.52 The activities aimed at increasing energy efficiency are also employment generating (perhaps more strongly still). It is estimated that, in Germany, 2 000 jobs could be created as per one Mtoe saved.53 In the USA, RE and REU industries created in 2006 over 8 450 000 jobs, of which 450 000 in the RE sector and 8 000 000 in the REU sector.[54]

In the SEMCs, the following examples show that the development of RE and REU, though at modest levels, also allow the creation of jobs and of value added generating industries and/or energy services:

- In Morocco, the decentralised rural electrification programme generated 140 jobs (either direct or sub-contracted) particularly thanks to the company TEMASOL which, on behalf of the National Electricity Utility (ONE), sells domestic energy services based on photovoltaic kits and ensures maintenance as well as batteries replacement over a 10-year period.
- In Tunisia, there were, in 2006, 14 solar water heater suppliers (including two manufacturers and two assemblers) and 384 installers. About 700 additional direct jobs are expected by 2011.
- In Egypt, the development of solar water heaters allowed the creation of 9 industrial enterprises. The 230 MW of wind mills installed are maintained by Egyptian teams. Besides, approximately 25% of the wind energy equipment is manufactured in Egypt and it is envisioned that this rate would reach 50% in 2007.
- In Israel, there is a significant industrial and R&D growth in geothermal and centralised solar thermal. Paradoxically, the development of certain sectors was based on incentives or contracts outside of Israel.[55] The company SOLEL is, for instance, a world leader in the field of solar thermal technologies for centralized electricity production. SOLEL, with the rise in the price of hydrocarbons and the increasing demand on alternative energy sources has risen from the status of a SME in R&D with a turnover of 5 million USD to that of an international player with an estimated turnover of more than 100 million in 2007.

[51] Putting Renewables to Work: How Many Jobs can the Clean Energy Industry Generate, Renewable and Appropriate Energy Laboratories, April 2004.

[52] Economics of Wind Energy, European Wind Energy Association. Some other european countries observe numerous employment in the some sectors: : 20000 jobs in the wind industry in Denmark (country where 20% of the national electricity demand is coming from wind energy) (Denmark Wind Energy Hub, Danish Wind Energy Association, 2004). In Germany, in 2004 : 64 000 jobs in the wind energy sector, , 57 000 in bioenergy and 36 000 in solar system industry, small hydropower and geothermic (source : Renewable Energy: Employment Effects, Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU).

[53] Not taken into account lost employment due to the diminution of the energy consumption. Source : Green Book on Energy Efficiency, European Commission, , 2005.

[54] Economic and Jobs Impacts of the Renewable Energy and Energy Efficiency Industries: U.S. and Ohio, Roger H. Bezdek of Management Information Services Inc. for American Solar Energy Society, July 2007

[55] The situation seems to evolve in 2007 with the creation of stronger incentives at national level , cf Amit MOR, Israel National Study, Plan Bleu, 2007. An other national study for Israël (Analysis by Dov Ravaiv of RMST) estimates that in the following 40 years , the Concentration Solar Photovoltaïc sector could create in the country 33 700 jobs, additionally to the 20 000 new employment allowed thanks to activities for exportations.

IV. SUMMARY AND CONCLUSIONS

In order to meet their energy needs, the Southern and Eastern Mediterranean Countries (SEMCs) use approximately 95% of fossil fuels. If the trend observed over the past 30 years were to continue, energy consumption would increase by 65% between 2000 and 2025 and would be met at 97% by fossil fuels in 2025. Such a scenario is not free from consequences, among which: increased dependence and energy insecurity, high energy bill (importing countries), loss of export incomes (exporting countries), vulnerability of the production and distribution system, high local air pollution and increasing contribution to climate change.

However, such a scenario is not inevitable. The alternative scenario developed by Plan Bleu in 2005 shows that by focusing on the high potential of a more rational energy use and on the development of renewable energies by 2025, average savings in the range of 20 to 25% of the total SEMCs needs is possible and that, in this case, the share of renewable energies is likely to account for 14% of the primary energy balance (exclusive of biomass), instead of 4% for the baseline scenario. Besides the advantages in economic and energy security terms, this scenario would allow a 25% reduction of CO_2 emissions for the region as a whole.

Where do the SEMCs stand today with regard to energy efficiency and the implementation of incentive policies allowing progress towards this type of scenario? This question is addressed in this chapter in view of the orientations/ actions and the objectives/ indicators put forward in the Mediterranean Strategy for Sustainable Development (MSSD) adopted in 2005 by the whole Mediterranean riparian countries.[56]

Apart from a few exceptions, recent developments in the SEMCs show that concrete RE implementations have a scope comparable to that of pilot projects and that they are financed, for the major part, by national government funds or by international funds (development aid). Besides, the REU potential utilisation seems to be "neglected" compared to the development of RE. In this context, the MSSD objectives for the year 2015, of (i) 7% of RE in the energy mix, (ii) between 1 to 2% per year improvement of EE, and of (iii) control over CO_2 emissions will not be reached if the trends observed persist.

Yet, in view of the many projects implemented and the experiences of a few countries (Tunisia, Morocco), it is proven that RE and REU are reliable and advantageous options for the SEMCs. Today, the challenge remains of a large-scale generalisation of these experiences and the creation of a Mediterranean RE and REU market.

To direct the SEMCs towards a scenario of this type, it emerges from the analyses by country that:

- The establishment of a stable and credible institutional framework favourable to the development of RE and REU is indispensable,
- Rational energy use must become a priority,
- Structuring R&D, the different sectors and the training in the fields of RE and REU is essential.

The three preceding points are prerequisites for a proper operation of the economic and financial incentives necessary to the creation of a bankable, large scale RE and REU Mediterranean market.

[56] Non binding framework strategy dedicated to help countries to update/define national strategy.

1. THE INSTITUTIONAL FRAMEWORKS DEDICATED TO RE AND REU ARE STILL INCOMPLETE, LITTLE VISIBLE AND, SOMETIMES, INSTABLE

Almost all the countries have institutions in charge of the promotion of renewable energies and/or energy efficiency (ANME, APRUE, CDER, PEC, OEP…) and have adopted framework strategies or objectives for the development of renewable energies. However, even though progress has recently been made (2006-2008), the legal framework is not yet finalised or is still incomplete in most SEMCs. Nevertheless, the Tunisian experience (and, to a lesser extent, the Moroccan one) shows that the establishment of a comprehensive institutional framework is indispensable to obtain significant results (large-scale development of RE and REU).

Past experience in the Mediterranean shows that time-located efforts over two or three years do not allow organising a sector sufficiently enough to ensure its "takeoff". Inscription in time of the current measures is particularly important today because certain sectors are, in several countries, at a critical stage of a change of scale (REU in buildings in Morocco, solar thermal in Tunisia, wind power in Egypt, etc).

Two of the major barriers which the institutional and legal framework can help overtake in the SEMCs are:

- The issue of the financial and administrative modalities of connection to the power distribution grid is still a major impediment even though legislations exist in certain countries;
- The lack of institutional coordination or absence of an institution in charge of energy efficiency is not conducive to a full utilisation of the energy efficiency potential.

2. THE ISSUE OF ENERGY EFFICIENCY IS NEGLECTED

The issue of energy efficiency is neglected in the policies of most of the SEMCs. Yet, consumption per capita of these countries is constantly on the increase, and it appears clearly that the best cost-effectiveness to reduce CO_2 emissions and gain control over increasing consumption lies in this field.

Within this perspective, the building/ residential/ tertiary emerges as a key sector, as it already accounts for about 40% of energy consumption in the SEMCs and, in view of the expected demographic growth and urban development, it is likely that it would induce significant increases in CO_2 emissions in the coming years. The legislation on the building sector is gaining momentum in countries that have gathered full awareness of this challenge, such as Morocco. Significant room for progress also exists in the efficiency of the power production and distribution sector.

3. INSUFFICIENT R&D, INFORMATION AND TRAINING NEGATIVELY AFFECTS RE AND REU FIELDS DEVELOPMENT AND THE EFFICIENCY OF INCENTIVE MEASURES

Often neglected since it is considered as non profitable in the short term, research remains fundamental in sectors such as RE and REU which are still in process of full technological development. For the SEMCs, the importance of applied research lies in the adaptation to national contexts of existing technologies, as well as in the definition of national standards and specifications.

Besides, the issue of quality of the whole range of stakeholders concerned by the RE and the REU chain is crucial because it makes the reputation of the fields and the equipment and, if it is good, this reduces the psychological cost of purchase or investment in equipment or related to actions that are still "unusual" in the Mediterranean. Moreover, energy efficiency is employment generating but the sustainability and quality of the latter is dependent on the existence of training networks. Thus, the success stories of Morocco and of Tunisia rest partly on the establishment of dedicated training.

In addition, lack of information of the investors (enterprises) and citizens in the SEMCs prevents full visibility of the energy saving potential and, hence, their mainstreaming in economic decisions.

The audit pilot experiments conducted by the RAC/CP in several SMEs/SMIs of the SEMCs give the impression that enterprises are not up to taking the most rational economic decisions with respect to energy consumption because of a lack of information. This is why, profitable actions are not implemented. The national experiences in matter of audit reveal incredible saving potentials; for instance, in Morocco, a CDER programme allowed a reduction of fuel-wood consumption in hammams (Turkish baths) by 50%! Lastly, only a few countries are starting to promote and sustain audits or to develop ESCOs.

Public information is also a key factor in decisions of purchase of individual renewable energy equipment or energy saving appliances. The promotion and use of energy labels can usefully contribute in this awareness process even though, generally, a regular national communication must be encouraged on climate and energy related issues.

4. INSUFFICIENT MEANS AND ECONOMIC INCENTIVES TO REACH SIGNIFICANT RESULTS

Besides incomplete information, the issue of access to funding for RE and REU actions is the main barrier to energy efficiency in the SEMCs. RE and REU fields development is hampered by the same barriers as the whole economic sectors (difficulties of access to credit, insufficient intermediary financing, etc…). Moreover, RE and REU have an initial over-cost (even though return on investments is often increasingly more rapid) and also experience disadvantages with respect to classical energy sectors.

The first disadvantage arises from the subsidies to fossil fuels which results into a fairly lower end user price, discouraging energy efficiency efforts (particularly in fossil fuel producing countries). It has clearly been noted that the solar thermal sectors in Israel or in the Palestinian Territories have developed spontaneously owing to high prices of electricity in the residential sector. Yet, the aspect of pricing must take into account social considerations in order not to disadvantage either the underprivileged social groups or the economic activity. A planning over time of a pricing reform, alongside with RE and REU actions, is put forward by several countries (Tunisia, Morocco…). [57]

In this context, several countries have set up economic and financial incentives for RE and REU to take up part of the initial over-cost (and partly compensate the subsidies to other energies). For example, a feed in tariff system (which has been proven in Europe) exists in Algeria, Egypt and Israel or, again, a guarantee or development fund system has been established in certain countries. However, the results of these measures are dependent/ scaled down owing to deficiencies of legislative frameworks (particularly in terms of access to the grid, cf infra) and the small financial State funds to supply them.

5. ODA EXPERIENCE IS PROMISING BUT FDIS ARE LITTLE ATTRACTED

Public international funds, via ODA, have so far contributed for the major part to RE and REU projects in the SEMCs. Recent experiences of ODA funds involvement in the PROSOL (Tunisia) and PROMASOL (Morocco) projects—financed partly by national public funds and private funds by commercial banks—seem to be quite promising as a lever.

Private international investments (direct foreign investments - IFDs) in RE and REU, in spite of the incentives created by the flexibility mechanisms of the Kyoto Protocol (in particular the CDM for which all the SEMCs are potentially eligible), are very little represented in the SEMCs. Besides the lack of attractiveness of the region as a whole, a significant impediment identified for RE and REU lies in the lack of attractive projects. And yet, CDM funds are available today in several NMCs (Spain, Italy…) and ready to be invested in priority in the SEMCs for RE and REU.

The national funds raising , generated by the policies of the countries, thus appear to be determining for the development of RE and REU, themselves being likely, if accompanied by industrial and services development, to generate employment and contribute in the creation of economic growth, as attested, for instance, by the Tunisian experience.

[57] A study on this topic is under preparation by the World Bank for the MENA region.

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CHAPTER 7

How much does cost the change of scenario toward a low carbon energy sector?

A. Tunisia

B. Egypt

CHAPTER 7A *How much does cost the change of scenario toward a low carbon energy sector?*

Rafik Missaouï
ALCO, Tunisie

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The period 1990-2004 was marked by laying the institutional, legal and incentive foundations for an environment that is conducive to the emergence of energy efficiency actions.

The increase in oil prices on the international market and the deterioration of the country's energy bill, as from 2005, have triggered a change of scale in Tunisia's energy efficiency policy. Thus, the period 2005-2007, has reported, on the one hand, the design of an ambitious investment programme in matter of energy efficiency and, on the other hand, the set up of new institutional and legal instruments conducive to the development of energy efficiency and the promotion of renewable and alternative energies.

Over this period, investments in energy efficiency can be estimated as 250 million Tunisian dinars (TND), that is the equivalent of about 140 M€, with a State participation estimated as 25 MTND (or 14 Million euros). The contribution of such investments is significant:

- a fall in energy intensity by about 2.8% per year;
- a penetration of renewable energies (exclusive of biomass) in primary energy consumption, passing from 0.5% in 2005 to 1% in 2007;
- a aggregate energy saving of about 800 ktoe over the period, that is about 3 Mtoe for the entire lifetime of the actions undertaken;
- avoided GHG emissions estimated as 2.4 MTECO2 over the period, that is about 10 MTE CO2 for the entire lifetime of the actions undertaken;
- energy products subsidies avoided by the State of about 463 MTND (260 M€), that is 18 times the amount of the subsidy granted for supporting energy efficiency.

The cost of the saved toe may be estimated as 90 TND/toe (50 €/toe), of which a State contribution in terms of subsidies granted by FNME (National Energy Efficiency Fund) estimated as 9 TND/toe (5 €/toe). Accordingly, the cost of the GHG emissions avoided would be about 20 €/TE CO2.

The Tunisian government has adopted in its new four years energy efficiency programme the objective to cut down energy intensity by 3% per year between 2008 and 2011 and put up at 4% the share of renewable energies (solar, wind, biogas) in the primary energy consumption (biomass not included), with a capital expenditure (investment cost) estimated as 1100 MTND (611 M€), of which 140 MDT (78 M€) provided by the FNME. Thus, the total amount of investment in energy efficiency over the period 2008-2011 accounts for about 13% of the investments earmarked for the energy sector over the same period.

The main results expected from this programme are as follows:

- energy saving of about 3.2 Mtoe over the period 2008-2011, that is about 15 Mtoe over the entire lifetime of the actions;
- GHG emissions avoided of about 9 MTECO2 over the period 2008-2011, that is about 45 MTECO2 over the lifetime of the actions recommended;
- Reducing the share of energy expenditure in GDP to about 18%, instead of 20% in the case of the underlying (trend-based) scenario.

The cost of the saved toe is about 73 TND, that is 40 €/toe, with a State contribution of about 5 €/toe. Consequently, the cost of a ton of CO2 avoided may be estimated as 24 TND/TECO2, that is about 14 €/TECO2.

The cost of the saved toe is to be compared with Tunisia's natural gas supply cost, which is currently over 400 TND/toe (222 €/toe).

Over the period 2012-2016, Tunisia is set to pursue its sustained energy efficiency policy, with the objective of ensuring an improvement of energy intensity by 3% per year in order to reach the European level. This should help reduce primary energy consumption by 23% for the time frame 2016, that is by about 3 Mtoe.

Finally, owing to its capacity to reduce GHG emissions, energy efficiency can largely benefit from funding under the Clean Development Mechanism (CDM). Indeed, as at early 2008, the Designated National Authority (DNA) had already approved some twenty projects in the energy sector, likely to generate earnings from the sale of units of Certified Emissions Reductions (CERs) of about 200 M€ over the crediting period.

INTRODUCTION

Context and objective of the study

Tunisia's energy efficiency policy was initiated in the mid-1980s, with the creation of the Energy Efficiency Agency (AME). Afterwards, the public authorities set up gradually a dedicated legal, institutional and incentive framework to promote energy efficiency and renewable energy actions. This political will was further urged by the gradual shift experienced by Tunisia from a net oil exporter to a net importer.

However, it was not until 2005, with the soaring international energy prices, that Tunisia incepted a change in scale in matter of energy efficiency, translating into a boost of investments in this field. The past actions have had significant impacts in terms of energy efficiency and the results expected in the near future are quite promising.

The present chapter purports to analyse the action cost of a energy policy allowing Tunisia to take control over its GHG emissions due to the energy sector. In other words, the purpose is to evaluate the cost of a sustainable energy policy contributing in the mitigation of climate change. Accordingly, this study would help share, with other countries of the region, an existing action plan, organised in terms of time and quantified in terms of cost. It should also help share Tunisia's considerations in matter of economic cost-effectiveness that had led to the options outlined in the adopted strategies.

methodological approach

The present chapter has been prepared based on an analysis of the documentation and data available in Tunisia. The latter have been collected at various national bodies, of which in particular:

- The National Agency for Energy Efficiency (ANME);
- The Directorate General for Energy (DGE);
- The Tunisian Electricity and Gas Utility (STEG);
- The Ministry of Finance;
- The Ministry of Economic Development and International Cooperation (MDECI).

Among the major documents analysed, it is worth mentioning, in particular, those related to the preparation of the XIth National Economic and Social Development Plan and the four-year programme (2008-2011).

Contents of the chapter

The present chapter comprises five main parts as follows:

- Overview of Tunisia's energy efficiency policy;
- Review of the energy efficiency actions conducted between 1990 and 2007;
- Evaluation of the cost of the action programme scheduled by Tunisia for the period 2008-2011;
- Outline of a plausible scenario for energy efficiency over the period 2012-2016;
- Presentation of "energy & climate change" linkages in the Tunisian context.

I. POLICY OF ENERGY EFFICIENCY IN TUNISIA

1. Overview and energy context

1.1. Energy resources

Tunisian energy resources comprise mainly fossil energies, with the production of hydrocarbons (oil and natural gas), and the rights on the natural gas generated by the operation of the Trans-Mediterranean (Algeria – Tunisia – Italy) gas pipeline.

Since 1990 (except for 2007), the level of energy resources has stabilised in the range of 5.5 and 6.5 Mtoe per year.

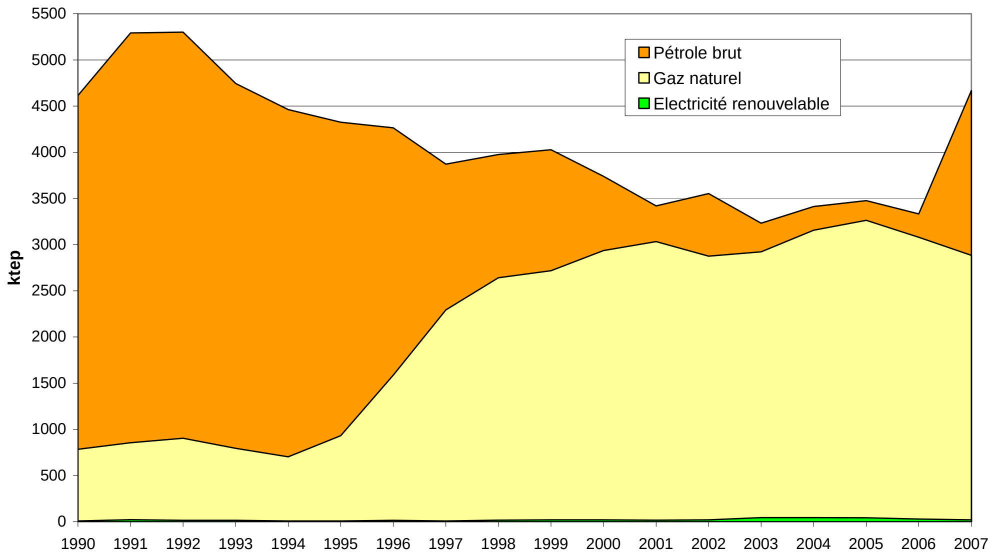
Oil resources are fairly modest, with the oil production reporting a significant fall from 4.6 Mtoe in 1990 to 3.3 Mtoe in 2006. In the wake of the upsurge in oil prices, the mining of marginal oilfields helped the oil production to report an appreciable increase, thus posting 4.7 Mtoe in 2007.

With the coming on stream of the Miskar gas field and the doubling up of the gas rights due to the Algerian – Italian gas pipeline, the gas resources tripled, passing from 900 ktoe in 1995 to about 3 Mtoe in 2007.

As regards renewable energies, the resources generated by hydropower, solar thermal and wind energy are negligible. The current resources comprise:

- Hydropower production, with a capacity installed of 61 MW;
- Solar water heating, with about 250000 m² of captors installed (as at end 2007);
- Wind power production, with a capacity installed of 20 MW.

Figure 1 – Primary energy resources evolution

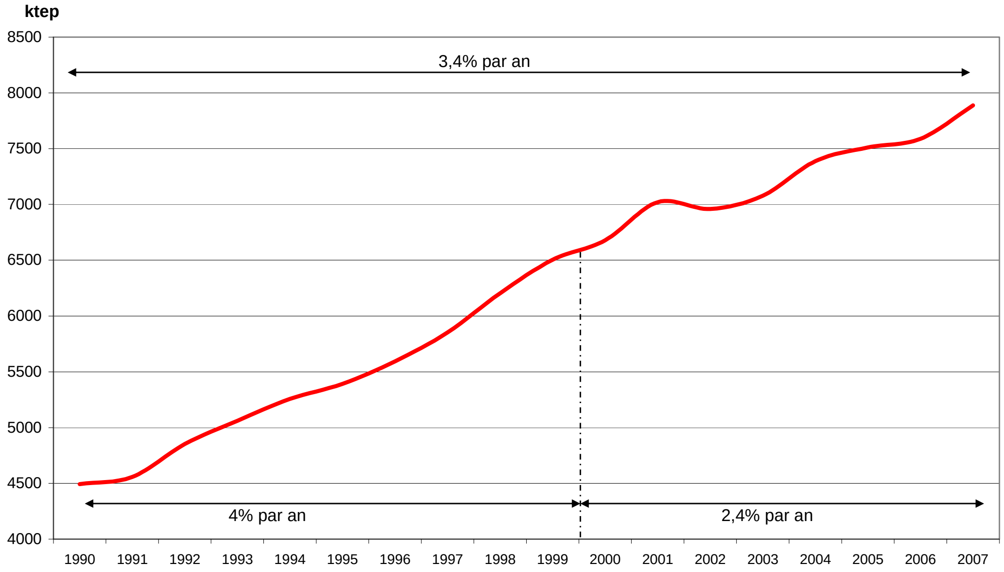


1.2. Primary energy demand

Primary energy consumption has increased by 75% over the period 1990-2007, passing from 4.4 Mtoe to 7.7 Mtoe. The average annual growth rate of consumption stood at 3.4% over the period, 4% between 1990-2000 and 2.4% over the period 2000-2007.

Thus, since 2000, the growth rate of primary energy demand has posted a significant drop, as shown by the following graph:

Figure 2 – Primary energy demand evolution



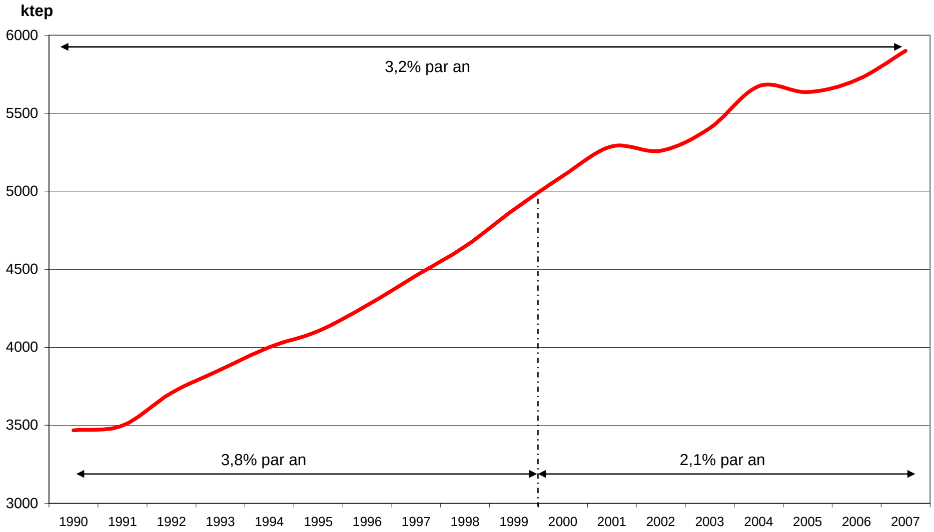
The evolution of primary energy consumption per product is marked by an increase in the share of natural gas and a decline in that of oil products. While the share of oil products stood at 71% in 1990, it dropped to 52% in 2007. Substitution has been made in favour of natural gas owing to the introduction of two combine cycle plants for power production (1996 and 2001).

1.3. Final energy demand

The consumption of final energy reported a 69% increase, passing from 3.5 Mtoe in 1990 to 5.9 Mtoe in 2007. The average annual growth rate amounted to 3.2% over the period, 3.8% during the period 1990-2000 and 2.1% during the period 2000-2007.

It is worth pointing out that the growth rate of final energy demand has reported a much more significant drop than that of primary energy demand, owing to improvements in the energy performance of the industrial sector.

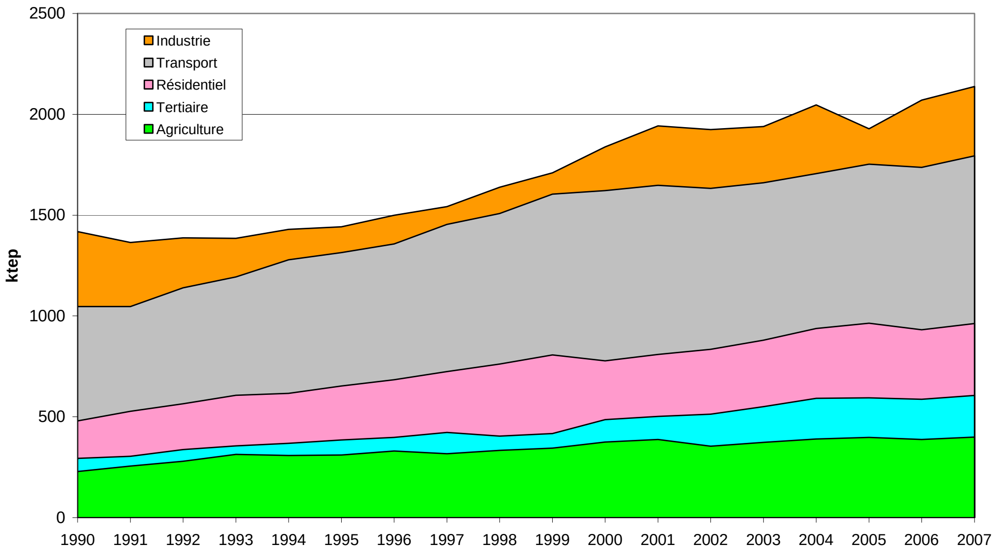
Figure 3 – Final consumption of energy trend



By sector, the breakdown of final energy consumption has not reported a significant change, given the fact that the breakdown indices have not been updated since the mid-1980s.

In 2007, industry accounted for 36% of the total consumption, transport 31%, the residential sector 9%, the tertiary 17% and agriculture 8%.

Figure 4 – Pattern of the final consumption by sector



Despite the gradual introduction of natural gas, final energy consumption remains dominated by oil products which currently account for about 70% of the total consumption, as against 14% for natural gas and 16% for electricity. In 1990, oil products accounted for 79% of the final consumption, while natural gas represented a mere 9% and electricity a mere 10%.

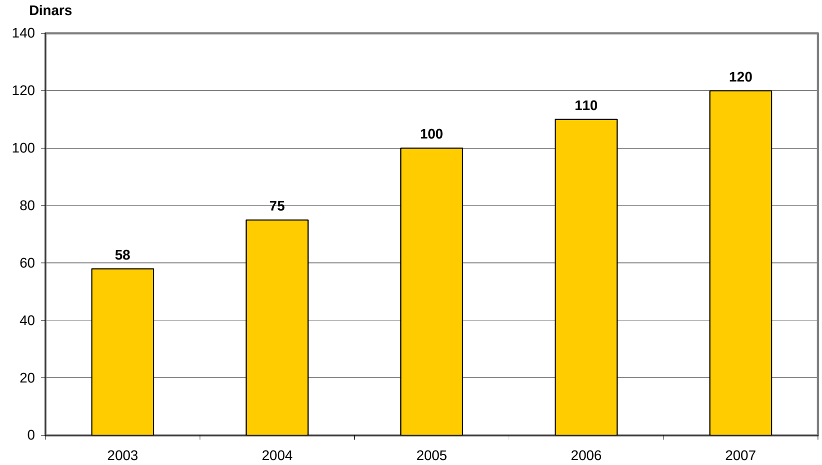
1.4. Economic impacts of the rise in international energy price

The Tunisian economy is vulnerable to energy price rises. This vulnerability is due, on the one hand, to an increase in energy expenditure and, on the other hand, to the pressure exerted on public finance, owing to the subsidization of conventional energy products. [1]

Energy expenditure

In 2007, energy expenditure amounted to 12% of GDP; in other words, to produce 1000 TND of GDP, Tunisia spent 120 TND on energy. Between, 2003 and 2007, the share of energy expenditure in GDP passed from 5.8% to 12%, as shown by the following graph:

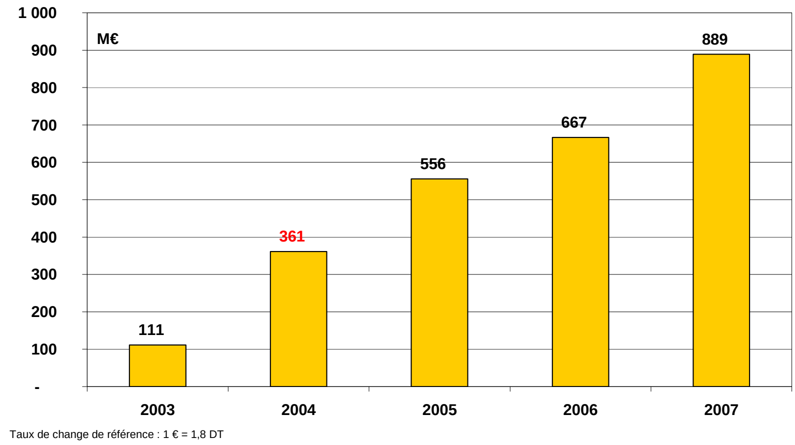
Figure 5 – Expenditure in energy to produce 1000 DT



Subsidies:

The prices of oil products and of natural gas are subsidized in Tunisia. The subsidies are reckoned based on the difference between prices on the domestic market and sale prices. The rise in oil prices has led the Tunisian Government to carry out adjustments of the domestic prices in order to narrow the gap with respect to sale prices. However, these increases have proved insufficient to reduce public expenditure on the subsidizing of energy products, as shown by the following graph:

Figure 6 – Public subsidies to energy products



Thus, in 2006, the share of energy subsidies may be estimated as about 4% of GDP at current prices.

1 Energy rates in Tunisia are administered by the State and are not pegged to the international price.

2. Public tools and instruments for the promotion of energy efficiency in tunisia

To promote energy efficiency, the Tunisian State has set up four types of tools: institutional, legal, financial and tax-related.

The institutional tool

The institutional tool for the promotion of energy efficiency in Tunisia is the National Agency for Energy Efficiency (ANME) created in 1986 per Order in Council of 14 September 1985, relating to energy saving. Its role is to implement the policy of the State in the matter. Its mission is, accordingly, the development of rational energy use and the promotion of renewable and alternative energies.

The legal tool

In Tunisia, the legal framework and of public incentive to investment in energy efficiency has been established since the mid-1980s. More recently, Law 2004-72, dated 2 August 2004, reaffirms this support: "Investments made in the field of energy efficiency shall be eligible for the advantages provided by the Investment Incentives Code". The mechanisms and methods of this support are specified by Decree 2004-2144, dated 2 September 2004, which sets the criteria for granting the dedicated allowance inherent in investments in the field of energy efficiency.

Loi n° 2004-72 du 2 août 2004

Art. 17. - L'agence nationale pour la maîtrise de l'énergie est chargée notamment des missions suivantes :

- gérer les actions d'audit énergétique obligatoire et périodique dans les secteurs de l'industrie, du transport et des services,
- instruire les projets consommateurs d'énergie assujettis à la consultation préalable obligatoire,
- proposer les incitations, les encouragements et les procédures susceptibles de développer le domaine de la maîtrise de l'énergie,
- octroyer des attestations pour les équipements, matériels et produits concourant à l'utilisation rationnelle de l'énergie ou relatifs aux énergies renouvelables et ce, en vue de bénéficier des avantages prévus par la législation et la réglementation en vigueur,
- inciter à l'exploitation des techniques et des technologies énergétiquement performantes,
- développer les projets de démonstrations dans le domaine de la maîtrise de l'énergie et en suivre la réalisation,
- promouvoir, en collaboration avec les organismes concernés, la formation dans le domaine de la maîtrise de l'énergie,
- préparer et exécuter les programmes nationaux de sensibilisation et d'éducation dans le domaine de la maîtrise de l'énergie,
- contribuer aux programmes de recherche scientifique dans le domaine de la maîtrise de l'énergie,
- étudier, programmer et évaluer les projets de maîtrise de l'énergie et effectuer les études portant sur l'atténuation des émissions de gaz à effet de serre liées à la consommation de l'énergie et plus généralement toutes études rentrant dans le cadre de ses attributions,
- élaborer un inventaire des émissions de gaz à effet de serre dues à la consommation de l'énergie et analyser les indicateurs de maîtrise de l'énergie.

These texts specify, on the one hand, the direct and indirect advantages granted to energy efficiency projects and actions and, on the other hand, the obligations to which energy operators and users are subjected. The main obligations are:

- mandatory periodical energy audit for entities whose annual energy consumption exceeds a certain threshold set by decree (1000 toe for industry and 500 toe for transport and the tertiary sector);
- mandatory preliminary energy audit for intensive energy consuming projects (plan based audit);
- obligation for STEG (Tunisian Electricity and Gas Utility) to purchase the surplus power produced by entities equipped with a co-generation installation;
- obligation of display of energy performance label on household electric appliances;
- prohibition of marketing household electric appliances whose energy performance is below certain thresholds set by decree;
- mandatory compliance by new buildings with the thermal (heat) specifications defined by the Buildings Code;

- obligation for municipalities to use high performance lighting for new street lighting networks;
- mandatory car engine check-up for annual technical car inspection.

Financial tool

Law 2005-82 constitutes a significant step forward in the choice of a extra budgetary resource to finance the official support to energy efficiency investment. Indeed, the said law established the National Energy Efficiency Fund (FNME) whose mission is to provide financial support for actions aimed at rational energy use, promotion of renewable energies and energy substitution. The National Agency for Energy Efficiency (ANME) is designated as FNME manager.

The National Energy Efficiency Fund (FNME) is supplied by levies generated by, on the one hand, a tax on first registration of private cars in a Tunisian series and, on the other hand, a tax due for importation or local production of air-conditioning equipment.

In terms of utilization, the FNME serves to provide the direct financial advantages granted within the framework of the law on energy efficiency and the texts related thereto:

	Rate	Maximum
Energy audit	50%	20.000 TND
Show-case project	50%	100.000 TND
Performance contract	20%	- 100 000 TND for entities with a consumption less than 4000 toe/year, - 200 000 TND for entities with a consumption between 4000 toe/year and 7000 toe/year - 250 000 TND for entities with a consumption above 7000 toe/year.
Connection to NG network in industry	20%	Industry: 400.000 TND
Connection to NG network in the residential sector	20%	- 140 TND per individual housing - 20 TND per flat in collective housing
Engine check-up stations	20%	6000 TND
Energy audit	20%	20.000 TND

Tax tool

The advantages granted by the FNME are complemented with tax advantages:

- Applying minimum customs duties (10%) and exemption from VAT on equipment and products used for energy efficiency and for which there are no equivalents manufactured locally;
- Exemption from VAT on energy saving equipments and products purchased locally;
- Applying minimum customs duties (10%) on importation of solar water heaters;
- Exemption from VAT for importation of solar water heaters.

II. COST OF OBSERVED ACTION SINCE 1990

1. Inventory of actions conducted

Monitoring and evaluation of the achievements made in the field of energy efficiency are fairly recent in Tunisia. It was not until 2005, with the upsurge of international energy prices, that the authorities started to focus on these aspects. Accordingly, it is difficult to conduct a precise inventory of the achievements over the whole period 1990-2007, in particular with regard to energy efficiency actions. In an indicative way, the actions having contributed in energy saving over this period are mainly:

- The signing of about 350 energy efficiency performance contracts in industry, of which about 230 within the period 2005-2007;
- The signing of about 150 performance contracts in the tertiary sector, of which about a thirty within the period 2005-2007;
- The installation of about fifteen MW of power self-cogeneration in the industrial sector;
- The installation of approximately 250000 m² of solar water heaters, mainly in the residential sector;
- Promotion of the use of natural gas in the industrial and residential sectors, in particular;
- The installation of a wind park of 20 MW;
- Extension of approximately 1 million low consumption lamps for street lighting;
- The installation of about 1.3 MWc of photovoltaic particularly for rural electrification and solar water pumping;
- Preparation and promulgation of thermal regulations in the building sector;
- Setting up a mandatory certification and labeling system for household electric appliances.

The PROSOL solar water heater promotion programme

The PROSOL programme was initiated in 2005. It is based on an innovative mechanism:

- A subsidy of 100 TND/m² (55 €/m²) to shorten the return on investment period for the end user,
- A 5-year loan to be reimbursed via the electricity bill, with loan recovery ensured by STEG (Tunisian Electricity and Gas Utility),
- Efficient quality control system,
- Active participation by the banking sector and by suppliers

On the institutional and legal level, the later part of this period has reported the implementation of a certain number of proactive measures, of which:

- Establishment of the FNME for purposes of contributing to the financing of certain energy efficiency actions;
- Adoption of a new law on energy efficiency promoting performance contracts in industry;
- Setting up Task Forces to coach certain energy efficiency actions.

2. Evaluation of investment costs

Emphasis has been laid on the period 2005 – 2007, in view of the availability of data related to the capital costs of the three-year energy efficiency programme.

Over the period 2005-2007, investments in energy efficiency can be estimated as about 250 million Tunisian dinars (TND), that is about 140 M€.

Out of this amount, State participation is estimated as about 10% (that is 25 MTND). The remainder was provided by private developers.

Public and private efforts were very strongly boosted by international cooperation, mainly under the form of coaching and of capacity building.

Among the cooperation projects implemented during this period, it is worth mentioning in particular:

- The project of promotion of the solar water heater, financed by GEF/World Bank and the Belgian cooperation, of an amount of 7.2 M$;
- The project of setting up the thermal regulation of buildings, financed jointly by GEF and FFEM (French Global Environment Facility), of an amount of 10 M$;
- The project of setting up certification for refrigeration equipment, financed by GEF/UNDP, of an amount of 3.5 M$;
- The Project of Energy Efficiency in Industry (PEEI), financed by GEF/WB, of an amount of 10 M$;
- Several small capacity building projects, financed by multilateral cooperation (mainly UNDP and UNEP) and bilateral cooperation (German, Italian, Spanish, Canadian and Japanese, in particular).

In these amounts, the Tunisian State counterpart, often under the form of contribution in kind, would range between 15 and 25%. Obviously, some of these projects have a significant action leverage in terms of mobilization of private investment. For instance, the PEEI project has helped mobilize private investments of about 10 times the project amount.

3. Evaluation of the energy impacts of the action observed

3.1. Impacts in terms of energy saving

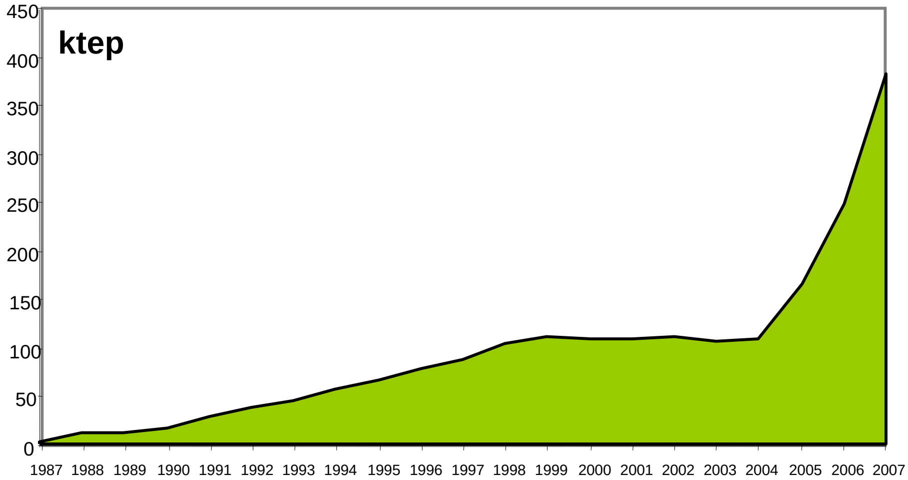
Other than the improvement of the output of power plants, the energy saving generated by the energy efficiency programme is estimated as 2 Mtoe over the period 1990-2007.

The actions engaged during the three-year energy efficiency programme of 2005-2007 have allowed an energy saving of

The Energy and Environmental Information System (SIM2E)

ANME (National Agency for Energy Efficiency) has developed, in the framework of cooperation with the French Agency for the Environment and Energy Efficiency, since 2006, an Information System (SIM2E) allowing calculation of energy and environmental indicators according to the same methodologies adopted by the European programme « Odyssée ».

over 800 Ktoe. Over the lifetime of these actions, energy saving may be estimated as about 2800 ktoe.



3.2. Impacts in terms of energy intensity

During the period 1990-2007, primary energy demand was multiplied by 1.8, while GDP was multiplied by 2.2. Over the same period, the growth of energy demand stood at 2.1% per year, while GDP increased by 4.2% per year.

The contrasted evolution of GDP and primary energy demand translates the improvement of the energy performances of the Tunisian economy and the decrease in energy intensity.

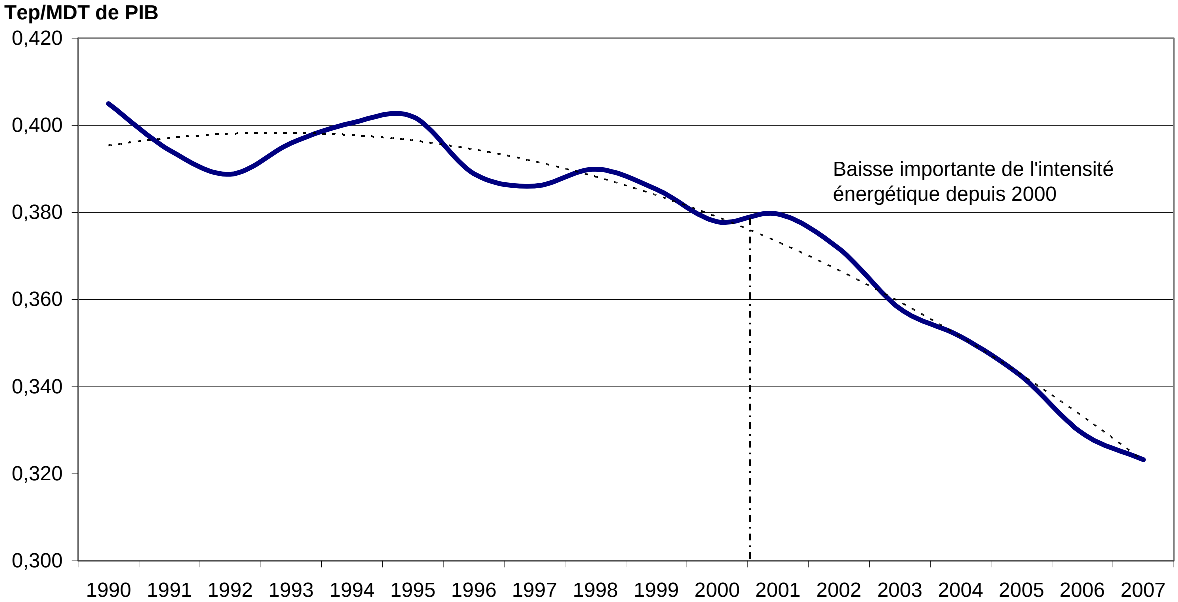
The analysis of the evolution of energy intensity reveals an average annual fall by 1.3% per year over the period 1990-2000, with a differentiation according to the sub-periods:

- 1990-2000: 0.7% per year
- 2000-2007: 2.2% per year.

The 2000s have been marked by a strong fall of energy intensity, resulting from:

- rise in the domestic prices of the various forms of energy (stagnation of fuel consumption for the transport sector);
- Sustained economic growth and upgrading of the industrial tool;
- Improvement of the output of power stations with the introduction of a second combine cycle plant in 2001;
- Orientation of the Tunisian economy towards less energy-consuming sectors (development of services);
- Positive impacts of the programme of rational energy use especially on unit consumption of large energy consuming industries (cement, brick, fertiliser, phosphate, etc.).

Figure 7 – Evolution of primary energy intensity



4. Evaluation of the cost of the saved toe

Based on the preceding evaluation, the cost of the saved toe can be estimated as about 90 TND/toe, that is about 50 euros/toe. This cost is to be compared with the international price of the natural gas toe, today standing at over 400 TND/toe.

With regard to State subsidies, they are estimated as approximately 9 TND/toe, that is 5 €/toe, based on 25 MTND (14 M€) outlaid by the State over the period 2005-2007.

In addition, the expenditure avoided by the State in terms of subsidy of energy products is estimated as around 463 MTND (about 260 M€), that is 18 times the amount of the subsidy granted in support for energy efficiency.

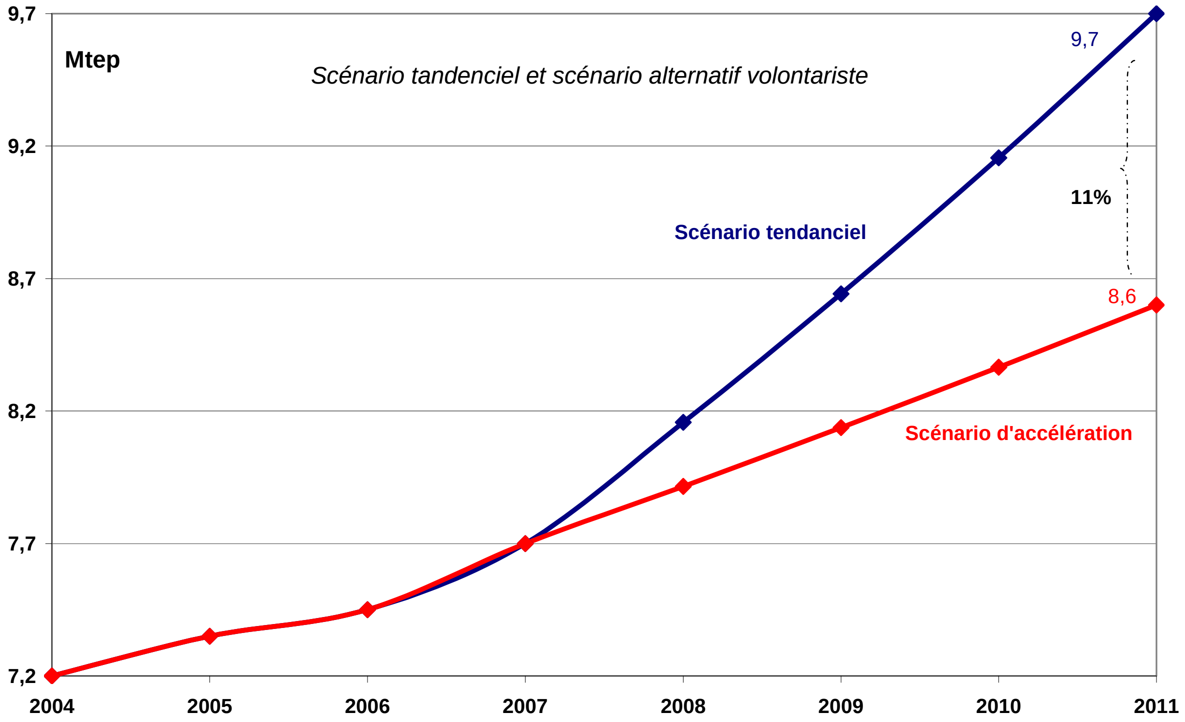
III. COST OF THE ACTION PROGRAMME ENVISAGED BY TUNISIA OVER THE PERIOD 2008-2011

1. Demand scenarios

Tunisia's XIth National Economic and Social Development Plan (2007-2011) has set an objective of sustained economic growth of 6.1% per year. To work out the projection of energy demand, two energy scenarios were envisioned:

- A steady trend scenario, which consists in a strong growth of demand while keeping constant the level of energy intensity of the baseline year 2007, that is 0.32 toe/1000 TND over the period 2007-2011. Primary energy demand would reach 9.7 Mtoe by 2011, that is an annual growth rate of 5.9%.
- A scenario of acceleration of the policy of energy efficiency which meets a very ambitious objective of reduction of energy intensity by 3% per year as from 2008. This results in a moderate growth of energy demand by 2.8% per year to reach 8.6 Mtoe. The success of this scenario requires:
- an intensified development of certain energy efficiency actions, such as cogeneration, thermal regulation of buildings and extended dissemination of power saving household electric appliances;
- Adoption of new standards and regulations fostering energy efficiency and renewable energies (self-production of electricity by wind power);
- Extending the financial incentives of the FNME (National Energy Efficiency Fund) to new actions (building for example) and setting up innovative funding mechanisms (credit facilities, loan subsidisation, investment fund);
- Gradual pegging of domestic prices to international prices, in such a way as to apply cost pricing as from 2011.

Figure 8 – Prospects of primary energy demand between 2008 and 2011



The difference in the level of the energy demand according to the two scenarios corresponds to the energy saving expected from the energy efficiency acceleration scenario. By 2011, energy saving would amount to 1.1 Mtoe, that is 11% of the underlying (trend-based) demand.[2]

2. Reminder of programme objectives

With the soaring energy prices on the international market, the Tunisian Government has opted for the proactive alternative scenario presented above, as a basis for setting up the new four-year energy efficiency programme 2008-2011. This programme aims at mitigating the vulnerability of the Tunisian economy vis-à-vis the increase in the weight of energy expenditure in the State budget. Indeed, the share of energy expenditure in GDP was about 12% in 2006, as against 4 to 6% in certain Western countries.

More concretely, early in 2008, the public authorities adopted some twenty measures aimed at leveraging Tunisia's means of reducing energy intensity by 3% per year between 2008 and 2011 and raising to 4% the share of renewable energies in energy consumption.

[2] Preparation documents of the four-year programme 2008-2011, ANME (National Agency for Energy Efficiency), January 2008.

3. Scope and content of the programme

The new four-year programme belongs in a perspective of accelerating the energy efficiency policy, together with boosting certain actions of rational energy use and promotion of renewable energies envisaged initially in the XIth Development Plan (2007-2011), in particular by:

- marketing 2 million low-consumption lamps per year;
- installation of a capacity of 70 MW for power production based on wind energy in large energy consuming industries;
- installation of 90000 m² of solar captors for water heating in the tertiary and industrial sectors;
- promoting performance contracts in the industrial, tertiary and transport sectors;
- power production from waste for a capacity of 40 MW;
- roof insulation of an existing stock of more than 20.000 households and 1500 tertiary buildings.

4. Additional legal measures

In addition, the four-year programme is supported by a set of new institutional and legal measures, of which the following aspects are particularly worth mentioning:

- subjecting new projects and extension projects with an annual consumption above 7.000 Mtoe to preliminary authorization, and bringing down the threshold of mandatory and periodical energy audit for industrial entities from 1 000 to 800 Mtoe;
- availing entities, entities groups, as well as individuals that produce electricity for their own needs of the right to convey the electricity produced via the national network and the right to sell the surplus to the Tunisian Electricity and Gas Utility (STEG);
- increasing the level of subsidies granted by FNME with regard to immaterial investments, energy audit, cogeneration and solar water heating in the tertiary sector;
- mandatory compliance by new collective constructions with the dedicated energy performance rules;
- prohibiting the marketing of refrigerators of classes 5 and 6 as from January 2008 and refrigerators of class 4 as from 2011;
- extending the energy labelling programme to air-conditioners, lighting equipment, washing machines, water heating equipment and ovens, while gradually prohibiting the marketing of intensive energy consuming equipment as from 2009;
- promoting the use of low-consumption lamps and prohibiting the marketing of incandescent lamps as from 2011;
- making the development of Urban Development Plans a mandatory requirement;
- establishing the obligation of vehicle engine check-up at the time of the annual technical vehicle inspection;

- making the use of renewable energies in water pumping and desalination eligible for FNME subsidy;
- setting up a regulation body in the energy sector;
- extending the presence of the regional services of the National Agency for Energy Efficiency (ANME) in the various Governorates of Tunisia, and strengthening its human resources;

Environmental credit facility of the French Development Agency (AFD)

In 2008, the French Development Agency (AFD) set up a credit facility of 40 M€ with concessional terms dedicated to funding energy efficiency and de-pollution projects.

- setting up credit facilities dedicated to energy saving, based on bilateral and multilateral cooperation.[3]

5. Evaluation of programme investments

The four-year programme 2008-2011 (see scope and content in 5.3) requires a capital cost estimated as 1100 million TND, of which 140 million TND provided by the FNME (National Energy Efficiency Fund), that is about 13% of the total investment. State subsidies are granted mainly for energy efficiency in large energy consuming industries (40%), wind energy connected to the network, and the building sector, in particular the solar water heater.

These investments constitute an appreciable effort, accounting for over 13% of the investments envisaged in the energy sector over the period 2008-2011 . The investments have been estimated based on the observed costs of the technologies used at the time of elaboration of the documents of the four-year programme (January 2008). For the sake of illustration, the following costs may be mentioned:

- wind energy: 1700 €/kW installed;
- cogeneration: 600 €/kW installed;
- solar water heater: 275 €/m² installed.

Accordingly, these investments need to be re-evaluated according to the increase in prices reported by certain technologies such as wind energy, heat insulation materials, etc.

6. Evaluation of the energy impacts of the action planned

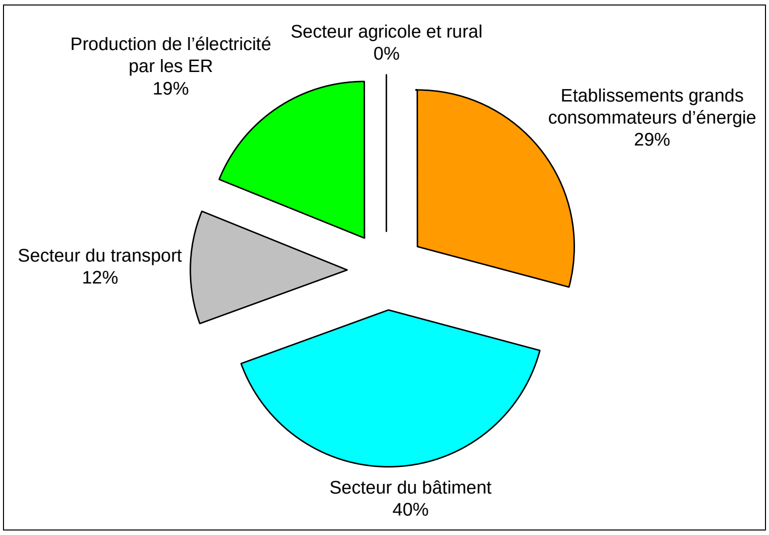
6.1. Impacts in terms of energy saving

The expected energy saving is estimated as 3.2 Mtoe over the period 2008-2011, that is about 15 Mtoe over the entire lifetime of the actions.[4]

These savings are distributed among the various action types as follows:

[3] Energy efficiency credit facility under discussion with the World Bank.
[4] An action conducted during the period 2008-2011 will continue to generate energy savings over the entire period of its technical lifetime. The task, then, would be to anticipate the energy savings made beyond the period 2008-2011.

Figure 9 – Energy saving expected by sector



6.2. Impacts in terms of energy intensity

According to the scenario adopted, primary energy intensity is set to report an average fall by about 3% as from the year 2007 (0.32 toe/MTND). Accordingly, it is likely to reach 0.28 toe/MTND by 2011.

7. Evaluation of the cost of the saved toe

In view of the above, the cost of the saved toe is about 73 TND, **that is 40 euros/toe**, with a State contribution in this cost of **5 euros per toe**. The supply cost of a toe is at least 5 to 6 times higher than that of a saved toe.[5]

Besides, as may be noted, the cost of a saved toe and, consequently, that of the avoided $TEC0_2$, as envisaged within the framework of the four-year programme, is approximately 20% lower than that observed during the three-year programme 2005-2007.

This decrease in cost is due, inter alia, to the effect of certain legal measures which were established during the period 2005-2007 and whose application will actually come into force as from 2008. They are inexpensive measures (though long and difficult to implement) but which have significant expected results. Of these, it is worth mentioning in particular the thermal regulation for buildings or the certification of refrigeration equipment.

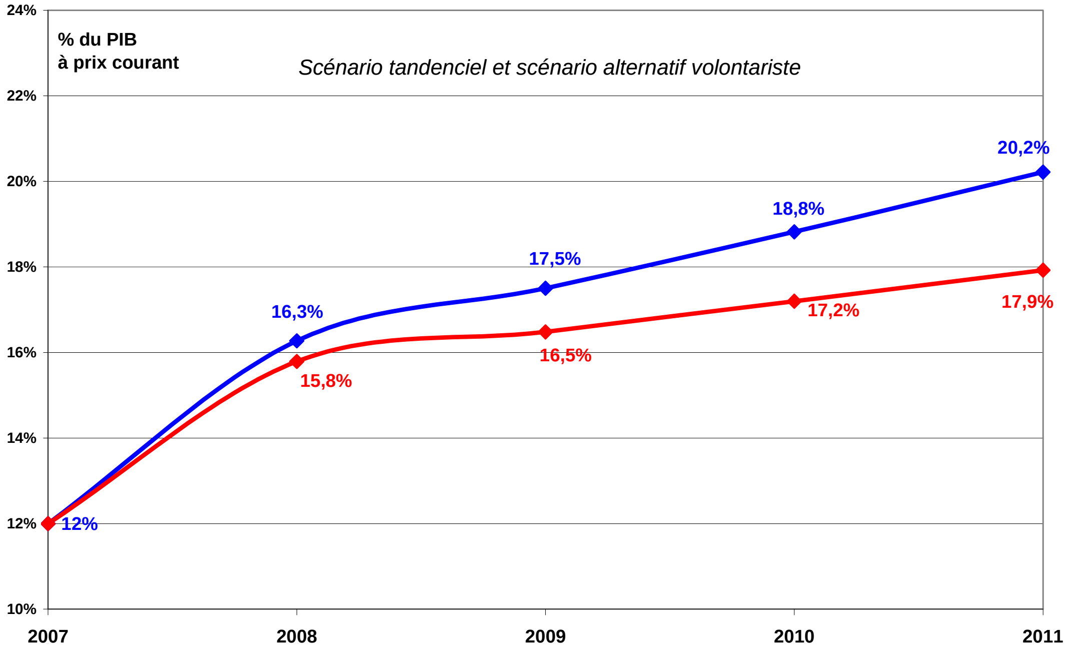
[5] Natural gas as reference.

8. Evaluation of the impacts of the action planned on energy expenditure

Based on the growth of GDP (in current prices) envisaged for the XIth National Economic and Social Development Plan, and assuming an oil price rise per barrel of 10% per year, the weight of energy expenditure in GDP should drop significantly thanks to the reinforced policy of energy efficiency.

In the scenario "without energy efficiency" (underlying), energy expenditure would reach approximately 12400 MTND (6890 M€), that is more than 20% of GDP by 2011, as shown by the following graph:

Figure 10 – Energy expenditure in % of GDP



In the scenario of accelerated energy efficiency policy (proactive scenario), energy expenditure on national level would amount to approximately 11000 MTND (6111 M€), that is about 18% of GDP by 2011.

Thus, the contribution of energy efficiency would result in a drop in expenditure of about 3100 MTND (1720 M€) over the whole period 2008-2011, that is about 5% of the GDP of 2011 considered in the scenario.

The following table presents the assumptions considered for the preceding calculation:

	2008	2009	2010	2011
GDP at current prices (TND)*	48 314	52 338	56 678	61 364
Price of a barrel ($)	110	121	133	146
Price of a toe ($)	803	883	971	1 066
Price of a toe (TND)	964	1 060	1 165	1 279

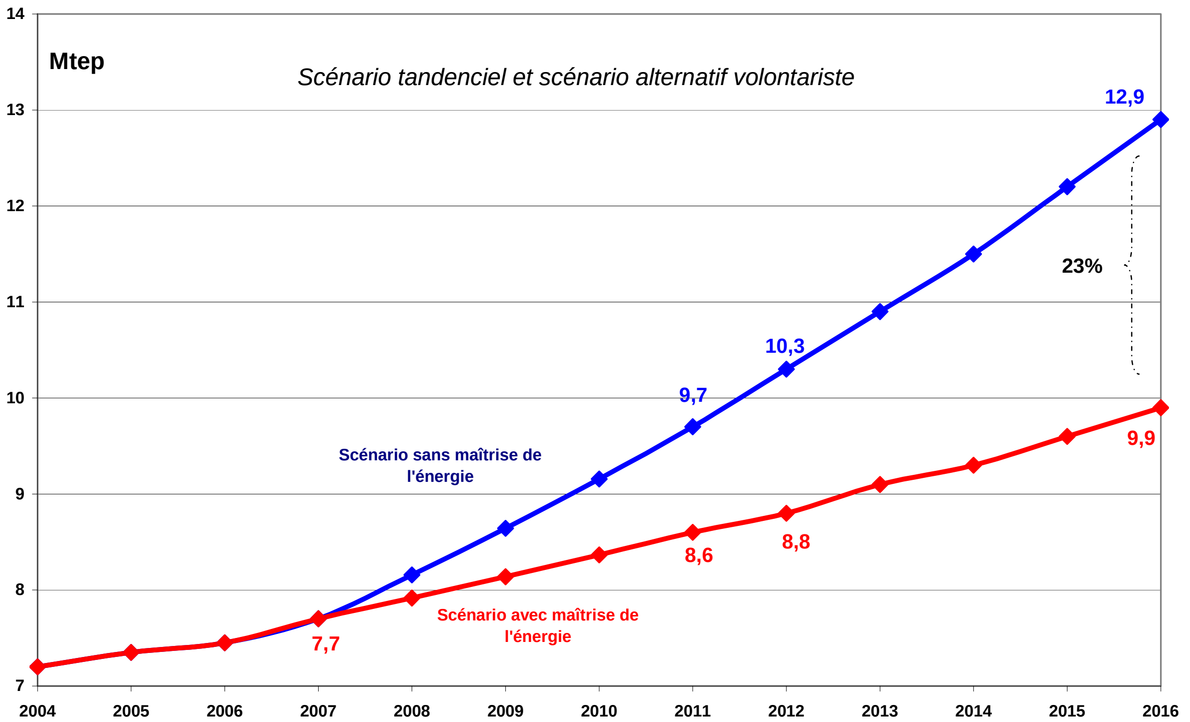
* Source: XIth National Economic and Social Development Plan.

9. Outline of an ambitious scenario of energy efficiency over the period 2012-2016

To reach the same level of energy performance of the OECD countries, energy intensity should continue to decrease by more than 3% per year as from 2012.

With this level of performance, primary energy demand should grow at an average annual pace of 3% between 2012 and 2016[6] , instead of 5.9% in the case of the underlying scenario. This will help reduce by 23% the primary energy demand for the time frame 2016, as shown by the following graph:

Figure 11 – Primary energy demand: prospective up to 2016



[6] Official assumption of GDP growth: 6.6% per year.

Consequently, the energy efficiency programme should be scaled up to cover all the energy chain: production, processing, transport of energy and consumption. This programme should be structured essentially around the following actions:

- development of power production based on wind energy and wastes, and sale via the national power network;
- reinforcement of energy efficiency actions, particularly in the building and transport sectors;
- reduction of power transport losses;
- valorisation of associated gases on oil production sites.

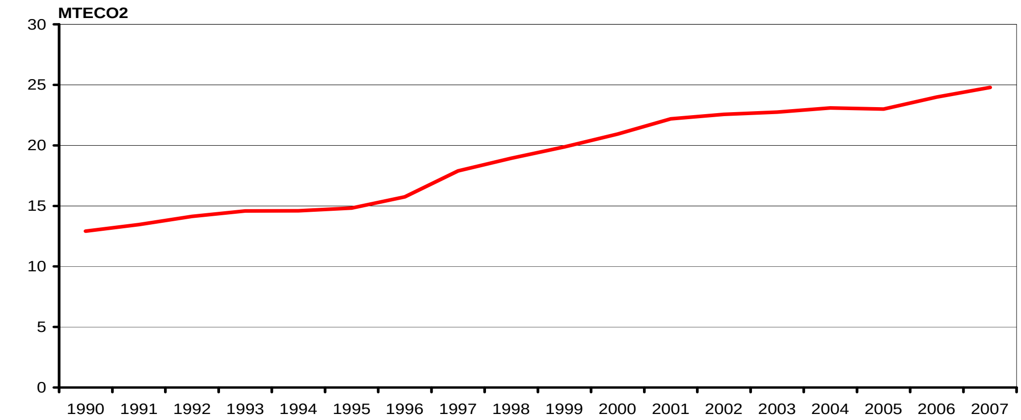
IV. ENERGY AND CLIMATE CHANGE IN TUNISIA

1. Environmental impact of the action observed

1.1. Evolution of emissions

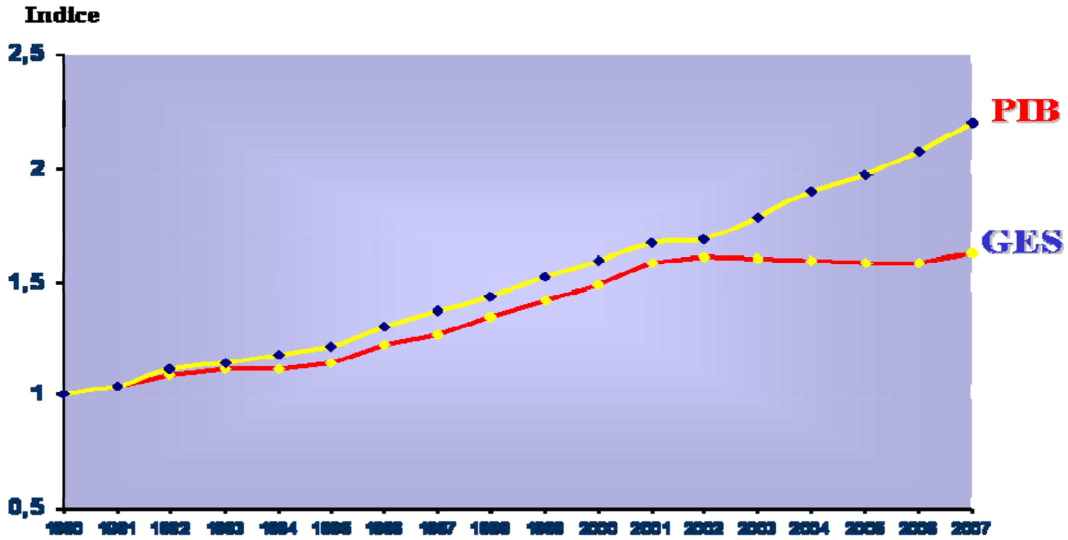
GHG emissions due to energy almost doubled between 1990 and 2007, passing from 12.9 MTECO2 to 24.8 MTECO2. The average annual growth rate stood at 3.9% between 1990 and 2007, 4.9% between 1990 and 2000 and 2.5% between 2000 and 2007.

Figure 12 – Trend in GHG emissions from energy use (1990-2007)



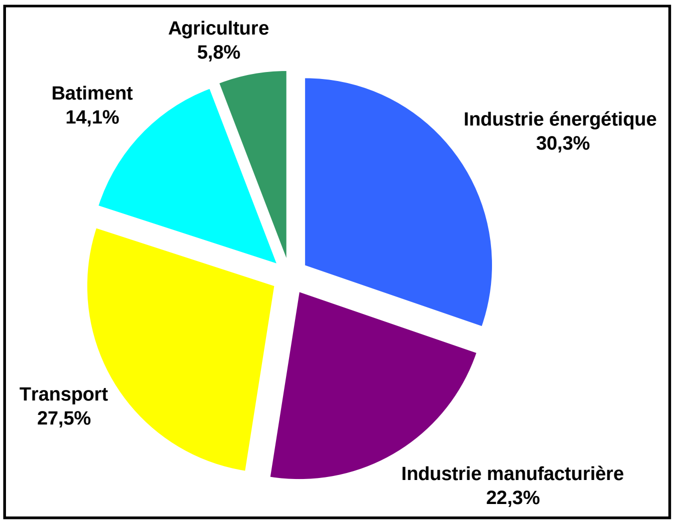
The period 2000-2007 was marked by a clear dissociation between economic growth and GHG emissions due to energy. Over the same period, GDP increased by 39%, while GHG emissions due to energy rose by only 19%.

Figure 13 - Evolution of economic growth and of GHG emissions due to energy (on national level)



The main growth of GHG emissions is generated by energy industry and transport. In spite of the development of two combine cycle power plants and the use of natural gas for power generation, energy industry (mainly in the power production sector) remains the chief sector in matter of emissions generated by energy combustion.

Figure 14 – GHG emission from energy use by sector, 2007

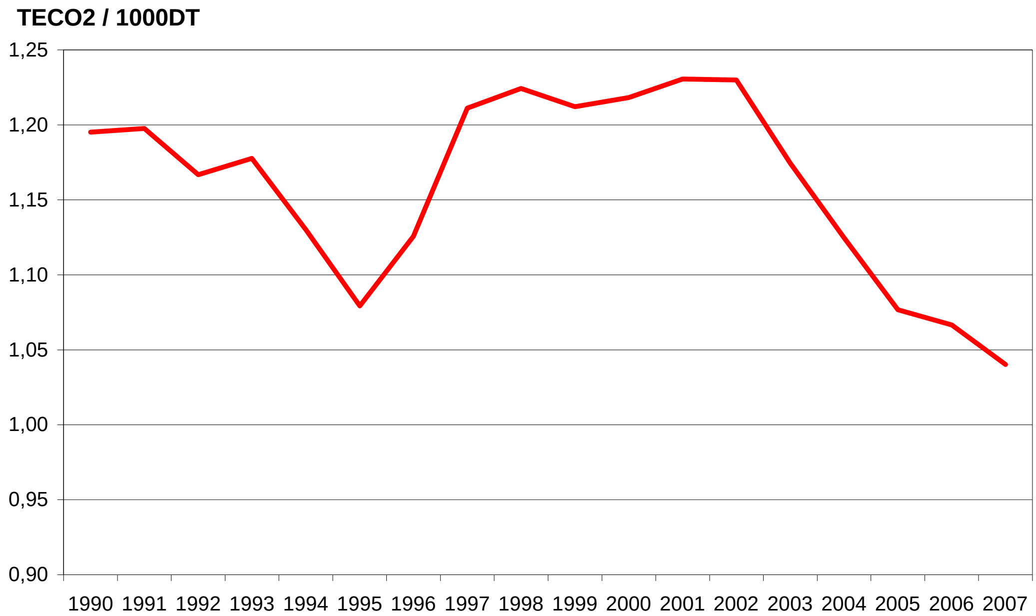


1.2. Impacts on carbon intensity

Over the period 1990 -2007, the carbon intensity of the Tunisian economy reported a significant fall, passing from 1.2 TE CO2/1000 TND in 1990 to 1.04 TE CO2/1000 TND in 2007. The period 2000-2007 was marked by a clear improvement of carbon intensity, that is a fall by 2% per year. This improvement is due to:

- The substitutions undertaken in favour of natural gas in the generation of electricity and in industry;
- The development of services and industrial sectors with high value added and low energy content;
- The success of the three-year energy efficiency programme 2005-2007, especially in large energy consuming industries.

Figure 15 – Carbon intensity 1990-2007



1.3. Cost of avoided TE CO_2

The GHG emissions avoided thanks to the energy efficiency actions conducted within the framework of the three-year programme 2005-2007 are estimated as about 7 MTE CO_2 for a total investment of about 140 M€ (see above). Based on this, the cost of the GHG emissions avoided would be about 20 € / TE CO_2.

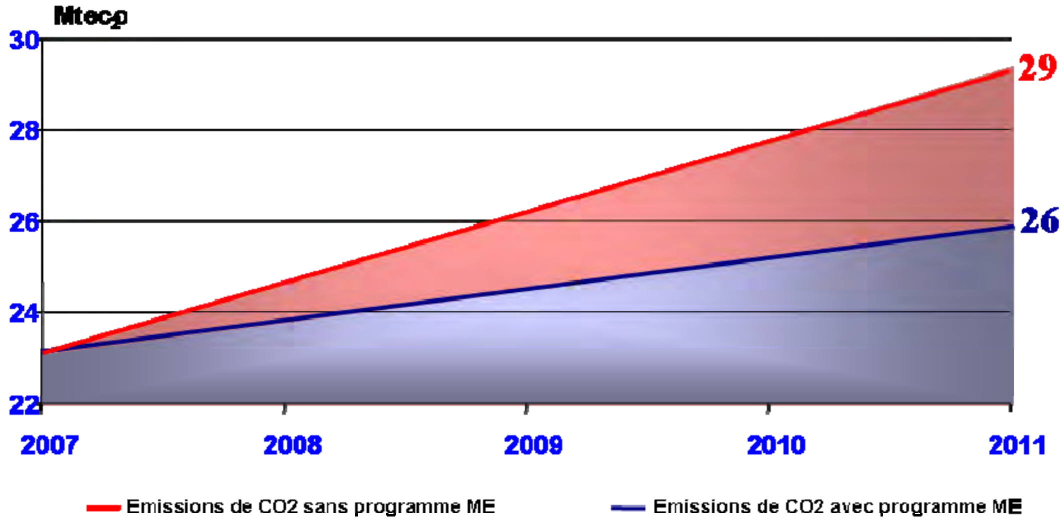
2. Environmental impact of the programme 2008 - 2011

2.1. Emissions scenarios

During the four-year programme 2008-2011, the evolution of GHG emissions related to energy consumption is worked out according to two scenarios:

- A scenario without additional energy efficiency measures, maintaining constant the level of carbon intensity of 2007. According to this scenario, the GHG emissions due to energy would be about 27 $MTECO_2$ by 2011.
- A proactive scenario of GHG reduction based on an accelerated policy of energy efficiency (see above). The energy saving achieved would help reduce GHG emissions due to energy to about 24 $MTECO_2$ by 2011.

Figure 16 – GHG from energy use: 2008-2011



It is the latter scenario which is officially selected by the Tunisian Government. The main assumptions considered in the second scenario are:

- Gradual pegging of domestic energy prices to the international market, with—as a main consequence—the stagnation of GHG emissions due to fuel consumption;
- Support for the development of renewable energies (wind energy in particular);
- Intensification of the energy efficiency programme (particularly, in industry and building);
- Development of the use of natural gas in power production, industry and building.

2.2. Impacts on carbon intensity

The impact of the alternative scenario on the evolution of carbon intensity would be at least equivalent to that of primary energy intensity. In other terms, carbon intensity should be reduced by at least 3% per year over the period 2008-2011.

2.3. Cost of the avoided $TECO_2$

The four-year energy efficiency programme should make it possible to avoid approximately 9 MTECO2 over the period 2008-2011, that is about 45 $MTECO_2$ over the total lifetime of the recommended actions. It is worth recalling that the total investment for the programme was estimated as about 1100 MTND (610 M€). Consequently, the cost of the ton of CO_2 avoided can be estimated as about 24 TND per $TECO_2$ that is about 14 euros per $TECO_2$.

3. The clean development mechanism (cmd) in the service of energy efficiency

Thanks to its proactive energy efficiency policy and its socio-economic development directed towards non energy intensive sectors, Tunisia is one of the developing countries with the lowest carbon intensity. The four-year energy efficiency programme 2008-2011 is set to contribute in accelerating the transition towards a low carbon intensity economy, with the adoption of a low carbon content scenario. By 2011, GHG emissions would be lower by 20% compared to those reported in the event of a underlying scenario (maintaining the energy intensity of the year 2004). Carbon intensity is set to decrease by at least 3% per year over the period 2008-2011.

Besides, owing to its capacity of reduction of GHG emissions, energy efficiency can largely benefit from funding within the framework of the Clean Development Mechanism (CDM). Accordingly, since its ratification of the Kyoto Protocol in 2002, Tunisia has granted priority order to the implementation of CDM projects in the energy sector. In order to avail itself of the international carbon market and to tap CDM financial contributions, the Ministry of Industry, Energy and SMEs (MIEPME) has set up a CDM Task Force entrusted with facilitating the development of CDM projects in the energy sector. The intervention of this Task Force revolves around three major axes:

- Preparation and updating of a CDM projects portfolio in the energy sector;
- Assistance to CDM project holders with the CDM Executive Board - EB (preparation of PIN (Project Information Note) and of PDD (Project Design Documents), validation, registration, etc.);
- Assistance in the sale of Certificates of Emission Reductions (CERs).

CDM projects in advanced progress status

Among the 20 projects approved by the Designated Operational Entity (DOE), two fairly advanced projects are worth mentioning. The first is the PROSOL programme, in process of validation by the DOE. This project is set to enlist CDM funds of about 3 M€ over the crediting period.

The second programme is that of the dissemination of low-consumption lamps which is set to enlist CDM funds of about 12 M€.

Both projects resort to the new pragmatic approach officially adopted by the CDM Executive Board (EB) in June 2007. This approach provides highly promising prospects for energy efficiency, especially in diffuse sectors, such as building.

Other than the CDM projects portfolio and the coaching of project holders throughout the various phases of the registration cycle, the actions of the Task Force should help towards mainstreaming the CDM in the financing plan of energy efficiency projects.

Indeed, the implementation of energy efficiency and renewable energies projects during the four-year programme involves fairly heavy investment needs estimated as over 1.1 billion TND. About 15% only of this amount can be leveraged via the National Energy Efficiency Fund (FNME).

The additional funds need to be mobilised via capital base and credit facilities dedicated to energy efficiency. In this regard, the CDM can generate substantial annual earnings to subsidise the interest rates of the credit necessary for financing such investments geared towards a reduction of the carbon emissions of the energy sector.

As of early 2008, the DOE had already approved some twenty CDM projects in the energy sector, submitted by the CDM Task Force. In terms of CDM earnings, these projects are set to generate about 200 M€ over the projects lifetime, which could be integrated in their funding.

Among the latter, some require heavy investments calling for the contribution of international donors. However, these projects bring in significant CDM earnings.

Among the said projects, it is worth mentioning the following:

- Wind energy self-production: 2 $MTECO_2$
- Cogeneration: 4.5 $MTECO_2$
- Recovery of associated gases: 56 $MTECO_2$
- Wind power connected to the network: 5 $MTECO_2$
- Natural gas substitution:1 $MTECO_2$.

V. CONCLUSION

Over the period 2008-2011, the investments earmarked for energy efficiency in Tunisia would amount to 13% of the total investments in the conventional energy sector (energy production, processing and distribution infrastructure). This unprecedented rate in the history of energy efficiency in Tunisia attests to a real acceleration of the Tunisian policy in the matter.

However, this scale-up of investments would not have been possible without preliminary preparatory work, incepted by the public authorities some twenty years ago. This structural work has helped establish the relevant institutional, legal, tax and financial tools, thus creating an environment conducive to energy efficiency. Besides, this long and exacting work has also helped pave the way for a change of scale: building and strengthening of competencies, building awareness among all stakeholders, public and private (administration, households, industrialists, financial sector, etc.), development of public-private partnership (PPP), strengthening of international cooperation, etc.

On the energy level, the impacts of this effort are undeniable, since the energy intensity of Tunisian economy and, hence, its carbon intensity has been constantly on the decrease over the past two decades, with a more marked decline since 2000. This pace is set to gain momentum in the future, thus reaching 3% per year throughout the period 2008-2016.

On the macro-economic level, the investments outlaid in the field of energy efficiency generate a high return for the community since the cost of the saved toe is currently 4 to 5 times cheaper than the cost of supply of a toe in natural gas, considered as one of the least costly conventional energies for Tunisia. Even more, the cost of the saved toe is set to decrease in the years to come, benefiting from the windfalls of the long term structural measures implemented in the past preparatory phase (thermal regulation of buildings, certification and labeling of household electric appliances, setting up of financial mechanisms, etc.).

Admittedly, the soaring international energy price observed since 2005 has triggered the acceleration of the process of change of scale in energy efficiency in Tunisia. Yet, such a trigger would have remained without effect if the conditions had not been conducive and sufficiently prepared in advance, thanks to a long term energy efficiency policy, both constant and independent of the barrel price fluctuation.

Accordingly, a future fall in barrel price—though scarcely likely—would not alter the energy efficiency efforts. A circumstantial policy in this field would often cost too dearly for the community and, in any case, much more dearly than a long term policy.

Finally, it is worth highlighting the importance of setting up reliable monitoring and evaluation systems dedicated to energy efficiency policies. This is indispensable in order to optimise these policies, on the one hand, and to provide the feedback necessary for dialogue and consultation among the national actors, on the other hand. For so doing, the indicator-based method is one of the most appropriate and least costly approaches to ensure monitoring. It requires, however, the setting up of reliable and updated energy and environmental information systems.

As regards the Euro-Mediterranean region, these information systems should be developed on the level of each country, but in a region-wide consistent way. This would allow comparison between the performances of the national energy efficiency policies of the countries of the region and gradually facilitate the identification of common objectives.

CHAPTER 7

How much does cost the change of scenario toward a low carbon energy sector?

A. Tunisia

B. Egypt

CHAPTER 7B *How much does cost the change of scenario toward a low carbon energy sector?*

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The energy institutional framework has a fundamental impact on the degree of how adequately addressing energy sustainability which should represent the core of any strategy formulation. Major energy institutional and market reforms would be needed to insure driving Egypt towards an alternative energy scenario based on more sustainable natural resources exploitation, more efficient end-use and hence lower CO_2 emissions.

As the energy sector contributes by more than 71% of total GHG emissions in Egypt, the growing dependence on fossil fuels will not only endangers the future national energy security but will also be jeopardizing the whole national sustainable development prospects. The cost of continuing with the business-as-usual scenario is expected to be considerably high particularly if the country will be, most probably, obliged to import a part of the needed fossil fuels at the currently astounding international prices.

The creation of the RE dedicated agency (NREA) under the ministry of electricity, facilitated the realisation of Egypt's declared commitment towards enhancing the role of RE in its energy system particularly for wind power generation. Conversely, less significant development can be seen in the RUE field due to the absence of such an institution. The questionable sustainability of conventional energy resources and the ever increasing demand makes the enhancement of the role of RE and RUE as a must rather than a choice.

The new ambitious wind power plan has a target to meet 12% of electricity demand by 2020 translated into 7200 MW total installed wind power capacity which will result in an annual GHG emissions reduction of about 17 mt CO_2eq and annual fuel saving of 7.2 mtoe after their completion. For the year 2014/15, the wind power ambitious plan targets installing 3000 MW in addition to the existing 600 MW wind farms already installed and also those being under construction to realise a total installed capacity of 3600 MW by that year.

Nevertheless, based on prevailing market conditions and favourable wind conditions in the area of Gable El-Zeit, this study estimates that only 2200 MW out of the officially planned 3000 MW till 2014/15 can be realised and hence will be considered under the business as usual scenario. Consequently, the remaining 800 MW together with additional proposed actions in this study is forming an alternative energy scenario less CO_2 emitter in the horizon of 2014/15. The baseline (business as usual) scenario estimates that the energy emissions by the year 2014/15 is 250 mt CO_2eq resulting from a total energy consumption of 91.5 mtoe during the same year.

Additional actions identified and estimated in term of possible investment under the alternative low carbon scenario are: Four wind power plants each of 200 MW (total of 800 MW helping to achieve the 3600 MW target), a solar water heating program and an efficient lighting initiative. The total investment cost of those actions, which are forming the proposed alternative scenario, are estimated at about 1.3 billion Euros. This investment amount represents about 10% of the total planned investments (about 12.7 billion Euros) in both petroleum and electricity sectors until the year 2014/15.

The economic analysis of the proposed projects reflects the negative impact of subsidised electricity price on the internal rate of return (IRR) and indicates that soft loans improve the cost effectiveness of these projects. Those two remarks reflect the fact that strong national institutional reforms are needed (including pricing reform) and that soft loans could strongly boost the achievement of an alternative scenario. Nevertheless, even with present energy subsidies energy efficiency applications show favourable cost effectiveness. The economic analysis of the wind energy proposed project also indicated that the cost of investment to save one toe (ton of oil equivalent) is estimated at 50 euro/toe while that from energy efficiency is ranging from 20 to 30 euro/toe. The cost of the avoided GHG emissions can be estimated as 19 and 10 euro/t CO_2eq from wind projects and from energy efficiency activities respectively.

Finally, the Euro- Mediterranean cooperation and a further contribution of the international financing institutions (IFIs) like the EIB could play a key role to assist Egypt in better formulating and implementing reforms and strategies needed to achieve a lower energy carbon scenario that maximises the role of RE and RUE.

INTRODUCTION

Context and problem definition

The analysis of energy consumption and production in Egypt for the last 25 years reveals that the average annual consumption growth rate (4.8%) is much higher than the production one (2.8%). This negative trend or gap entails the need for enhancing the contribution of RE in the production side and in the same time reducing the consumption through the RUE measures. If the current practice for energy production and consumption continues without any improvement (business as usual scenario), the fossil fuel resources will fall short in satisfying the increasing demand in the short to medium term.

The energy institutional and the legislative frameworks have a fundamental impact on the degree of how adequately addressing energy sustainability which should represent the core of any strategy formulation. Major energy institutional and market reforms would be needed to insure driving Egypt towards an alternative energy scenario based on more sustainable natural resources exploitation, more efficient end-use and hence lower CO_2 emissions.

In order to be able to evaluate the cost of any lower CO_2 energy scenario for Egypt until the year 2015, one has to start from a baseline energy scenario that has an elaborated plan of defined consecutive actions based on available knowledge and business as usual practices. Whenever the details of such a baseline scenario are developed, its GHG emissions as well as its investment cost can be estimated. Based on the evaluation of the expected GHG emissions from the baseline scenario, a "better" alternative energy scenario less emitter in GHG can be proposed. Any proposed alternative scenario will be considered relevant if it could provide the same amount of services and products as per the original baseline scenario by using either less quantity of energy (RUE) or the same amount of cleaner energy (RE) or a mix of these two processes. The degree of merit of each proposed alternative scenario stems from its cost of investment related to the resulting GHG emission reduction below the baseline emissions reference value.

Objective

As Egypt does not have a declared GHG emission reduction target, the main objective of this sub-chapter is to estimate a baseline scenario for emissions from the energy sector based on officially declared conventional and wind energy plans and also to suggest an alternative lower carbon scenario until the year 2014/15 through other proposed additional projects not currently included in existing plans. The proposed alternative scenario cost estimate is an integral part of the objective of the current report.

Source of information

Most of information used in this sub-chapter is obtained from a previous study developed early 2007 entitled "Egypt's National Study" under the Mediterranean and National Strategies for Sustainable Development. Up dates of energy and GHG data was made through published statistical annual reports if available and also through direct communication with different concerned organizations. Another important source of information was the study reports developed by experts under cooperation with international organizations (WB, KFW, DANIDA, JBIC, GEF, UNDP etc) particularly concerning renewable energy. The information on the new proposed electricity law and other legislative frameworks was mainly obtained from presentations developed and exposed by the electricity regulatory agency (ERA). Cost estimates was based on latest data available in internal reports within the energy sector and mostly available from different presentations in national conferences or through personal contacts. Other information was extracted from news papers articles and websites. Expert's judgment was rarely used to fill any lack of credible information.

Contents

The first part of this sub-chapter on Egypt includes an overview on energy current practices in both supply and demand sides. The second part discusses the prospects for GHG emission reductions in the energy sector until the year 2015. Based on the current practices that has been considered as the business as usual scenario, GHG reduction targets have been proposed to shap an alternative low carbon energy scenario for Egypt in the horizon of the year 2015.

The third part of this work presented the planned reform policies and action plans that would lead to lower CO_2 emissions in the energy sector as well as those proposed by the authors. Proposed legislation and market reform measures to enhance the role of RE and RUE was also discussed particularly the new electricity law that has been sent to the parliament for ratification. Electricity market reform measures proposed by the ERA to complement and support the implementation of the electricity law once it will be approved, have also been presented. The fourth party discusses the cost issues of the proposed lower CO_2 energy scenario and the prospects for realizing a favorable investment environment for RE/RUE. Finally a synthesis of conclusions and recommendations are developed.

I. OVERVIEW ON ENERGY CURRENT PRACTICES IN EGYPT

This part of the chapter on Egypt gives a quick overview and analysis of the historical evolution, current status and future trends of energy production and consumption matrices and patterns. It presents information on the existing two energy sectors in Egypt namely petroleum (oil products and natural gas) and electricity.

This part also presents an overview and a systematic analysis of the present institutional framework in the energy field in Egypt. This overview covers power, petroleum, renewable energy and energy efficiency activities. Institutional barriers and proposed enhancement aspects are also discussed. Different observations and remarks are pointed out particularly on the need for energy institutional and market reforms as well as on strategic planning needed for the enhancement of for the role of the RUE and RE.

1. ANALYSIS OF CURRENT ENERGY PRODUCTION MATRIX AND PRACTICES.

1.1. Electricity production matrix

Electricity generation installed capacity has grown for the last five years by an average annual growth rate of almost 6.5%. For the year 2005/06 the total installed capacity reached 20.5 GW.

1.1.1. Conventionally fuelled power plants

In 2005/2006 almost 85% of Egypt's power generation capacity was depending on conventional energy resources mainly oil and gas. About 57% of electricity generation capacity came from steam turbine power plants using natural gas or heavy fuel oil, 17% from combined cycle gas turbine (CCGT) power plants using natural gas as fuel, and 12% are open cycle gas turbine power plants using natural gas and/or light fuel oil.

1.1.2. Electricity generation facilities from renewable energy

All hydro-power generation are being considered under this category. In 2005/2006, hydropower plants generating capacity was 2783 MW representing less than 14% of total installed capacity as well as an installed wind power capacity of 183 MW representing about 1% of the system's installed capacity. It should be noted that the installed wind farms capacity for electricity generation has reached 310 MW by early 2008.

1.2. Evolution of electricity production matrix

Historically, the installed hydropower capacity represented about 70% of the total generation capacity for the year 1970. This percentage has continuously decreased along with the ever increasing demand on electricity. Due to the limited potential of adding new hydropower capacity, thermal power plants were installed to meet the increasing demand. The percentage of hydropower installed capacity decreased to 14% for the year 2005/06 and it is expected to be as low as 4.1% for the year 2029/30.

The fuel mixture utilised in the thermal power plants used to be heavy and light fuel oils. However, since the early 1990s natural gas share started to increase until being the main fuel used for electricity generation in the thermal power plants. The natural gas share in fuel mix for power generation reached its peak value of 91% during the year 2001/02 and then the trend has reversed. During the last five years, this share of natural gas was swinging around an average value of 81%. For the year 2005/06 the natural gas share decreased to 79.6%. The recent declining trend of the share of natural gas was compensated by heavy fuel oil (17% for the year 2005/06) at the request of ministry of petroleum. This can be attributed to the following reasons: natural gas long term export obligations as a main source for hard currency, somewhat lower natural gas net calorific value experienced during the last few years and possibly the tendency of oil sector to sell more gas to other sectors who buy it with a higher tariff than that paid by the electricity sector.

The new trend of using combined cycle power plants has appeared in the last decade with 17% share of total generation capacity for the year 2005/06 and is expected to reach 27% by the year 2020/21.

During the year 2007, the government expressed its intention to start a program of building a series of nuclear power stations starting by the first one to be commissioned around the year 2017. The Nuclear Power Plants Authority has already issued a call for international tenders during February 2008 for selecting a consultant to help Egypt in the formulation and execution of its nuclear power plants program including the consultancy work for the first plant initially planned in El-Dabaa along the north western Mediterranean coast.

The wind energy generating capacity is expected to reach about 7200 MW for the year 2020/21. The RE national plan includes an additional installed capacity of around 600 MW of wind turbines each year starting from the year 2010/11; an issue that calls for major electricity and energy market reforms as will be detailed later in part III of this chapter.

1.3. Petroleum (oil and natural gas) production

1.3.1. Crude oil production

The crude oil production is constantly decreasing since the year 1990/91 where the production was 45.6 mtoe then reached a lower value of 32 mtoe for the year 2006/07 with an average annual decrease rate of about 2.4%.

1.3.2. Natural gas

The natural gas production has increased from 7.2 mtoe for the year `1991/92 to reach 41.3 mtoe during the year 2006/07 with an average annual growth rate of 12.3%.

1.4. Evolution of oil and natural gas production mix

Total oil and gas production in Egypt for the year 2005 was 58 mtoe out of which the share of Egypt was only 39 mtoe while the rest was the share of the foreign partner. Knowing that the consumption was 49 mtoe for the year 2005, thus Egypt was obliged to buy 10 mtoe from the foreign partner companies with the international market prices.

For the year 2006, Egypt has intensified natural gas production for export where the total petroleum products production reached 71 mtoe and the share of Egypt was 44 mtoe while total consumption reached 52 mtoe. The purchased quantity from the foreign partner during 2006 decreased to 8 mtoe.

During the last 10 years and due to the decrease in oil production and the increase in natural gas production the ratio of the share of natural gas in the national fuel energy mix has increased from about 20% for the year 1996/97 to about 56% for the year 2006/07.

During the period 1980 to 2006, the total oil and natural gas production increased from 34.5 to 71 mtoe reflecting an average annual production growth rate of both oil and natural gas of about 2.8% during this period.

2. ANALYSIS AND EVOLUTION OF ENERGY CONSUMPTION PATTERNS AND PRACTICES

2.1. Electricity consumption

The residential and the industrial sectors are major end users of electricity in Egypt. In 2005/06, out of a total demand of 93 TWh these two sectors accounted for 36% and 35% of Egypt's total electricity demand, respectively. These two sectors have also been major drivers for electricity demand fast growth, accounting for 67% of the total growth in electricity demand over the last 5 years.

Annual growth rate per sector over last five years are as follows:

- Industry 5.9%
- Residential 7.5%
- Commercial 10.2%
- Public utilities 9.4%
- Government 8.3%
- Agriculture 7.9%

The per capita electricity consumption for Egypt grew on average by 5% per year since 1980/81, as it increased from 380 KWh/capita in 1980/81 to 1225 KWh/capita in 2004/05. Although the per capita electricity consumption in 2004/05 is still below world average (2330 KWh/capita), the annual growth rate is more than 3 times the world annual average growth rate (1.6%).

The annual growth rate of the aggregated peak load is almost the only driving force for electricity sector generation expansion plans. With the assumption of different saturation degrees in the end use sectors, the future annual growth rate is expected to have an average value of 5.7% based on energy demand. The growth rate is assumed to follow the following changes:

- For the period 2005/06 to 2010/11: 6.6% per year.
- For the period 2010/11 to 2020/21: 5.8% per year.
- For the period 2020/21 to 2029/30: 5.2% per year.

It should be important to mention that during the last 25 years the electricity consumption has increased by an annual average growth rate of about 6.7% while the Gross Domestic Product (GDP) has increased by a lower annual average value of 4.5%. This would be attributed to current electricity consumption behavioral practices which are characterized by relatively low efficiency of electric energy usage (high electric energy intensity). It is expected that the situation will be improved through anticipated electricity tariff reform and market liberalization. The GOE is recently engaged in a dialogue with the EU, through the Euro-Mediterranean Partnership, on prospective integration into a regional electricity market. Such integration will require important reforms in the Egyptian power sector, in order to establish fully liberalized electricity markets (in principle by 2010). Some assistance on how to achieve this is being provided through the MEDA Program on the financial and technical measures needed to accompany the reform of the economic and management structures, always under the framework of the Euro-Mediterranean partnership.

Nevertheless, significant work remains on the detailed steps required to meet the liberalization objective, as well as Government policy on how to finance sector investments in the longer term, including the respective roles of the public and private sectors. On the latter, although the GOE remains open to private sector participation, the pressure on the financial status of the power sector due to the overall low retail tariffs has led to the GOE opting for public sector financing for the time being.

2.2. Oil products and natural gas consumption

During the period 1980 – 2006 the total oil and gas consumption has increased annually by about 4.8% from 15.6 million ton oil equivalent (mtoe) to 52 mtoe. The oil and gas consumed for electricity generation has increased from 4 mtoe to 21 mtoe with a growth rate of 6.6% annually, while the oil and gas consumption for other sectors increased from 11.6 mtoe to 31 mtoe with an annual average increase of 4%.

Domestic gas consumption is dominated by the power sector at 60% for the year 2005/06, followed by the fertilizer industry, petrochemicals and other industrial sectors. Natural gas for power generation is expected to decline to about 50% of local gas demand by 2029/30.

Gas exports were equivalent to 25% of Egypt local gas demand in 2005/06, but are expected to peak at about 60% in 2012/13, and eventually reducing to about 35% by 2029/30.

As natural gas is becoming increasingly important to the economy of Egypt, particularly with the growing potential for exports, moving towards cost-based pricing of gas is becoming increasingly important. As a result, the government of Egypt (GOE) is planning to undertake an assessment to determine the cost of gas and has requested the World Bank assistance to do so. The objective of the study will be to calculate the economic cost of natural gas for domestic customers at certain off-take points from the network, including at power stations. The study objective has been modified later to include a strategy for energy pricing and should be completed by the end of 2008 and will provide important input to the GOE's long-term energy pricing policy and strategy including sensitivity analysis of gas price changes impact on the long run marginal cost of electricity.

3. ANALYSIS OF PRESENT INSTITUTIONAL FRAMEWORK

3.1. Historical background

3.1.1. Power sector

The Ministry Of Electricity and Energy (MOEE) has different affiliated authorities including:

- The Egyptian Electricity Holding Company (EEHC) established in 2000 and currently owns 6 generation companies (including one for hydropower), 9 Distribution Companies and one Transmission Company which is responsible for operating the system and is representing the single buyer in the electricity market.
- The Hydropower Projects Executive Authority.
- The Rural Electrification Authority (REA) that is being partially dismantled and expected to disappear by 2012 as electricity reached about 99% of the population including rural areas.
- The Nuclear Power Plants Authority (NPPA) which has not practiced any significant activity yet. However, there is a political intention to start a program for installing nuclear power plants in Egypt as indicated earlier hereby in item 1-1.2. Beside NPPA there are two other related organisations under the same ministry which are The Egyptian Atomic Energy Authority and the Nuclear Materials Authority.
- The New and Renewable Energy Authority (NREA).

A regulatory agency (The Egyptian Electric Utilities and Consumer Protection Regulatory Agency - ERA) was established since the year 2000 under the supervision of the minister of electricity and energy to coordinate and licence all activities of generation, transmission and distribution and to ensure availability of supply at fair prices. One other main aim of ERA is to set the regulations to ensure lawful competition in the electricity market.

3.1.2. Petroleum sector

The Ministry of Petroleum (MOP) consists of five (5) governmental bodies covering all the aspects of the ministry's activities, they are as follows:

- Egyptian General Petroleum Corporation (EGPC), which manages all exploration and production activities, as well as exports and imports transactions. It also records the quantity of petroleum products consumed by each sector and consequently plans for the future needs to be made available for these sectors. EGPC is the governmental partner in all joint ventures in the oil sector.
- Egyptian Natural Gas Holding Company (EGAS), which manages all natural gas chain of activities including exports transactions. It also records natural gas consumption and plans for future needs to be made available for different consuming sectors.
- Ganoub El-Wadi Petroleum Holding Company (GANOPE) involved in the development of exploration activities in Upper Egypt.
- Egyptian Petrochemicals Holding Company (ECHEM), involved in its field of specialisation indicated by its title.

- Egyptian Mineral Resources Authority which has been recently annexed to the ministry.

3.1.3. Energy efficiency and renewable energy activities

There is no single institution responsible for the energy efficiency activities in Egypt yet, that would otherwise perform necessary integrated planning including the formulation of the RUE targets, implementing related activities and following up the degree of its achievements. Rather, the energy efficiency activities are limited, non-coordinated and being implemented by different institutions inside and outside the energy sector.

On the other hand, renewable energy activities are the responsibility of the New and Renewable Energy Authority (NREA) established in July 1986, and is affiliated to the Ministry of Electricity and Energy that is supervising the management of the whole electric power sector.

3.2. Existing institutional barriers

The main institutional barrier is the absence of a single governmental body or ministry responsible for setting a long term integrated energy strategy looking at all available resources on equal footing, hence formulating an optimum energy strategy. The Supreme Council of Energy, founded in 2007 and headed by the Prime Minister, is supposed to play a major role in that direction. However, it needs many supporting institutions deeply experienced in such multi-disciplinary issues. Some other barriers are mentioned in the following subsections.

3.2.1. Power sector

The enforcement of the role of the regulatory agency should pave the road for subsidies alleviation which is the main reason of tariff distortion hindering the private sector involvement in electric power generation, transmission and distribution in Egypt on free market basis. The existing situation of having a single buyer monopoly represents another major barrier.

Officially, the regulatory agency is directed by the Minister of Electricity and Energy; an arrangement which questions its independence from government institutions and hence its ability to support the development of a free market enabling environment.

3.2.2. Petroleum sector

The absence of any regulatory body that regulates and controls the relation between end-users and both oil producers and natural gas suppliers represents one of the main barriers. From another side, the non-existence of an organisation within the petroleum sector that keeps track of the consumption of oil products and natural gas in different end-use sectors hence evaluates and plans for rationalizing such consumption, hinders the evaluation of the energy intensity in each sector as well as the estimation of the potential actions targeting the rational use of petroleum products and the follow up of the implementation of such actions.

3.2.3. *Energy efficiency*

As indicated above, there is no single national organisation or governmental institution responsible for the energy efficiency activities in Egypt. Many scattered activities have been implemented without significant impact on the national energy scene and without accumulated experience or replication of successful applications. As a result, there are no declared goals or targets on the national level neither for the short nor for the long terms for RUE and energy intensity improvement.

3.2.4. *Renewable energy*

The creation of the New and Renewable Energy Authority (NREA) as an affiliated organisation to the ministry responsible for the power sector drifted the main focus of its scope towards the bulk electricity generation applications of renewable energy resources, particularly wind. This situation has led to undermining other high potential RE applications such as solar water heating and biomass. Another barrier is the present role of NREA being involved in policy and decisions making for the RE promotion and in the same time plays the role of projects development along with their operation and maintenance, which may create some conflict of goals.

3.3. Proposed enhancement aspects for existing institutional framework

To overcome the existing institutional barriers that are hindering the promotion of an effective role of RE and RUE activities in the energy supply/demand matrix in Egypt, interdependent institutional developments and market reform legislations have to be undertaken.

The role of the Supreme Council of Energy should be activated in order to formulate an integrated vision towards establishing the national energy strategy on short, medium and long terms perspective. The required strategy should define the role of all stakeholders in the energy supply and consumption matrices. The strategy has to put targets for RE and RUE that are quantifiable, measurable and achievable. The council should also play an active role in the regulatory and legislative framework towards free market development.

The Council has already approved a declared target of supplying 20% from the annual electric energy generation from RE resources by the year 2020. Such target includes12% intended to be mainly from wind farms along Gulf of Suez north of the Red Sea, which will make the total wind power installed capacity reaching about 7200 MW by the year 2020. The remaining 8% will be mainly from existing hydropower in addition to other renewables. The council has also showed its intention to formulate a program to install nuclear power plants in order to diversify the energy resources and to face the potential shortage in conventional resources.

However and in order to realise its objectives for RUE, the Council has to adopt RUE as one of "the existing energy resources" and to create an organisation under its umbrella to refine and put the targets of rational use of energy into implementation on the national level. This new governmental organisation should perform public awareness campaigns accompanied by proper incentives programs adapted to local market conditions. The organisation has to be solely responsible for setting targets, proposing policies and legislations to be approved by the Council, setting plans of action and assigning roles for stakeholders and finally following up achievements and propose necessary modifications in the legislations and implementation mechanisms.

Further details on proposed electricity market reform and new legislations with consequent needed institutional development are discussed in chapter III.

4. CONCLUSION

- The analysis of energy consumption and production for the last 25 years reveals that the average annual consumption growth rate (4.8%) is much higher than the production one (2.8%). This negative trend or gap entails the need for enhancing the contribution of RE in the production side and in the same time reducing the consumption through the RUE measures.
- If the current practice for energy production and consumption continues without any improvement (business as usual scenario), the fossil fuel resources will fall short in satisfying the increasing demand in the short to medium term.
- The energy institutional framework has a fundamental impact on the degree of how adequately addressing energy sustainability which should represent the core of any strategy formulation. Major energy institutional and market reforms would be needed to insure driving Egypt towards an alternative energy scenario based on more sustainable natural resources exploitation, more efficient end-use and hence lower CO_2 emissions.

II. PROSPECTS FOR GHG EMISSION REDUCTIONS IN THE ENERGY SECTOR UNTIL THE YEAR 2015

This part of the chapter discusses the sources of GHG emissions in Egypt and elaborates its historical evolution. It also discusses Egypt's high vulnerability to CC in spite of its current low contribution to global emissions. The current practices to reduce and control CO_2 emissions in the energy sector are also being presented.

As Egypt does not have a declared GHG emission reduction target, the main objective of this part is to estimate a baseline scenario for emissions from the energy sector based on officially declared conventional and wind energy plans and also to suggest an alternative lower carbon scenario until the year 2014/15 through other proposed projects not currently included in existing plans.

1. GHG EMISSIONS IN EGYPT

Estimation of Egypt's GHG inventory has started as early as 1993 using comprehensive inventory for the fiscal year 1990/91. The Initial National Communication (INC) on climate change was issued in 1999 by the Egyptian Environmental Affairs Agency (EEAA) depending on previous reports particularly the Organization for Energy Planning (OEP) study of 1998 "Egypt National Green House Gases Inventory". Since that date OEP issued annual energy reports including emissions from all energy sectors until the year 2004/05 after which OEP ceased to exist and the report stopped to be published.

EEAA is currently working with other concerned Egyptian institutions to issue the Second National Communication in July 2009 including the national GHG inventory, vulnerability consequences as well as an assessment of adaptation and mitigation possibilities to decrease such vulnerability.

1.1. Sources of GHG emissions

The GHG inventory estimated that the total GHG emissions of Egypt in 1990 were equal to 116.608 mtCO2 equivalent using the 1995 Global Warming Potential (GWP) of the IPCC, while the net emissions were equal to 106.708 mtCO2 eq. as GHG sinks represented 9.9 mt. As shown in table 1, the energy sector is the main source of GHG emissions having 71% of total emissions.

Table 1 - Contribution of GHG emissions from Different Sectors for 1990/1991 in Mt CO_2 eq. and as % of total emissions

Sector	Emissions (mtCO_2 eq.)	% of total emissions
All Energy	82.726	71
Industry	10.276	9
Agriculture	17.913	15
Wastes	5.691	5
Total	116.608	100

In the absence of other published data on GHG inventory in Egypt, data were taken from OEP annual reports until 2004/05 when this report stopped. There after data were estimated through personal communications and experts' judgment.

Data revealed that GHG emissions for the year 2006/07 in Egypt are estimated as 235 mtCO2 equivalent out of which about 169 mtCO2 equivalent are originated from all energy usage representing about 72% of total GHG emissions. Based on these figures, during the last two years the emissions from energy sources has increased by about 11% annually compared to an average of 6.5% for the period from 1996/97 to 2004/05, reflecting higher rates of energy consumption and also a possible change in the structure of energy mix towards more polluting fuels, e.g. partial use of heavy fuel oil instead of natural gas, particularly for power generation.

The GHG emissions share originated from the electricity generation related to the total energy emissions has increased from 31.55% for the year 1996/97 to 37.1% for the year of 2006/07 with an average yearly growth rate of this share of about 5.5%.

Table 2 shows the historical evolution of total emissions of the entire energy sector with electricity generation having the highest share followed by the transportation sector and then the industrial sector.

Table 2 - CO_2 equivalent total emissions from energy consumption (in mtCO_2 eq.) and distribution on end-use sectors with relative percentage share of each sector

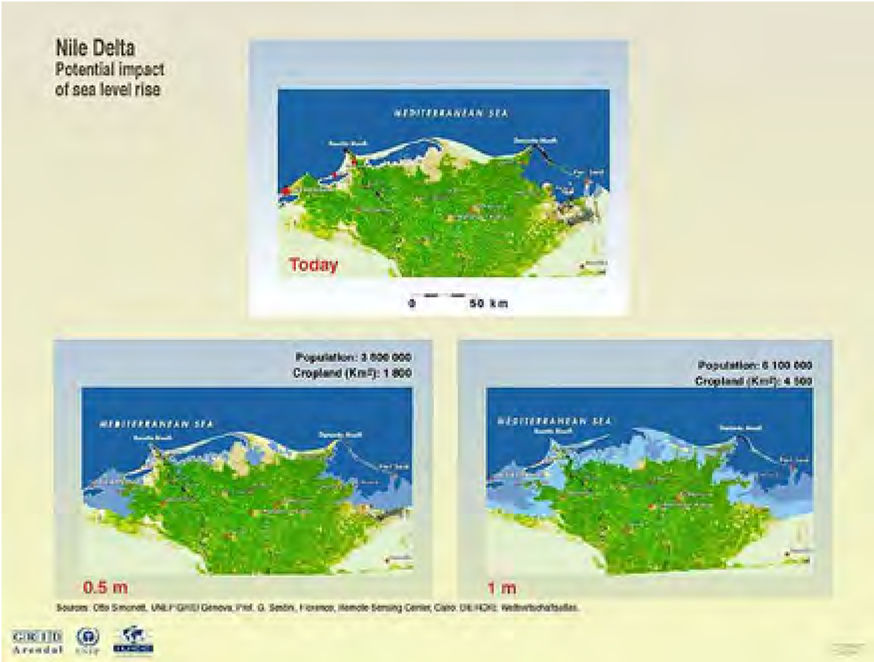
Sector	96/97	97/98	98/99	99/00	00/01	01/02	02/03	03/04	04/05	05/06	06/07
Industry	23.19	25.02	23.71	24.68	26.82	28.36	30.74	30.31	28.04	30.2	33.03
Percentage share (%)	27.19	26.72	24.38	24.08	24.38	25.62	25.99	24.60	20.45	19.97	19.52
Transport	22.24	24.21	26.80	28.39	29.14	28.17	29.04	31.59	35.66	38.80	43.17
Percentage share (%)	26.09	25.84	27.57	27.70	26.50	25.45	24.55	25.63	26.00	25.66	25.51
Agriculture	0.35	0.34	0.33	0.31	0.32	0.28	0.27	0.26	2.37	2.43	2.66
Percentage share (%)	0.41	0.36	0.33	0.30	0.29	0.25	0.23	0.21	1.73	1.61	1.57
Resid & commercial	8.84	9.42	9.94	10.37	10.99	11.25	11.61	11.47	14.29	15.62	17.28
Percentage share (%)	10.37	10.05	10.22	10.12	9.99	10.16	9.82	9.31	10.42	10.33	10.21
Electricity sector	26.90	30.43	31.91	33.71	35.32	35.00	38.22	42.01	48.47	54.89	62.78
Percentage share (%)	31.55	32.49	32.82	32.89	32.12	31.63	32.32	34.09	35.35	36.3	37.1
Petroleum	3.75	4.25	4.54	5.02	7.40	7.62	8.39	7.59	8.28	9.27	10.31
Percentage share (%)	4.40	4.54	4.67	4.90	6.72	6.89	7.09	6.16	6.04	6.13	6.09
Total	85.26	93.66	97.22	102.47	109.98	110.68	118.26	123.22	137.11	151.21	169.21

Source: the Organization for Energy Planning (OEP) and others

1.2. Emissions versus vulnerability

Although Egypt's population represents 1.1% of the world's total and its GHG emissions represent only around 0.5% of total world, the country is highly vulnerable to climate change. Global temperature rise will result in a significant loss of the highly populated agricultural lands in the Nile delta as well as many parts of Egypt's northern Mediterranean coast. The Nile catchments areas are also subject to climate change negative impacts which would affect the already limited surface water resources in Egypt. Food production could be also adversely affected in an area suffering from nutrition deficiency.

Figure 1 - Nile Delta potential impact of sea level rise (SLR)



According to Egypt's Initial National Communication (INC) to the UNFCCC, UNDP Global Human Development Report 2006 and the IPCC Fourth Report, Egypt proves to be highly vulnerable to climate change impacts that may jeopardize Egypt's development gains. Accordingly, climate change threats would inflict serious damage to human settlements, large parts of the productive agricultural lands and industrial areas in the North Coast. Estimates show that 0.5 m Sea Level Rise (SLR) would lead to the permanent submersion of 1,800 km2 of cropland in low lands in the Nile Delta (See figure 1) and increase soil salinity

In the remaining lands. The economic losses are estimated at over US$ 35 billion, including the loss of 30% of the total land area of the Nile Delta , and 195,000 jobs, jeopardizing the food security balance, and relocating more than 2 million people to the already over populated Nile Delta and Valley. SLR would also inflict severe damage on the large investments in summer resorts along the North West Coast. Climate Change could also cause significant variation in Nile stream flow, which provides Egypt with more than 97% of its renewable water resources. Available hydrological models have predicted an increase of 30% or a decrease that can reach 70% in the annual Nile flow. These two scenarios can have serious implications in terms of increased flood risks or droughts that could lead to cultivated lands shrinking associated with decrease in food production. In recognition of the above-mentioned challenges, the government of Egypt (GOE) through its relevant authorities has revealed its needs to formulate different initiatives to address these climate change challenges.

The same threats are also confirmed by a World Bank Policy Research Working Paper which has been issued in February 2007 and it was entitled "The Impact of Sea Level Rise on Developing Countries: A Comparative Analysis". This comparative analysis has covered 84 developing countries and concluded that severe impacts are limited to a relatively small number of countries among which is Egypt.

2. CURRENT PRACTICE OF GHG EMISSIONS CONTROL AND REDUCTION IN THE ENERGY SECTOR

Egypt is currently a minor petroleum (mainly natural gas) exporter but will become a net importer (for mainly oil) in the near future. Hence there is a national drive to become a more energy efficient economy and to make greater use of Egypt's large RE potential. This will have the added benefit of putting the country on a less CO_2 intensive development path. Nevertheless, the energy price subsidies are currently constraining investment in RE and RUE resulting in limited GHG reduction outcomes in the energy sector.

2.1. Emission control/reduction in electricity sector

2.1.1. Direct measures in the electricity supply side

Since the early 90s, the Egyptian electricity sector adopted fuel switching strategy from heavy fuel oil to natural gas. The natural gas ratio to total fuel used in the power generation sector has grown rapidly to reach a peak of 91% for the year 2001/02 and then this trend started to reverse since natural gas share decreased to reach 79% by 2006/2007. This fuel switching has decreased dramatically the GHG and other emissions that were supposed to be generated if new added power plants had been fuelled by fuel oil.

Other measures taken to control/reduce the emissions in the electricity sector in the generation side are:

1) Improve transmission and distribution network losses expected to have resulted in emissions reductions of about 1.4 $mtCO_2eq$.
2) Monitor emissions from new power plants to cope with the requirements of lending agencies.
3) Improve the efficiency of old power plants through rehabilitation programs including emissions monitoring.
4) Prepare Environmental Impact Assessment (EIA) for new projects to ensure that all new projects are adhering to related environmental laws.
5) Increase the use of RE electricity generation particularly from wind energy along Gulf of Suez which represents an important practice, as in 2006 the annual wind electricity generation reached about 636 GWh representing about 0.56 % of the total annual electricity generation and resulting in GHG emissions reduction of about 0.35 $mtCO_2eq$.

2.1.2. Indirect measures through electricity demand side management

All actions taken by end users to improve the efficiency of their energy consumption lead to reducing this consumption hence decreasing GHG emissions.

Different actions have been considered in the demand side management as follows:

1) Power factor improvement at end users level.
2) Load shifting of industrial end users.

3) Encouraging local manufacturing of Compact Fluorescent Lamps (CFLs) and electronic ballasts.
4) Selling efficient lighting equipment such as CFLs through some Electricity Distribution Companies where its cost can either be paid on cash or added in instalments to be paid with the electricity bill.
5) Issuing energy labels for appliances.
6) Issuing of buildings energy codes.

2.2. Emission control/reduction in petroleum secto

2.2.1. Direct measures in the petroleum supply side

Gas flaring reduction prevents wasting a valuable resource and considered an important measure for energy saving and climate change mitigation through contributing to reduce global warming. Consequently the ministry of petroleum is now implementing a program to capture and use the flared gases. This is being implemented as an effort not only to reduce global carbon emissions, hence contribute to CC mitigation, but also to conserve a valuable resource. Different studies based on satellite observations during the period from 1995 to 2006 indicated that Egypt has decreased gas flaring.

The Ministry of Petroleum has also implemented a program to improve efficiencies in the refineries. Different environmental management programs are also established in oil companies as well as oil refineries to ensure that environmental standards are met.

2.2.2. Indirect measures in the petroleum demand side

Presently, the ministry of petroleum is implementing several programs in the field of fuel switching to use natural gas, among which the following are the most significant:

1) Expand the use of natural gas in the residential, commercial and industrial sectors as follows:

- During the period from 1980/1981 – 2004/2005 the gas network expanded to cover 18 governorates in Egypt where 2.1 million customers have been connected to gas supply network among which about one million have been supplied during 2000/2001-2004/2005. The overall figure reached 2.3 million in 2005/2006.
- The ministry of petroleum plan targets to connect 6 million residential units to the gas network during the coming six years.
- The plan includes connecting new industrial zones as well as the main cities of Upper Egypt.
- The investments of gas national plan are estimated to reach about US$ 5.5 billion by 2019/ 2020.

2) Encouraging the Use of Natural Gas in Vehicles as follows:

- The natural gas to be used for transportation has been priced at 0.45 L.E/m3 equivalent to about 50% of the price of one liter of gasoline 80 octane, and to about 35% of that of gasoline 90 octane (one m^3 of gas is estimated to accommodate the same kilometric distance as that of one liter of gasoline). This low tariff allows a pay back period of less than 2 years (particularly for taxi owners) against transformation cost of 5000 LE to work in a dual mode (gas/gasoline).

- The quantity of vehicles transformed to operate through dual fuel supply gasoline/natural gas reached about 70 000 cars until 1/7/2006 among which 75 % are taxis. The number of gas supply stations reached 103 stations distributed in the whole country.

3) Gas Conversion Program (GCP)

- The program targets to promote the transformation to use natural gas as a substitute for heavy and light fuel oils through supporting the cost of such transformation in both the industrial and commercial sectors through several measures and incentives including:
- Decreasing the interest of loans financing the targeted conversion by a maximum of 10 % of the prevailing interest rate where the customer will bear the rest of interest plus the original loan amount.
- Estimate a certain amount of money for each ton of liquid oil to be substituted by natural gas to be paid to the customer upon completing the conversion process.

2.3. Baseline CC mitigation scenario in the energy sector until 2015

Egypt has signed and ratified the UNFCCC Convention and the Kyoto Protocol as a non-Annex I Party not bound by specific targets for GHG emission reductions. However, the high degree of vulnerability of Egypt to climate change raised the awareness in the country towards integrating CC mitigation and adaptation objectives into different development strategies.

Consequently, during the recent years, the Government has declared its intention to promote the RUE and RE through the establishment of the Supreme Energy Council headed by the Prime Minister. This Council aims to revise national energy policies including energy efficiency measures, propose incentives for renewable energy, enhance private sector investment in energy services and revise energy prices for large industrial facilities and other end-users. Continuing these efforts should help the Government better manage its sustainable energy development and environmental challenges, among which the GHG emissions control is being taken into consideration.

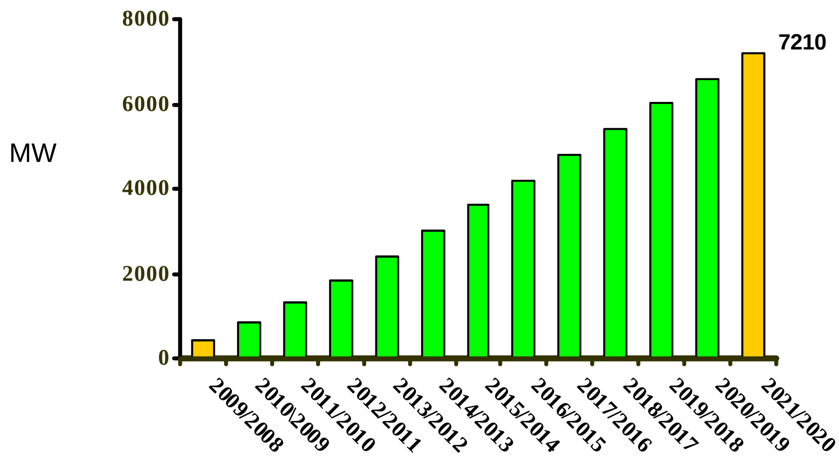
We should keep in mind that Egypt's high vulnerability to climate change coupled with its relatively historical low contribution to the global GHG emissions both per capita and in absolute value, lead the country to devote more efforts and attention to potential adaptation measures rather than mitigation measures. This would explain why there are no declared quantifiable CC mitigation targets or an existing alternative low carbon energy scenario.

It should be mentioned that Egypt is performing different activities with a main objective to contribute to improvement of air quality in the country. However, many of these activities can be seen also as GHG mitigation/ reduction actions though not purposely designed for such.

For the purpose of this study the baseline or (business as usual) scenario will be estimated based on historical data for GHG emissions. In addition, as there is no declared quantifiable CC mitigation target for the baseline scenario, this study will also include in this estimated baseline scenario expected emission reductions based on existing official plan for wind power generation until the year 2014/15 as it will be discussed in the next item.

2.3.1. Wind power action plan

Figure 2 - Accumulated installed wind capacity planned until 2020/21



The preliminary wind energy long term action plan was elaborated by NREA during January 2008. By 2020/21, the plan targets to install a total of 7210 MW installed capacity of wind power plants. After their installation they are expected to generate about 31 billion KWh annually where the expected amount of corresponding GHG emission annual reductions is about 17 mtCO_2eq.

Figure 2, shows the accumulated planned installed wind capacity until 2020/21. It can be seen that the targeted accumulated installed capacity by the year 2014/15 is 3600 MW.

Currently there are 600 MW already operational in addition to those which are under construction. To satisfy the ambitious target of this plan up to the year 2014/15, 3000 MW of new additional wind farms installation has to be developed during 7 years with an average rate of about 430 MW/year either by NREA or by private investors.

The area, which is assigned for wind farms to be implemented during the coming years, located in Gabal El-Zeit (Gulf of Suez) has exceptional conditions for wind energy being an attracting factor for investors. However, as market and institutional reforms that would encourage the involvement of private investments are still not being materialised as it will be explained later, this targeted 3000 MW will be hard to be achieved. We would suggest that only 2200 MW (about 300 MW/year) of additional new wind farms is achievable by both NREA and the private sector until the year 2014/15.

This suggested achievable added installed capacity of 2200 MW, in addition to the present 600 MW which is either operational or under construction, would make a target of 2800 MW total accumulated installed capacity by 2014/15. The difference between the original declared plan objective of 3600 MW and the 2800 MW achievable target proposed by this study; evaluated as 800 MW of wind power in addition to other proposed projects will represent the backbone of our proposed alternative scenario as it will be developed in the following items.

2.3.2. Estimate of baseline GHG emissions from energy sector

The baseline emissions scenario is derived from the previous status that was having a very little wind energy contribution. According to the available historical data from 1990/91 to 2006/07, total GHG emissions for year 1990/91 were 116.6 mtCO_2eq and then increased to reach 235 mtCO_2eq for the year 2006/07. This annual historical data has been used to estimate the total emissions until 2014/15 supposing no additional wind farms will be installed. To include the achievable 2200 MW (mentioned in item 2-3.1) of wind into the baseline (business as usual) scenario, the estimated emission reductions that will result from the wind farms have been deducted from the previous values not considering the wind power additions. According to this "calculation protocol", the baseline GHG emissions from the energy sector by the year 2014/15 will reach 250 mtCO_2eq while the total GHG emissions on the national level are expected to reach 343 mtCO_2eq. We note that the percentage ratio of the energy emissions to the total has almost maintained its value as it varied only from 71% to 73%.

Figure 3 - evolution of total GHG emissions and energy related emission until 2014/15

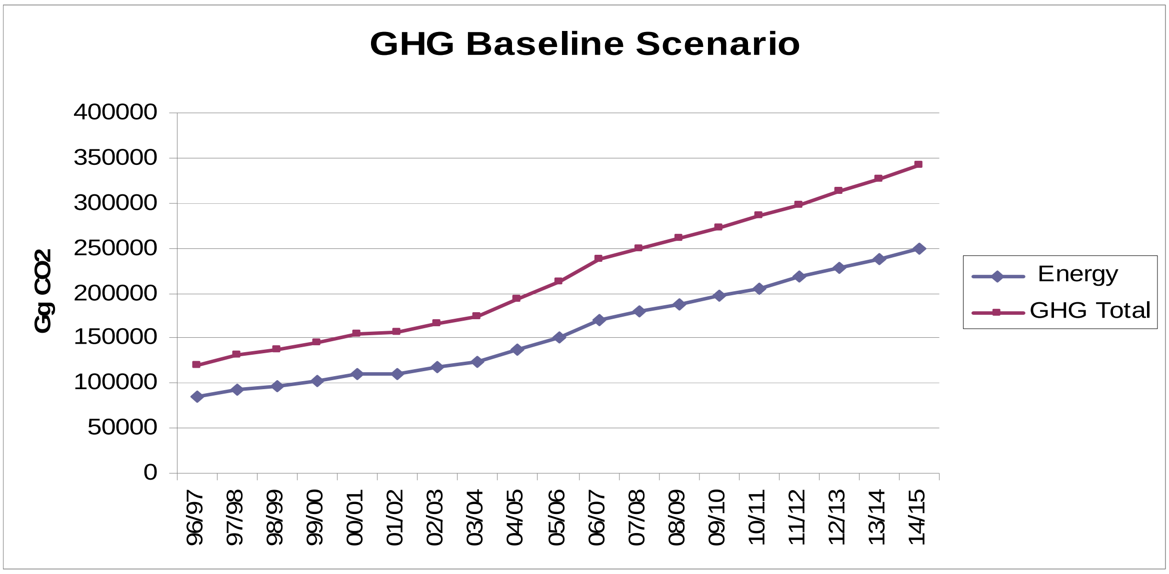


Figure 3 shows the evolution of historical total and energy GHG emissions until 2006/07 as well as the forecasted baseline emissions until 2014/15 evaluated according to the above mentioned assumptions.

2.4. Towards an alternative lower carbon scenario for the energy sector

As indicated above, Egypt, being a developing country, does not have a declared target for GHG emissions reduction. Developing countries standpoint is that it would not be fair to burden them with the economic cost as well as other consequences of CC mitigation measures and procedures in view of their low share in present and historical accumulated GHG level. The plea of India for example, is that each country should be entitled to an equal per capita share in GHG emissions. This conception has widely sounded among other developing countries during international UNFCCC conferences.

The developers of the Egyptian Second National Communication planned to be issued in 2009, are not going to set any targets for GHG emissions reduction; however they shall develop a list of proposed projects to be implemented under the condition of availability of necessary funds where CDM projects will have an important weight in such a list.

Nevertheless, if present energy trends (or business-as-usual scenario) continue in Egypt in the future, particularly the growing dependence on fossil fuels along with inadequate attention to promoting RUE and RE, then not only future national energy security will be jeopardized but also the whole national sustainable development prospects. The cost of continuing with the said business-as-usual scenario is expected to be considerably high particularly if the country will be, most probably, obliged to import a part of the needed fossil fuels at the currently astounding international prices. This cost should be added to the environmental damage cost resulting from the increased GHG emissions due to burning such imported fossil fuels. These emissions which are expected to be relatively important in the future will also contribute to worsen the country vulnerability that is already high.

It is recommended that policy makers would take into account such consequences, and formulate from now an alternative low carbon energy scenario adopting much greater use of RUE and RE in order to overweigh such high expected costs in the future. The benefits of such an alternative scenario would include:

1) Increasing energy sustainability due to conserving fossil fuel resources as a strategic reserve for future generations.
2) Securing the energy supply for short, medium and long term national sustainable development plans.
3) Adopting new technologies of RUE and RE that are having growing economic advantages and enhancement of local manufacturing of systems and components required by these technologic.
4) Creating social benefits such as improving quality of life and creating new jobs.
5) Protecting the environment from serious pollutants associated with fossil fuel burning.
6) Finally, avoidance/decrease or at least delay the need for expensive fossil fuel imports.

For the purpose of our study and as we have already estimated a baseline GHG emissions scenario from the energy sector, we shall be proposing a "package" of RE and RUE projects that would result in additional reductions of GHG energy related emissions by 2014/15. These proposed additional projects in additional to those that are being considered under the baseline scenario are assumed to direct the energy sector towards a lower emission scenario of less GHG emissions compared to the baseline one.

2.4.1. Additional proposed projects that would lead to the alternative scenario

In addition to all the projects included under the baseline scenario, a "package of some other RE and RUE additional projects is proposed to be considered in order to convert the baseline scenario into an alternative one having lesser emissions from the energy sector.

These additional projects that are suggested to be installed until the year 2014/15 are as follows:

- Four wind farms for power generation in Gabal El-Zeit area each of 200 MW capacity making a total of 800 MW representing the remaining target of the official plan not included in the baseline scenario, as discussed in item 2-3.1. After their completion by the year 2014/15, these 4 wind farms are expected to further reduce the GHG emissions from the energy sector by 1.9 $mtCO_2eq$ during the same year.
- A program to install solar water heaters in Egypt of a total collector's area of 500000 m2 could be implemented between 2010 and 2015. This project is proposed to be realized through a Solar Water Heating Initiative (SWHI) covering the whole country. Each square meter of solar collectors would result in 0.5 ton of emission reduction per year. This would lead to a GHG emission reduction from additional installed solar water heaters by 0.25 $mtCO_2$ eq. during the year 2014/15.

- Similar to the SWHI, an Egyptian Efficient Lighting Initiative (EELI) has to be formulated and implemented. Through this initiative a project for lighting market transformation towards CFLs taking into consideration (disposal of burnt lamps) and targeting the utilization of additional 40 millions lamps during the period 2010 to 2015 will result in additional GHG reduction of about 2.0 mtCO_2 eq during the year 2014/15.

The total emission reduction expected by the year 2014/15 from the proposed projects is 4.15 mtCO_2eq representing 1.25% of total baseline emissions and 1.7% of baseline energy related emissions for the same year. This 1.7% emissions reduction share is resulting from the saving of burning fossil fuels of 1.56 mtoe during the said year.

These estimated reductions will result in a lower value of emissions for the year 2014/15 of 245.85 mtCO_2eq representing a better alternative scenario rather than the baseline one of 250 mtCO_2eq emissions from the energy sector during the same year.

Based on the assumption that all implementation activities for the proposed additional projects would start on 2009/10 and will be finalized on 2013/14, the emission reduction resulting from these projects is supposed to grow annually by 20% starting from 2010/11 to reach its full amount after the completion of all installations by 2014/15. The total emission reduction during the period from 2009/10 to 2014/15 is estimated to be 12.5 mtCO_2eq and the total expected emission reduction during the life time of the equipment is estimated at 80 mtCO_2eq.

2.4.2. Other prospective for alternative scenarios aiming at reducing energy emissions

It is important to point out that, the potential of reducing the emission reduction values of the baseline scenario in the Egyptian energy sector through RE and RUE is much higher than this proposed figure. If, for instance, a RUE strategy to improve the energy intensity by only 1% each year will be formulated and implemented by a dedicated agency starting from 2010, an additional emission reduction rate of 5% can be reached by 2014/15 representing an added 12.5 mtCO_2eq. and avoiding the burning of 4.6 mtoe. This option needs more elaboration as it seems to have good results on both fuel saving and emission reduction as well as a better cost to benefit ratio.

2.5. Conclusion

- Despite Egypt's minor contribution on global warming, climate change and its associated effects are likely to aggravate the current environmental challenges as the country proves to be highly vulnerable to CC impacts that may jeopardize many development gains.
- The energy sector contributes by more than 71% of total GHG emissions and will continue to be the major source of these emissions. If the existing practices will continue, emissions from energy sources will continue to increase and Egypt will become one of the major emitters in the region by 2025.
- Based on planned and proposed RE and RUE activities in the energy sector, an estimated baseline scenario was developed and also an alternative lower carbon energy scenario was

elaborated to reduce CO_2 emissions by 4.15 mtCO_2eq from the baseline value of 250 mtCO_2eq and saving 1.56 mtoe out of total consumption of 91.5 mtoe during the year 2014/15.

- Another reliable option that would merit more elaboration (outside the scope of this study) is to formulate and implement a RUE strategy aiming at improving energy intensity by only 1% each year starting from 2010. This would add emission reduction rate of 5% by 2014/15 representing 12.15 mtCO_2eq and avoiding the burning of 4.6 mtoe.

III. REFORM POLICIES AND ACTION PLANS PROPOSED TO ACHIEVE LOWER CO_2 EMISSIONS IN THE ENERGY SECTOR

It would be comprehensible that Egypt is more concerned by enhancing its energy security in the future rather than achieving an alternative energy scenario that is less CO_2 emitter. But fortunately, all the considered options to increase its energy production are less CO_2 emitters as they include more natural gas dependence, more use of RE and RUE in addition to the nuclear option.

This part of the chapter concentrates on presenting the role of RE and RUE in the formulation of an alternative low carbon energy scenario for the coming years until 2014/15. This alternative energy scenario is being proposed within the framework of this study based on the findings of the analysis of lessons learnt from previous practices together with other legislations and market reforms proposed by the government and still not ratified.

To complete the features of the proposed alternative scenario including its quantitative targets, this study has moreover formulated additional policy measures required to complement those originally planned by the government as they were not initially anticipated for this purpose.

The presence of a regulatory agency in the electricity sector is the prime mover behind drafting most of the new legislations and electricity market reform measures that are currently under discussion. The lack of the presence of a similar agency in the petroleum sector explains the fact that this sector is far behind the electricity one in this regard.

1. REVIEW OF THE ROLE OF RE AND RUE IN EGYPT'S CC MITIGATION EFFORTS

Climate change mitigation is an inherent result of all RE and RUE implemented and planned projects. Hence, the following discussion addressing RE and RUE in Egypt implies in the same time a discussion on CC mitigation policies and action plans.

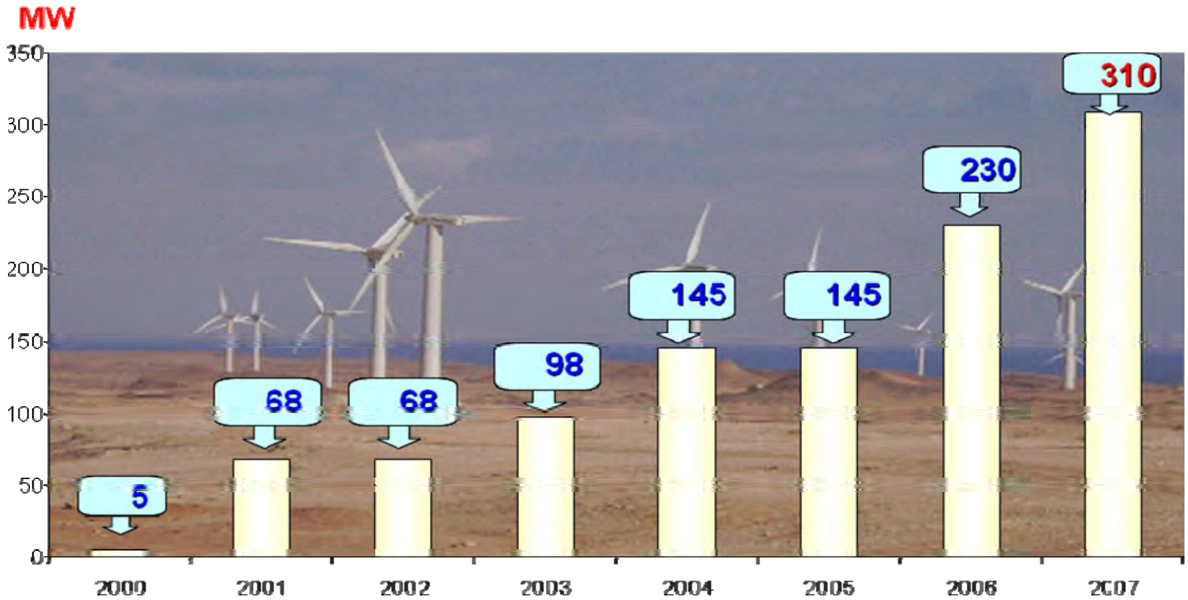
1.1. Historical review of renewable energy activities

Although Egypt enjoys a considerable solar potential being located within the sun built countries, wind energy has attracted by far more attention reflected in future plans. This can be attributed to the impact of the tremendous worldwide technology development and economic maturity as well as the very favourable wind potential in some locations in the country; mainly Gulf of Suez. Another reason could be attributed to the willingness of the fund raisers and donors in the countries of advanced wind industry to get involved in such projects in Egypt, for the benefit of both sides.

1.1.1. L'éolien

Figure 4 shows the historical evolution of installed wind power plants capacity that has reached 310 MW

Figure 4 - Evolution of installed wind power capacity until 2007



by the end of 2007, resulting in an estimated GHG emissions reduction of more than 0.5 $mtCO_2eq$ annually. The said installed capacity is less than the previously declared objective of 430 MW by the same year that was slightly delayed due to the shortage of wind turbines in the world market as a result of the rapid increase of international demand and consequent reservation of wind turbines production for several years.

1.1.2. Solar

Historically, solar thermal energy activities have been concentrated in the field of domestic solar water heating and have started as early as 1979. However, there has been a limited achievement in this area reflected in the implementation of an estimated total accumulated number of about 250000 installed systems (typical system: 2 m2 of collectors and 150 litres storage tank) by 2007 resulting in GHG emissions reduction of about 0.25 $mtCO_2eq$ annually. The installed solar water heating systems represent only 5% of the national potential market evaluated at more than 5 million. This limited achievement is attributed mainly to the heavy energy subsidy and the absence of a dedicated institutional structure that could set targets and in the same time manage and coordinate necessary roles and actions required from all stakeholders to achieve these targets. The existing RE organisation, NREA, being under the ministry of electricity, is oriented mainly towards the bulk electricity generation projects rather than distributed small applications. In line with this trend, NREA has signed recently in February 2008 a contract for the installation of about 155 MW nominal installed capacity of integrated solar combined cycle power plant including about 20 MW nominal capacity solar field having a solar fraction of about 4% representing the contribution to the overall plant's yearly total electric energy generation and expected to result in GHG emissions reduction of about 27.5 $KtCO_2eq$ annually.

In the same time PV activities were rather limited to small applications in remote areas that are not connected to the unified power network which presently supplies electricity to almost 98.5% of Egypt's population. The total installed capacity of PV applications reached about 5.6 MW peak by the end of 2007, resulting in an annual emissions reduction of 7 KtCO_2eq.

1.1.3. Others

Most of Hydropower resources in Egypt have been so far exploited as the total installed capacity reached 2783 MW by 2007 with a limited expansion capacity for mini and micro-hydropower installations.

The biomass potential (mainly agricultural residuals, animal dung, sewage and municipal solid wastes) in Egypt is estimated to be about 16 mtoe annually out of which 5 mtoe are poorly exploited for energy purposes mainly due to the lack of appropriate technologies and market support as well as the absence of adequate institutional structure that should perform necessary planning and coordinate between the related diversified stakeholders, e.g. Ministry of Agricultural, Ministry of Electricity and Energy, Municipalities, Local Authorities and the Industry.

For the purpose of this study, emission reduction from hydropower and biomass is not being taken into consideration.

1.2. Historical review of energy efficiency activities

Many national and international studies has indicated that the present practice in the energy supply/demand matrix particularly the latter, in Egypt is not satisfactory or even poor from the point of view of energy efficiency. This has mainly led to a growth rate of electricity demand that surpassed the economic and population growth rates. Accordingly, this poor efficiency is translated to a very high potential for the RUE measures and applications to be implemented particularly in the demand side on the end-users' level. This specific feature that the massive RUE activities are dispersed and attached to the motivation of end-users and mostly required to be implemented in their premises, represents one of the major obstacles towards reaching considerable achievements. The power sector prevailing experience remains considerably centralized and not well adapted to such kind of business (except in cases of connecting to the supply grids and electricity billing) that requires stimulating interaction with a wide spectrum of end users.

From another side, the hazy awareness of the sustainability concerns of energy availability in Egypt coupled with the lack of positive interactive business culture of all implementing agencies of prior activities to mobilise and involve energy end-users, would be added to other existing constraints.

1.2.1. Supply side

The electricity sector has performed many activities to improve energy efficiency in the supply side such as:

- Rehabilitation of old power plants.
- Fuel switching from oil based fuels to natural gas.
- Working on loss reduction in transmission and distribution network which has led to a fuel saving of about 0.5 mtoe that reduced GHG emissions by about 1.4 mtCO_2eq.

From another side, the oil sector has mainly worked in the field of gas flaring reduction and refineries efficiency improvements. There are neither published GHG emission data, nor available information on petroleum products or natural gas transmission and distribution losses.

1.2.2. Demand side

During the last three decades different RUE activities have been implemented. A considerable part of these activities were proposed and carried out mainly through the financial support of international donors and some United Nations agencies. A rough estimate of US$ 200 millions has been directly or indirectly invested in different fields of RUE applications.

A previous effort to develop a National Energy Efficiency Strategy (NEES) was exerted in the year 2000 as part of the Egyptian Environmental Policy Program (EEPP) to be jointly implemented by the Egyptian Environmental Affairs Agency (EEAA) in cooperation with all concerned stakeholders. However, the lack of political will and support of energy related governmental bodies have led to the bereavement of the targeted benefits of such an effort. Again, this is not a fate; as if there had been an institution responsible to create such a strategy and to follow up its implementation; outcomes would have been totally different.

For more details about energy efficiency demand side implemented activities, one can refer to the previous report of "Egypt National Study".

Three important remarks have to be noticed:

7) 1. The above mentioned RUE activities were typically proposed by the fund raisers and were not necessarily performed in an integral way based on an incorporated national vision or plan of action. This has led to minor impacts on technical and business practices in the local market and on raising awareness among stakeholders particularly among policy makers.

8) 2. Due to the fact that the implementing agencies of previous RUE activities were dispersed inside and outside the energy sector, all presumably targeted accumulation of knowledge and experience were not effectively reflected in proposing future policies or action plans.

9) 3. In spite of official declarations of being committed to the RUE, no national institution is assigned to perform these commitments with corresponding plan of action and funds allocation. However, the newly founded supreme council of energy should presumably play a key role in that direction.

1.3. Lessons learned and the identification of required policies

1) The government has to declare clearly without any ambiguity the relatively critical situation of the availability and sustainability of energy resources in the country and the risk of being a net importer of oil and natural gas in the short and medium terms respectively. The present perception of the stakeholders and the general public assume that Egypt has abundant energy resources with a surplus for export even on the long term. Also, negative climate change implications of continuing with present fossil fuel practices are not properly addressed at different national levels; an issue that should be handled adequately.

2) Without both the stakeholders and the population's full awareness of the size and danger of such existing real challenge that is facing the present and future generations, not only in terms of energy sustainability but also in terms of climate change negative consequences, the

mobilisation of the whole country towards an efficient and rational energy economy hence a low carbon energy scenario, will be seriously jeopardised.

3) The role of the supreme council of energy should be promoted, supported and activated as elaborated else where in this report.

4) The energy subsidy issue should be tackled and handled as soon as possible through adopting a balanced approach between indispensable need for subsidy diminishing weight which would normally be associated with some negative impacts in the short term, particularly social ones, and the need to mitigate such negative impacts through adequate economic and financial means, e.g. liquid subsidies to the poor and those most adversely affected. However, awareness campaigns about the long term potential benefits of subsidy decrease to the national economy and hence the general public would prove to be valuable and effective to accommodate short term possible negative impacts.

5) It has become almost imperative to develop the present energy regulatory framework and introduce new legislation in favour of both RUE and RE to support and promote their wide spread utilization as well as to diffuse their technologies in relevant applications. New legislation should be accompanied by competent measures fostering creation of investment enabling economic environment to ensure the best success opportunities for RE & RUE spreading.

6) Far more attention and consideration should be given to promising RE applications and technologies other than bulk electricity generation, either through NREA or any other organization to be decided by the supreme council of energy.

7) It has become of critical need to create a national agency dedicated to RUE that should be responsible to develop a national strategy, set priorities and quantifiable targets, suggest relevant plans of action, propose related legislations and formulate national initiatives and programs. This agency should define the role of each party of stakeholders, support financial incentives availability, cooperate with international organizations and fund raisers, monitor achievements as well as modify and update its activities based on feed back. The proposed RUE agency would also address distributed or the non-centralized RE applications.

8) It is of critical importance to promote local manufacture of RUE and RE equipment in Egypt. A program to support partial manufacture for some components of wind energy systems in Egypt started in 2000 where prototypes of wind towers and blades were manufactured. This activity was stopped since the fast rate of technology development at that time particularly towards larger sizes of wind turbines has quickly made obsolete the types and sizes selected for local manufacture.

9) In view of the rapid increase in RE and wind equipment prices in last few years, the ambitious wind action plan realization can not continue on depending to a great extent on imported equipment, which is the present practice, otherwise the wind plan implementation could be seriously jeopardized. Different local manufacturing proposed schemes should be considered and addressed seriously. Local manufacture has to be viewed from a regional dimension to take advantage of economy of scale. It can take the form of joint ventures, under license or as branches of international companies with special agreements guaranteeing, among others, technological development support to avoid obsolescence improper timing.

10) It becomes imperative to facilitate the founding of strong RE and RUE service providers in the local market including consulting firms, equipment manufacturers and/or suppliers, installers, after sales service providers, and maintenance contractors. Adequate standards have to be developed and applied to insure a high quality for equipment and services to be made available in the local market.

11) It becomes also necessary to foster the creation of civic advocacy groups and think tanks that can develop independent studies and assessments of the apparently critical energy situation in Egypt and address the need for a more sustainable energy efficient economy coupled with lower GHG emissions by incorporating all possible forms of RE and RUE technologies. These think tanks are also supposed to popularize the concept of cost effectiveness of most of RUE and many RE technologies from the societal perspective. These civic society efforts are essential to create a national momentum and conscience among policy makers and consumers to consider RE and RUE in their plans.

12) It will be essential to promote the concept of forming energy end-users' associations and groups that should facilitate the contribution of energy end-users in proposing adequate RE and RUE policies and supporting mechanisms, the exchange of experience among energy end-users on the national, regional and international levels and the formulation of sizable projects through grouping of individual participants in order to benefit of available financing support mechanisms such as CDM and others.

2. PROPOSED LEGISLATION AND MARKET REFORM MEASURES TO ENHANCE THE ROLE OF RE AND RUE

The Egyptian government decided to start energy market reforms of the electricity sector through new legislations represented in the new proposed Electricity law sent to the Egyptian parliament for approval and ratification since the end of 2007. Important remarks on the background behind this decision and on the present status of the law can be summarized as follows:

- Since its inception in 2000, the Egyptian Electricity Utilities and Consumer Protection Regulatory Agency (ERA) has been deeply concerned with electricity market conditions and the possible need for its development. During 2003, actual studies started by ERA, with the assistance of an American consultant and the financial support of USAID, for addressing alternatives of potentially feasible electricity market reforms. Studies also addressed the corresponding legislative and regulatory frameworks required for implementing such reforms with a main goal of developing a free electricity market along with the creation of an enabling environment for encouraging private investments in that market.
- We shall be presenting the proposed reform plan of the electricity market, the new proposed electricity law and measures adopted by the law for the support of both RE and RUE as well as relevant action plans proposed for each, if any. The ERA played a key role in that effort, supported by the foreign consultant, particularly in formulating the proposed law and market reform overall plan in coordination with the Ministry of Electricity and Energy affiliated companies and authorities who in turn developed the proposed action plans.
- We should note that the new electricity law and the market reform plans are still proposed and not yet approved neither ratified by the Egyptian Parliament, but this process is expected to take place during this year 2008.
- The proposed electricity law establishes a general framework, nevertheless, elaborated action plans including proposed financing mechanisms as well as time schedules remain necessary to be developed. Accordingly, some additional proposed measures, action plans and institutional reforms will be presented during the course of this study.

We should stress the issue that the existence of the ERA for the electricity sector was the main reason for developing such proposed legislation and market reforms which is so far unrealized for the petroleum sector, in spite of its necessity, where this sector still lacks a similar regulatory agency.

2.1. Rationale behind proposed electricity market reform

Since more than 15 years, the Egyptian government has had concerns about the negative impact of petroleum products and electric tariff's subsidies on the whole economy. In 29/1/2003 the government has taken a decision to float the Egyptian pound in an important step to liberalize the local market. The immediate result was a serious and recurrent devaluation of the Egyptian pound to almost 50% of its original value. Such devaluation resulted in two main implications in the local energy market as follows:

1) A decision has been taken by the government to stop implementing any further power stations according to BOOT (Build, Own, Operate & Transfer) scheme due to the following:
   a) The government was obliged contractually to supply such BOOT stations with natural gas at the same old prices; otherwise the purchase price of the KWh from these stations should be adjusted accordingly.
   b) The electricity tariff to local consumers was kept the same, entailing that the sever burden of the pound devaluation should be borne by the state budget due to purchasing the KWh from BOOT stations in US$ and selling it locally to the end users in Egyptian pound, without any adjustment for the tariff.
2) The natural gas (NG) price paid by power stations in L.E was kept without revision, similar to the electricity tariff, entailing a real actual decrease of N.G price from 1.05 to 0.7 US $/MBTU (MBTU: Million British Thermal Units), while the net back value of NG was estimated to be 1.5 US $/MBTU (natural gas market price in Europe at that time minus shipping and transportation costs, minus liquefaction costs, minus local transmission costs to the well head plus transportation costs to consuming thermal power stations). It should be noted that the NG netback value represents the opportunity cost or the potential revenues for Egypt being a NG exporter.

The abovementioned issues together with the recurrent sharp oil and N.G price increases in the international market made the government opt to take the decision of gradually alleviating energy subsidies and of restructuring the electricity market legislative framework along with implementing necessary reforms. Such effort resulted in finalizing the draft of the New Electricity Law by late 2007 and sending it to the Parliament for revision and approval during this year 2008.

2.2. Proposed reform plan of the electricity market

The objective of the electricity market reform is to establish a fully competitive electricity market, where electricity generation, transmission and distribution activities are fully unbundled. The proposed market will adopt bilateral contracts with a balancing and settlement mechanism.

The proposed reform plan of the electricity sector includes the arrangement of two distinct but interrelated market structures; the regulated market and the competitive market, along with a proposed approach of two stages for transition between the two, where such arrangement was developed by the ERA. The approach implies the shrinking of the regulated market in favor of the competitive market across the time, however, no time frame has been specified yet for such transition process.

The rationale behind such arrangement of the two distinct interrelated markets is that the transition to competitive market should overcome and accommodate two major constraints of; i) the present tariff is still less than the economic cost of service and, ii) the need to establish an attractive environment for investors.

Main targets of the electricity market reform are:

1) Attract funds able to meet the growing electric demand related to Egypt's development plans.
2) Improve the electricity sector efficiency and performance.
3) Achieve wider economic benefits particularly reaching a tariff reflecting actual cost of service.
4) Tackle the subsidy problems in a gradual balanced approach that considers social burdens.
5) Promote the role of RUE and RE within the electricity market.
6) Prepare for integration to the regional (including the Mediterranean) electricity grids through modernization of the electricity market.

More details concerning electricity market reform are given in annex A.

2.3. Proposed new electricity law

The proposed electricity low is developed by the government to provide the legislative and regulatory frameworks needed to realize the electricity market reform targets and further supports the creation of a favorable economic environment for private investments.

2.3.1. Main features of the low

- Establishment of competitive electricity market which is based on bilateral contracts and adoption of the concept of eligible customers.
- Third Party Access (TPA).
- Establishment of Transmission System Operator (TSO) and provide assurances for its independence and full unbundling from other sector participants.
- Tariffs are ratified by the regulatory agency
- Supporting renewable energies, cogeneration and power generated from secondary resources.
- Supporting energy efficiency and demand side management.
- Matching worldwide legislation to facilitate integrating the national network to the regional and Mediterranean networks through progressive interconnections
- Protecting both the consumer and the electrical industry interests.
- Providing for attractive environment for private investments.

2.3.2. Overview of contents and main parts of the law

The law consists of ten parts covers 85 articles including:

1) General Provisions
2) Definitions
3) Electric Utility and Customer Protection Regulatory Agency
4) Licensing
5) Electricity sector and security of supply; generation transmission system operator, distribution, trading and consumers
6) Renewable energies and energy efficiency.
7) Electricity facilities
8) Whole sale and services
9) Penalties
10) Final Provisionss

3. PROPOSED MEASURES TO IMPLEMENT MARKET REFORM

The proposed electricity law formulated by the ERA contains a general outline of policy measures to be adopted in favor of both RUE and RE utilization. This law should enable developing more elaborate action plans to promote the use of RUE and RE on both the short and long terms. However, owing to the existence of NREA as an institution responsible for RE promotion, unlike RUE, the RE action plans, basically for wind, have been significantly more elaborated with specific quantifiable short and medium term targets.

3.1. Measures to be adopted for RE

As earlier indicated, the supreme council of energy in Egypt has adopted a resolution that calls for satisfying 20% of electric energy needs from RE, including hydro, by 2020, out of which 12% will be from wind energy. In line with this resolution, the proposed electricity law has adopted guidelines targeting the integration of RE into the electricity market reform plan as follows:

1) In addition to market reform which guarantees third party access (TPA), power generation from renewable sources will enjoy priority in dispatching whenever they are available.
2) The establishment of RE fund that will close the gap between RE cost and market prices taking into consideration adequate marginal profits that foster private sector investment in RE. The main source of finance of the fund will come from the difference between the international market price of fossil fuel saved due to the use of RE and the subsidized price of that specific amount of fossil fuel saved.
3) It is expected that starting from the year 2009/10, the proposed RE implementation plan will consist of two consecutive approaches/ phases as follows:

Phase I will employ competitive bidding process for a preset installed capacity, or mandated market share approach, where bids will be awarded to the lowest cost per generated KWh.

The criteria for such approach include:

- Achieving the lowest possible prices.
- Control the increase in RE capacities with reference to the capacity of transmission system and capacity of the market to absorb.
- EETC (and later TSO) is committed to purchase the generated RE electricity.
- Increase local manufacturing.
- Increase private investment.
- Provide the investors with guarantees through long term power purchase agreements.

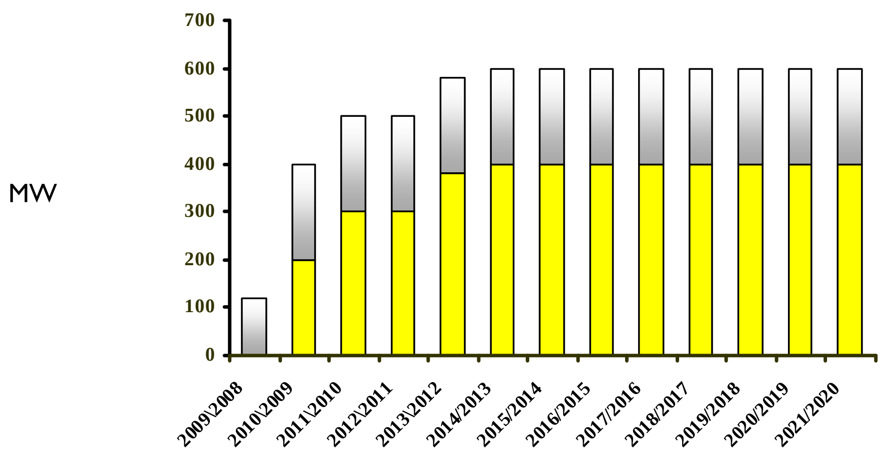
Phase II will employ a feed-in tariff for RE KWh, where prices attained in phase I will be used as guidelines to estimate the most appropriate and economic value for the feed-in tariff and how it would evolve across the time.

No time schedule has been established yet for the phases of the market reform action plan. Also, it should be noted that the said action plan detailed elements, financing schemes and implementation procedures still needs to be developed and elaborated.

3.2. Perspective market size for wind power generation

Figure 5 shows the evolution of wind installed capacity additions till the same year, starting with 120 MW capacity additions in 2008/2009 followed by 400 MW in 2009/2010, 500 MW in 2010/2011 then annual additions of about 600 MW until 2020/2021. The planned annual wind capacity additions are broken down to capacities planned for both NREA and the private sector investment. We note that the planned share of NREA is almost constant at 200 MW annually for 12 years while the planned share for the private investment increases gradually up to 400 MW annually for almost the last 9 years of the plan till 2020/21. This is equivalent to two thirds of the overall yearly target for capacity additions which underlines the crucial role of private investments and the consequent need for market reforms realization.

Figure 5 - wind capacity annual additions and relative shares of NREA and private sector until 2020/21



3.3. Measures to be adopted for RUE

The following measures are proposed by the electricity law which is still under ratification:

- Investment portfolio for electricity companies should include projects/programs for RUE and DSM improvements through specific investment targets.
- Third party access (TPA) with priority in dispatching is also guaranteed for cogeneration and power generated from secondary energy sources.
- Support utility based ESCOs.
- Request of energy managers and energy registrar for facilities which have contracting capacity above 500 kW.
- Plan for expanding the Labeling & Standards program as well as phasing out the low efficiency equipment.

Such generic measures specified in the electricity law still need to be translated into elaborate action plans having specific quantifiable targets for the coming years in different end-use sectors together with detailed issues of implementation. Necessary information such as energy benchmarking for different types of industries and services have to be made available for different energy end-users.

We would like to stress again our proposal for the creation of a dedicated national institution responsible for RUE, preferably under the supervision of the Supreme Council of Energy. This dedicated entity will be responsible for the formulation of the relevant RUE national strategies and programs along with setting short and long terms quantifiable goals, monitor achievements, specify stakeholders' roles and perform all other tasks indicated elsewhere in this study.

IV. COST OF INVESTMENT AND ECONOMIC ASPECTS OF A LOWER CO_2 ENERGY SCENARIO

In order to be able to evaluate the cost of any lower CO2 energy scenario for Egypt until the year 2015, one has to start from a baseline energy scenario that has an elaborated plan of defined consecutive actions based on available knowledge and business as usual practices. Whenever the details of such a baseline scenario are developed, its GHG emissions as well as its investment cost can be estimated. Based on the evaluation of the expected GHG emissions from the baseline scenario, a "better" alternative energy scenario less emitter in GHG can be proposed. Any proposed alternative scenario will be considered relevant if it could provide the same amount of services and products as per the original baseline scenario by using either less quantity of energy (RUE) or the same amount of cleaner energy (RE) or a mix of these two processes. The degree of merit of each proposed alternative scenario stems from its cost of investment related to the resulting GHG emission reduction below the baseline emissions reference value.

The approach adopted by this study to establish an alternative energy scenario is to propose a "package" of RE and RUE projects to be implemented until the year 2014/15. The implementation of these proposed projects (alternative scenario) will entail the avoidance of implementation of planned facilities using fossil fuels originally considered under the base line scenario.

In order to assure the successful formulation and implementation of a lower carbon energy scenario, indispensable considerations have to be given for the establishment of relevant responsive realization mechanisms and measures. This part of the chapter is dedicated to the elaboration of the following main relevant aspects:

- Presentation and evaluation of different alternatives and market schemes for creating an enabling investment environment for the enhancement of the role of RE & RUE in the energy scene.
- Development of the economic analysis of the proposed projects which are formulating a lower energy carbon scenario as being proposed within this study including the financing through soft loans from international financing institutions (IFIs) to reduce cost of investment.
- Total cost of investment of the additional projects proposed for the alternative lower CO2 emissions energy scenario to be compared to the estimated cost of investment for the baseline energy scenario.

1. PROSPECTS FOR REALIZING A FAVORABLE INVESTMENT ENVIRONMENT FOR RE/RUE

1.1. Creating an enabling investment environment for RE activities

As indicated in part 3, the wind energy long term plan calls for an annual installed capacity additions of almost 600 MW, out of which NREA can contribute in the development of about 200 MW at best leaving 400 MW for the private sector investments, i.e., two thirds of the annual target. This outlines the importance of the private sector investment role and the consequent need to develop a corresponding enabling environment both from the regulatory and economic stand points. To fulfill this objective the new electricity law and action plans are proposed. The generic aspects of this new electricity law, which is still under approval, would pave the road for creating the needed favorable investment environment along with the corresponding market reforms. Additional work is still required to develop the detailed legislative and regulatory frameworks that would enable the implementation of the proposed law.

We can summarize the specific measures proposed by the electricity law to support the creation of a favorable RE investment environment as follows:

- The establishment of an RE fund to cross the gap between RE real cost and local market price of KWh produced, through a financial support based on channeling part of the savings earned from the difference between local and international prices of saved fossil fuels for overcoming the said gap.
- Guarantee the priority of dispatching power generation from RE resources whenever they are available.
- Adopting a two phases approach for market development to accommodate the changes anticipated from new legislations as presented in part 3 and will be elaborated particularly for wind energy in item 2.3.

1.2. Creating an enabling investment environment for RUE activities

The new proposed electricity law also included limited measures proposed to support RUE implementation. We notice that these proposed measures are quite limited reflecting inadequate attention given to RUE for reasons indicated earlier in this study. Accordingly, we shall be proposing additional complementary measures.

The measures indicated in the electricity law for creating such RUE enabling investment environment are:

- Mandate the electricity companies to allocate a certain portion of their investments to meet the increasing power demand through RUE and DSM activities.
- Guarantee priority in dispatching for cogeneration as well as power generation from secondary resources to the grid through the third party access.
- Offer support for the creation of utility based Energy service companies (ESCOs).
- Foster the creation and enforcement of energy labeling and standards that would insure the application of RUE measures and phasing out low efficiency equipment.

In addition to the measures indicated in the electricity law, some other complementary ones are suggested by this study as follows:

- Create an independent National Energy Efficiency Fund (NEEF) for a limited period of time with the participation of international donors and fund raisers that could start to create a niche in the markets through breaking the vicious circle between the availability of the adequate service in the local market with a reasonable and competitive cost from one side, and the size of demand on that service from the other side.
- Create a non profit nongovernmental agency as an "Egyptian Energy Efficiency Centre – E3C" that can carry out the role of technology and knowledge transfer from the countries that have

realised a noticeable success in this field in order to be able to offer technical assistance to local manufacturers and service providers to ensure the provision of adequate quality of products and services required for developing an energy efficiency market. E3C would also play the role of a catalyst to create joint ventures between international and local enterprises. It will also provide technical support to energy end-users and hence will be able to be a matchmaker between EE service providers and the potential demanders of these services.

- Create risk guarantee funds for investments in RUE projects.

1.3. **Proposed investment and market schemes for wind energy in Egypt**

In order to participate into the drawing of the future arrangement for the wind energy market in Egypt, NREA has performed different studies in cooperation with international consultants to analyze and evaluate the relevance of different schemes to the Egyptian context. These studies are addressing different choices of market schemes as proposals to foster a viable economic market for wind in Egypt that can attract private investments. We should differentiate between push and pull mechanisms for promoting wind. The abovementioned studies proposed a plan based on a mix of both but more favoring the pull mechanisms. This explains why the electricity law has not specified any specific mandatory percentage or share for both RE & RUE contribution to the energy mix. Almost two thirds of the declared objective of 12% wind by 2020 is subject to market enabling mechanisms.

In general, there are two basic categories of approaches to RE market development, one is price–based and the other is quantity-based. The first is represented in the "Feed-in tariffs" and the second, or quantity-based, is sometimes referred to as "Mandated Market Share", where each has its merits and market relevant conditions, and also each category has a number of sub-categories.

There are some sub-categories under price-based schemes or feed-in tariffs, among which we can distinguish between fixed price/uniform tariff, declining scale tariff and feed-in tariff/KWh either alone or together with a subsidy scheme.

Quantity-based schemes are based on bidding for long-term Power Purchase Agreements (PPAs) with the system operator/national transmission company. Tender schemes differ with regard to mechanisms to fix the PPA price. Either marginal bid price is given to all bidders, thus drifting this method somewhat towards the feed-in scheme, or each bidder is paid his bid price which is more consistent with the bidding objectives of achieving the lowest possible tariff.

Tender schemes also differ with regard to how the contract quantity is established, where the tender can fix the quantity to be contracted (thus bid prices will define the financial cost of tender) or fix the overall financial support to be offered to the potential contractor (thus bids establish how many MW or MWhs can be bought with the amount of price support allocated).

1.3.1. Factors influencing the choice of wind market schemes and their impact

The studies performed by NREA and its consultants has shown that there are different factors influencing the choice of the most relevant and feasible method and procedure among feed-in tariff and bidding schemes. In adopting a specific choice for Egypt, we should have a quick overview of such factors and particularly how they relate to the local market conditions on the short and long terms. In the same time, we shall be comparing different schemes as they also relate to the Egyptian market conditions to point out the most appropriate among them.

1) Impact of insufficient information on market size

The information on the market size and the dynamic forces affecting its near term development in Egypt are generally not sufficient for different reasons among which are the market distortions extent, mainly due to the energy subsidy impacts that permeate all aspects of the economy. There is also insufficient information about how such energy subsidy decrease will impact the national economy and to what extent would the consequent repercussions affect individual sectors of the economy as well as the general public. Consequently, if opting for the choice of feed-in tariff scheme for wind energy market proposed development, it may be set too low to achieve declared goals or too high leading to severe financial burden on the economy and hence the energy consumers at the end.

The tender scheme is known for providing new RE-electricity supply at low-priced PPAs (Power Purchase Agreements). Indeed, this is more favorable for countries having a lot of subsidies along with RE ambitions targets, like Egypt. However, feed-in tariff support faster development and larger market sizes compared to bidding schemes.

2) Impact of insufficient Information on the level of subsidy burden

Due to the inability of the planners to set the feed-in tariff at the most appropriate price, which is the case in Egypt, the potential needed RE financial support burden can not be reasonably estimated. This is a serious barrier confronting proper planning. This issue discourages using this scheme at least in the earlier stages of development where major market reforms are taking place with the normal associated uncertainty.

3) Impact of transaction costs on the type of investor

The feed-in tariff is ideal for investors as there are almost no market risks. This would attract a broader scope of investors and wind projects developers than tender scheme. Feed-in tariff's attracted developers and investors could include small, large and ad-hoc investors and project developers, utilities and IPPs (Independent power Producers). Much more projects would be implemented leading to wind capacities beyond originally planned with consequent larger potential RE financial support burden. The tender scheme is at the opposite end as it attracts major players only, either investors or wind projects developers. In case of Egypt this could be viewed as an advantage, as this would entail dealing with more professional and reliable entities and, thus securing minimum possible risks and loss considered very important for the national economy still suffering from different inefficiencies.

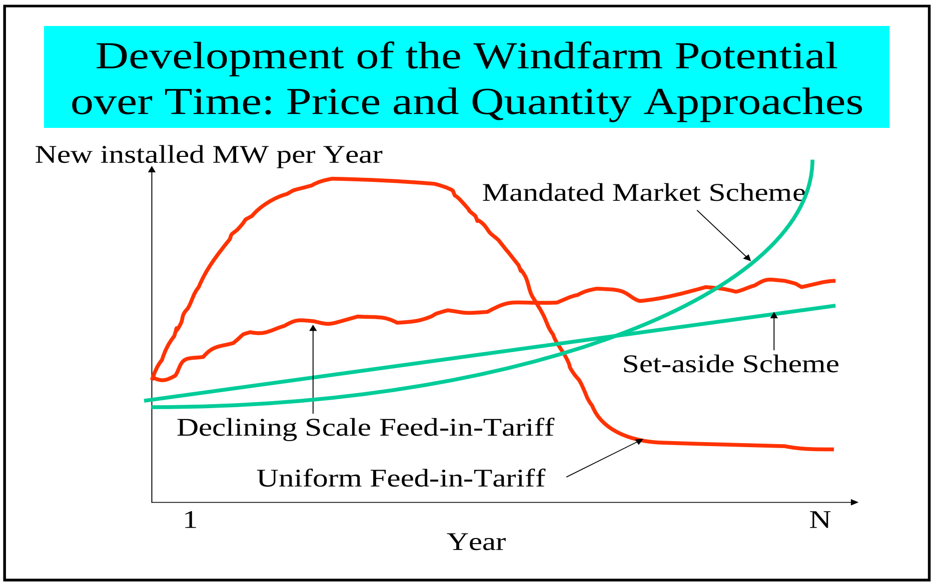
4) Impact of technological progress on cost and market size

Despite the fast wind technology development in the last decade and the associated productivity increase, it has not yet become fully matured and reached the normal rate of productivity improvement of fully matured industries in spite of the slow-down in the rate of productivity increase lately. This would made us assume that uniform feed-in tariff might result in a growing increase of profit for wind projects developers in the longer term rather than direct increasing benefits for Egypt.

1.3.2. A choice for wind market and investment scheme for Egypt

Based on the findings of NREA's studies, figure 4.1 illustrates the effect of the factors above mentioned on the considered four market schemes across time, namely; a) the uniform feed-in tariff, b) the declining scale feed - in tariff, c) the mandated market scheme implemented as a tender scheme, and d) the set-aside scheme, where a specific predetermined amount of RE or wind is purchased each year through tendering, based on an earlier decided plan.

Figure 6 - Development of wind farm market potential based on different approaches



In comparing such schemes we notice the following:

- Market development under the uniform feed-in-tariff is fast, the major reason being its low risk for investors. The sites having the highest wind resource potential in the country are, therefore, exploited very quickly which may not allow taking advantage of anticipated productivity increase in the future.
- Under the declining scale feed-in-tariff the development of the market is more gradual. Yet, it may be less predictable and more fluctuating than the development under a mandated market scheme, due to uncertainties about how productivity improvement may develop as well as the whole wind market.
- The mandated market scheme imposes on electricity retailers the obligation to secure a fixed percentage of their supply from renewable energy systems. The quota may grow each year, until its politically fixed plateau is reached, making contracts for new investments each year a necessity. Growth in national power demand adds further demand for annual investments in renewables. In such a case the annual growth rate in contracted quantity is the cumulative result of the growth in the national power demand and the obligatory rate of increase in the percentage of the RE quota.
- Under a set-aside scheme, the Government may use either a fixed MW quantity for new annual RE supply capacity, or let the contracted quantity increase steadily each year. The latter case is the one shown in figure 4.1.

In view of the previous discussion, it can be concluded that the recommended market scheme most relevant for Egypt in the short term until 2015 is a set-aside scheme along with bidding for the lowest price (tariff) per KWh. The following reasons would also support such a decision:

1) The availability of reasonable and reliable information on wind speeds and profiles from the wind resource assessment earlier carried and yielded comprehensive data on favorable wind locations.
2) The availability of land areas already earmarked for wind utilization, that are endowed with abundant wind resource at very favorable conditions and considerably low cost, being almost

exclusively arid deserts with no constraints on use for wind farms, where the government plans to offer incentives for such land areas development.

The approach which is being proposed to be adopted by the Egyptian government and NREA for achieving wind plan targets calls for proceeding with two consecutive phases as indicated in part III of this chapter. It will start by phase I of competitive bidding according to the criteria indicated in item 3-3.2, hence after some time, not yet defined but expected to take at least five years, phase II of implementing the feed-in tariff can take over. This proposed approach can be summarized as follows:

- Different recurrent bidding rounds will take place for the first couple of years, not yet defined, for all or a portion of a predetermined or set aside quantity of wind installed capacity out of the annual plan mentioned in part III, where the successful bidder(s) shall be the one offering the lowest price/KWh.
- After these least cost/KWh bidding rounds, prices per KWh attained will be used as guidelines to determine or estimate the feed-in tariff to be used for the second phase.

1.3.3. Other potential wind investment schemes

Beside the above mentioned proposed market reform approach, the authors of this chapter has perceived that there is another important investment scheme in wind power generation that came up recently with a reasonable potential for replication. This scheme has been practically proposed by the international companies owning and operating manufacturing facilities in Egypt characterized by energy intensive consumption. The motive has twofold: the first is the announced intention for market reform coupled with the gradual increase in tariff for all consumers, while the other is the high energy consumption of these facilities purchased at a higher tariff than regular consumers.

One example of this new trend is the memorandum of understanding (MOU) signed between Ital-Gen being the energy specialized company among the Italcementi Group which owns Suez Cement Group having 5 cement factories in Egypt , and NREA for the implementation of a wind power project ranging from 120 to 400 MW in Gabal El-Zeit area, south of Zafarana along the Gulf of Suez.

The Role of NREA is to:

- Supply the wind resource data to Ital-Gen Company.
- Identify an area for the project implementation among those allocated to NREA for wind projects.
- Attribute the relevant site to the (Ital-Gen) for the sole use of wind power project implementation.
- Assist in developing the power purchase agreement between the investor and the transmission company in such a way which insures that the generated wind electricity will be wheeled through the grid to supply the investor's manufacturing facilities. The power grid shall compensate for the deficit needed by Italcementi and absorbs any extra wind generation.
- Offer technical assistance, when needed, particularly in the operation and maintenance phase.

The role of Italcementi is to:

- Carry out detailed feasibility study as well as environmental impact assessment (EIA).
- Study jointly with NREA the possibility of local manufacturing of part of the equipment.

- Raise all necessary funds to implement the project along with considering the investment option as Foreign Direct Investment (FDI).

Despite the fact that necessary details to develop this kind of investment mechanism are not well defined yet, other international companies have shown their intent to follow the same approach for investing in wind energy in Egypt. This trend points out the growing importance of investment opportunities in Egypt in the field of wind power generation even before the accomplishment of the anticipated market reform measures.

2. ECONOMIC ANALYSIS OF PROPOSED RE AND RUE PROJECTS

The adopted economic analysis approach is presented in annex B. Three types of RE and RUE projects are being analyzed to demonstrate their economic features. In order to illustrate the investment opportunities in RE and RUE, this economic analysis has been developed under different financing schemes as it will be shown in the following cases.

2.1. 200 MW wind farm for electricity generation

Based on the national plan, wind power generation represents a major area for investment. A model example of wind power project is presented to demonstrate the economic features that would encourage creating favorable opportunities for investing in wind power in Egypt. The table 4.1 represents indicative simple economic analysis results from the utility perspective for a typical 200 MW project proposed to be implemented at Gabal El-Zeit area. This particular area enjoys a considerably high wind potential estimated to be able to accommodate about 3000 MW of wind farms.

The analysis of this 200 MW project "model" is specifically elaborated for this study for the purpose of demonstrating the economic conditions that would make such project a "bankable one". Taking into consideration the wind energy target of 800 MW indicated earlier under the alternative lower CO_2 energy scenario which is planned to be implemented until the year 2014/15 in addition to the projects targeted under the baseline scenario. The choice of this particular project size (of 200 MW) was also suggested by other recent internal studies developed by NREA in cooperation with foreign consultants as a recommended size for future projects to be developed by NREA.

The economic analysis calculations is being developed for a "base case" according to given data for main project variables such as: energy yield, KWh selling price, saved fuel price and loan conditions for both foreign and local required investment. CDM revenues based on 10 Euros for CER were also taken into consideration.

The cost of investment of this project is 270 million euros and the life time of the equipment is 20 years. The project financing scheme consists of 75% foreign currency component (203 million euros) and 25% local currency component (580 million LE equivalent to 67 million euros). The "base case" assumes that 75% of the foreign currency component will be covered through a soft loan (152 million euros) while the remaining 25% (51 million euros) is covered through a commercial loan with OECD conditions. The local currency component is covered by a local loan from the National Investment Bank of Egypt.

The first part of table 3 presents the results from the analysis of the "base case", while the second part of the table indicates the results of the sensitivity analysis cases when varying one of the main variables as specifically indicated for each case taking into account that the local component of 25% was a common parameter for all scenarios.

The major financial indicator results are the annual levelized cost for the KWh produced from the wind power plant and the internal rate of return (IRR) on the investment allocated for the project. One can notice that the IRR values are always negative except for the two following situations:

- Doubling the KWh selling price which confirms that this issue is crucial to attract foreign investments.
- Considering the earnings from saved fuel valued at international prices which indicates that all the cases are beneficial to the national economy from a societal perspective.

Tableau 3 - Economic analysis results of a project of 200 MW wind farm to be implemented in Gabal El-Zeit (Gulf of Suez) area

"Base Case"	
Installed Capacity	200 MW
Cost per KW (Euro/KW)	1350
Project Total Required Budget	270 Million Euro
Capacity factor	45%
Energy Produced	788400 MWh/year
Energy selling Price	14.6 LE/MWh
Energy selling price Growth Rate	7.5% per year
CER units per MWh	0.55 per MWh
1 CER	10 Euro
Discount Rate	6%
O&M	1.5% from the total investment cost with 2.5% growth rate
Overhaul Cost after 10 years from operation	10% from the total investment cost.
Price of Exported Natural Gas (fuel Saving due to Wind Farm production)	3 EURO/MBTU
Average Fuel consumption rate for the Power Plant	226.2gm TOE/kWh
Local loan 25%: 13% interest rate, 10 year repayment period, 2 year Grace period (N.B.: The local loan is common for all cases)	580 Mio LE
Foreign loan 75% of total budget (to cover the foreign currency component)	203 Mio Euro
1- 75% Soft loan: 1.5% interest rate, 20 year repayment period 7 year Grace period	152 Mio Euro
2- 25% commercial loan: 4.5% interest rate, 10 year repayment period, 1 year Grace period	50 Mio Euro
<u>Results of the "Base Case"</u> a. Levelized Prod. Cost Without CDM =3.3 Cent Euro/kWh b. IRR Without CDM =-14% c. Levelized Prod. Cost With CDM = 2.78 Cent Euro/kWh d. IRR with CDM = -9% e. IRR with Fuel Saving = 16%	
Results of Sensitivity Analysis	
1- 11% more energy output (Capacity factor 50%) a. Levelized Prod. Cost Without CDM =2.97 Cent Euro/kWh b. IRR Without CDM =-12% c. Levelized Prod. Cost With CDM = 2.45 Cent Euro/kWh d. IRR with CDM = -5% e. IRR with Fuel Saving = 18%	
2- The Foreign loan is 100% soft a. Levelized Prod. Cost Without CDM =3.12 Cent Euro/kWh b. IRR Without CDM =-13% c. Levelized Prod. Cost With CDM = 2.59 Cent Euro/kWh d. IRR with CDM = -8% e. IRR with Fuel Saving = 17%	
3- 100% increase in the energy selling Price(0.292LE/kWh) a. Levelized Prod. Cost Without CDM =3.3 Cent Euro/kWh	

b. IRR Without CDM =7% c. Levelized Prod. Cost With CDM = 2.78 Cent Euro/kWh d. IRR with CDM = 11% e. IRR with Fuel Saving = 21%
4- Changing the Local loan conditions, 6% interest rate, 15 year repayment period, 5 year Grace period a. Levelized Prod. Cost Without CDM =2.85 Cent Euro/kWh b. IRR Without CDM =-10% c. Levelized Prod. Cost With CDM = 2.33 Cent Euro/kWh d. IRR with CDM = -1% e. IRR with Fuel Saving = 19%
5- Increase in Economic price of Natural Gas consumed at Power Plant (6Euro/MBTU) a. Levelized Prod. Cost Without CDM =3.3 Cent Euro/kWh b. IRR Without CDM =-14% c. Levelized Prod. Cost With CDM = 2.78 Cent Euro/kWh d. IRR with CDM = -9% e. IRR with Fuel Saving = 22%

2.2. A project to install 50,000 (100,000 m^2) solar water heating systems

Solar water heating represents the other renewable energy field of relatively acceptable economic feasibility in Egypt. The proposed project aims at installing 100,000 m2 of solar water heaters during one year to replace 50,000 electric water heaters. The lifetime is 20 years and the solar fraction is assumed 80% and the remaining 20% is auxiliary electric heating. The total cost of this project is 22.1 million euros and the financing conditions for the base case of this project are the same assumptions as of the proposed wind project including 75% as a foreign component and 25% as local component. The economic analysis is carried out for three situations: the base case, and then for a case of 100% soft loan for the foreign component which represents 75% of the total budget, and the third case for a 100% increase in electricity tariff. For each of the above mentioned three situations a sensitivity analysis was carried out for different values of CERs: 0, 5, 7.5 & 10 Euros/CER.

The results of the analysis shown in figure 4.2 indicate that for all situations this project has positive IRR values. In case of doubling the electricity selling price (the foreign component of the required budget is covered like in the base case with 75% soft and 25% commercial loans) and even without any revenues from CERs (0 euros/CER) this project is an attractive business for investors. From another side if the foreign component of the budget is covered by soft loan and even without changing the electricity selling price, high prices of CERs (7.5 and 10 euro/CER) makes such project a bankable one.

2.3. Energy efficient lighting initiative to disseminate 40 million CFLs

2.3.1. Introduction

The compact fluorescent lamps (CFLs) offer a considerable increase in energy efficiency compared to conventional incandescent lamps, but its much greater first cost tends to deter purchase by households. Subsidized residential tariffs and low household incomes are other severe constraints confronting the purchase of CFLs, while there has been a limited effort on the part of utilities to promote their wide spread use.

Household lighting demand is a major component of Egyptian peak electricity load. Achieving a high penetration of CFLs for household lighting will reduce growth in peak electricity demand and permit the deferral of costly investments in expanding the electric power supply system, save fuel and reduce sales of subsidized electricity, as well as reduce environmental impacts.

By examining the economic viability of CFLs from the perspectives of society, utility, and different classes of electricity consumers, the results of such an analysis could be used to design specific programs aiming at achieving specific goals. As more detailed studies in this specific area are required, we are presenting a preliminary program to indicate the economic merits of this important RUE activity that would be considered a good potential investment opportunity.

An energy efficient lighting program (EELP) is proposed to disseminate 40 million CFLs in the whole country over a five year period, particularly among households consuming less than 350 kWh/month, for which electric rates are heavily subsidized and purchase of CFLs is not financially attractive. In this way, the utility can reduce its subsidy loss and also provide a public service by reducing lighting costs for low-income customers particularly in view of the government's plan to alleviate the electricity subsidies. The total cost of investment of this project is 102 million euros and the financing scheme is 75% foreign currency component and 25% local currency component. For the convenience of reading the numbers of the cost analysis we will work out this project evaluation in US$.

Tableau 4 - Economic analysis results of a project for installing 100,000 m^2 of solar water heaters to replace electric water heaters

		The foreign loan is 75% soft + 25% commercial (Base Case)				The foreign loan is 100% soft				100% increase in the electricity selling price (0.292 LE/KWH)			
Installed Capacity(Solar Water Heater systems)	m2	100000	100000	100000	100000	100000	100000	100000	100000	100000	100000	100000	100000
Total Required Budget	Million Euro	22.1	22.1	22.1	22.1	22.1	22.1	22.1	22.1	22.1	22.1	22.1	22.1
Capacity Factor	80% Solar + 20% electricity												
Energy Produced	MWh/year	94186	94186	94186	94186	94186	94186	94186	94186	94186	94186	94186	94186
Energy selling price	LE /KWh/ Year	0.146	0.146	0.146	0.146	0.146	0.146	0.146	0.146	0.292	0.292	0.292	0.292
Energy selling price groth Rate	per MWh	7.5%	7.5%	7.5%	7.5%	7.5%	7.5%	7.5%	7.5%	7.5%	7.5%	7.5%	7.5%
CER	kgCO2/kWhe	0.55	0.55	0.55	0.55	0.55	0.55	0.55	0.55	0.55	0.55	0.55	0.55
Different cases for CER price	Euro/CER	0	5	7.5	10	0	5	7.5	10	0	5	7.5	10
Discount Rate		6.0%	6.0%	6.0%	6.0%	6.0%	6.0%	6.0%	6.0%	6.0%	6.0%	6.0%	6.0%
O&M (from the total investment cost)		0.70%	0.70%	0.70%	0.70%	0.70%	0.70%	0.70%	0.70%	0.70%	0.70%	0.70%	0.70%
Local loan Mio LE	25%	48	48	48	48	48	48	48	48	48	48	48	48
13% interest rate		13.0%	13.0%	13.0%	13.0%	13.0%	13.0%	13.0%	13.0%	13.0%	13.0%	13.0%	13.0%
10 year repayment period		10	10	10	10	10	10	10	10	10	10	10	10
2 year Grace period		2	2	2	2	2	2	2	2	2	2	2	2
Foreign loan (Mio Euro)	75%	16.6	16.6	16.6	16.6	16.6	16.6	16.6	16.6	16.6	16.6	16.6	16.6
soft loan (Mio Euro)	75%	12.4	12.4	12.4	12.4	16.6	16.6	16.6	16.6	12.4	12.4	12.4	12.4
interest rate		1.5%	1.5%	1.5%	1.5%	1.5%	1.5%	1.5%	1.5%	1.5%	1.5%	1.5%	1.5%
year repayment period		20	20	20	20	20	20	20	20	20	20	20	20
year grace period		7	7	7	7	7	7	7	7	7	7	7	7
commercial loan (Mio Euro)	25%	4.1	4.1	4.1	4.1	0.0	0.0	0.0	0.0	4.1	4.1	4.1	4.1
interest rate		4.5%	4.5%	4.5%	4.5%					4.5%	4.5%	4.5%	4.5%
year repayment period		10	10	10	10					10	10	10	10
year grace period		1	1	1	1					1	1	1	1
Results													
Levelized prod. cost of each solar KWh produced (Cent Euro/KWh)		1.250	1.073	0.984	0.896	1.228	1.050	0.962	0.873	1.250	1.073	0.984	0.896
IRR		9.0%	12.0%	13.6%	15.4%	11.1%	16.1%	19.3%	23.4%	55.8%	68.2%	75.4%	83.3%

2.3.2. Rationale behind the EELP program

A previous OEP survey indicated that there is a high acceptance potential of CFLs and a very minimal penetration of the market by this lighting technology. The study also reflected a strong consumer desire to purchase CFLs if they were more affordable and if better information were available about their performance and capability. Experts' opinion indicated that approximately 120 million CFL retrofit opportunities exist in Egypt. These "opportunities" are defined to be equal to the number of incandescent lamps of at least 25 W and operates at least four hours per day in all residential, commercial and industrial sectors.

The goal of the project is to disseminate 40 million CFLs in the country over a five year period, particularly among low income households consuming less than 350 kWh/month. We assume that 20% of the 40 million CFLs will be procured and installed each year. The project design should include a series of delivery methods (including door-to-door/direct sales) that can effectively improve penetration for each given sector of the market, while maintaining the lowest possible administrative costs. The customers may purchase the CFLs outright by paying cash or they may choose to finance their purchase over a one or two year period for an additional financing fee and will be billed for their purchase in conjunction with their monthly utility bill. One of the project key objectives is to target customers in the lowest income groups and to assure the saturation of this portion of the market.

An elaborate evaluation program will be operated to not only monitor CFL sales to different customer groups, but also include follow-up to ensure CFLs are used properly and to examine customer acceptance, satisfaction, and lamp usage.

2.3.3. Methodology and data

The economic value of the use of CFLs differs for society, utility and residential customers. Neither the benefits nor the costs are identical in each case, and the discount rate that is appropriate to derive the present value of future benefits and costs varies among them as well. In addition, the benefits vary among residential customer groups because they face different marginal electricity prices. Societal benefits arise because the same amount of lighting service will be delivered at a lower overall societal cost than before. The society will incur the cost of CFLs and of administering the related implementation program.

The utility benefits from the use of CFLs include deferment of investment in new generation, transmission, and distribution capacity; fuel savings from avoided electricity generation and associated reductions in negative environmental impacts. The utility costs depend on the share in the CFL purchase and program costs that the utility absorbs. The utility would lose revenue depending on customer categories to which it will sell less electricity. These "lost revenues" are not a cost, properly speaking, but it could affect the utility finance.

From the customer's perspective, the benefits are reduced electricity bills and foregone purchases of incandescent bulbs, while the cost is the purchase price of the CFL.

Lamp savings and costs
The majority of incandescent lamps used in Egypt are having wattage of: 25, 40, 60, 100 and 150 W. For the calculation purposes, we are considering an average “representative” lamp of a wattage value of 60 W to be substituted by a CFL with an average of 18 W which would save 42 watts per lamp. We consider that with bulk procurement, CFLs could be purchased at an average price of not more than (US$ 3) per unit of CFL and is assumed to carry no taxes, so the price to society and

consumers is the same. The estimated implementation program's cost which include program execution and evaluation, would amount to (US$ 1) per lamp.

We also assume that a peak coincidence factor of 0.75 (i.e., 75% of the 40 million CFLs are in use during the peak hours of around 7 to 11 pm). We assume that the move to more efficient lighting does not lead consumers to use the CFLs more than they used the incandescent lamps.

The period over which savings will accrue is the useful life of the CFL, which is assumed to be 7500 hours. This amounts to about 5 years at 4 hours of use per day. A long-term involvement by the utility in the promotion of CFLs should help to ensure that users replace worn-out CFLs with similar products through a structured disposal program.

Avoided power sector costs
Residential lighting demand coincides with peak system load. Thus, use of CFLs will reduce the need for investing in relatively expensive peak generation. We used estimates of the long-run marginal cost of on-peak energy and capacity that had been determined in a recent internal study for EEHC. For residential customers, the annualized on-peak marginal capacity cost was estimated at US $150/kW and the on-peak energy cost at US$ 5 cents/kWh. These values include the cost to transmit and distribute electricity to residential customers. Generation from thermal power plants would be avoided and fuel savings and reductions in emissions of GHG emissions and airborne pollutants would be realized.

Discount rates
Since the use of CFLs involves a tradeoff between a higher initial investment and a stream of future savings, the choice of a discount rate has an important impact on the results. For the purpose of the present analysis, we use a 6% discount rate for the societal and utility perspectives and 8% for the customer perspective.

Electricity prices
The residential electricity tariff in Egypt is divided into 5 categories according to the level of monthly consumption. The price per kWh rises with consumption. We used an estimated average avoided electricity cost of 3.5 US$ cents/kWh. We also assumed that real electricity prices would increase by 7.5% over the five-year life of a CFL used 4 hours/day.

2.3.4. Results

In the following sections, we shall present results of the benefit-cost analysis assuming that the program costs are distributed over 40 million CFLs.

a. Societal perspective

If 40 million CFLs are used during an average of four hours per day, the total peak capacity savings at the end of program amount to 1260 MW and the avoided electricity generation for the first year of the program is 370 GWh per year. Annual fuel savings are 265,000 barrels of oil equivalent.

The net present value (NPV) of benefit at 6% discount rate is US$ 8.3 per lamp. For the 40 million CFL program, this translates into a total NPV of US$ 332 million compared to a net present value of cost of US$ 160 million.

b. Customer perspective

We can present the customer perspective if the customer were to pay the full cost of a CFL, as well as program costs.

At four hours per day of CFL use and 8% discount rate, the NPV per lamp for the average customer (whose monthly electricity use is in the 201-350 kWh range) is around US$ 1.60 and the payback period is 2.25 years.

The NPV and payback period vary for customers paying different marginal electricity prices. For customers in the lowest tariff class, who account for around 20% of all customers, the payback period is roughly nine years. This is longer than the expected life of the CFL, and their NPV is negative. These customers pay a low (and heavily subsidized) marginal electricity price and thus gain no benefit from CFL use if they have to pay full cost. Only customers using more than 350 kWh per month will have a positive NPV. In contrast, for households in the highest tariff class, who account for around 10% of all customers, the payback period is less than one year.

There are no clear indicators of the acceptable payback period for Egyptian households, but it seems unlikely that large numbers of customers would purchase CFLs if their payback period was greater than two years. The utility has to pay a portion of the costs to make all customer classes benefit from CFL use.

c. Utility perspective

The attractiveness of the project to the utility depends on the amount of lost revenue and thus on the tariff-class of customers that purchase the CFLs. The utility gains the most from CFLs purchased by customers in the lowest tariff category; since these customers pay a marginal tariff much below the avoided costs. In contrast, the utility suffers a net loss on CFLs purchased by customers in the highest tariff class. If the distribution of CFLs reflects the costs and benefits applicable for the average customer, the utility would receive a NPV benefit of US$ 122 million from the project.

d. Discussion

From the societal perspective, the net gain from the EELP program will be considerable regardless of what type of residential customer purchases a CFL. For the utility as well, the avoided costs are approximately the same whether a CFL is used by a low- or high-income customer. However, the utility's residential tariffs are much less than marginal cost for most customers (those using under 350 kWh/month), so the utility gains when these customers conserve electricity. In contrast, the utility suffers a net loss when customers in the highest tariff class use CFLs.

It is in the utility's interest to sell as many CFLs as possible to customers in the lower tariff categories. Along with reduced price, the option of spreading out payment for CFLs over time may help overcome the first-cost barrier for many households in the middle or even lower tariff classes.

3. ESTIMATE OF THE TOTAL COST OF PROJECTS PROPOSED FOR A LOWER ENERGY CARBON SCENARIO IN EGYPT

As it have been already indicated in part 2 of this chapter, the alternative lower CO_2 energy scenario includes a proposed "package" of RE and RUE projects to be implemented until the year 2014/15 over and above the projects in the declared plan that has been considered after some adjustments (detailed in part 2) as the baseline scenario for the energy sector until the same year.

The additional "package" of projects for the alternative scenario includes:

- 4 wind power plants 200 MW each, making a total capacity of 800 MW to be implemented until 2014/15. This 200 MW size of a wind power generation project has an investment cost of 270 million Euros and can be implemented within 2 years. The total cost of investment for this activity is estimated at 1080 million euros.
- A program to install 500,000 m2 of solar water heating collectors (representing 250,000 systems) in replacement of electric water heaters currently used in households during 5 years until 2014/15, is proposed to be implemented through a non-profit non-governmental organization that should be able to cooperate with other national and international stakeholders and also to be able to assure the sustainability of this activity beyond the timeframe of the project. The estimated total investment cost of the program is 125 million euros including 14 million euros for the project management.
- An energy efficient lighting program (EELP) disseminate 40 million CFLs in the whole country over a five years period until the year 2014/15, particularly among households consuming less than 350 kWh/month, for which electric rates are heavily subsidized. The total cost of investment of this project is 102 million euros.

To realize this alternative scenario, additional investment cost is needed. This additional investment represents the grand total cost of the above mentioned projects "package" which represents the additions to transform the baseline scenario into a lower CO_2 emitter energy one. Table 5 summarizes the total cost of the alternative scenario.

Tableau 5 - Total cost of proposed projects that would transform the baseline energy scenario to an alternative scenario until 2014/15

Proposed Project	Investment cost Million Euros
800 MW wind farms	1080
250,000 solar water heaters program	125
40 million CFLs initiative	102
Alternative Scenario Total Investment Cost	1307

Based on available estimated information, the cost of the baseline scenario for the energy sectors until the year 2014/15 can be projected as follows:

Tableau 6 - Cost of baseline energy scenario until the year 2014/15

Sector or activity	Investment cost Billion Euros
Electricity sector (not including wind power)	5.7
Wind power plants to add 2200 MW	3
Petroleum sector	4
Baseline Scenario Total Investment Cost	12.7

As shown from tables 5 and 6, the total required investment cost of the additional projects proposed to transform the baseline energy scenario to an alternative scenario represents about 10% of the baseline cost investment in the energy sector till the year 2014/15.

From another side and based on the cost of investment of the wind generation projects and the simplified calculations of the total amount of the fossil fuel saved during the 20 years lifetime of the wind power generation facilities, we could guesstimate that the cost of investment to save one toe (ton of oil equivalent) is about 50 euro/toe while that from energy efficiency is ranging from 20 to 30 euro/toe. The cost of the avoided GHG emissions can be guesstimated as 19 and 10 euro/tCO_2eq from wind projects and from energy efficiency activities respectively.

V. SYNTHESIS OF CONCLUSIONS AND RECOMMENDATIONS

1. CONCLUSIONS ON THE EGYPTIAN CONTEXT TOWARD ELABORATING A LOWER CARBON ENERGY SCENARIO

1.1. Observed trends and obstacles in the energy sector and the need for a reform

1) Most of energy production and consumption patterns and profiles generally maintained their previous trends. Oil production experienced a negative average annual growth rate (or a decrease) of 2.4% during the last 25 years, while the natural gas exhibited an average annual growth rate of 12.3% during the same period yielding an overall average annual total combined growth rate for both of about 2.8%. The average annual consumption growth rate of these two petroleum products was about 4.8% i.e. more than 70% above the production rate reflecting the real need for RE and RUE contribution.

2) Also previous trends continued for the electricity demand where the peak load, that is almost the only governing factor in the generation expansion planning, grew at an average rate of more than 6.6%during the last 25 years, i.e. at a rate surpassing both the population growth rates entailing relatively high energy intensity (electrical) which in turn calls for the necessary adoption of RUE long term strategy and action plans.

3) The energy institutional frame work remained almost unchanged where the electricity sector remains considerably centralized while the petroleum sector still lacks a regulatory agency.

4) The petroleum sector is still behind other energy sectors in terms of the institutional frame works, despite its crucial role in the Egyptian national economy, where available data (which are limited anyway) are still a source of inconvenience and even confusion in some instances particularly regarding production and exports against necessary reserves that should be maintained to protect national energy security without jeopardizing future energy sustainability. Furthermore, in spite of its absolute necessity, it is not clear that a petroleum regulatory agency is planned for the near further.

5) RE present development plans mainly address bulk electricity production applications where other potential applications still lack support particularly in view of the considerable potential of some of these applications such as solar water heating. This explains why important achievements have been attained in wind electricity generation with very favorable future prospects.

6) Energy subsidies remain a dilemma from both the economical and social perspectives in spite of the progress made lately particularly in view of the apparent government policy to start with electricity market reforms. The petroleum sector still needs similar efforts.

7) Integrating both RE, with the exception of wind, and RUE particularly, into both the national strategic sustainable development plans and energy planning, is still lower than required levels. The same can be said about incorporating CC mitigation effort into the same national planning.

1.2. Positive results expected from the anticipated reform

8) The legislative and regulatory frameworks are currently experiencing major attention. It is expected that the anticipated changes will result in the enhancement of the role of RE and Rue in the Egyptian energy system that will entails positive consequent climate change mitigation outcomes.
9) Such anticipated major changes has resulted also in a very important recent trend for electricity market reform which has started at last, after a long standing and waiting situation, through proposing a new electricity law and sending it to the People's Assembly for approval and ratification.
10) An important feature of the electricity law objectives, particularly for promoting RE utilization, is the financial set up that will attract private international investments to contribute to the realization of the ambitious wind plan targeting to meet 12% of electricity demand by 2020 translated into 7200 MW installed capacity of wind power plants and expected to result in annual GHG emissions reduction of about 17MtCO2eq.

1.3. Actions still needed to enhance results expected from the anticipated reform

11) A lot of work and effort remain necessary to be performed in order to realize the actual implementation of what the new electricity law is proposing and aiming with regard to the development of a progressively liberated electricity market.
12) In spite of the limited favoring measures in the new proposed electricity law, RUE remains undermined with no specific quantifiable targets to achieve, nor even an entity entrusted by its promotion. This situation is true for both energy supply and demand sides but specially, and to a noticeable extent, for the demand side one.
13) More technical assistance is needed for policy and institutional support initiatives on the national and regional levels under the euro-med cooperation framework. It is suggested that a centralized RE and RUE policy and institutional support initiative task force should be created in the SEMCs to coordinate, harmonize, integrate and upgrade the national and regional efforts in this aspect.

2. RECOMMENDATIONS

The analysis presented in this report has been developed to estimate the cost of an alternative energy scenario less CO_2 emitter mainly through the enhancement of the role of RE and RUE. In order to pave the road for the formulation and the implementation of such lower carbon energy scenarios, some recommendations are proposed and summarized as follows:

1) Market reforms along with the enforcement of relevant procedures and tools to accomplish sustainable development should consider the integration of RE and RUE as a key element into energy strategic planning in Egypt.

2) There is an urgent need to develop a national RUE strategy and to create a dedicated entity that would refine the strategy and develop RUE programs and initiatives along with quantifiable targets. The proposed agency should formulate and follow up the implementation of corresponding action plans as well as monitoring the degree of achievement of implementation hence recommend plans for modification and readjustment.

3) Develop an appropriate RUE incentive program targeting wide diversity of energy end uses and should also be well-tailored to suite different classes and types of end users.

4) Consistently perform economical analysis based on the three proposed perspectives of consumer, utility and society in such a way that always takes into consideration the need for optimizing the cost-benefit analysis of the three considered economic perspectives concurrently, to the maximum extent possible.

5) Push the developmental efforts addressing local manufacture of RUE and RE equipment, to its extreme limits along with targeting the regional markets as an indispensable component to achieve appropriate economy of scale.

6) Look for, investigate, possibly formulate and recommend innovative financing mechanisms for supporting RE & RUE wide spread use.

VI. CONCLUSION

Egypt has a declared commitment towards enhancing the role of RE and RUE in its energy system. As there is a dedicated agency for RE, represented in NREA, a reasonable progress has occurred in this field. Conversely, less significant development can be seen in the RUE field due to the absence of such an institution.

The questionable sustainability of conventional energy resources and the ever increasing demand would start to endanger the security of supply. That is why the enhancement of the role of RE and RUE becomes a must rather than a choice. This trend of anticipated enhanced contribution of RE and RUE paves the road to start a national dialogue on establishing an alternative energy scenario characterised by less CO_2 emissions. This alternative scenario will not be achieved unless realising adequate market reforms and an enabling investment environment to increase the private sector involvement in these activities.

The electricity regulatory agency (ERA) in cooperation with the state owned electricity companies have drafted a new electricity law and send it to the parliament for ratification. The new proposed law aims at boosting the contribution of both RE and RUE. Electricity market reform measures are also proposed by the ERA to complement and support the implementation of the electricity law once it will be approved. Some additional aspects and measures have been shaped by this study in order to join up all these elements together to form a kind of general framework that would enable formulating a detailed lower carbon energy scenario for Egypt. Most of the measures specified in the electricity law still need to be translated into elaborate action plans having specific quantifiable targets for the coming years in different end-use sectors together with detailed issues of implementation.

CHAPTER 8

The electricity sector challenges, related CO_2 emissions and potential solutions

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The total energy demand of the region is marked by an exponential growth of demand on electricity, at a pace much faster than that of GDP, of primary energy consumption and of population, particularly in the Southern and Eastern Mediterranean Countries (SEMCs). For this set of countries, the demand is likely to increase by 2.6 between 2006 and 2025, mainly due to a tripling of the consumptions of Turkey, Tunisia and Algeria, and a doubling up of the consumptions of Egypt and Morocco.

The expected development of the industrial sector, the accelerated access to electricity, and the improvement of standards of living (directly connected with the consumption of the residential sector) are the reason for these consumption upsurges.

In 2006, the electricity consumption of the SEMCs accounted for 26% of the total electricity consumption of the Mediterranean basin. This figure is likely to reach 40% by 2025. Turkey and Egypt account for about 60% of the total electricity production of the SEMCs. The average annual electricity consumption per capita is 3.8 times lower in the SEMCs than in the Northern Mediterranean Countries (NMCs); this ratio is likely to shrink to 2.3 by 2025. In the SEMCs, the fossil energies used to produce electricity accounted for over a third of primary energy (34%) in 2006. The choice of sectors depends on the natural resources available in the countries (gas in Algeria and in Egypt; coal in Israel, in Turkey and in Morocco). Over the past 35 years, a salient fact has been the penetration of natural gas which accounted, in 2006, for 50% of the sources of energy used to produce electricity, as against 3% in 1971. The oil share in electricity production has reported a reverse trend: passing from 56% in 1971 to 17% in 2006. Coal, which accounted for 10% in 1971, rose to 20% in 2006. For the time frame 2025, coal is likely to account for 31% of fossil fuels for electricity (as against 23% in 2006) and gas for 64% (as against 55% in 2006). The nuclear option is under consideration in the SEMCs; it is likely to emerge in the energy mix within the time frame 2025.

It ensues from these evolutions that CO2 emissions due to the electricity sector have grown tenfold (x 10) between 1971 and 2006. By 2025, these emissions are likely to grow more than twofold with respect to their level of 2006 in the SEMCs. They will then be 1.2 times higher than the emissions due to the electricity sector of the NMCs, while they were 1.5 times lower in 2006. The emissions of the sector accounted, in 2006, for 34% of the total CO2 emissions, a share which is likely to remain identical by 2025.

The strong penetration of natural gas at the expense of oil since 1970 (whose combustion emits 1.2 times less of CO2 than that of oil) has contributed in curbing emissions rises. However, the increase in demand and the growth in the share of coal for electricity production (whose combustion emits 1.7 times less than that of gas and 1.4 times more than that of oil) have tended to dent the advantages provided by the penetration of natural gas.

In this chapter, three options are examined to estimate the reduction potential possible in the future:

- Accelerated shift from one type of fuel to another (natural gas): according to the trend scenario in the SEMCs, the share of natural gas in primary energy consumption (of which about a half is used for power production in the SEMCs) will pass from 34% in 2006 to 38%. This evolution would help bring the level of CO_2 emissions within the range of 7 to 10%[1] by comparison with a scenario in which the share of natural gas would remain at its level of 2006;
- Use of more efficient and less fuel consuming, technologies: the previous trend-based evolution may be inverted via a large-scale programme of rehabilitation of the old plants over a ten-year time period. OME has inventoried a fleet of over 22000 MW of plants liable for rehabilitation or reclassification. Such a programme would allow—via new higher performance plants (50% in combine cycles)—a reduction in fuel consumption in the order of 10 Mtoe per year, that is the equivalent of an additional reduction of CO_2 emissions in the range of 3.7% to 5.2% for the time frame 2025[2];
- Finally, the capture and storage of the CO_2 emitted by power plants could mitigate the high emissions of coal-fired plants. However, this option is as yet costly (cost twice higher than for a non equipped plant); it is also energy consuming, without a mature market, and is beset with several uncertainties—especially of an environmental character—, which hardly entertains the likelihood that the SEMCs would be using it on a large scale within the time frame 2025.

The expected growth of energy consumption in the SEMCs is considerable for the time frame 2025, which is connected, above all, with the development of electricity production, such as developed in this chapter.

This growth could, nevertheless, be slowed down by difficulties related to the financing of infrastructures. One of the major constraints, for the SEMCs and for Turkey, is connected with the investments necessary for the new plants (+120 GW by 2020) which have been estimated by OME, based on the costs of January 2008, as about 110 billion Euros.

To this, there must also be added the investments related to coal ports and natural gas production and transport infrastructures, which are equally considerable; this explains, among other reasons, the predilection for projects of gas combine cycle plants (+60 GW), which are less costly and easier to construct than coal-fired plants, for instance.

[1] This represents a reduction by 50 to 71 Mt of CO_2 for the time frame 2025 thanks to the gas penetration projected in the various countries. These reduction rates are calculated with respect to the current level of total emissions in the SEMCs standing at 709 Mt of CO_2.
[2] This represents 26 to 37 Mt of CO_2 for the time frame 2025. These reduction rates are calculated with respect to the total emissions of 709 Mt of CO_2 in 2006 in the SEMCs.

It may be further added that the development of power interconnections and power exchanges will help optimise the operation of the production plants and contribute in reducing the needs for new production capacity. It is, therefore, indispensable—in order to overcome the impediments and constraints hampering a sustainable development of the region—to boost the infrastructures which will increase the exchanges and, above all, the power and gas interconnections.

INTRODUCTION

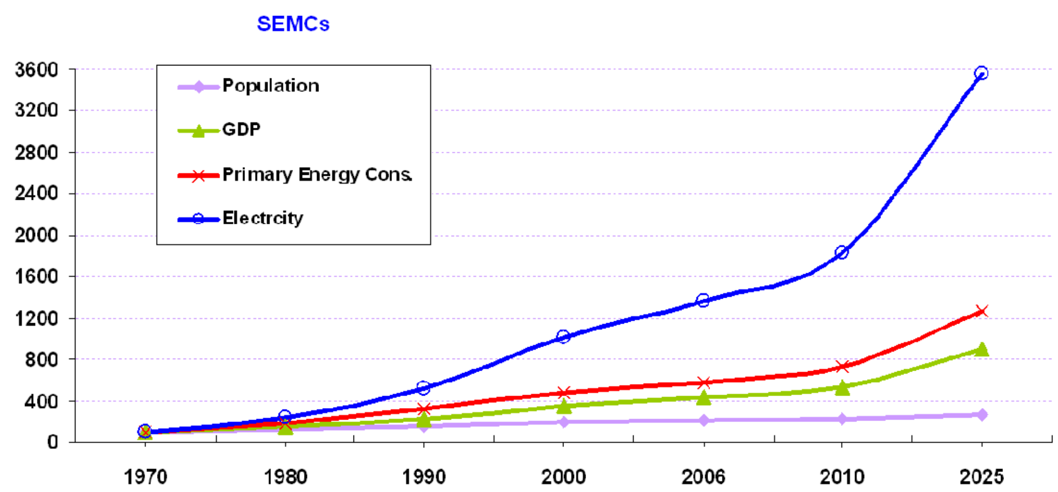
Context and objectives

The electricity sector in the Mediterranean region is developing fast and electricity growth is much higher than the economic, primary energy consumption and population growths. This is more specifically the case in SEMCs, where both electricity and primary energy consumption grow much faster than economic and demographic parameters. For this group of countries, the electricity demand could be multiplied by 2.6 between 2006 and 2025.

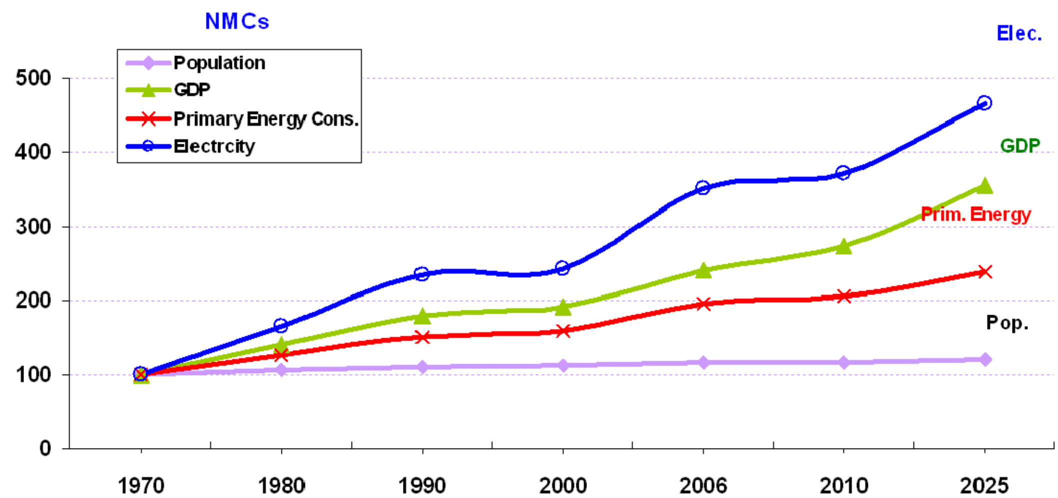
The developments in the industrial sector (for example new processes and automation) and improvements in living standards in the residential sector (for example appliances and air-conditioning) are the main factors explaining this fast trend.

Figure 1 - Mediterranean: Trends in selected parameters (1970 = index 100)

SEMC



NMC



Source: OME

Strong electricity demand is one of the main determinants of the important growth in primary energy consumption in the Mediterranean countries. In 2006, in the SEMC, fossil fuels used for power generation represents 34% of the total primary energy supply.

Most striking in the electricity trends observed is the spectacular increase in the share of natural gas mainly in substitution of oil and the "resistance" of coal influencing strongly CO_2 emissions.

The objective of this chapter is to review the situation and prospects of this challenging sector, the related CO_2 emissions and potential solution to address CO_2 concerns.

Sources of information

The chapter is based an update and extension of an existing study already performed by OME. Additional information has been gathered from OME members, literature and international organizations.

About the chapter

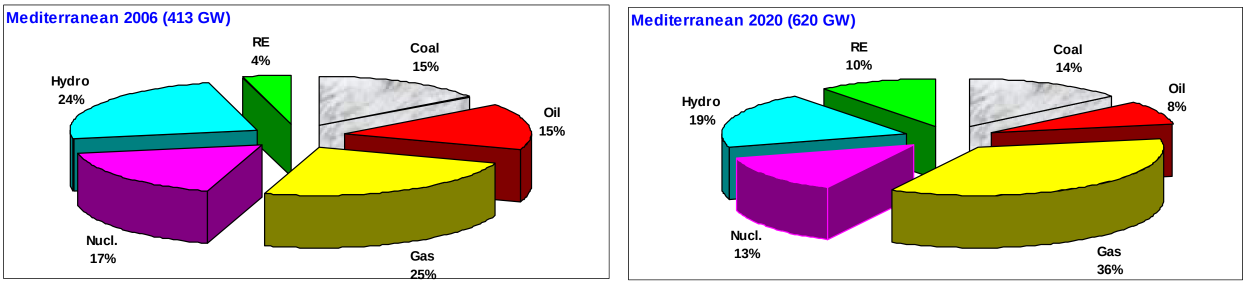
The chapter first analyses the power sector in detail; based on this, it estimates the emission of CO_2 according to the trend scenario proposed. In a last stage, it explores options to limit CO_2 emissions from the power plants production.

I. INSTALLED POWER CAPACITY: 208 GW ADDITIONAL ARE NEEDED UP TO 2020[3]

Installed power capacity in the Mediterranean region has grown considerably over the past three decades to reach 413 GW in 2006. The capacity has increased by one-third in the past decade. In 2006, the share of natural gas dominates the power generation park (25%), followed by hydro (24%), oil (15%, each), nuclear (17%, each), coal and renewable energies (15 and 4%, respectively).

Between 2006 and 2020, an additional of about 208 GW of new power plants should be completed. The vast majority should be natural gas-fired power plants (57% of the increase, i.e., +120 GW) and RE (22% share of the increase; i.e., +46 GW), which shows a spectacular increase. It should be noted that the share of oil capacity will decrease throughout the region (Figure 2).

Figure 2 - Total installed capacity in the Mediterranean region (2006 and 2020)



Source: OME

In NMCs, about two-third of the total 309 GW installed capacity in 2006 is covered by hydro, nuclear and natural gas (respectively, 26, 23 and 18%). Total installed capacity is expected to increase to 400 GW by 2020, where the share of natural gas should dominate, followed by hydro and nuclear. Renewable (excluding hydro) should see their share increase significantly to 10.2% (against 5% in 2006). This phenomenon is driven by the development in wind-based power generation.

Total installed capacity in SEMCs reached 103 GW in 2006, dominated by natural gas, oil and hydro (45, 20 and 19% of the total). Capacity should increase to 220 GW by 2020 (additional capacity of about 120 GW), with gas representing as much as 53% of total installed capacity (+64 GW), followed by hydro and coal. Nuclear should appear in the fuel mix by 2015 through the Egyptian and Turkish projects (Tunisian after 2020).

Between 2000 and 2006, 64 GW of new power plants have been built (about 11000 MW/year). In the baseline scenario (business as usual), this trend will continue at an average rate of about 15000 MW/year, amounting to an additional 200 GW capacity by 2020 (this represents as much as 400 new power plants with 500 MW capacity each).

[3] Forecasts for installed capacity foreseen by the companies are available only for 2020. Data for 2025 have not been published yet.

II. POWER GENERATION

1. Fast growing power generation

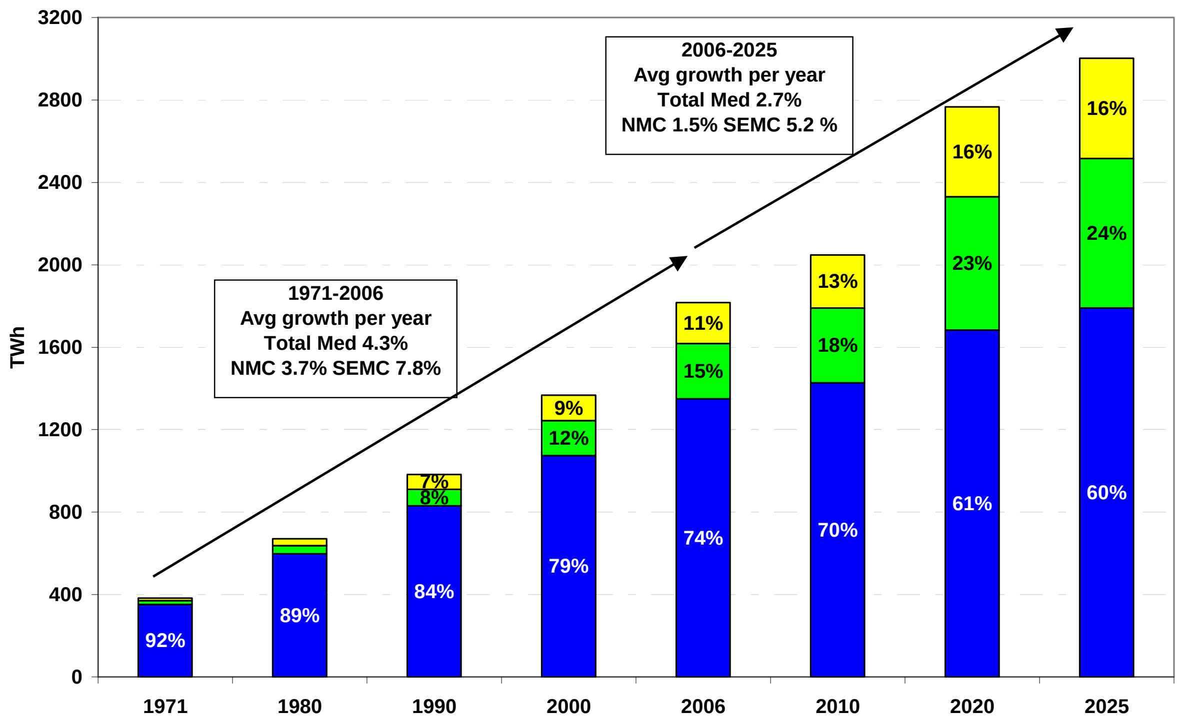
Power generation in the Mediterranean has reached 1816 TWh in 2006 (419 TWh in 1971), three-fourth produced in the NMCs (92% in 1971) and the remaining 25% in SEMCs (8% in 1971). Electricity generation has been experiencing a sustained growth in the whole region (4.3%) and more specifically in the SEMCs, with a strong average growth rate of 7.8% between 1971 and 2006 compared to 3.7% for NMCs.

According to forecasts issued by power companies, total power generation in the Mediterranean should reach 3000 TWh by 2025, with an annual average growth rate of 2.7% between 2006 and 2025. In NMCs, total power generation should increase from 1350 to 1790 TWh (average annual growth 1.5%). Meanwhile, SEMCs production should more than double from 466 to 1212 TWh (average annual growth 5.2%) (Figure 2.1).

Turkey and Egypt together account for about 60% of the total electricity generation of the SEMC. In 2025, Turkey could be the second largest electricity producer of the Mediterranean basin (after France).

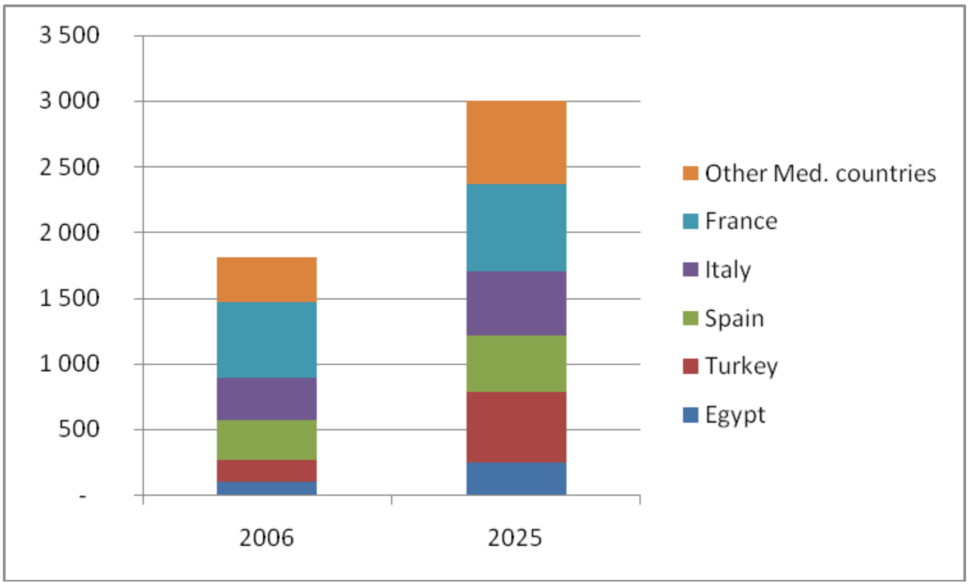
Electricity consumption in the Mediterranean countries is closely linked to the level of economic development. It can be noted that the per capita electricity consumption differs between the two shores of the Mediterranean, with an average of 6810 kWh/cap in NMCs as compared to 1780 kWh/cap in SEMCs. The ratio of per capita electricity consumption between SEMCs and NMCs has decreased from 1/8 in 1971 to 1/4.2 in 2006 and should reach 1/2.3 in 2025. (see Table 2).

Figure 3 - Trends in Mediterranean power generation (TWh)



Source: OME

Figure 4 - The 5 main electricity producers in the Mediterranean (TWh)



Source: OME

Table 1 - Per capita electricity consumption (in kWh/cap)

	1971	1990	2000	2006	2020	2025
NMCs	2259	4776	6119	6810	8205	8700
SE Med	417	1168	2074	2504	4975	5499
SW Med	191	715	1021	1278	2271	2504
SEMCs	281	897	1451	1778	3364	3713
Mediterranean	1437	2799	3524	3944	5248	5641
FEMIP	284	513	1247	1504	2442	2722

Source: OME

Table 2 - Electricity production in the Mediterranean (in TWh)

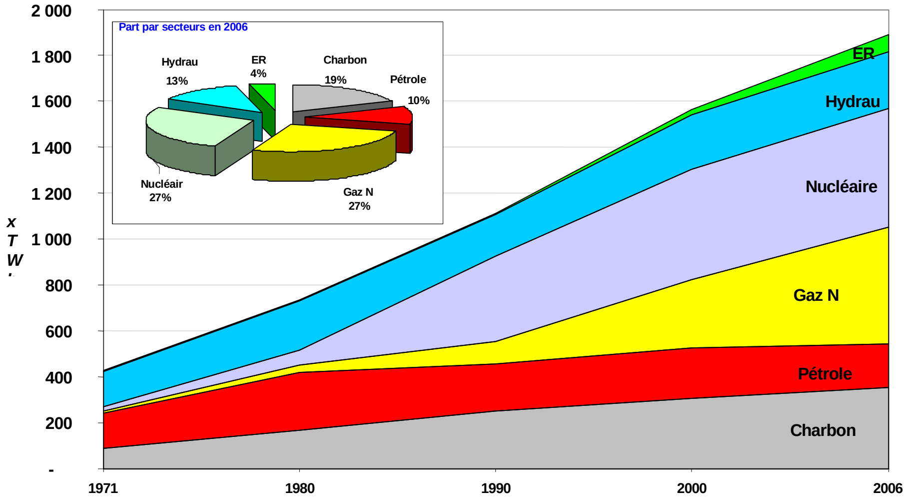
	Power Generation *(in TWh)*				Annual rate of growth *(%)*	
	1971	1990	2006	2025	1971-2006	2006-2025
North Med	385	899	1350	1790	3,7%	1,5%
SE Med	20	92	268	725	7,7%	5,4%
SW Med	14	84	199	487	7,9%	4,8%
SEMCs	34	176	466	1212	7,8%	5,2%
TOTAL	419	1075	1816	3002	4,3%	2,7%
FEMIP	24	54	284	647	7,3%	4,4%

Source: OME

2. Power generation by source

Strong growth in power generation in the Mediterranean is illustrated in Figure 5 The growth of natural gas-based production has reached an annual average growth rate of 11.5%, as opposed to a very low oil growth (0.7%).

Figure 5 - Trends in Mediterranean power generation (by source)



Source: OME

The growth of power generation by energy source between the two regions is summarized in Table 3 Natural gas growth rate has been very strong in the last three decades in both NMCs and SEMCs. The spectacular 17.1% increase in the growth in SEMCs is due to the low use of this fuel in the 1970s (the growth reached 8% per year over the past six years). In NMCs, natural gas has continued its penetration at an increasingly rapid rate over the past few years (10.6% between 2000 and 2006).

Table 3 - Trends in the growth of power production (by source, 1971-2006)

	Coal	Oil	N. Gas	Nuclear	Hydro&RE	Total
NMCs	3.1%	-0,8%	9.6%	10.6%	1.5%	3.7%
SE Med	9.8%	3.6%	-	-	7.7%	7.7%
SW Med	11.3%	5.3%	15.5%		2.2%	7.9%
SEMCs	10%	4.3%	17.1%		5.3%	7.8%
Total	3.9%	0.5%	10.6%	10.6%	2.0%	4.3%

Source: OME

Starting with 1 TWh natural gas-based power generation in 1971, SEMCs have reached a level of 230 TWh in 2006 and are expected to reach 682 TWh in 2025. This trend corresponds to natural gas-based power generation accounting for a share of 3% in 1971, rising up to 49% in 2006 and 56% in 2025.

In the meantime, the share of oil-based power generation has greatly decreased for the benefit of natural gas. Oil-based generation was 20 TWh in 1971 (57% of total power generation), reached 81 TWh in 2006 (17% share) and is expected to decrease to 41 TWh in 2025 (3% share).

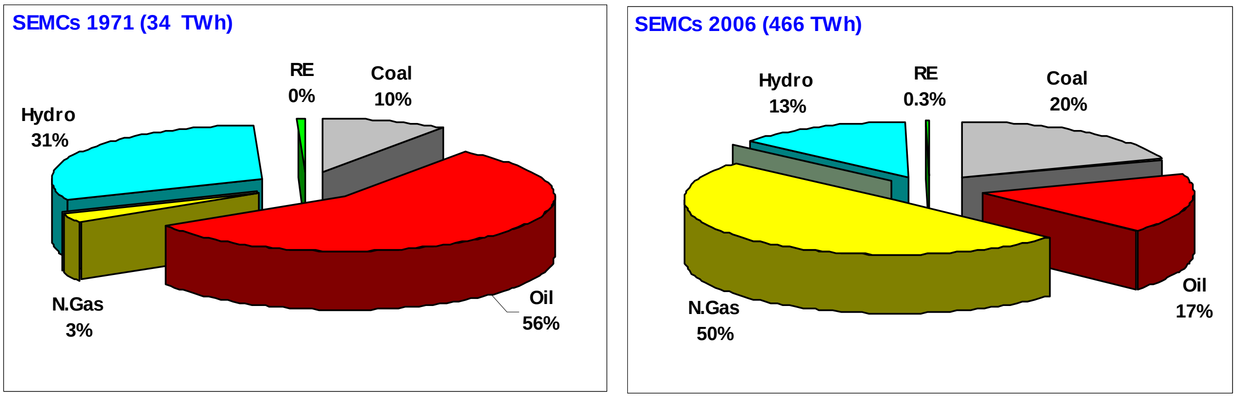
Coal-based power generation concerns three countries, namely Turkey, Israel and Morocco. Its production has increased from 3 to 92 TWh between 1971 and 2006 (share of 10 and 20% of total power generation, respectively); In addition to those three countries, Tunisia has recently planned a coal-based power generation of about 10 TWh by 2020 (1600 MW) and 15 TWh by 2030 (2800 MW). For the total SEMCs, coal is expected to represent 252 TWh of the electricity generated by 2025 (21% share).

As for hydro-based power generation, it has increased from 10 to 62 TWh in the period under consideration, and is expected to reach about 142 TWh in 2025. Its share in total power generation diminished from 31 to 12%, stabilizing at this level by 2025. While SEMCs have reached their full hydro potential, Turkey will be the only country experiencing further growth.

RE-based power generation started in the 1990s in particular with projects in Morocco and Egypt and has reached 1.4 TWh in 2006 (0.3% share of total power generation) and expected to increase to 42 TWh in 2025 (3.4% share).

While currently non-existent, nuclear-based power generation should see some development with the power plant projects planned in Egypt and Turkey starting in 2015 and in Tunisia since 2025.

Figure 6 - Share of energy sources in power generation for SEMCs



Starting with 11 TWh natural gas-based power generation, NMCs have reached a level of 258 TWh in 2006 and are expected to reach as much as 578 TWh in 2025. This trend corresponds to natural gas-based power generation, accounting for a share of 3% in 1971, going up to 19% in 2006 and 33% by 2025.

In the meantime, the share of oil-based power generation has greatly decreased to the benefit of natural gas. Oil-based generation was 132 TWh in 1971 (34% of total power generation), diminished to 100 TWh in 2006 (7% share) and is expected to decrease to 69 TWh in 2025 (4% share).

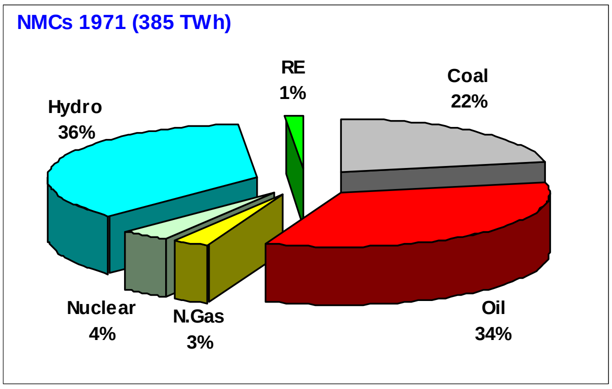
Coal-production has increased from 83 to 237 TWh between 1971 and 2006 (share of 22 and 18% of total power generation, respectively). It is expected to decrease to 217 TWh by 2025 (12% share). This is due to the coal power generation expected decrease to the benefit of natural gas, mainly in Spain and France.

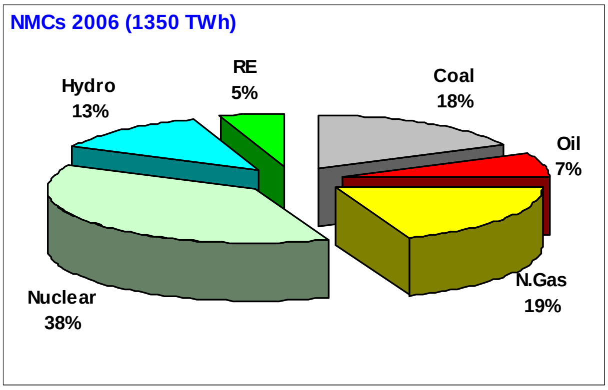
As far as hydro-based power generation is concerned, it has increased from 139 TWh in 1971 to 172 TWh in 2006. It is expected to reach about 204 TWh in 2025. Its share in total power generation diminished from 36 to 13%. This share is expected to be stable at least up to 2025.

RE-based power generation started with small quantities 5 TWh in 1971 (1.3% share of the total) and has reached 69 TWh in 2006 (5.1% share of total power generation). It is expected to increase to 207 TWh in 2025 (12% share). This share should be higher if EU countries comply with the new EU mandatory targets related to renewables.

Nuclear-based power generation started in the 1970s with the development of the French nuclear program. The production has since increased from 15 to 515 TWh between 1971 and 2006 (share of 4 and 38% of total power generation, respectively). Nuclear power generation is expected to increase to 518 TWh by 2025 (29% share).

Figure 7 - Share of energy sources in power generation for NMCs





Source: OME

Table 4 - Power Generation by Source and by Area (in TWh)

	North Med	SE Med	SW Med	SEMCs	TOTAL
	Coal	Coal	Coal	Coal	Coal
1971	82,8	3,0	0,3	3,3	86,1
1980	157,1	6,0	1,0	7,0	164,1
1990	200,8	30,6	2,2	32,9	233,7
2000	209,4	67,8	8,8	76,6	286,1
2006	237,3	78,9	12,9	91,8	329,0
2010	199,2	103,1	13,0	116,1	315,3
2020	178,7	204,3	23,6	227,9	406,7
2025	217,4	224,0	27,6	251,6	469,1

	North Med	SE Med	SW Med	SEMCs	TOTAL
	Oil	Oil	Oil	Oil	Oil
1971	132,4	13,4	5,8	19,3	151,6
1980	207,6	21,4	15,5	36,9	244,6
1990	137,0	21,9	34,9	56,8	193,8
2000	131,9	42,6	27,1	69,7	201,6
2006	99,6	46,0	35,1	81,0	180,6
2010	64,1	25,2	20,4	45,7	109,8
2020	56,8	30,5	23,6	54,1	110,9
2025	68,7	31,0	9,5	40,5	109,1

	North Med	SE Med	SW Med	SEMCs	TOTAL
	N.Gas	N.Gas	N.Gas	N.Gas	N.Gas
1971	10,5	0,1	0,9	0,9	11,4
1980	20,4	0,1	10,9	11,0	31,4
1990	47,5	12,6	35,5	48,1	95,6
2000	141,1	55,6	92,8	148,3	289,4
2006	258,3	93,9	135,6	229,5	487,8
2010	362,9	164,0	201,5	365,5	728,4
2020	568,0	247,6	338,5	586,1	1154,1
2025	575,6	301,6	380,4	682,0	1257,6

Table 4 - Power Generation by Source and by Area (in TWh) (continues)

	North Med	SE Med	SW Med	SEMCs	TOTAL
	Nuclear	Nuclear	Nuclear	Nuclear	Nuclear
1971	15,2	0,0	0,0	0,0	15,2
1980	68,6	0,0	0,0	0,0	68,6
1990	373,0	0,0	0,0	0,0	373,0
000	482,1	0,0	0,0	0,0	482,1
2006	514,8	0,0	0,0	0,0	514,8
2010	525,0	0,0	0,0	0,0	525,0
2020	521,5	31,7	10,5	42,2	563,7
2025	518,4	31,7	23,3	55,0	573,4

	North Med	SE Med	SW Med	SEMCs	TOTAL
	Hydro	Hydro	Hydro	Hydro	Hydro
1971	138,7	3,5	6,9	10,4	149,2
1980	178,8	14,8	11,6	26,4	205,2
1990	134,7	26,4	11,3	37,7	172,5
2000	176,0	34,6	14,5	49,1	225,1
2006	171,5	48,4	13,9	62,3	233,9
2010	190,9	65,0	16,1	81,1	272,0
2020	202,5	123,1	18,1	141,2	343,7
2025	203,7	123,3	18,3	141,6	345,3

	North Med	SE Med	SW Med	SEMCs	TOTAL
	RE	RE	RE	RE	RE
1971	5,0	0,2	-	0,2	5,1
1980	5,0	0,1	-	0,1	5,2
1990	6,2	0,1	-	0,1	6,3
2000	19,9	0,3	0,2	0,6	20,5
2006	68,5	0,4	1,0	1,4	69,9
2010	84,5	6,2	7,2	13,4	97,8
2020	155,8	10,1	21,4	31,5	187,2
2025	206,6	13,3	28,2	41,5	248,0

	North Med	SE Med	SW Med	SEMCs	TOTAL
	Total	Total	Total	Total	Total
1971	385	20	14	34	419
1980	638	42	39	81	719
1990	899	92	84	176	1 075
2000	1 161	201	143	344	1 505
2006	1 350	267	199	466	1 816
2010	1 427	364	258	622	2 048
2020	1 683	647	436	1 083	2 766
2025	1 790	725	487	1 212	3 002

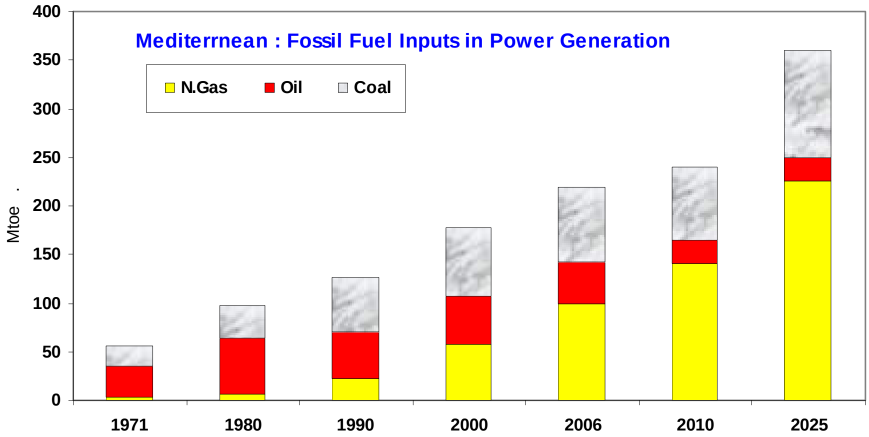
Source: OME

3. Fuel input and electricity efficiency

3.1. FUEL INPUTS IN POWER GENERATION

Fossil fuels for power generation in the Mediterranean have reached 220 Mtoe in 2006 (which represents 23% of the TPES) and are divided as follows: 45% for gas, 35% for coal and 20% for oil. By 2025, the fossil fuels dedicated to power generation are expected to reach 360 Mtoe (about 25% of the TPES), gas, coal and oil representing shares of 63%, 31% and 7%, respectively.

Figure 8 - Total fossil fuel inputs in power generation

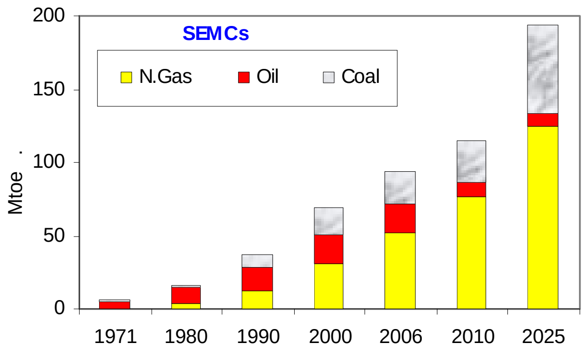


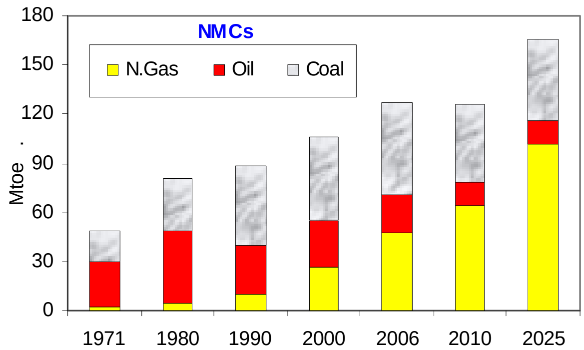
Source: OME

For the SEMCs, fossil fuels for power generation amount to 93 Mtoe in 2006 (which represent 34% of the TPES), gas, coal and oil representing shares of 55, 24 and 22%, respectively. By 2025, the fossil fuels dedicated to power generation are expected to reach 194 Mtoe (about 32% of the TPES) of which 64% for gas, 31 and 5%, for coal and oil, respectively.

For the NMCs, fossil fuels for power generation reached 127 Mtoe in 2006 (which represent 18% of the TPES) of which 38 percent for gas, and 44 and 18% for coal and oil, respectively. The fossil fuels dedicated to power generation are expected to reach 166 Mtoe (about 20% of the TPES) of which 61% for gas, 30 for coal and 9% for oil.

Figure 9 - fossil fuel inputs in power generation for NMCs and SEMCs





Source: OME

Total fossil fuel inputs into power generation are provided in Table

Table 5 - Electricity fossil fuel inputs (in Mtoe)

		2006			2025	
	NMCs	SEMCs	MED	NMCs	SEMCs	MED
N.Gas	48	51	99	101	125	226
Oil	23	20	43	15	9	24
Coal	56	22	78	49	60	110
TOTAL	127	93	220	166	194	360

Source: OME estimations

In general, it can be concluded that the share of fossil fuels going into power generation would remain relatively stable between 2006 (23% of the TPES) and 2025 (25% of the TPES) for the region as a whole and for the sub-regions. As expected from the trends described in previous section, oil going into power generation diminishes while natural gas increases. It is also important to underline that coal-based power generated will also increase, which will heavily impact the CO2 emissions in the region.

3.2. ELECTRICITY EFFICIENCY

Fossil fuel efficiency in power generation is provided in Table 6 for coal, oil and natural gas. Generally, all three fuel efficiencies have had a tendency to improve in the period under consideration. The most notable improvement is for natural gas, thanks to the substantial progress in combined cycle generation (50% efficiency against about 25% for a gas turbine).

Table 6 - Efficiency in fossil fuels for power generation (Mtoe/TWh)

Coal	1971	1980	1990	2000	2006	2025
North Med	0,264	0,242	0,242	0,244	0,236	0,227
SE Med	0,409	0,314	0,264	0,244	0,236	0,242
SW Med	0,303	0,358	0,321	0,216	0,244	0,225
SEMCs	0,399	0,321	0,268	0,240	0,237	0,240
TOTAL	0,270	0,246	0,245	0,243	0,236	0,234

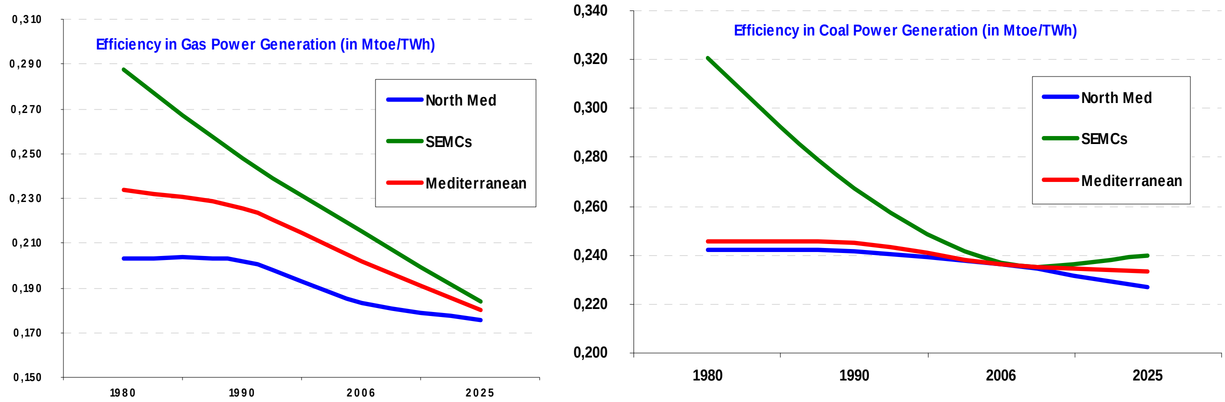
Gas	1971	1980	1990	2000	2006	2025
North Med	0,210	0,203	0,202	0,185	0,183	0,176
SE Med	0,237	0,299	0,214	0,174	0,199	0,171
SW Med	0,353	0,288	0,261	0,229	0,242	0,195
SEMCs	0,346	0,288	0,248	0,208	0,215	0,184
TOTAL	0,221	0,234	0,225	0,197	0,202	0,180

Oil	1971	1980	1990	2000	2006	2025
North Med	0,212	0,220	0,220	0,218	0,226	0,221
SE Med	0,253	0,269	0,278	0,228	0,231	0,237
SW Med	0,283	0,331	0,252	0,293	0,276	0,181
SEMCs	0,262	0,294	0,263	0,251	0,249	0,225
TOTAL	0,218	0,231	0,233	0,230	0,236	0,223

GLOBAL	1971	1980	1990	2000	2006	2025
North Med	0,229	0,227	0,229	0,220	0,212	0,192
SE Med	0,281	0,279	0,259	0,216	0,219	0,202
SW Med	0,292	0,315	0,258	0,242	0,248	0,197
SEMCs	0,284	0,296	0,259	0,227	0,232	0,200
TOTAL	0,234	0,236	0,237	0,223	0,220	0,196

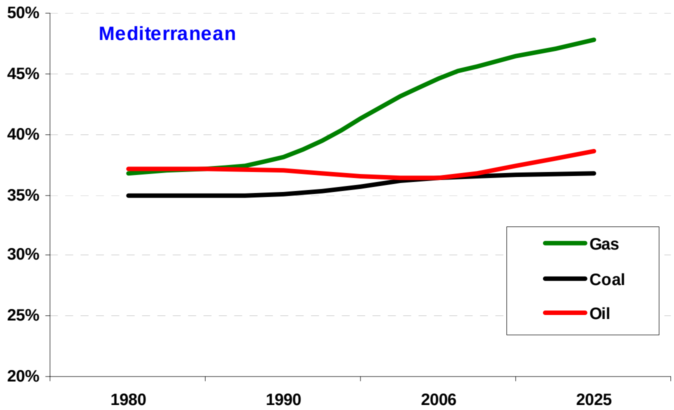
Source: OME

Figure 10 - Efficiency in gas and coal power generation

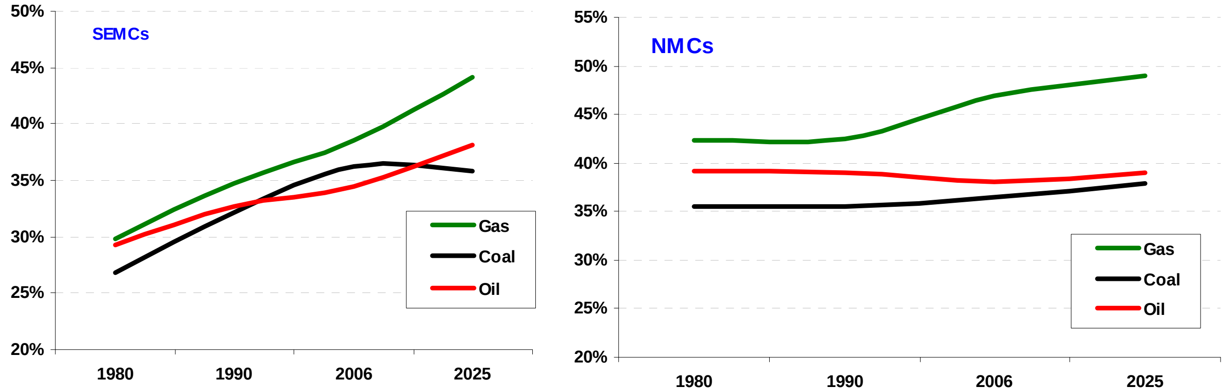


Source: OME

Figure 11 - Efficiency in fossil fuels for power generation (in%)



Source: OME



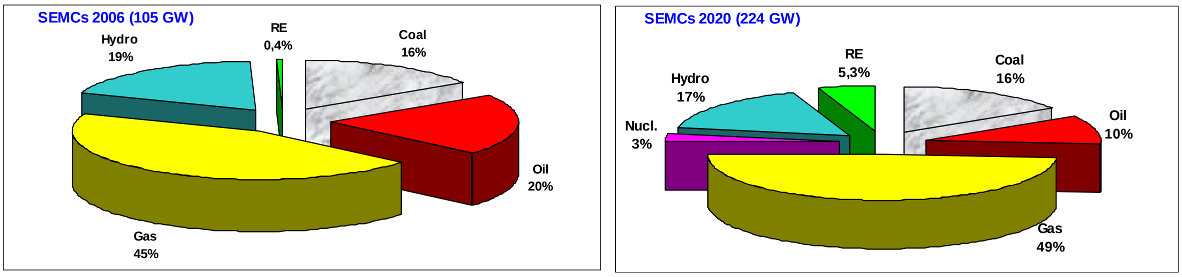
Source: OME

4. Huge investment needed for additional power plants up to 2020

Due to the strong increase in electricity demand, SEMC face a growing need for new energy services and related infrastructures. In particular, generation capacity in these countries will more than double within the next 15 years, necessitating to build an additional capacity of about 120 GW by 2020.

It is difficult to estimate precisely the long-term investments. Although there exists a strong volatility of costs (construction and engineering) of the different thermal power plants (according to the cost published by "European Power- CERA Watch, April 2008), and a significant increase over time, an approximate estimation, based on the January 2008 costs, gives for this additional capacity, cumulative investment needs of about 110 billion €[4] (176 billion USD, see table 7) up to 2020. Given the difficulties in attracting investment for domestic energy projects, SEMC will face a serious challenge.

Figure 12 - SEMC INSTALLED CAPACITY



Source: Eurelectric, UAPTDE and OME direct communication with companies.

Maghreb's, Egypt's and Turkey's future needs are particularly challenging, since they are expected to more than double their installed capacity in the next 15 years, from 83 GW in 2006 to 188 GW in 2020, accounting for 89% of SEMC additional capacity. More than half of this additional capacity will be gas-fired, mainly Combined Cycle Gas Turbines -CCGTs-(+38%). So far, there are projects for approximately 40 GW of additional capacity.

Substantial investments are also needed for upgrading the existing generation capacity. SEMC thermal power generation park is in fact characterised by quite high age of thermal power plants. A first scoring in the SEMC indicates that more than 180 power plants or units have an age between 20 and 50 years, and therefore would be part of a decommissioning programme that the SEMC should most probably consider.

Table 7 - Estimations of Investment Needs for Additional Power Plants H2020 (x1000 millions $)

	Coal	Oil	Gas	Nuclear	Hydro	RE	Total	Share by country
Turkey	30729	0	20311	11250	21095	4221	87606	49,8%
Syria		122	2992		206		3320	1,9%
Lebanon		20	651				671	0,4%
Israel	4788	1651	3909		960	350	11657	6,6%
PNA			1400				1400	0,8%
Jordan		50	1404			71	1525	0,9%
Egypt			27492	3000	91	5040	35623	20,2%
Libya			10405			678	11084	6,3%
Tunisia	3040		2800		5	1595	7439	4,2%
Algeria		968	7840			2672	11480	6,5%
Morocco	1397	551	778			1509	4235	2,4%
SEMCs	39953	3361	79983	14250	22357	16137	176040	100%

Source: OME

[4] OME estimates are based on CERA costs (see graph) which presents the volatility of costs of the different fossil thermal power plant projects. For nuclear power plant costs are based on range of 2100 to 2500 €/kW.

III. WHAT OPTION TO LIMIT THE INCREASE OF CO2 EMISSIONS FROM THE ELECTRICITY SECTOR?

For the Mediterranean region, the share CO_2 emissions in electricity sector represent 30% of the total CO_2 emissions in 2006; the share is more important in the SEMCs with 36% against 27% in the NMCs. The total CO_2 emissions coming from electricity sector amounts 636 Mt CO_2 in 2006 of which 253 Mt in the SEMCs and 383 Mt in the NMCs.

According to electricity demand forecasts and production facilities implemented, an increase in CO_2 emissions is expected (in absolute values) in the electricity sector of the Mediterranean region from 636 Mt in 2006 to 992 Mt in 2025, but the share of the electricity sector in the total emissions in the Mediterranean remain stable around 30%.

Table 8 - CO_2 emission in the electricity sector

	1971	1980	1990	2000	2006	2010	2025
N.Gas	6	16	49	130	223	317	511
Oil	90	154	130	135	116	66	65
Coal	75	129	218	265	297	288	417
Total	170	300	397	530	636	671	992

Med : CO2 emissions in Electricity sector (Mt CO2)

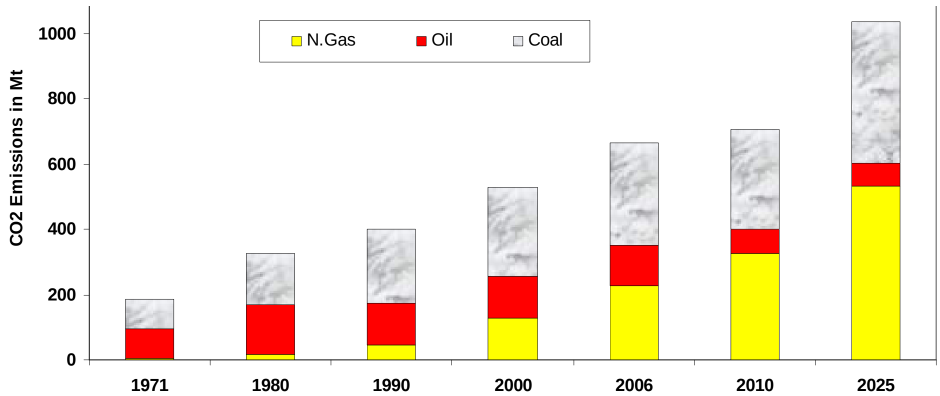
	1971	1980	1990	2000	2006	2010	2025
N.Gas	5	9	22	59	108	144	229
Oil	75	120	81	78	61	39	41
Coal	70	121	185	195	214	182	187
Total	150	250	288	333	383	365	457

NMCs : CO2 emissions in Electricity sector (Mt CO2)

	1971	1980	1990	2000	2006	2010	2025
N.Gas	1	7	27	70	116	174	282
Oil	14	30	43	52	55	27	24
Coal	5	9	33	70	83	106	229
Total	19	46	103	192	253	306	536

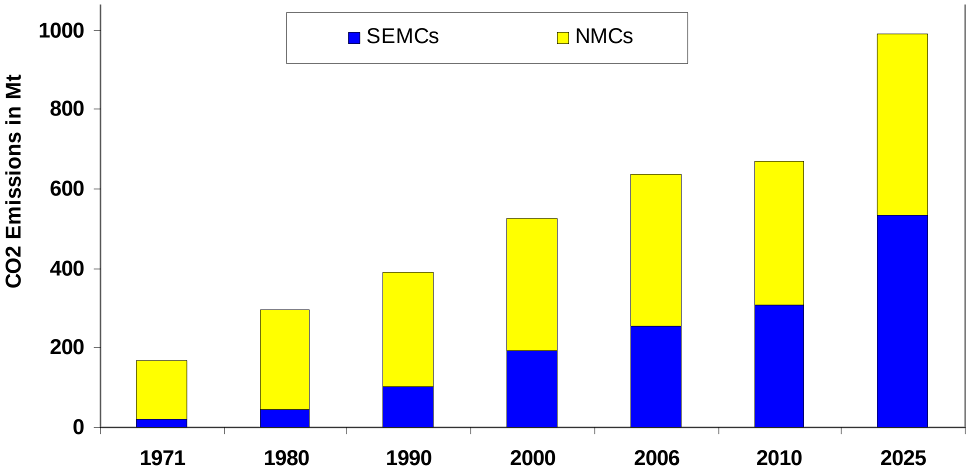
Source: OME

Figure 13 - CO_2 emission in the electricity sector by source



Source: OME

Figure 14 - CO_2 emission in the electricity sector by region



Source: OME

However, the increase of these CO_2 emissions is not a fatality and several options exist. It has to be underlined here that the large integration of natural gas in substitution to oil allowed during the last decades avoiding substantial higher CO_2 emissions. Nevertheless, the expected increase of coal will lower the environmental benefits linked to the development of natural gas. Thus, improving the energy efficiency of fossil based sectors, and switching from one fossil source to another for some uses (from coal or oil to natural gas) should be among solutions to reduce CO_2 emissions.

In the following we will focus on three options in order to estimate the potential of the reduction of CO_2 emissions by switching between sources of energy (less carbon content as natural gas), by pushing efficient technologies, less consuming of fuels and by CO_2 capture and storage. These two first actions include the highest natural gas penetration, and the renewal of the old power plants under operation in the SEMCs with new more efficient power plants.

1. Fuel switching and upgrade of older power plants

1.1. Increased gas penetration contributes to reduce CO_2 emissions

In the Mediterranean region, we notice a strong penetration of natural gas in the energy mix of the countries. The share of natural gas in the energy balance increased from 6% in 1971 to more than 25% in 2006. By 2025, it should reach a level of 33%, about 550 bcm of gas consumption.

In the early 1970s, only five Mediterranean countries used natural gas, whereas currently natural gas has a significant share in the energy balance of almost all Mediterranean countries (except Cyprus, Malta, Lebanon and Palestine). The last entrants were Greece in 1999 (with Algerian LNG), Jordan in August 2003 (with Egyptian gas via the Arab Gasline), Israel since 2004 (with local off-shore production), and Morocco in January 2005 (with commissioning the first NGCC power plant at Tahadart supplied by Algerian GPDF gasline). With the extension of the Arab Gasline, Cyprus, Lebanon and Palestine will join the gas consumer countries. It is also expected that all Mediterranean countries will increasingly consume natural gas. Favourite source of fuel for the new power stations in the North as in the South, gas will also see an increase by its penetration in the residential and tertiary markets of the SEMCs, boosted by the demographic growth and by the increased urbanization of coastal areas. The high natural gas consumption levels should easily be satisfied by the availability of the gas reserves (8500 bcm in SEMCs), but will of course require major investments in infrastructures to link production regions to consumption centres.

The foreseen highest gas penetration in the region contributes to avoid substantial CO_2 emissions in the Mediterranean region.

Indeed and as an illustration, if we consider by 2025 that, the share of natural gas in the primary energy consumption would remain at the level of 2006 (34% in the SEMCs, and 26% for global Med) and that the additional energy consumption needed (of about +98 Mtoe for all Mediterranean or +20 Mtoe for the SEMCs) would be covered by oil or/and coal sources, then the CO_2 emission would be higher[5] in 2025 than in the trend scenario presented here. Hence, in the trend scenario, the penetration of gas contributes in a certain way to the limitation of CO_2 emission growth.

Nevertheless, an option to decrease the growth of CO_2 from the electricity production in the trend scenario would be to accelerate on a voluntary basis the observed gas fuel input in power generation trend. From a technical point of view, we can assume than the gas fuel input generation speed could be two times faster than in the trend scenario[6].

In this case, the CO_2 emissions in the SEMCs will be lower by 55 to 77 Mt CO_2 in 2025, compared with the trend scenario. It represents 7.8% to 10.9%[7] of SEMC CO_2 emissions in 2006. .

This very brief and simple calculate clearly shows the potential of emission reduction with fuel switching. It also clearly show that switching from coal to gas gives results much impressive than from petrol to gas.

These emissions can be further lowered. This may be possible thanks to an increased penetration of new and efficient technologies such as combined cycle, concentrated solar power, etc. and particularly for those very old plants that will need to be replaced in the future.

1.2. CO_2 emission reduction by the upgrading of the oldest power plants: what potential?

The second potential of CO_2 emission reductions is closely linked to the renewal of the old power plants under operation in the SEMCs with new efficient technology power plants.

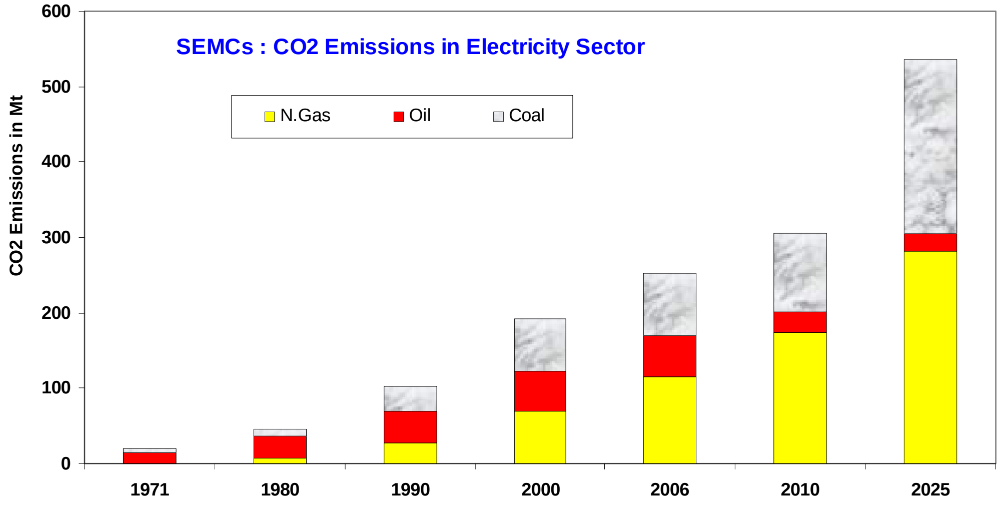
CO_2's emissions, originating from the electric sector in the SEMC's, are estimated at 253 Mt CO_2 in 2006. According to the forecasts, they could reach about 536 Mt by 2025. This is due to the need of fossil fuels power plants (mainly lignite, coal and oil).

[5] 266 Mt CO2 in the case of additional energy needed is covered by oil, 374 in the case of coal for all Med, or corresponding to 55 to 77 Mt CO2 for the SEMCs

[6] It means going from 51 Mtoe gas input fuels (55% of the total fuels) in 2006 to 2025 gas planned 125 Mtoe (64% of the total fuels) or to the voluntary quantity of 144 Mtoe gas input fuels (74% of the total fuels), representing about +19% of more gas input in the SEMC power plants.

[7] These reduction rates calculated comparatively to present level of total CO2 emissions in the SEMCs of 709 Mt CO2 in 2006.

Figure 15 - CO2 emission in the electricity sector by source in SEMCs



Source: OME

To face up to the growing need in electric power, the SEMCs must build new power plants as well as renew some of the ones that should be decommissioned. About 50% of the brand new ones are expected to be gas-based power plants and therefore producing less CO_2.

A recent survey in the SEMC's shows that more than 180 power plants or group of power plants are more than 20 years old. These old power plants are also characterised by very low efficiency rates, and poor environmental performance. As a result, they should be part of a decommissioning program that SEMC's should initiate.

If we consider that the present 22000 MW older plants (burning coal and/or oil, with a low average performance varying between 22 and 33%) are to be replaced by more performing ones such as gas combined cycle power plant (exceeding 50% efficiency), it is expected to safe more than 10 Mtoe of input fuels in power plants; Thus means an additional CO_2 emission reduction in SEMC's of about 3.7% to 5.2% (as compared to the 2006 level of total CO_2 emissions of 709 Mt[8]in the SEMCs). The following box lists some of the oldest power plants in some countries, illustrating that an important potential for CO^2 emissions reduction already exist and can be easily exploited.

Table 9 - Old power plant capacities in the SEMCs

	Nb of Power Plants	Capacity installed in MW over >20 years	Share of thermal capacity in%
Turkey	55	4757	18%
Syria	7	1602	29%
Lebanon	3	1065	45%
Jordan	5	556	31%
Egypt	15	4358	27%
Libya	46	3719	59%
Tunisia	18	1255	27%
Algeria	18	2931	38%
Morocco	14	1517	41%
TOTAL	**181**	**21760**	**29%**

Source: OME

[8] This reduction rates are 10.4% to 14.7% if it is compared to the 2006 level of CO2 emissions in electricity sector in the SEMCs of 253 Mt.

To conclude, one can notice that the combined action, to build more performed new power plants and to choose higher efficient technology for the upgrading old power plants, could provide an important CO_2 emissions reduction in the power generation. The rehabilitation program could be implemented on 9 to 10 years to renew the old power plants (2000 MW by year) with a reduction estimated at 8-12% as compared to the 2006 level.

The third option for reducing CO_2 emissions is passing through the carbon dioxide capture and storage which is illustrated in the next section.

Box 1 - Example of existing old power plants in Mediterranean countries

In **Egypt**, there are about 15 power plants that have between 20 and 40 years old, and it involves a capacity likely to be decommissioned of 4400 MW or about 27% of the total installed thermal capacity. Some oldest units exceed 40 years old as the 113 MW El Seiuf (since 1961 and 1969, with 21% efficiency in 2005). A first step will be the initiative of Egypt to push a new CCGT development. In this context, EGAS signed in April 2008 a MoU with Italy's Eni and Egyptian Electricity Holding Co., to conduct a feasibility study into applying the latest technologies to Egypt's power plants. The study will focus on introducing CCGTs to some of the country's power plants, in order to improve efficiency and reduce gas consumption. The MoU plans to save over 20% of gas currently used in these plants, and bring significant "environmental benefits". Part of the savings achieved in reducing the gas demand will be used to cover the costs of the project.

In **Algeria**, there are about 18 plants that are between 20 and 40 years old, and it involves a capacity likely to be decommissioned of 2930 MW or about 38% of the total installed thermal capacity. Among the oldest units who exceed 40 years old with an average efficiency under 29% in 2006, there are Algiers Port (120 MW commissioned since 1961); Oran Ravin Blanc (133 MW, 1965) and Annaba (125 MW, 1973). To be facing these problems, Sonelgaz has initiated a program of construction of new additional power plants to face the high increase in demand and to gradually replace the oldest power plants (ST and GT arriving at the end of life). It is including 3600 MW of combined cycle power plant projects (to cover base load) and 2000 MW Gas Turbine Units (for peak load).

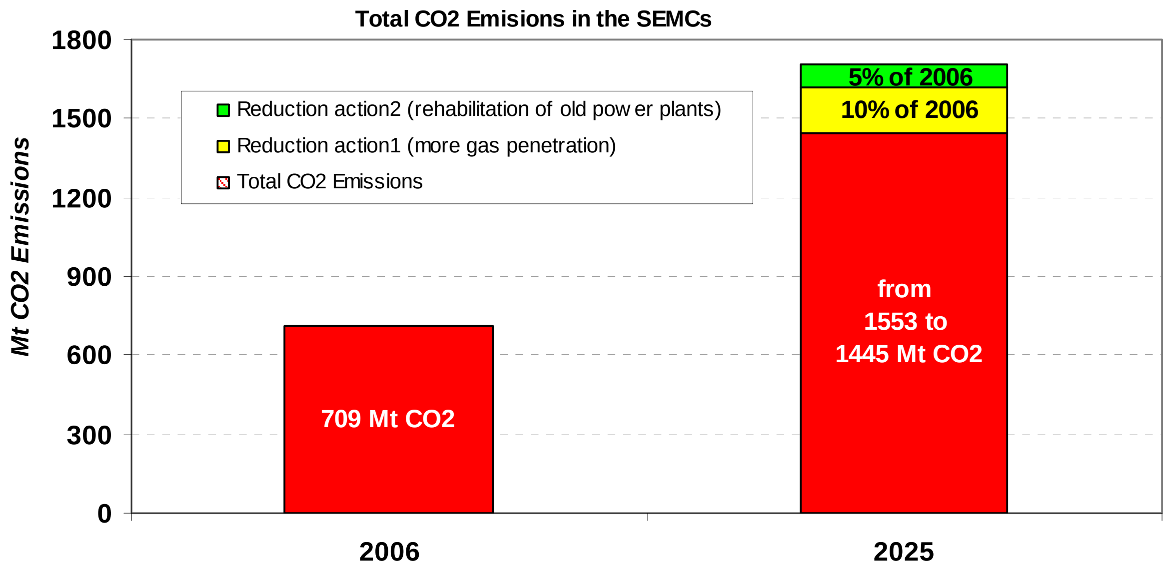
In **Morocco**, there are about 14 units beyond 20 and 40 years old, and it involves a capacity likely to be decommissioned of 1520 MW or about 41% of the total installed thermal capacity in the country. Among the oldest units who exceed 35 years old, they are Jerada (coal 160 MW existing since 1972); El Ayoun (36 MW, 1971); Agadir (40 MW, 1974); Tangier (40 MW, 1975); Tetouan (40 MW, 1975/1977) and Kenitra (300 MW, 1979).

In **Tunisia**, there are about 18 power plants which exceed 20 and 40 years old, and it involves a capacity likely to be decommissioned of 1260 MW or about 27% of the total installed thermal capacity in the country. Among the oldest units, they are Goulette (54 MW since 1965/1968); Ghanouche (52 MW, 1972), Ghennoude (44 MW, 1973); Tunis-South (52 MW, 1975); Gabes (23 MW, 1974/1978); Sfax (44 MW, 1977) and El Borma (44 MW, 1977).

In **Turkey**, there are about 55 power plants which exceed 20 years old, and it involves a capacity likely to be decommissioned of 4860 MW or about 18% of the total installed thermal capacity. Among the oldest units exceeding 30 years old, it is mainly lignite and oil fuelled power plants as Tuncbilek A&B (lignite 365 MW since 1956 & 1978); Soma A (lignite 44 MW, 1958); Zongdulak (oil, 75 MW, 1961); Isdemir-Hatay (220 MW, 1970); Ambarli (630 MW, 1970) and other autoproducer units of over 150 MW (lignite operated since 1922 and 1978).

1.3. Total benefit of CO_2 emission reduction, estimate of investment needed

Figure 16 - Total CO_2 emission reduction thanks to the two options proposed



In 2025, the sum of CO_2 emission reduction estimated from the two options proposed in this paragraph (fuel switching and power plant upgrade) is equivalent to 15% of total CO_2 emissions from energy use in 2006 (figure 16).

The two options proposed are partially tied since the renovation of power plant can integrate more use of natural gas. But, in any case, oldest power plants have to be renovated because there expectancy life is coming to the end. Nevertheless in other cases, the fuel switching can be done independently from up grating and renovation of power plants, which explain that the two options are presented independently.

Previously in this chapter, the investment needed for electricity power plant in the trend scenario in the SEMC up to 2020 is estimated at 110 billion euros. The two options presented here to decrease CO_2 emissions would necessitate an additional cost. The renovation of old power plant using combined cycle technology would necessitate additional 19 to 20 billion euros. The fuel switching option (conversion of existing power plants) is considered to cost a bit less than building a new power plant; In that case, investment needed is estimated to be between 8 and 10 billion euros.

2. The option of carbon dioxide capture and storage

In order to avoid high CO_2 concentration in the atmosphere a technical solution is to decrease emissions of the large and concentrated sources: in the electricity sector and in the other energy intensives industries. These include cement production, refineries, iron industry, steel industry and petrochemical industry (see Annex 'Localization of the world's largest emitting facilities'). But among all the energy intensives industries, the electricity sector represents more than 75% of the CO_2 emissions. Carbon dioxide Capture and Storage (CCS) is a possible solution. It consists of isolating CO_2 in the production process and then compressing, transporting and storing it for a long term.

2.1. Capture technologies

In a first hand, traditional power plant exhausts fumes contain principally gases which are not pollutants. In the other hand, storage capacities are limited and are technically complex to exploit. For these reasons the first operation which consists in CO_2 isolation is necessary.

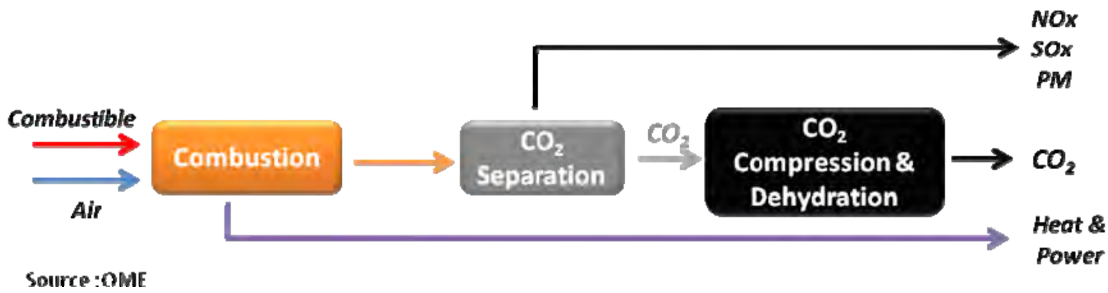
In case of electricity production CO_2 separation can be made at different steps of the production process: after, before or during the combustion. A capture process entails a decrease of 8 to 12 points of the power plant efficiency. With capture, the CO_2 emissions reduction is over 85% in power plants.

For coal power plants, the term 'clean coal technology' is often abusively used today. In fact, 'clean coal' is just a concept referring to CCS for coal technologies.

Post-combustion process

In this case, the treatment of the gases is just after the combustion step. First the sulphur oxides (SOx) are isolated. The residual mix, which contains 15% of CO_2, is transported to an absorption tower where CO_2 is trapped by a chemical solvent. The principal issue is the large volume of exhausts fumes which is treated because CO_2 is diluted and at a low pressure. In a second tower the solvent is heated to recover the CO_2. This solution is the most advanced and also the most expensive. But only this solution can be adapted for existing power central.

Figure 17 - Post-combustion capture



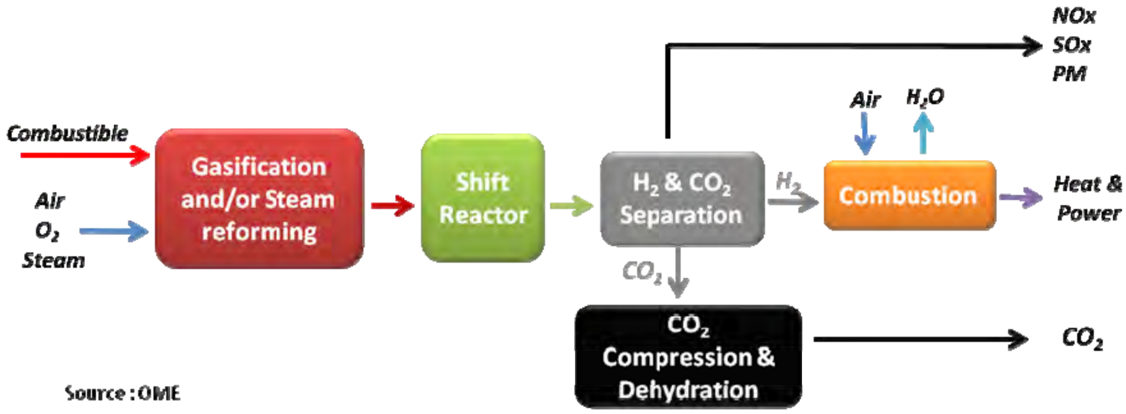
Currently, amines are used as solvents to trap the CO_2. But they are very sensitive to impurities and are quickly deteriorated: for one tonne of CO_2 captured, about 1 kg of the solvent has to be renewed. Because of this and also to reduce the costs, constructors are developing other solutions.

Nitrogen Oxides (NOx), Sulphur Oxides (SOx) and Particulate Matter (PM) are toxic pollutants which are already submitted to emission reduction laws. These pollutants are locally harmful for human health and they also contribute to the global atmosphere pollution.

Pre-combustion capture

In this kind of installation, several steps are necessary. First, the combustible is partially burned with oxygen (O_2) in a steam reforming unit. If the combustible is coal or biomass there is a gasification step before the reforming. These processes produce hydrogen (H2) and CO_2. But H2 exploitation requires designing a new global energy scheme.

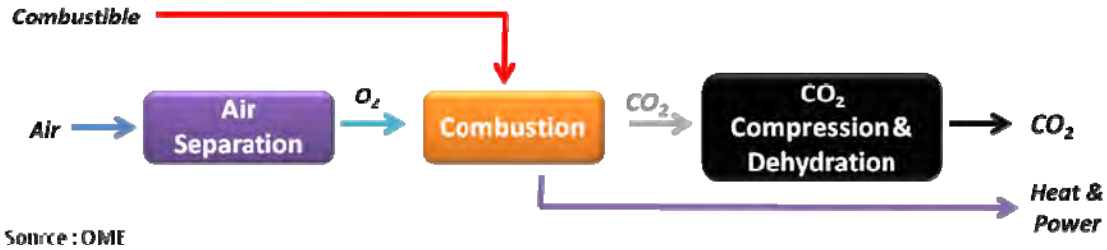
Figure 18 - Pre-combustion capture



Oxycombustion

This last process is in a demonstration phase, it combines the aspects of the other systems. All the combustion is made in one step with pure oxygen. Exhaust fumes contain only CO_2 and water steam, so the volume which has to be treated is significantly reduced.

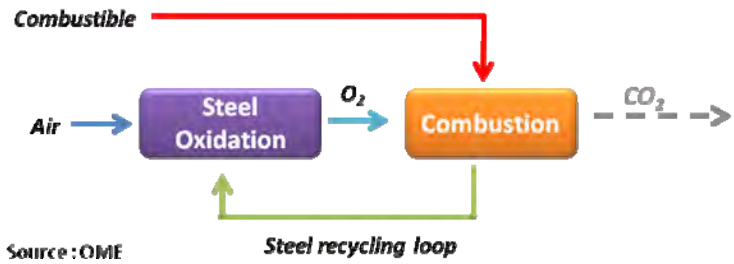
Figure 19 - Oxycombustion process



The second huge advantage of this technique is the emission reduction of NOx, SOx and PM. But the principal difficulty is the materials capacity to resist to the extreme temperatures of pure oxygen combustion. Another issue is the air separation made currently by cryogenic distillation which consumes a lot of energy. The Vacuum Pressure Swing Adsorption is an alternative; but today this process is used only in small installations of oxygen separation because it needs a specific adsorbent.

At the French Petroleum Institute research is lead to develop a cheaper way to produce oxygen, *'the chemical looping process'*:

Figure 20 - Oxycombustion, the chemical looping



2.2. Transport

The CO_2 transport from the capture site to the storage site does not entail specific difficulties. All the techniques from natural gas transport are available. Pipelines can be used for short and middle distances. In order to avoid pipelines corrosion a step of dehydration is combined with the compression of CO_2. The cost of transport in an existing pipeline is very low for short distances (under 1000 km). But for longer distances, and especially for offshore installations, pipelines construction presents difficulties. In these situations transport of CO_2 by ship may be preferred. The marine tankers exploited in the Mediterranean on a large commercial scale to transport LNG (Liquified Natural Gas) can also ship CO_2 if the demand increases.

2.3. Storage techniques

After be trapped and transported, the CO_2 has to be stored for hundreds of years in order to cover the whole period of greenhouse gases emissions issue. There is no need to store the CO_2 for 'always' but rather use secure buffer storage to differ the emissions in the atmosphere. The two kinds of techniques currently studied are geological storage and ocean storage. Ocean storage is still in a research phase and would not be available within the one or two next decades mainly due to the safety matter. The geological storage presents also difficulties but in a lower level. The discovery of CO_2 natural geological reservoirs, in the South of France for instance, makes this process credible.

Geological storage can be made in:

- Depleted or exploited Gas and oil fields
- Deep saline formations
- Unmineable coal beds

<u>Gas and oil fields</u>

Gas and oil fields have many advantages. The geological ground is well known, the sealing has already been tested. For the specific case of in exploitation oil fields the CO_2 injection contributes to the production optimization: this process is called Enhanced Oil Recovery (EOR).

The huge issue is that, this kind of reservoirs is unequally distributed on the planet and the available capacities do not seem to be enough, face to the long term storage needs.

Gas and oil fields seem to be safe but some risks still exist: behavior of cracks, chemical interactions between gas and rocks, constraints on the depleted reservoirs… The monitoring of current projects will bring answers to these issues.

<u>Deep saline formations</u>

These brine ground waters are located in depth. Due to the salinity, the liquid can't be exploited as freshwater or for irrigation. The storage potential is higher than the gas and oil fields one and the deep saline formation are also better distributed on the world regions. The researches on these reservoirs have been launched recently and there is especially no information about long term evolution in case of CO_2 injection. Here a specific risk is the pollution of freshwater formations which are next to the saline formations.

<u>Unmineable coal beds</u>

Coal beds have the capacity to adsorb preferentially the CO_2 than the methane naturally present in the coal. This storage mechanism can be coupled with the exploitation of the methane in order to decline his cost: this process is called Enhanced Coal Bed Methane (ECBM). But the long term feasibility is not yet proved because unmineable coal beds are more permeable than the other reservoirs.

Potential

The world total storage potential estimated is over 2 000 $GtCO_2$, about 80 years of current emissions. Currently there is no specific study that estimates the Mediterranean potential.

2.4. Economic Aspects

With a capture process the average power plant efficiency decrease is 8 to 12 points. So capture costs are high because of the investment part and also the exploitation contribution. Currently, the investment in a demonstration power plant with capture installations is twice the investment in a power plant without capture. It results quasi double production costs. The costs for the CO_2 transport and the storage are more affordable.

For these reasons, even if some SEMCs have storage capacities, with depleted gas reservoirs especially, capture costs are a considerable obstacle to install CCS widely in the region.

The low value of CO_2 is the major barrier to the development of CCS. The European Union Emission Trading Scheme (EU ETS) creates a price for CO_2. But CCS project are not including in EU ETS and, even if it was, the current value of CO_2 is too low. The uncertainty about regulatory is the second element that slows investments from industrials.

Table 10 - CCS Costs, source IEA 'Energy Technology Essentials', dec. 2006

Costs	
Investment ($/kW)	Some 50% of the power plant investment cost (demonstration plants with CCS)
O&M ($/kW)	Same as the power plant (2.5-4% of the investment cost per year)
Capture from p. plants	\$ 20-80/tCO_2 (\$20-40/t for cost-effective separation techniques)
Transport	\$ 1-10/tCO_2 per 100 km for large-scale transportation by pipeline
Storage & monitoring	\$ 2-5/tCO_2 site-sensitive
Total cost from p. plants	\$ 30 to 90/tCO_2 (may be much higher depending on technology, site, CO_2 purity)
Impact on electricity cost	$ 20-30/MWh (incremental electricity cost due to CCS)
Separation from nat. gas	\$ 5-15/tCO_2 (onshore-offshore)
Cost projections	Total CCS cost expected to fall below \$ 25/tCO_2 by 2030, depending on technology learning/advances, with incremental electricity cost of $10-20/MWh

2.5. Safety Aspects

Risks

For the capture process, there are no specific risks but the regular health, safety and environment risks for a such industrial process have to be managed.

Carbon dioxide transport presents fewer risks than hydrocarbon transport by pipelines or shipping.

The case of the reservoirs is more complicated; CO_2 storage can entail important changes in the geological environment and migrate up to the surface. To prevent or almost to decrease these risks, a well structured management is compulsory, it means:

- Attention for the site selection
- Precise monitoring of the reservoir evolution
- Regulatory independence
- Possibilities to adapt the procedures if an incident appears

Legal Aspects

No international law defines conditions for the carbon dioxide capture, transport and storage. Especially for storage, a specific regulation is necessary. For onshore installations, national regulation can be enough; few legal frameworks for long-term CO_2 storage have begun. Offshore transport and storage is more complex, international treaties are compulsory. And CO_2 issue has to be studied and precisely described in existing international instruments like the London Convention and the OSPAR Commission

The insurance problematic is related to legal aspects: insurance companies should develop standards for CO_2 transport and storage coverage.

Public information

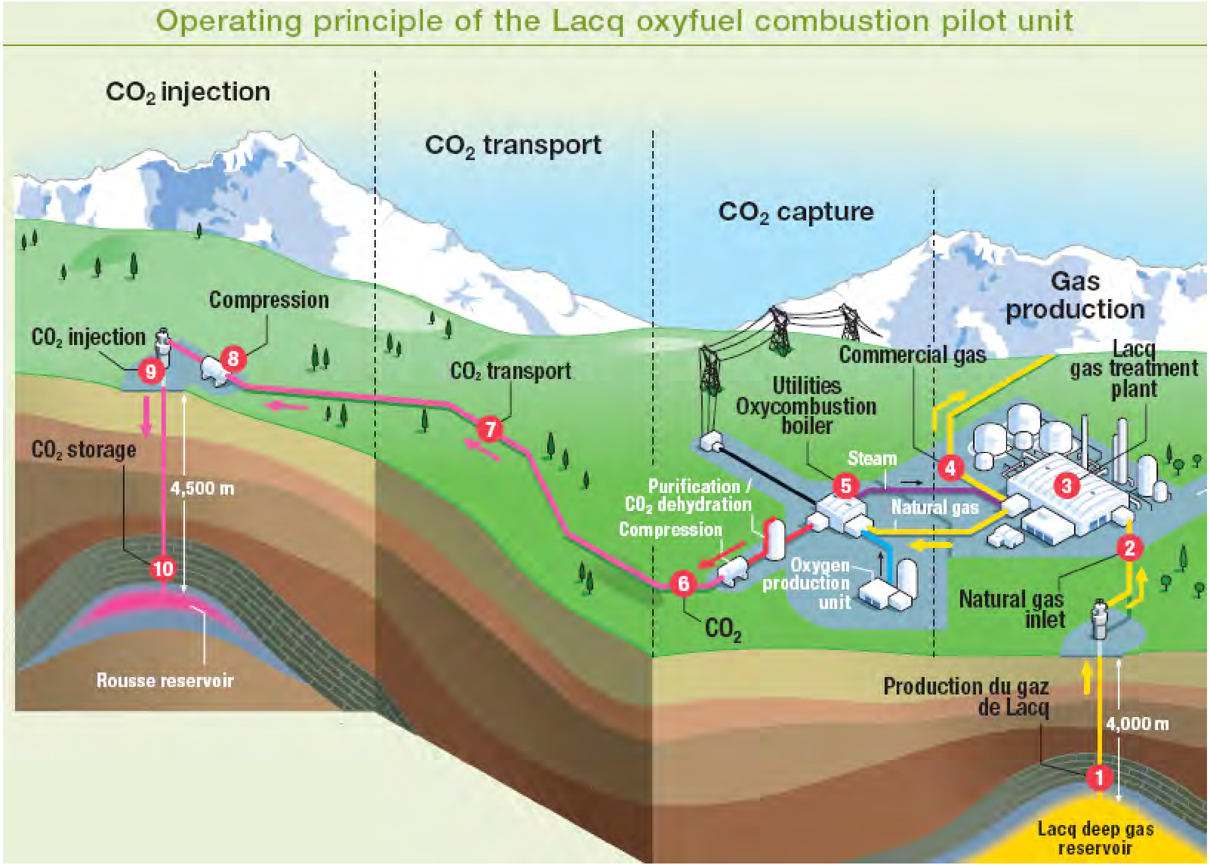
Public do not seem to be well informed about Carbon dioxide Capture and Storage. For instance in France, a recent opinion poll reveals that only 6% of the persons already know something about CCS. After explanation of the CCS processes 59% are favorable to storage, but 63% are worried about the risks and ask for more researches (Source: Sofres). There is a necessity to consult all the partners in order to avoid the NUMBY syndrome (Not Under My Back Yard).

2.6. On-going projects in the Mediterranean

The majority of CCS projects are located OECD countries and only few projects are located in Mediterranean countries.

In France: the Lack CCS project (Source: Total)

The French program will test the entire CO_2 capture and storage process, from the CO_2 emissions source to underground storage in a geological formation. This project entails converting one of the five steam boilers of the Lacq field's steam generating plant to an oxycombustion unit, then capturing and compressing its CO_2 emissions, transporting the gas via a 27-kilometer gas pipeline, for injection into the nearly-depleted Rousse natural gas reservoir in the Lacq area, at a depth of 4,500 meters. The pilot plant, which will produce some 40 tons of steam per hour for use by the industries of the Lacq complex, will emit up to 150,000 tons of CO_2 over a two-year period.



Source: Total

The Rousse well will be subject to close monitoring, with detectors located throughout the surface and subsoil regions to measure the injection flow, pressure, temperature and concentration of the CO_2.

The demonstrator unit is scheduled to start up in late 2008, after two years of studies and preparation. The project has three key objectives:

- to improve mastery of the oxycombustion process, particularly with a view to applications in the production of extra-heavy oils,
- to halve the cost of carbon capture compared to existing processes,
- to develop monitoring methods and instruments to demonstrate on a larger scale the reliability and sustainability of long-term CO2 storage technology.

<u>In Algeria: In Salah project (Source: BP Alternative Energy)</u>

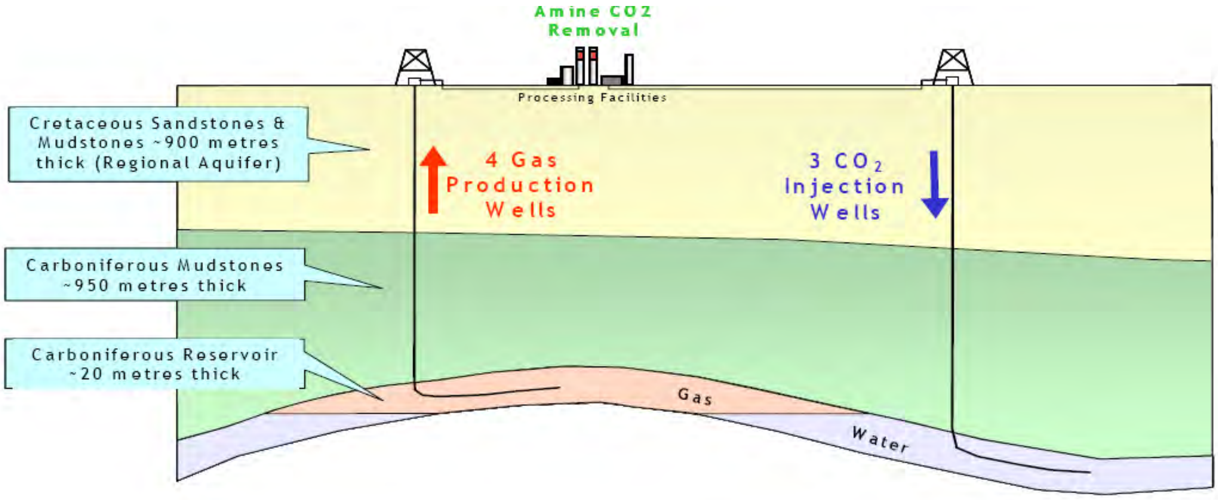
The In Salah project is a joint project which gathers BP, Sonatrach and Statoil. This project in divided in three parts:

- In Salah Gas Development
- In Salah CO2 Storage (1 MtCO2 / year)
- In Salah CO2 Assurance R&D

There is no commercial benefit for the CCS which is only an industrial scale demonstration of CO2 geological storage with post-combustion capture.

So, the In Salah Joint Industry R&D Project goals are:

- Provide assurance that secure geological storage of CO2 can be cost-effectively verified and that long-term assurance can be provided by short-term monitoring,
- Demonstrate to stakeholders that industrial-scale geological storage of CO2 is a viable mitigation option,
- Set precedents for the regulation and verification of the geological storage of CO2, allowing eligibility for CO2 credits.



Source: BP Alternative Energy

2.7. Perspectives in the Mediterranean

The table hereafter sums up the advancement state of the CCS different components. It clearly shows that Carbon dioxide Capture and Storage is not yet a totally mature market. Even though demonstration projects already exist in NMCs, a scenario with CCS huge development does not seem relevant for MCs. The only way to allow for a significant penetration of CCS in MCs would be that CCS projects account in EU ETS, with higher carbon prices and a structured regulatory and a better risks management.

Table 11 - Technical and economical maturity of CCS technologies

		Research phase	Demonstration phase	Economically feasible under specific conditions	Mature market
Capture	Post-combustion			X	
	Pre-combustion			X	
	Oxycombustion		X		
Transport	Pipeline				X
	Shipping			X	
Geological Storage	Enhanced Oil Recovery (EOR)				X
	Depleted gas and oil fields			X	
	Deep Saline formations			X	
	Unmineable coal beds		X		
Ocean Storage	Direct injection (lack or dissolution)	X			

Source: OME, adapted from IPCC document

IV. CONCLUSION

The growth in energy consumption and particularly of electricity in the Mediterranean countries is expected to increase over the next twenty years, particularly in the SEMCs. This heightened consumption is one of the key factors of the economic and social development of these countries, which is expected to be sustained by 2025.

Energy consumption will increase considerably, between 2006 and 2025, with a hike of over 480 Mtoe (of which over 330 Mtoe in the South and East). This is essentially the result of the development of electricity production which will consume over 30% of the primary fossil energies of the Mediterranean Basin in 2025 (34% in SEMCs). Electricity production should increase significantly with a hike of over 1186 TWh, in particular in the South and East where it is expected to triple (+746 TWh by 2025).

This development could be slowed by infrastructure financing issues. One of the main constraints, for Southern and Eastern countries, stems from the investments required for new power plants (+120 GW by2020-2025) estimated at nearly 10 Billion €.

Furthermore, investments for coal ports and natural gas production and transport infrastructures are considerable as well, which may explain the focus on combined cycle plants (+60 GW between 2006 and 2025) less expensive than coal plants, for example.

Developments in electric interconnections and electricity exchanges will help streamline production park operations and reduce the need for new production capacities. The amplitude of electricity exchanges will depend upon the differences in production costs, and therefore indirectly on fuel prices in the different Mediterranean countries.

Increased electricity production will cause a very significant increase in coal and natural gas consumption.

In the case of coal, forecasts point to high-level imports and consumption, particularly in the field of electricity, where requirements are assessed at 110 Mtoe in 2025 (60 Mtoe in SEMCs) versus 78 Mtoe in 2006 (22 Mtoe in SEMCs). This development may be impacted by environmental considerations (construction of ports and plants, air emissions…).

Total consumption of natural gas by the electricity sector could near 226 Mtoe in 2025 (of which 125 Mtoe in SEMCs) versus 99 Mtoe in 2006 (of which 51 Mtoe in SEMCs). With the exception of Algeria, Egypt, Libya and Syria, all other Mediterranean countries are importers, and imports should increase strongly by 2025, requiring the development of current sources and calling upon gas supplies from ever-more remote countries: Siberia, Middle East, Nigeria. This distance will lead to the inevitable rise in investment requirements to fund the required infrastructures (gas ducts and LNG networks).

The main obstacles SEMCs may be facing could be the strong growth in the use of fossil fuels to produce electricity, increasing CO_2 emissions, and the high levels of investment required to build new power plants.

There are solutions which should be encouraged, such as increased use of renewable energies and natural gas in the SEMCs. Another possibility is to support the development of electric interconnections to complete the electric network around the Mediterranean, knowing that the development of electric interconnections and electricity exchanges would enable optimal production park operations and reduce requirements for new production capacity.

Three options have therefore been analyzed to estimate the future reduction potential in CO_2 emissions:

- - Accelerating the transition to other fuels (such as natural gas), with lower CO_2 emissions. In the trend scenario to 2025, this first step would limit emission increases to between 7.1 and 10% vs the scenario showing the share of natural gas at 2006 levels.
- - The use of the most efficient and the least energy-intensive technologies, starting with their implementation within the framework of the rehabilitation program for nearly 22000 MW of the power plants up for decommissioning. Such a program, and new, higher-efficiency power plants (50% in combined cycle plants), could reduce fuel consumption by 10 Mtoe in 2025, the equivalent of an additional drop of between 3.7% and 5.2% in CO_2 emissions by the same date.
- - A third possibility, electric power plant CO_2 capture and storage could offset the high emissions from coal-fueled plants. However, this option is expensive (twice the investment than for non-capture plants) and energy-consuming; the potential market has not yet reached maturity, and many uncertainties remain, in particular as regards the environment. This situation does not point to the massive use of this option in SEMCs by 2025.

If the first two steps of this action plan were applied simultaneously, CO_2 emissions could be reduced by 10.4% to 15.2% in SEMCs by 2025.

Another and fourth option could be to encourage more sustained electricity and natural gas exchanges by 2025, which of course hinges upon the economic development and level of cooperation in the region. To overcome regional obstacles and to increase exchanges, the development of infrastructures and more specifically, electric and gas interconnections, is paramount. Electric interconnections could be used in addition for « green » electricity exchanges from such RE sources as solar energy, for which potential in the region is very high[9].

[9] Each kWh (ER or natural gas) exchanged through these electric interconnections would contribute to the reduction of CO_2 emissions in the Mediterranean.

PART 3

Vulnerability and Adaptation of the energy sector

CHAPTER 9

Wooded lands, climate change and energy in the Mediterranean

CHAPTER 10

Water for energy/energy for water and climate change in the Mediterranean

CHAPTER 11

Cross-cutting challenges : energy/tourism, cities/energy and climate change

INTRODUCTION

Parts I and II placed the energy system at the hart of climate change issues. It is a significant emitter of CO_2 and is the target of emission reduction policies. It is also subject to constraints due to infrastructures issues and water resources (e.g.: size of dams, hydro-electricity). Finally, adaptation measures in other climate sensitive sectors will have a direct impact on the future energy consumption and, as a consequence on the compatibility of energy development with sustainable development targets.

The objective of this final section is to consider some key sectors/resources, adaptation options possible and challenges.

To do so, this part reviews climate/energy issues related to wooded land area (chapter 9), electricity production, water management (chapter 10), tourism, building and urban transport (chapter 11).

CHAPTER 9
Wooded lands, climate change and energy in the Mediterranean

Jean de Montgolfier
Plan Bleu

TABLE DES MATIERES

KEY MESSAGES

- Mediterranean woodlands play a key role in the protection and management of certain global public assets: biodiversity, combating desertification, water resources. They also provide environmental services that are crucial to the sustainable development of an economy of which sustainable tourism is a core component: landscapes, nature recreation space, eco-tourism.
- Their role as carbon sink is fairly limited, because their little biological productivity, the little carbon accumulation in their soil and the growing fire risk in a context of rising temperature and declining rainfall.
- These areas, shaped by a long process of co-evolution with man and his livestock, have so far proved to have a high resilience capacity. This capacity is set to bear the brunt of the foreseeable climate change. Anthropogenic pressures and climate aggravations act in synergy: it is, therefore, required to ease the anthropogenic pressure to remain within the possible resilience conditions. Management must be much more "ecological" and adapted than it has, generally, been so far.
- There will probably be observed a certain side-slipping to the north, or in altitude, of the areas of distribution of the various plant species. It will, accordingly, be advisable to facilitate this natural swing by avoiding to create ecological barriers, or "insularisation" phenomena, liable to induce the extinction of many species.
- Their traditional use (production of wood, notably "fire wood", and other non wood products, notably grazed fodder resources) has quite significantly decreased in the countries of the Northern rim (NMCs) for several decades now, but still prevails in the countries of the Southern and Eastern rim (SEMCs) where overexploitation and overgrazing have induced, and still induce sometimes, serious degradation.
- In the Northern countries, a certain resumption of the use of fire wood is likely, based on highly automated methods (platelets), but at a higher average cost than in the forests of other regions, being more accessible and more productive. Strict measures of prudent and sustainable management must be observed.
- In the Southern countries, overexploitation of fire wood is still a serious threat. One priority is to not substitute to wood other forms of renewable energy.
- The Mediterranean region seems to be hardly favourable for the development of second-generation bio-fuel industrial sectors (ethanol from cellulose or Fischer-Tropsch synthesis) or heavy wood based bio-chemistry. On the other hand, it would be possible to develop "niche" products (small market), such as the use of waste from the wood/forest industry.
- In order to be sustainable, the management of woodlands must be participatory and must associate, within a spirit of good governance, all stakeholders concerned: local government, owners and users, economic developers, NGOs … It must, therefore, be conducted on suitable territorial scale.
- Besides, it must be integrated in the framework of the more comprehensive policies and strategies established on the level of the States and their regional subdivisions, as well as within the scope of dedicated monitoring and evaluation mechanisms.
- Cooperation between the countries of the Mediterranean basin is more than ever of crucial importance, not only on the intellectual level (research and development of innovative experiences, academic education and technical training, information), but also on operational level (means, of which in particular large-scale fire-fighting air means).

INTRODUCTION

Context, main issue

The subject of this chapter is linked with several major prospective topics addressed by Plan Bleu: global climate change, conservation of biodiversity, optimisation of "environmental services", sustainable management of natural resources, alternative energies, combating erosion and desertification, poverty reduction, land use management, sustainable and equitable local development, good governance… Though focused on the issues of carbon and energy balance, this text seeks to connect them to all these other overarching topics.

Objective of the chapter

The objective of this chapter is to analyse:

- on the one hand, the possible impacts of global climate change on Mediterranean woodlands; and
- on the other hand, the contributions that these lands may bring to combating such a change, by storing carbon and producing renewable energy and natural resources.

Information sources, methodology

Faithful to the spirit of the approaches developed by Plan Bleu, this chapter endeavours to be as systemic and prospective as possible. Being systemic is essential in view of the multiplicity of the stakes, the complexity of the interrelations between natural and anthropogenic factors, and the diversity of the time and space scales involved. Being prospective is related to the fact that this analysis belongs in the logical continuation of the Blue Plan's Environment and Development Outlook on a sustainable future for the (the Blue Plan, 2005). Its specificity lies in the central position given to global climate change, and in taking into account markedly more long term time frames (between 2050 and 2100), owing to the long durations implied not only by climate evolutions but also by wooded ecosystems.

Among the principal sources of information, it is worth mentioning the documentation collected at the time of drafting Plan Bleu booklet n°12 on Mediterranean wooded lands (Montgolfier, 2002), the whole of the documents and presentations given at the Rabat forum on the Mediterranean forestry sector (Morocco, 2005), and those of the recent Marseilles conference on climate change (Mediterranean Forestry Association, 2007). Synergy with the works in progress on sustainable rural development, conducted jointly by Plan Bleu and CIHEAM, has also proved to be quite useful.

Content of the chapter

This chapter consists of three parts.

Part I examines the impacts of global climate change on Mediterranean wooded ecosystems. It is divided into two sub-parts:

The first sub-part, of an overriding systemic character, lays the foundations for a prospective approach by describing the main linkages, in the Mediterranean, between wooded lands and climate.

The second sub-part, of a rather prospective character and resting on the previous analysis, considers the various alterations that global climate change is likely to cause to the functioning of these wooded systems, as well as the evolutions and challenges connected with these alterations.

Part II considers the contributions that these woodlands are likely to bring to combating this change, by storing carbon and by producing renewable energy and natural resources. It analyses, respectively, carbon accumulation on the stump, traditional energy uses, new bio-energies or bio-products foreseeable, as well as the conditions of their production. It concludes that, while these woodlands do bring in a real contribution, the latter is more limited than that of other types of forests: tropical, temperate or boreal.

Part III puts forward, for the consideration of "decision-makers"—and as pragmatically as possible—a set of conclusions and recommendations for action, in order to mitigate, to the extent possible, the adverse impacts of this change and to bring these wooded lands to bear on the major environment and sustainable development stakes (combating global warming, poverty, erosion … ; conservation of "global public assets", biodiversity, "environmental services"…).

I. CLIMATE CHANGE AND WOODED LANDS

1. Relations between wooded lands and climates

The purpose of this first sub-part is to outline, for the non forestry specialist, the grounds of the systemic analysis underlying the argument, conclusions and recommendations presented in the following parts. It considers the Mediterranean wooded lands as complex "eco-socio-systems", where many natural, but also anthropogenic, factors interact: over millennia, the influence of men and societies on the Mediterranean ecosystems and landscapes have been considerable, even decisive.

1.1. Which woodlands?

In the Mediterranean Region, it is preferable to address the issue in terms of wooded lands, rather than in terms of forests. Indeed, according to **FAO statistical** definitions, wooded lands comprise forests,[1] and the other wooded lands.[2] Under this class, there may be included matorral, scrubland, maquis, wooded steppes, which extend over a very large expanse around the Mediterranean: in Spain, in Greece, in Turkey, the other wooded land areas cover about a half of the total wooded area; in North Africa, they cover about a third of the area. The Mediterranean case is, thus, one of "wooded lands" rather than of "forests per se".

Below the thresholds of cover defining forests and other wooded lands (10% and 5%), the areas are considered as non wooded. There may be found, there, not only natural type areas (mountain pastures, high-altitude non wooded steppes, pre-desert non wooded steppes, esparto steppes), more or less used by pastoralism, but also areas kept artificially deforested by a more intensive exploitation (permanent grasslands). These areas belong, when they are grazed, under the FAO statistical class: **permanent pastures** (that is itself part of the agricultural area, which also includes arable lands and permanent crops). But it should be noted that many forests and other Mediterranean wooded areas are currently grazed (in the south) or were so in the past (in the north). This issue of pasture is far from being anecdotal. On the contrary, it creates a strong interdependence between the forestry issues and "biodiversity", "combating erosion" and "poverty reduction" issues.

1.2. Plant needs

In order to elucidate the complex relations between the foreseeable evolutions of the Mediterranean climate, the evolutions of wooded areas likely to result from them and the roles of these areas in carbon storage and in energy production, it is worth recalling a few major underlying principles of the functioning of plants and ecosystems. This overview is quite sketchy, and multiple clarifications would be necessary to elucidate such or such particular question; nevertheless, the overview helps focus the overall issue.

1 Are defined as forests areas where the cover of trees exceeding 5 metres in height (or likely to exceed 5 metres at maturity) is more than 10% of the total area. Forests can be natural or planted. Orchards, hedges, line plantations and thickets of less than 0.5 hectare are excluded.

2 Are defined as other wooded lands those areas which: either have a cover ranging between 5% and 10% of trees exceeding (or likely to exceed) 5 metres; or else have a cover of more than 10% of small trees (less than 5 metres), bushes or shrubs.

Woody plants are made up of **wood and other organic matter**. Wood constitutes the trunk, branch and root support material; it accumulates, year after year, in superimposed layers (or "rings"). The other living matter constitutes in particular the barks, the liber,[3] the twigs, the leaves, the flowers, the fruits, the fine roots; many of the latter have a creation and disappearance cycle over a year, sometimes less (fine roots…), sometimes more (leaves of evergreen trees). Non woody plants are, by definition, those which do not accumulate wood.

Wood is made up mainly of cellulose (very highly polymerised sugar), of lignin (polyphenol) and of hemi-cellulose. It thus consists primarily of carbon (about half of its dry weight), of oxygen and of hydrogen. In the other plant tissues, there are also nitrogen (component characteristic of the amino acids and proteins), phosphorus, potassium, calcium, magnesium (characteristic of chlorophyll) and many trace elements.

To give an **order of magnitude**: one hectare of temperate forest (or a Mediterranean forest amply supplied with water) can annually produce between 10 and 20 tons of dry organic matter, of which about a half consists of wood which accumulates in the trees, and a half of other matter undergoing an annual cycle. Tropical forests can be much more productive (30 to 50 tons of dry matter/ha/year). “Ordinary” Mediterranean forests are generally much less productive (1 to 10 tons of DM/ha/year), owing to the "limiting factor" related to water supply, a major constraint of Mediterranean climate.

Indeed, to produce wood and other living matter, plants need several natural elements and factors:

- energy, supplied by capture of sunlight photons. Light constitutes the ultimate limiting factor when all the other factors are in superabundance. In Mediterranean region, this is hardly the case;[4]
- carbon, supplied by carbon dioxide, CO_2, present in the atmosphere, which penetrates in the leaves via small apertures, the "stomatas", then is processed into various products, particularly into sugars (subsequently polymerised into cellulose, starch, etc), using the light-generated energy;
- water, which supplies the oxygen and the hydrogen of the organic molecules, and which, in much greater quantity, evaporates via the stomatas of the leaves, this evaporation inducing rise by capillarity of the crude sap from the roots. About 500 litres of water are necessary to produce 1 kilogram of dry matter. Thus, to produce 1 ton of dry matter on one hectare (which is quite little), 500 cubic metres of water are needed, that is, a *usable* water sheet of 50 millimetres. However, not all water obtained from rainfall is usable: a good part is lost by evaporation, runoff or deep drainage. The only water really usable is that which infiltrates in the soil layers prospected by the roots; and, still, this infiltrated water (often falling in autumn and winter) must remain available until the moment when the plants need it most (spring and early summer). A few figures may help give an order of magnitude: in an “average” Mediterranean climate, about 600 mm of rainwater is received per year; but it is deemed that only 200 to 300 mm will be really useful, thus allowing the production of 4 to 6 tons of dry matter, of which a half at best could be stored under the form of wood; finally, the "carbon sink" will be at best of 1 to 1.5 tons per hectare and per year. This example clearly highlights the very strong constraint represented by water in the Mediterranean ecosystems;

[3] Liber is the conducting tissue of the elaborate sap, located on the periphery of the trunk, branch and root wood. To be more comprehensive and precise, one should be talking about the distinction between sapwood and heartwood, base, bark, etc. But this report is confined to the smallest pattern possible in order to better grasp the plant/climate/energy linkages.

[4] At least in the higher stage of the vegetation. On the other hand, the underwood is sometimes quite dim: there can grow there such plants as “shade trees” or "sciaphile" species, which can be contented with low luminosity.

- various "nutrients" (nitrogen, phosphorus, potassium etc.) mined in the soil by the roots, and by the fungi (mycorrhiza) associated with them. When the soil is sufficiently rich in all these elements, no particular problem arises. But certain deficiencies in one or the other of these nutrients may turn out to be limiting factors, in particular deficiencies in nitrogen, phosphorus or potassium; it is the reason why these three nutrients are often brought by fertilisers in cultivated lands.

1.3. Eco-socio-systemic aspects

What has just been said relates to the vascular plants (trees, shrubs, herbaceous plants) considered on an individual scale. The matter grows complex when considering the whole of **the ecosystems** to which they belong. On the one hand, it is necessary to consider all the living organisms interfering between them: non vascular plants, fungi, algae, bacteria, viruses, animals of all kinds, worms, molluscs, insects, other arthropods, birds, mammals, etc, without forgetting man, obviously, whose role is absolutely essential. On the other hand, it is necessary to consider all the processes through which these organisms interact: habitat, propagation, consumption, cooperation, parasitism, diseases, decomposition, pedo-genesis (soil formation), cycles of water, carbon, nitrogen, others nutrients, etc.

There is, obviously, no room to undertake here a description, be it quite sketchy, of all these relations; all one can afford to do is highlight a few, particularly significant aspects in order to elucidate how the wooded ecosystems are likely to react under the impact of global changes.

Human (anthropogenic) action has been, for several millennia, a fundamental component of the Mediterranean ecosystems. Since the Neolithic era, these spaces have been moulded by clearings for temporary or permanent cultivation, whether by slash and burn or accidental fire, by the pressures of a more or less intensive pasture, by gathering or hunting, by collection of wood for domestic fire, industries (pottery, metallurgy…), construction, tool-making… According to the centuries and the areas, intense pressure periods—during which the forest had receded and was degraded—have alternated with periods of demographic and economic decline—when the spontaneous dynamics of the vegetation allowed expansion of the forest.

The Mediterranean wooded ecosystems are indeed quite resilient, or at least have proved to be capable of significant resilience (cf. further down) within the framework of the stable climatic conditions of the past centuries. In other words, they could recover their former state, within a few ten years (50 to 100 years for the forests, 10 to 30 for maquis and scrubland), even after a very strong disruption such as caused by fire or by temporary cultivation.[5]

Today, the situation presents a glaring contrast between the two rims of the Mediterranean basin. Throughout the Northern Mediterranean Countries (NMCs), the forest is markedly on the increase, both in terms of area and of stumpage. This is due to agricultural abandonment, during the 20th century, thus resulting in a gradual forsaking of agricultural and pastoral practices on most of the marginal lands, which were no longer profitable in a context of enlarged agricultural markets. The increase in wooded areas due to natural plant expansion was further fostered by the reforestation actions conducted by the forestry services. This expansion of forests with generally an important under-storey of brushwood is, on the other hand, one of the reasons behind the increase in fire

[5] Thus, if a forest burns on average once every 100 years, it will grow again as forest. But if it were to burn once every 20 years, it would be degraded into scrubland or maquis. However, were it to burn once every 5 years, it would be degraded into dry grassland. But, conversely, if a scrubland or a maquis does not burn over a period of 50 years, it will spontaneously and naturally grow into a forest. The only phenomenon which is irreversible over a century time-period is massive erosion. It fairly seldom occurs after a fire, but much more frequently in the event of clearing and harrowing of steep slope land.

outbreaks.[6] By contrast, in the Southern and Eastern Mediterranean Countries (SEMCs), wooded areas are still subject to very high pressures: clearing and cultivation of marginal lands, overgrazing, overexploitation of fire wood. It seems, however, that, for a few years now, the situation has been in the process of stabilization in many places.

To what extent will the remarkable resilience shown by the wooded areas under a stable climate continue to persist in the event of global climate changes? Are there any irreversible thresholds? These are key questions which will be addressed again further down.

The soil is a very important compartment of the ecosystems, yet difficult to study and elucidate based on precise measurements. With respect to the issue of climate changes, it intervenes in three main ways: by its capacity to store a water reserve usable by the plants, its nutrient content, and its role in the cycle of organic matter and, hence, of carbon. Usable water and nutrients determine the total productivity of the ecosystems (cf. above).

Its role in the carbon cycle stems from the recycling of organic matter other than the stump accumulated wood. Leaves, twigs, flowers, fruits, together with animal dejections and corpses, fall on the ground and decompose there under the action of multiple living organisms: bacteria, fungi, earthworms, micro-arthropods, etc. As for fine roots, they re-grow and decompose in the soil itself. After complex processes, the carbon contained in all this decomposing matter may end up under two main forms: either under the form of CO_2, rejected, in fine, in the atmosphere by the breathing of the decomposer organisms, or else under the form of fairly stable organic molecules constituting the soil humus.[7]

Moreover, the wood stored in the stumps and the large **roots** constitute also a relatively significant biomass, particularly in the Mediterranean region. To withstand weather conditions, and in particular to seek out water at far deep distances, the trees, there, often have a highly developed root system and a root biomass/ total biomass ratio that is much higher than in other types of climate.

All in all, wooded areas present 2 "carbon sinks": stumpage and soil. Wet tropical forests can store considerable quantities (hundreds of tons to the hectare) of carbon in the stumpage, but store little humus, owing to the quite active respiration of decomposer organisms due to heat and moisture. Boreal forests store less wood, but can accumulate huge quantities of humus or, more precisely, of peat. Mediterranean forests—as well as dry tropical forests, in fact—present poor performance, not only in terms of wood—as they are little productive—but also in terms of humus—since it decomposes too quickly there.

1.4. Climate and plant distribution

Two major climatic parameters control the space distribution of Mediterranean plants (cf. the classification proposed by Pierre Quézel, as taken up in [Montgolfier 2002]): the average annual rainfall determines the type of bio-climate (from per-arid to per-humid, through arid, semi-arid, sub-humid and humid). The average of the minimum values of the coldest month determines the heat variant of the bio-climate (from extremely cold to hot) as well as the plant altitudinal stage.

To each of these bio-climates and to each of their variants, there correspond certain plant associations, which group species having close requirements in terms both of climate and soil.

[6] One need, however, guard against reversed reasoning, such as is too often the case with the popular press: it is because there are more and more forests with an under-wood rich in brushwood (which is normal in Mediterranean region) that there are increasing fire hazards; nevertheless, in spite of these more numerous fires, the forest is markedly on the increase throughout the countries of the northern rim, by natural vegetation dynamics, without it being necessary, save for exceptional cases, to undertake manmade reforestation after fire.
[7] In highly water-saturated and non oxygenated soils, anaerobic decomposition processes can emit methane. These cases, typical of marshes, are rare in Mediterranean zone.

Associations are organized according to plant series. A series is composed of various associations likely to follow upon one another at the same location according to plant dynamics. A typical Mediterranean series may be made up of a succession of grassland, low maquis, high maquis, clear forest, dense forest. The plants may be classified into pioneer plants (abundant in the first phases of a succession), post-pioneer plants (in the intermediate phases) and "dryads" (mature, or maturing, plants, sometimes called "climax" plants). Normally, vegetation develops naturally from one phase to another, but a strong disruption (recurrent fires, clearing, prolonged overgrazing) can relegate it to an early phase, from which it will again evolve in a natural dynamics, unless a new disruption takes place.

This capacity of the ecosystems to resume a dynamic evolution after a strong disruption constitutes their so-called resilience. But resilience is not always effective. There may be cases of a blockage where the ecosystem cannot recover its former state any more: disappearance of the seed-bearer of one or more key species of the ecosystem; high soil degradation, due for example to massive erosion…; change in weather conditions: herein lies, precisely, one of the major concerns related to global changes: how will the resilience of plant formations evolve in the event of climate (hence, bio-climate) change?

2. Impacts of climate change

2.1. Evolutions of climate parameters

There are many models to forecast changes of climate parameters. Their results vary according to the modelling hypotheses selected to describe what we currently know about global and regional climate parameters, and according to various scenarios related to the volume of GHG emissions (cf. Chapter 1). As far as the Mediterranean basin is concerned, the models concur that the following phenomena are extremely likely:

- - average temperatures will increase in all seasons;
- - average rainfall will decrease in all seasons and, probably proportionally more in hot season, in which it is already very low, than in cold or mild season;
- - extreme phenomena (storms, violent winds) will increase, even though this increase is less certain than those of temperature and aridity;
- - climate variability (estimated from standard variance of the statistical series of temperature and rainfall parameters) will increase; in particular inter-annual rainfall variability, which means that the probability of succession of several dry or very dry consecutive years will increase; it being a fact that Mediterranean climate is already characterized by a strong variability.

The main climate features unfavourable for vegetation will thus worsen: very strong heat and prolonged drought in the summer, as well as great inter-annual variability, requiring perennial plants to develop capacity to withstand, several years on end, very tough survival conditions.

The only apparently favourable aspect would be the rise in average temperatures in temperate season: it should allow plants to have a longer autumnal growth period,[8] and an earlier spring re-growth, thus fostering a better optimisation of the water falling during these periods. Yet, the other

[8] This type of growth which does not exist normally in cold moderate climate is all the more marked that the Mediterranean climate is hotter. In fact, generally, evergreen species are suited to benefit from it.

side of the coin would be that this earliness presents the great disadvantage of further exposing the young shoots to the risk of late frosts. Then, because of variability, such risk will probably not, or only fairly, decrease. Besides, perennial plants need some cold to allow for the blossoming of buds in spring; these needs are likely not to be met, which would lead to the deterioration of the species concerned.

This general information relates to the whole of the basin. The more one goes further down to the level of the sub-regions, the more the data provided by the various models will differ. It seems, nevertheless, that the aggravation will be worse in already arid or semi-arid areas, especially present in the countries of the southern and eastern rims, than in the sub-humid or humid areas.

The speed at which these evolutions are foreseen depends, obviously, very strongly on the hypotheses advanced on the result of the policies conducted, on global level, to reduce GHGs. But it also depends on the structure and the hypotheses of the model and, in particular, on the way in which the interactions between atmosphere, biosphere and oceans are modelled. This is why the forecast figures for a given year (2050, 2100…) often vary quite widely. However, the overall trend of the variations is not questionable. Besides, the models tend to become increasingly pessimistic the more they are refined, which is a worrying fact.

Henceforth, significant observations can be made of this aggravation of the Mediterranean climate.

2.2. Impacts on plants and ecosystems

2.2.1. Impacts of drought and temperature

Water availability being the main limiting factor of plant natural growth in Mediterranean climate, the decrease in average annual rainfall will undoubtedly slacken this growth and, hence, decrease the net primary production of plant matter, thus reducing the storable annual carbon quantity.

When water supply is good and does not constitute a limiting factor, the rise in temperature increases at the same time photosynthesis, which stores carbon, and plant respiration, which de-stocks it. On the whole, the balance is tipped in favour of storage, which increases with temperature, as long as the latter is not excessive (less than 30 to 35 degrees C), and—above all—as long as there is water available for evapotranspiration. In cool season, this effect will take place and allow better use of the rains of such season; this phenomenon will operate fully in the case of those rare plant formations which experience the major part of their vegetative cycle in winter (for instance "phryganeas" with *Euphorbia arborea*).

On the other hand, temperature rises in hot season will be definitely less beneficial, because of the lack of water available. Starting from a certain temperature, and a certain drought, the leaves slow down then stop photosynthesis altogether, but respiration continues: there is, on the whole, carbon de-stocking. Should the temperature rise further, the leaves would likely die, then the plant as a whole follows suit. Lethal temperature varies significantly according to each plant species.

The rise of maximum summer temperatures, prolonged duration of dry season, and increased probability of successive several dry years will increase plant mortality. Even though Mediterranean plants are well adapted to temperature and drought, there are limits to their capacity in this regard, and once these limits exceeded, they die.

Seedlings and small plants are, almost always, much more sensitive to these phenomena than adult plants. The regeneration of wooded ecosystems will thus become more difficult and more random. It will properly occur only during wet years or, better still, during a succession of wet years, which events are set to become increasingly rare. On the other hand, old trees will resist all the better when they have a significant root system, thus exploring a vast soil volume. They will, accordingly, be able to behave as “seed bearer” reserves, allowing to withstand long dry years in wait for wet years that are favourable for regeneration. But this is subject to the fact that human actions (felling, overgrazing, fires…) do not come to destroy either these seed-bearers, or the rare and precious regenerations when they occur.

2.2.2. Impacts of the chemical composition of air

The increase in carbon dioxide content in the air is favourable for photosynthesis; it thus increases net biological production and, consequently, potential carbon storage, at least when a limiting factor of this production is precisely this dioxide content. There are many experimental data confirming this effect on crop plants. For natural ecosystems, the same undoubtedly applies. The problem is that for the large majority of Mediterranean wooded areas, the main limiting factor is water, and not dioxide. This favourable effect of dioxide can thus occur only for those periods of the year when water supply of the trees is satisfactory.

Moreover, an increase in nitrogen oxides content has a contrasted effect: on the one hand, rain acidity increases, which may result in harmful effects commonly called "acid rain"; however, they are hardly as significant in Mediterranean region as in more northern regions; on the other hand, the nitrogen brought in by the rain comes to enrich the soil, which is favourable for plant growth, as nitrogen scarcity is often another severe limiting factor in many Mediterranean ecosystems.

All in all, in countries where forests form the subject of a regular statistical monitoring by means of periodic forestry inventories, there has been observed a marked increase in annual wood production since these inventories started to exist. This increase may be due at once to rises in carbon dioxide, nitrogen oxides, and average temperatures. The decrease in average rainfall has not, in the recent past, cancelled out these positive effects. But in the decades to come, things will take a different turn if the water deficit increases.

2.2.3. Impacts on risks

Fire hazards will be increased by rising temperatures, by greater desiccation of plants during the long dry periods, and perhaps (though this is one of the points where the results of the models are the least certain) by the increase in the number of days of violent wind. A certain compensation will be brought by the presence of a smaller combustible mass: low woody plants, commonly called brushwood, which constitute the main fuel for the flames having, like the others, a slackened biomass growth. And, after brushwood clearance for purposes of preventive fire control, this brushwood will grow again more slowly. Nevertheless, the risk will increase on the whole and, consequently, the difficulties of fire fighting, too.

Today, there is a dynamic state of balance between fires and natural regeneration of wooded areas after fire. When fires are not too frequent, this balance is in favour of increased wooded areas, which extend in most of the countries of the northern rim, owing to a fall in agricultural, pastoral and forestry pressures. But what will become of this balance in the future, when fire hazards are higher, and the regeneration difficulties are greater? Control over big fires will be at once more essential and more difficult. Certain recent facts are alarming in this regard: 300 000 hectares of burnt forests in Portugal in 2003, a heat wave year, but which would seem to be just normal before the end of the century.

As regards the evolution of the health of the wooded areas, it is more difficult to make forecasts. The plants, subjected to more prolonged heat and water stress will certainly have lower resistance to attacks by diseases and pests. It may be held that, on the whole, pathogenic fungi will be rather disadvantaged by drought, while certain devastating insects will be advantaged by the rise in temperatures. For instance, there has currently been observed in France a northward spread of attacks by pine processionary caterpillars, as winter cold is one of their main limiting factors.

2.2.4. Impacts on the soil

Concerning the storage of carbon in the soils, the situation is complex to analyse. Heat (except when it becomes really excessive) increases the respiration and activity of living organisms, hence, in particular, those of soil micro-flora and micro-fauna. Their action of decomposing soil organic matter, and of processing the stored carbon into CO2, will therefore be accelerated by it. But also water is needed so that this activity could be significant. The increase in drought thus compensates partially that of heat. A precise analysis would require comparing the foreseeable evolutions of temperature and rainfall curves with the body of knowledge available on the eco-physiology of the main elements of this micro-flora and of this micro-fauna. It appears, nevertheless, quite likely that the general trend will be towards de-stocking. All the more so as the fires, whose risk will increase, can periodically destroy the organic matter of the uppermost soil layers.

It is also probable that the sensitivity of the soils to erosion and desertification will increase, owing to lesser plant cover and lesser organic matter content of the soil. Erosion and desertification will also increase if extreme events increase: violent winds—as factors of wind erosion and sandstorms—, or rare but torrential rains—as factors of water erosion. These processes have, themselves, harmful impacts from an energy point of view: loss of soil fertility, and silting of dam reservoirs.

2.3. Risks for biodiversity

Each species has a certain intra-specific genetic biodiversity; also, within each species, each stand, present on a given site, has its own genetic diversity. Climate change will exert a strong "selection pressure" on the species and their stands.

2.3.1. On-site adaptation ?

It is probable that certain species will be able to draw upon their genetic diversity to adapt, and that their stands will be able to evolve on site and cope in spite of harder climatic conditions. It is quite probable, as well, that some other species, or stands, will not manage, because the extent of the changes will exceed that of their genetic adaptation capacities. They will have thus to move via the dissemination of seed or propagates, or disappear. But, in the absence of precise genetic knowledge on the overwhelming majority of species, it is quite difficult to predict today which will be in either of these situations.

2.3.2. or displacement of distribution areas ?

Notwithstanding these possibilities of on-site evolution of certain species, it is quite probable that there will be observed, in the course of the century, significant displacements of the geographical areas of most of them. Indeed, each of the species will appreciably maintain the same bio-climatic requirements (rainfall and temperature).

On the other hand, the bio-climatic features of a given geographical site will evolve according to the decreases in average rainfall and the increases in average minimum temperatures of the coldest month: certain humid places will become sub-humid; certain sub-humid places will become semi-arid, etc. Likewise, certain cold places will become cool; certain cool places will become temperate, etc.

To remain under the same bio-climatic conditions, plants will thus have to shift geographical area by dissemination of seed. In certain cases, this will be relatively easy: for instance, it would be enough easy to ascend a few hundred metres up a slope to find the same climatic conditions, or to shift from a southern slope to a nearby northern slope, or from a dry slope to a better watered slope. In other cases, it will be more difficult: plain or plateau along which it would be necessary to migrate several hundred kilometres to find analogous conditions. In some case it will be impossible at all: close to a mountain top or a sea shore.

Topographic constraints are, thus, decisive as to the possibilities of migration of the species. However, it is obvious that man can aggravate them, particularly by splitting up the ecosystems into separated small islets, or by creating broad manmade cuts. But man can also help towards easing such constraints by transport of seeds or seedlings, either intentionally or accidentally. Besides, man can create "biological corridors" facilitating natural progression of the species.

Vis-à-vis the need to migrate, plants stand unequal chances, according to their propagation and dissemination pattern. Annual plants and perennial plants which reproduce at a very young age will be advantaged by comparison with those which reproduce at an advanced age: the stands of the former can thus migrate at a much quicker "pace" than those of the latter. But, above all, it is the plants whose seed can be disseminated over a long distance by wind, birds or mammals will be largely advantaged compared with those which are disseminated only in the vicinity of seed-bearer ones. It may thus be held that that stands of pioneer plants and, to a lesser extent, of post-pioneer plants, will not find it too much difficult to migrate to follow the displacing of their favourite bio-geographic areas. Conversely, stands of maturity plants (dryads) will encounter much more difficulty, and it is likely that entire stands will simply disappear. The case will be particularly serious for endemic dryads whose stands are very localised: disappearances of species are then probable.

In short, the situation will be likely as follows: adaptation on site of certain species, a shift higher in altitude and northward of most of pioneer and post-pioneer species, and disappearance of maturity endemic species.

2.4. Cumulative impacts of human and climate pressures

Over millennia, Mediterranean wooded areas have often undergone very strong anthropogenic stresses: over-exploitation of firewood, very intensive pasture, temporary cultivation of marginal land. These stresses have induced two types of evolution:

- irreversible impacts, or at least reversible on the very long term (in the order of centuries, if not millennia), due to erosion and loss of soil loose layers. Plato already deplored erosion in ancient Greece.
- reversible impacts in the medium and long term (in the order of a few decades) inducing a degradation of forests in a process of "matorralisation" (change into maquis, scrubland or more or less wooded moors) and of "storey lowering".

Thus, the naturalists of the early 20th century (the term ecologist was not common then) were describing the Lower Provence and the Languedoc "Garrigues" as the typical Holm Oak area. However, in these areas, there may be observed, over several decades now, a general trend toward the return of the pubescent Oak, which had been considered by these same naturalists as climacic in the wetter medium mountains of Upper Provence and Upper Languedoc. This return is now thought to be due to a reduction in the very high anthropogenic pressures of the 19th and early 20th century. Repeated cutting of coppices to produce firewood, as well as forest pasture, largely advantaged the Holm Oak at the expense of the pubescent Oak, even though the latter was well adapted to the bio-climatic conditions.

This is but one example, but it is quite typical and can be easily generalised. The stresses caused by climate change and the stresses caused by an intense anthropogenic pressure have similar impacts: on the one hand, impacts of alteration of plant formations—generally reversible in the medium term owing to the good resilience of the Mediterranean flora; on the other hand, quasi-irreversible impacts due to erosion.

The main conclusion to derive from this is that climate pressures and anthropogenic pressures add to each other. The Mediterranean ecosystems prove, on the whole, to have good resilience, but the latter has its limits, which unfortunately we know little about. If the pressures accumulate, the limits of resilience may be exceeded, and irreversible evolutions may be brought on.

One of the best ways of combating the adverse impacts of climate change is, besides the Kyoto Protocol, that of preventing these cumulative effects and, hence, of reducing anthropogenic pressures.

In the Northern Mediterranean Countries (NMCs), this reduction of the pressures has been carried out de facto, over a more or less long time, via the modernisation of agriculture and the rural way of life: intensive exploitation of firewood, forest pasture, and temporary harrowing have all very largely disappeared; the forest quite significantly benefited from it to spontaneously develop again, increasing in all these countries in terms both of area and of stumpage. The main threats now are fires and the clearings connected with a not always properly controlled urbanization and, hence, inducing great area wastage (houses, tourism facilities, transport infrastructures…).

In these countries, it is however advisable to remain quite vigilant: prevention and control of fires, whose risk is set to increase; proper land planning; balanced management of still exploited resources; and, of course, prudent energy use of natural vegetation biomass. One should not, under pretext of intensive utilisation of an existing biomass, exert new excessively high pressures which would aggravate those of the climate, even though a certain reopening up of the spaces can be favourable, particularly in terms of biodiversity.

Prudent management of the forests and wooded areas of European countries is thus more than ever a necessity. To be really efficient, it must involve all the stakeholders of an area (owners, elected representatives, users, NGOs, economic stakeholders) within a good governance framework. Many proven experiences exist in European Union countries.

In the Southern and Eastern Mediterranean Countries (SEMCs), the situation is more difficult. Modernisation of agricultural production is, admittedly, in progress, but agriculture is still markedly dual there, with very poor subsistence farming sectors. And, unfortunately, the wooded areas are part of the latter. The struggle for the conservation of wooded areas, just like the fight against erosion and desertification, is there, first and foremost, a struggle against rural poverty and requires sustainable rural development actions integrating not only the modernisation of farming and pastoral practices, but also education, health care, infrastructures, and the development of secondary and tertiary economic activities. The governments and the administrations of these countries are, on the whole, quite aware of this imperative need. But much remains to be done, and difficulties of implementation are considerable. The works in progress by CIHEAM and Plan Bleu on sustainable rural development—which integrate pastoral and forestry aspects—and the implementation of the Mediterranean Strategy for Sustainable Development (MSSD) account for it.

II. CONTRIBUTIONS TO COMBATING CLIMATE CHANGE

1. Carbon accumulation by natural wooded areas

Mediterranean forests and wooded areas are not highly-active carbon sinks, and this owing to the fact that their primary productivity is fairly low, their soils contain relatively little organic matter, and they are subject to fire hazards.

Nonetheless, at present, these sinks function rather well in the countries of the northern rim (NMCs), as the wooded areas increase, as well as the volumes to the hectare of standing timber.

Let us attempt a very rough calculation :

The whole of these countries (Spain, France, Italy, the Balkans, Greece) have 50 million hectares of forests. But, if one were to consider only the "really" Mediterranean forests, one would eliminate a large part of France and of the Balkans, as well as the north of Spain, of Italy and of Greece. Thus, there would remain 20 to 25 million ha of really Mediterranean forests. To these, there should be added 20 million ha of other woodlands which, themselves, are almost all really Mediterranean. Let us assume that, currently, timber on the stump storage represents on average about 500 kilos of carbon per hectare and per year in the forests, and about a hundred in the other woodlands. This would yield an order of magnitude in the range of 10 to 15 million tons of carbon stored per year.

The large Eastern forest country, Turkey, has 10 million ha of forests and 10 million other woodlands. Forest areas are on the increase there, and probably stumpage, too, even though less rapidly than in Europe.

The Maghreb has 6 million ha of forests, and 4 million other woodlands. The forest areas seem to be stabilised. On the other hand, the volumes are probably on the decrease, particularly in Morocco, which would induce a certain de-stocking, though undoubtedly compensated, for the major part, by storage in the north.

As for the other countries, they are too small or too little wooded to strongly influence the overall balance.

For the Basin as a whole, the order of magnitude of carbon storage by the Mediterranean forests and other wooded areas, thus, remains about 10 to 15 million tons per year. This figure must, obviously, be considered with great caution.

Should the climatic conditions remain identical, this storage—modest though it may be, but nevertheless appreciable—could continue to accumulate over many decades, as Mediterranean forests are very far from having reached their maximum stumpage. The additional volume annually stored on stump could even grow for several reasons:

- In the north, the forests are back to a better biological state after centuries of agro-sylvo-pastoral overexploitation. Their capacity to produce more wood, accordingly, increases. This is quite visible when one compares the growth data of the French national forestry conducted at decennial intervals;
- Much of other wooded areas (matorrals, scrubland, maquis) spontaneously convert into forests and, hence, develop their capacity to store carbon;
- In the south, the efforts for rural poverty reduction and for development should lead, inter alia, to a fall of anthropogenic pressure on the forests and, hence, an increase in their storage capacity.

But, these promising prospects may be called into question by the aggravation of the climate, which will slow down the forests growth potential. All in all, one may assume that, for some time still (some twenty years or so?), the annual storage capacity of Mediterranean wooded areas will continue to grow, then it will probably stabilise and regress. But at which pace and to what extent? The answer depends obviously on the effectiveness of combating GHGs, but also on many unknown factors on the resilience of the forests and their capacity of response to climate change.

2. The fire issue

Fires periodically come to jeopardise the sustainability of the carbon stock made up by the forests. For a better grasp over this aspect, let us try to estimate not precise figures, but orders of magnitude of the quantities of carbon de-stocked during a fire.

When a fire comes to pass, there only burn the leaves, small branches, twigs, litter and the surface parts of the trunks and of the large and medium branches. The quantity of carbon released depends on the intensity of the fire, its speed, and the nature of the vegetation. Let us say that the order of magnitude could be in the range of 1 to 10 tons of carbon per burnt hectare released in the atmosphere.

In the aftermath of a fire, there remain standing the trunks, as well as the large and medium branches, which represent the major part of the biomass.[9] Certain trees can survive: those with a very thick bark (cork oaks) or those incompletely burned. Those that die fall on the ground only a few years after the fire; then, their biomass continues to decompose on the ground, under the effect of wood insects and, especially, of decay fungi. This process can take a few ten years, during which carbon is gradually released. Decay is accelerated by heat and moisture. In the soil, part of the stumps and dead roots also decompose and release their carbon; another part may, however, end up incorporated into the organic matter of the soil. Finally, certain stumps remain alive and give rise to shoots. The total quantity of carbon de-stocked during this slow process of decomposition is quite variable, and depends on the biomass of the stand that has burned. It can range from a few tons to the hectare, for a not very dense matorral, to over a hundred for a high forest. Fortunately, among the areas burned, those of matorral are generally much wider than those of high forest.

After a fire, several issues come to the fore. There is, initially, that of reforestation. In most cases, under the climatic conditions of the 20th century, reforesting was not necessary: nature spontaneously restored an ecosystem similar to that which had burned; therein, precisely, lies resilience. But once climate has changed, it will perhaps be, more often than in the past, necessary to reforest with species better adapted to aridity, as the limits of resilience of the burnt stand will have been exceeded.

Another question is: after the fire, would it be advisable to recover the biomass of the burned trees, instead of letting it decompose on the stump? The answer to this question must be qualified. From a carbon balance point of view, this seems to be desirable, when this biomass is sufficiently significant. But it should not be forgotten that economic efficiency is the third pillar of sustainable development: it is necessary, therefore, that this biomass should be valuable and that its operation costs (manpower, transport…) are not too high. From an ecological point of view, it is generally recommended to cut back (close to the ground) the trees likely to stump shoots (oak coppices, more

[9] This pattern is that of Mediterranean forest fires, where the fire face passes very quickly, within a few minutes, driven by often violent wind. It thus has time to burn only fine or surface elements. In the northern forests, the process is generally quite different: the fire face advances very slowly and burns a much larger portion of tree biomass; if, in addition, the soil is made up of a thick layer of dried peat, the carbon mass released can be very large.

especially). But it is also advisable to leave on stump any damaged or even dead conifers which still carry seed (pine cones in particular). These trees can also provide relative shelter to seedlings.

In the countries of the northern rim (NMCs), fires have so far been under control, enough for forestry areas and stumpage to increase. This control is obtained thanks to a considerable and fairly expensive fire prevention and fighting mechanism: maintenance and preventive equipment of certain wooded areas, increasingly professionally qualified firemen, modern and high-performance land means (specialized vehicles) and air means (fire-fighting helicopters and planes). However, risk does increase with climate change, and this has been confirmed over the last few years by very vast fires, connected with heat wave episodes. To sustain the pace of carbon storage, it will be certainly necessary to intensify prevention and control, and, hence, increase their cost.

In the countries of the southern and eastern rim (SEMCs), fire was not, until recently, a major problem, as the underwood was kept "clean", i.e. well cleared of brushwood, by very intensive animal pasture. But the modernization of farming and of stockbreeding is reducing this beneficial effect. It is very difficult to strike proper balance between too much pasture, which causes degradation of plant cover and erosion, and not enough pasture, which increases brushwood proliferation and fire hazards. These countries are thus set to be faced with a difficult problem: proper management of fire prevention based on stockbreeding so as not to have to purchase quite costly modern fire-fighting means in large quantity.

3. Traditional or enhanced energy uses of forestry biomass

3.1. Traditional uses

Over millennia, wood has made up the main source of energy used by Mediterranean societies, not only for domestic use (heating, cooking) and for urban use (thermal baths, hammams), but also for crafts and pre-industrial uses (brick/ tile/ pottery firing, manufacture and melting of glass, metallurgy of copper/ iron/ lead and other metals…). To obtain the high temperatures often necessary (glass, metals), charcoal was used, and not wood directly. Produced in forest, charcoal has, moreover, the advantage of being much lighter than wood and, hence, easier to transport, for instance to supply cities that are remote from the forest.

These uses have too often led to an overexploitation of the forests, i.e. a non sustainable exploitation where annual wood abstractions were higher than biological increase. This overexploitation, coupled with overgrazing and temporary cultivation, has—in various areas and at various times—caused the degradation of the plant cover and of the soil, as well as the decline of the activities which rested on them. Forestry history is a long succession of conflicts between holders of property rights, often abusive users with disputed rights, and public authorities seeking more or less successfully to arbitrate; which conflicts being often contained on political and legal level, but aggravating at times and degenerating into violence.

During the 19th and 20th centuries, such energies as coal, oil, natural gas, or electricity came to be substituted to the majority of these pre-industrial uses of wood and charcoal. In the countries of the northern rim (NMCs), domestic uses of fuel wood endured longer, especially in the countryside, but they very strongly regressed in the second half of the 20th century, before experiencing a certain revival for a few years now. By contrast, the use of fuel wood is still quite significant in the countries of the southern and eastern rim (SEMCs), where it continues to put at risk the sustainability of some forests.

This difference between north and south is due to a difference of incomes, or, more precisely, a difference of labour opportunity cost. Felling wood in the forest, cutting it into logs, handling and transporting it require great work. The low price of alternative energy sources and the high level of wage costs were such that, in the countries of the northern rim, it was no longer economically profitable to pay workmen to do this job. There continued to cut wood in the forest only those people who had a little costly labour capacity (farmers without another more profitable activity in off-season, often cutting wood for their subsistence), or who had access to a "niche" market optimising the product above its mere energy value (fire lighting in the chimneys of second homes).

Conversely, in the countries of the southern and eastern rims, the necessary work is quite as hard, but latent unemployment in poor countryside, and the ensuing low opportunity cost of the work, are such that there still exist many people in rural areas who are willing to cut wood in the forest, sometimes even illicitly.

3.2. What prospects for platelets ?

If one observes today a certain recovery in the countries of the northern rim, it is due to the rise in the prices of fossil energies and, more still, to awareness of the need to reduce GHG emissions. However, interventions by the public authorities often prove to be necessary (subsidies for wood-fired boilers). In any case, it does not seem that "traditional" log cutting would allow a significant resumption of the use of fuel-wood. If this were to occur, it would be based on fully mechanized methods, after processing the wood into platelets delivered by trucks to boilers installations, the latter being themselves fully automated. These platelets will often be manufactured by chopper machines, tractor-drawn or motorized, circulating in the forest, collecting either exploitation remnants (rare in Mediterranean forests), or small or medium-sized whole trees (coppice cuts, fire-wall brushwood clearance).

It is worth considering, on the one hand, the economic viability of such a fully mechanized sector and, on the other hand, its ecological impacts.

Currently, the cost of a platelet delivered to the user is estimated in France, by ITEBE, as between 31 and 85 € ton,[10] hence a cost per kilowatt-hour of about 1.5 to 2 cents of a euro per ton. This cost is thus competitive, it being of the same order as that of the main alternative fuels (industrial coal, industrial heavy fuel, natural gas).

Platelets obtained from Mediterranean wood, being drier and dense, have a rather high thermal value. But collection conditions are frequently difficult (little dense stands, often sloping and rocky grounds giving rise to difficult working conditions to both personnel and equipment, distant access roads), and, hence, collection cost may then rise rapidly. If the sector develops, it is probable that these costs will drop (better professional qualification of the personnel, optimisation of the equipment, organisation of timber yards …), though it is likely that the platelet produced in Mediterranean natural forest will continue to have an average production cost higher than in other regions.

On the ecological level, it may be considered that this consists in a renewal of coppice cuts, but with a modern technology. At constant climate, there would be undoubtedly no major problem, subject to the work being based on proper forestry land use plans, observing minimum rotation time-

[10] Two modes of supply may be distinguished:
- in direct flow, wood is processed into platelets in the forest, then directly conveyed to the user. The costs are lower, but the platelets are still wet and have a thermal value in the range of 2200 to 2800 kWh per ton;
- with intermediate storage: the wood is stored to dry, before or after shredding into platelets. The costs are higher, but the thermal value, too: 3300 to 3900 kWh per ton.

periods (20 or 25 years at least), and carefully avoiding erosion risks (particularly by access roads). It would be observed, no doubt, that easy stump shoot species (Holm Oak, especially) would again be much advantaged: there would thus be a certain move backwards with respect to the evolution of the past few years. But we are not any more at constant climate. Synergy between the pressures due to the climate and those due to cutting could foster the regression of the stands to ecosystems that are more adapted to aridity, but less productive. A precise monitoring of these ecological evolutions would need be to established.

With regard to the carbon balance, recourse to forest biomass helps avoid the burning of fossil fuels. But maintaining an increasing carbon stock on the stump also has advantages: the optimisation of such contradictory advantages depends much on the assumptions made as to the evolution, over the coming decades, of the opportunity cost of a ton of carbon stored: if this cost decreases, one may find it more beneficial to rapidly consume the stocks. But if it increases, one would be better advised to preserve over the longest time possible the stock on the stump. Calculations are complex, and they depend on global energy scenarios.

Besides, on social and political level, there may be a concern that large-area timber yards would give rise to vigorous opposition in the residential or touristical areas.

On the whole, the use of Mediterranean forest platelets as fuel is an economically viable solution provided that the harvesting not too difficult and that its cost remains fairly low. It can only be done by observing the conditions of rigorous forestry land use plans ensuring yield sustainability. It should not be undertaken if it involves notable risks of erosion or loss of biodiversity.

However, so that the cost of use of platelets be competitive, it is necessary that the price of the standing timber paid to the owner be also as low as possible: this is not quite incentive, and is likely to limit the mobilisation of wood. It is, therefore, possible to consider that, in practice, this technology will develop in the following cases:

- a certain number of rural owners get equipped with small boilers and will call upon small choppers on their forest plots which will manufacture platelets for their own-use and, possibly, to be passed on to their neighbours and acquaintances. The advantages of the mechanisation and of the automation of the boiler will play a major role;
- forest municipalities will equip some of their public buildings with boilers supplied with platelets produced in their municipal forests, either by workers under control of the green spaces service, or by contract with enterprises that are generally small-sized and local;
- a large-scale industrial sector would probably develop only if the cost of alternative energies were to increase significantly.

A particular case proper to the Mediterranean region is that of optimising the biomass crushed during brushwood clearance operations for purposes of fuel reduction and protection against fire (alongside roads and tracks, strategic fuel cuts, safety arrangements in the vicinity of buildings and other sensitive spots): it is perfectly advisable to turn this biomass into energy, if this allows reduction of the cost of brushwood clearance which, in general, remains high. Moreover, if it were to be left on the spot, this biomass would release its carbon as it decomposes: accordingly its use as fuel would amount to carbon saving. In fact, in the case of brushwood clearance, the relevant logic is that of optimisation of waste.

As for the use of the biomass generated by the wood sector industry wastes, its advantages are the same in the Mediterranean region as in other regions, and it is not likely to meet with any particular difficulties there. The only problem is that the quantities available are relatively low: preliminary processing industries (paper pulp, sawn wood) are little developed around the Mediterranean, and this, for various reasons (the resource is very heterogeneous, not very abundant, difficult to mobilise and exploit; absence of historical traditions); secondary processing industries are developed locally (furniture industry in Italy…), but produce less waste.

3.3. Combating overexploitation in the south

All this relates to the European countries. In the countries of the southern rim, particularly in the Maghreb, the issue is completely different. Very poor rural populations still often exert, there, a very strong pressure of firewood gathering, notably in the Maghreb, hence a degradation of the plant cover and increase of erosion. The responses provided are of several types:

- Repression of "felling offences" by the local forestry services. This classical solution did not always help achieve the results expected, and it leads sometimes to violent conflicts. The political disadvantages are obvious. Moreover, the image of forest guards as "green policemen" does not quite match the role of sustainable rural development agents that the new forestry policies seek, quite justifiably, to confer upon them;
- Plantation of fast-growing species, particularly eucalyptus, in the vicinity of consumption zones, to ease the pressure on natural forests. Thus, Moroccan foresters often say that the eucalypti have saved the forest of Mamora, natural cork oak forest located north of Rabat. But this is only possible on favourable soils that are enough supplied in water;
- Substitution of wood, for domestic use, by fossil energies: butane, propane, fuel. This policy is put into question by the current evolutions, especially in non oil-producing countries;
- Replacement of traditional open hearths (which recover not more than about 10% of the potential energy) by satisfactory energy efficiency devices: for instance, in Moroccan mountains, by sheet metal stoves, which help at the same time to heat the room where they are found, to cook food, and to have a hot water reserve. The models promoted are sufficiently simple to be repaired, or even built by local craftsmen. As for urban hammams, more energy efficient boiler models have also been developed. The development of solar energy also has a role to play in countries where sunshine is quite favourable.

4. Towards the production of new forest bio-energies ?

4.1. Which bio-energies ?

What has just been analysed relates to classical uses (direct wood or charcoal combustion) of matter collected either from natural forests (particularly oak coppices), or from reforestations based on species traditionally present in the Mediterranean (above all, various species of pine, and some other conifers). It is worth considering now other uses (bio-fuels, wood chemistry) or other production methods (fast-growing species).

Back in the Second World War already, to compensate the lack of oil products in Germany and in the occupied countries, substitutes had been developed:

- Certain private or transportation vehicles had been equipped with "gas generators". These devices, mounted on the rear of the vehicles, processed via pyrolysis of the small wood sticks into fuel gas in the engines, based on some adjustment in their supply. The energy output was low, and the engines were quickly clogged, but that helped moving on;

- On the industrial level, the processing of coal into liquid fuels, particularly for military vehicles, tanks and aircraft, had been largely prompted, based on carbon hydrogenation reaction (Fischer-Tropsch synthesis). The same type of synthesis is also possible based on wood or on charcoal.

The "bio-fuels" or, rather, first generation "agro-fuels" used today, have several origins:

- cereal starch processed into ethanol, usable in petrol engines;
- beet or cane sugar, also processed into ethanol;
- vegetable oils, processed into diester, usable in diesel engines.

The forest stands are not yet fit to provide such products. On the contrary, they are liable to significantly suffer from their development. Thus, there have been observed in Indonesia and in Malaysia massive deforestation of the wet tropical forest to establish plantations of oil palm trees intended for "bio-diesel", and massive deforestation of the dry tropical forest of the "Cerrado", in Brazil, to produce sugar cane for ethanol. However, Mediterranean wooded areas seem little threatened by such clearings, owing to the little productive potential of most of the soils which they cover.

These first generation fuels, issuing from cultivated food plants, are increasingly subject to debate, and it is likely that, in the medium term, the main trend would be towards the production of second generation bio-fuels, using the woody-cellulose matter of the whole plants, and not just their nutritive part (starch, sugar or oil). Two major processes are possible:

- processing into sugars of the whole plant by cellulose hydrolysis, then by processing of these sugars into ethanol;
- processing the whole plant into oil type products, by "Fischer-Tropsch" hydrogenation of the contained carbon.

Forest plants lend themselves well to these second generation productions. However, for this use, as for many other productive uses, Mediterranean natural forests present several deficiencies: relatively low productivity, difficult access, often sloping and rocky soil. It looks likely that the sources of biomass used will be mainly:

- on the one hand, the wastes of the wood sector industries and the "remnants"[11] (branches, small wood, bark) of forest cuts;
- on the other hand, fast-growing plantation species, especially dedicated to the production of bio-fuels.

The relative structural deficiency of forestry utilisation and of preliminary processing industries in the Mediterranean region is likely to continue to limit the importance of the resource available in terms of remnants and waste. On the other hand, it is worth considering the extent to which fast-growing plant species are likely to develop on industrial scale.

[11] Besides, in the use of remnants, it is necessary to guard against causing loss of fertility of the ecosystems by excessive export of nutrients, as the latter are markedly more abundant in the remnants than in the wood; as well as against inducing a loss of biodiversity by too significant a reduction in "necro-mass", formed by dead plant elements, as the latter accommodate a flora (fungi, in particular) and a fauna (insects) essential to a proper balance of the ecosystems.

4.2. Fast-growing plant species ?

Many species can be envisioned, whether indigenous (poplars, willows, platanus …) or introduced (eucalyptus…); there may also be considered non-arborescent plants (Arundo donax …); they may, furthermore, be selected or genetically modified to maximize their cellulose production. The heat of the Mediterranean climate is a very favourable factor for high productivity. Rather than forestry production, in the classical sense of the term, it will be a form of intensive agriculture, with recourse to mechanization for all operations of cultivation, fertilisers, plant health products and, very often, irrigation.

A first limitation is due to the fact that such plantations can only be envisioned on easy to mechanise land for purposes of their setting, tending and harvest. On these areas, which are relatively limited around the Mediterranean, they will thus be in competition with the other agricultural productions, and the choices made by the farmers will depend primarily on the comparison between the incomes which they can derive from these various productions and, hence, on the relative demand on the various products.

An even more severe limitation will be related to water availability. To fully develop their productive potential, these species will need ample water: a water sheet of about 1500 to 2000 millimetres per year. Rainfall is not as ample as this, except in a few rare sectors of the Mediterranean basin (coastal mountain zones facing the incoming wet winds). Even in these rare cases, rain does not fall mainly during the most favourable seasons. And, almost everywhere, it will undoubtedly be necessary to apply at least subsistence irrigation to help these plantations survive without serious, if not mortal, decay during the long dry summers.

However, water is rare in the Mediterranean region; and it will be increasingly so in a context of climate change. Its opportunity cost is high and it is set to grow higher. It would, thus, be necessary that energy prices should become very high so that it would be convenient to use water to produce energy crops. But, in any case, many other areas of the world are fit for the production of such crops at lower cost. Therefore, it is quite likely that intensive energy crops will not develop in the Mediterranean, except for the rare cases where water would be available in abundance, at low cost, and in the absence of more optimal uses.

Conflicts might, however, arise in places where water provides significant environmental services without this resulting in a corresponding commercial value: natural wetlands consume by evapotranspiration a significant water sheet, of the same order of magnitude as that which would be consumed by an energy crop. The value produced by these lands is partly economic (fishery products, tourist attractiveness…), but also non commercial, to a large extent: environmental services, chief among which is the conservation of biodiversity. If energy costs increase, it is likely that a pressure would be exerted to cultivate these lands, which might seem to be financially profitable for certain economic developers, but would nevertheless incur a loss of overall economic value, both commercial and non commercial.

4.3. And, what about bio-products ?

Besides energy production, plants can be used as raw material for several chemical substances. Many used to be collected and processed over centuries, if not since antiquity, based on traditional techniques (resins, gums, perfumes, dyes, tanning products…); some experienced a significant growth in production at the beginning of the industrial era: vegetable dyes, products derived from the resin of intensively tapped pines, products derived from wood pyrolysis, synthetic materials developed based on cellulose, lignin, tar, charcoal… In the 20th century, for most of these productions there were substituted synthetic products derived from coal, oil or natural gas. But if these carbon fossil sources become more costly than wood (including the internalisation of their respective ecological costs, in particular those related to the carbon cycle), it is quite foreseeable to resume, at least partially, a chemistry based on wood.

The issue concerning the plant resource for chemistry is quite similar to that for energy. The Mediterranean region appears to be little favourable: scarcely productive and not easily exploitable natural stands; low woody waste potential; intensive plantations in competition with other productions not only for land fit for mechanisation, but also, and more especially, for water. Obviously, there remain traditional "niche products" in the Mediterranean related to aromatic plants (essential oils) and to the large diversity of plants (cosmetic, pharmacology). The quantities are limited, by definition, but the value added can be quite high.

In the construction sector, recourse to wood helps improve the carbon balance in two ways: on the one hand, the wood used immobilizes carbon for very long periods; on the other hand, it is substituted, at least partly, for cement or for metals whose production emits much carbon dioxide in the atmosphere. But, here again, Mediterranean forests are hardly competitive: very heterogeneous wood, difficult to collect, difficult to work, or at least poorly suitable for current technologies. Currently, wood used in the region is often imported from Scandinavian countries (sawn wood) or tropical countries (veneer wood). The recourse to modern products of reconstructed wood can ease these difficulties, but there arise again the impediments already emphasized with regard to energy or basic chemistry. Moreover, in spite of a few local exceptions, Mediterranean cultures value more stone-built houses (rich people's houses) than wooden houses (poor people's houses).

Moreover, wooden houses do not properly insulate against heat (whereas they insulate well against the cold) and do not have thermal inertia allowing for optimisation of the natural coolness of Mediterranean summer nights or the heat of the winter sunny days.

On the whole, the Mediterranean region does not appear to be quite favourable for a large-scale development of second generation bio-energy or biochemical sectors based on the exploitation of intensive woody crops; which by no means excludes the development of local projects based on an often original and diversified local resource, coupled with other renewable sources of energy whose potential is significant in the Mediterranean: solar, wind, geothermal.

III. CONCLUSION: RECOMMENDATIONS FOR ACTION

1. Need for a prudent management

The stresses due to anthropogenic pressures and those due to climatic pressures combine their impacts on wooded ecosystems (cf. above, § II – 4). In order to avoid serious and irreversible consequences (significant biodiversity losses, extinction of many endemic species, massive resumption of erosion, encroachment by desertification), it is essential not to exceed the capacity of resilience of these ecosystems. However, the thresholds beyond which this capacity declines, if not breaks down, are scarcely known today. It is thus essential to adopt a prudent management.

This prudent management rests, in the north as in the south, on a common base, which is that of all proper sustainable forest management:

- not to annually yield, on average, more than the annual growth (principle of sustainable yield, stipulated, in France, in royal edicts since the 14th century, but not always strictly enacted before the 19th);
- respect the integrity and the fertility of the soil, by prohibiting any interventions likely to cause erosion, compaction, loss of organic matter (soils left unprotected, unsuitable working machinery, badly designed access roads…);
- respect the "environmental services" provided by the ecosystems, in particular the conservation of biodiversity, in general, and of rare or endangered species of flora and fauna, in particular, as well as the protection of the water cycle. Should it prove difficult to reckon these services in monetary terms and to internalise their value in calculation of the costs, they should be considered as constraints to be observed;
- take into account the various goods and economic and social services provided by wooded areas: products other than wood, gathering, hunting, pasture, forest recreation, landscape. Likewise, should it prove difficult to reckon and internalise their value, they should be considered as constraints to be observed;
- identify with precision the property and user rights and ensure legal assurance thereof.
- establish participation procedures allowing all social agents intervening in actual management of the wooded area, and all the stakeholders concerned by the produced goods and services, to be actually involved in the good governance of these areas (Lazarev, 2008).

These common principles of sustainable and prudent management will apply in various ways according to the countries, and according to their social and economic specificities. In the north, the main threats are connected with fire hazards which are set to increase (cf. § III – 2), as well as with the land pressure related to urban sprawl and infrastructures. In the south, these threats are already quite present, though those due to overexploitation of the resources by a very poor rural population are still quite high.

In the north, local government al all levels (municipalities, provinces or departments, regions) and civil society (major national or international NGOs, more local user associations or those dedicated to the defence of a site) are generally quite present and very active in the management of wooded areas. Forest owners and managers, be they public or private, are accustomed to working with them. In the south, "local government" and civil society are in full development, but they are in general weaker than in the north; private forest property plays generally a minor role there. State foresters continue, accordingly, to hold a key role in the south. In order to implement a sustainable management of wooded areas, the methods and procedures of necessary governance, thus, depend strongly on the economic, social, cultural and legal context of the country.

A high-value resource to be prudently managed in view of the risk of decay: the Cork Oak

The case of the cork oak forests eloquently attests to this need for prudent management. These forests are found in all the countries of the western Mediterranean, from Portugal and Atlantic Morocco to Sardinia and northern Tunisia, provided that the soil is free from limestone (cork oak is quite limestone intolerant). Over millennia, cork has been put to various uses: stoppers, floats, hives… Demand on quality cork (stoppers) rose considerably in the 19th and 20th centuries, and new products derived from cork have emerged: decoration products and, especially, thermal insulation materials, which corresponds to an appreciable potential market, owing to energy saving. Alternative products, based on various plastic matter, have come to compete with it, but it may be held that, owing to its exceptional physical and thermal qualities, and in a context of return to products of plant origin, it still has good prospects ahead.

Initially, the harvest could be done by mere gathering based on barking the trees. But, for a long time now, highly organised and rationalised exploitation methods have been developed. The most notable are those of the Iberian southwest: they combined periodic barking (once every 9 to 12 years, according to the location) of the trees over a certain height, under-storey pasture of various animals (cattle, sheep and, even, pigs which are fattened in the autumn, feeding on acorns), and temporary cultivation of cereals. They helped create, over millions of hectares, quite specific agro-sylvo-pastoral landscapes, called “dehesas” in Spain and “montados” in Portugal. In the other producing regions (Catalonia, Provence Maures, Corsica, Sardinia, northern Tunisia, north-eastern Algeria, north-western Morocco), rationalised methods of periodical barking have been introduced everywhere, at various dates. Under-storey pasture, and even cultivation, have also been practiced there, at quite variable intensities, though—on the whole—hardly organised and, sometimes, quite damaging (overgrazing and erosive harrowing).

Today, there may be observed, in many cork oak forests around the Mediterranean, frequent decay of cork oak, of quite variable intensity, ranging from slight clarification of foliage through to high mortality, and this, not only in the dehesas and montados regions, traditionally managed, but also in sectors where exploitation is now largely abandoned. One reason could be that climate change, added to the stress of traditional exploitation (barking, pasture, harrowing), has caused certain stands to fall below their resilience threshold. The most affected could be those where the cork oak forests had been extended by plantation beyond the optimal distribution of cork oak. Would it be advisable to change certain exploitation practices, in order to make them less stressful in a climate grown hotter and drier? Studies are underway, especially in Portugal, a leading country in matter of cork, in cooperation with the other Mediterranean countries.

2. Knowledge development and sharing

In order to carry out prudent management, it is necessary to have appropriate knowledge; and when this knowledge is lacking, there is a need to step up prudence so as not to reach the—still little known—irreversibility thresholds.

The relationship between climate change, evolution of wooded areas and energy sets many questions for research: these questions are complex and interdisciplinary. Some are being addressed, but knowledge is still rather uncertain or incomplete. Without seeking to be fully exhaustive, one may mention some of the most significant ones:

- How will the climate evolve in each of the sub-regions of the Mediterranean basin? This is a question which decision-makers and the public at large are, quite legitimately, asking. Only research conducted on global level can provide parts of the answer. Such research is underway, within the framework of the IPCC, and relate not only to deepening fundamental environmental knowledge (atmosphere, oceans, biosphere) but also to the building of models which are, by definition, quite complex;

- How will the Mediterranean wooded ecosystems react to this climate change? In view of the economic stake involved, works have already been conducted concerning certain crop plants. As for wild plants, as well as for the natural ecosystems, little research is conducted in the Mediterranean region, and the reasoning proceeds mainly by analogy. Mediterranean forest ecology is, however, a field where the need for a good international cooperation was felt very early: already before the First World War, some foresters had set the principle of what was later to become the Silva Mediterranea commission of FAO. Yet, the results have not always been up to the intentions, for lack of a sufficiently strong will among the participating Sates. The European Union has, fortunately, been quite supportive of Mediterranean forestry research, which allowed notable progress and maintenance of research networks, in particular as regards forest genetics and prevention of forest fires. For a few years now, European or national networks of forestry ecology observation and monitoring sites have contributed a large amount of data, whose analysis is quite profitable. It would be very useful to extend these networks to all the countries of the basin;
- How to better evaluate and better optimise the multiple environmental assets and services (biodiversity, protection against desertification, carbon storage, social and cultural amenities…) provided by these wooded areas, in order to properly take them into account in management decisions? Some preliminary results have been obtained by the MEDFOREX programme, whose works could be taken further by the EFIMED network within the framework of the EFI;
- How, in the face of the risks and of the importance of the stakes, to improve the governance of Mediterranean wooded spaces, by bringing on board the social agents and stakeholders concerned? Rather than research works per se, some reflection is in progress, related to exchange of experiences and best practices, particularly within the framework of AIFM (Association Internationale Forêt Méditerranéenne/ International Association Mediterranean Forest);
- In the field of energy, research, and development on large-scale industrial processes for second-generation bio-fuels or basic biochemistry are issues arising on global, and not Mediterranean, level. However, "niche", or typically Mediterranean, productions rightfully claim dedicated research (plant-based fine chemistry, cosmetics, medicine … and, cork, of course);
- a more economical and sustainable use of forest and pastoral resources by the poor rural populations of the south is a key question with regard to the future of the natural areas of these countries. It is currently the subject of local experiments which deserve to be better known and coordinated.

The development of knowledge on the linkages between climate, forests and energy thus calls upon a very large number of disciplines: mathematics, data processing, physics, chemistry, biology, ecology, agronomy, economy, sociology, law, technologies…, and ranges from basic research to "do-it-yourself", through operational research and research & development, hence its major relevance, but also its great difficulty, further increased by the natural tendency of research to prefer more basic, or mono-disciplinary, issues.

Moreover, works related to the wooded areas of the Mediterranean region are scantier than those concerning other types of forests. This region groups, in fact, on the one hand, countries which have relatively scarce research means and, on the other hand, countries which have more significant means, but where the Mediterranean is not a top priority. A very active cooperation between all countries is, therefore, indispensable to enable them to progress in spite of these small means.

But this cooperation should not be limited to exchanges between scientists and technologists to advance the state of scientific and technical knowledge. It should also help disseminate best practices and good behaviour among all agents concerned, be they institutional (local government, professional organizations, NGOs…) or individual (farmers, stockbreeders, forestry owners, various types of users…). For so doing, it must also facilitate a better understanding by these agents, and even by the whole public opinion, of the main problems and stakes; hence, the importance of training in and information on these issues. Indeed, "best practices" can be identified only in view of these shared stakes.

One issue is particularly central: that of participation. States can no longer today claim to want to manage forest areas in a centralised manner, even when having a quality forestry administration. They need to rely on the active participation of other stakeholders: communities, civil society, economic developers. Such participation cannot function properly unless all these stakeholders have a minimum common vision of the problems, the stakes and the objectives to be achieved. This common vision is long and difficult to build, but it is fundamental. Herein lies the objective which the development and sharing of knowledge should seek to achieve.

3. Institutional and financial means

So that sustainable management improves, it would not be enough to have the necessary knowledge available. There must also be set up adequate institutional, legal and financial mechanisms.

The actions targeted at mitigating the negative impacts of climate change on wooded areas (fire prevention, combating desertification, conservation of the natural heritage…) and those aimed at harnessing their potential in the best way possible (storage of carbon on stump, substitution of wood for energies and for fossil raw materials) must be mainstreamed in consistent projects, resting on a diagnosis and a vision shared by the local stakeholders, and must relate to relevant territories. This concept of project territory may take various forms according to the countries: regional natural reserves, country contracts and area-based forestry charters in France; development of comarcas in Spain and comunita montane in Italy; LEADER+ on European level… It is, of course, up to each country to construct its own approach, and many examples prevail all around the Mediterranean. In spite of the specificity of each situation, experience sharing is always very enriching.

The consistency of any project on the level of the local territory is fundamental; but it is quite as necessary that there should exist, on the level of each State, a clear vision and formulation of a strategy, with its objectives and its means. This strategy must be integrated within a National Strategy for Sustainable Development (NSSD). It can take various forms, according to the countries: national forestry plan, national forestry strategy, guidelines, forestry framework law … and cascade into various components (combating desertification, protection of catchment areas, wood sector …), and also be integrated in other dimensions (poverty reduction, rural development, energy, water resources, biodiversity…). All the countries of the Mediterranean basin are currently engaged in processes of design, monitoring or updating of such strategies. According to the extent of decentralization of the countries, this strategy design function may be carried out mainly on national State level, or on the level of the regions or provinces, according to their reciprocal attributions.

There is no applicable strategy without the necessary human, technical, legal and financial means. However, these means are scarce in many Mediterranean countries. Significant efficiency gains and economies of scale can be made by pooling some of these means, particularly in such areas as higher education, research, expertise: convincing achievements are already there to attest to it, especially CIHEAM and MAP. The European Union has certainly a significant role to play in this regard.

The joint use of big fire control means, in particular, fire-fighting planes and helicopters, is also a promising field: these means are very costly to purchase, maintain and use. Nevertheless, big fire control is essential for many reasons, not least among which is avoiding release into the atmosphere of the carbon stored on the stump in forests. Many cooperation agreements between the riparian countries exist already and they operate well. They could, however, be extended and make of this control a flagship of Mediterranean joint action.

Lastly, it should never be forgotten that economic efficiency is the third pillar of sustainable development: there can be no safeguarding of the natural asset in the long run, nor can there be any equity in the distribution of the wealth produced, unless the wastages of natural, human and economic resources are avoided. Any policy or any project, whatever its scale, must be liable to evaluation, as regards its efficiency (results/means ratio) and its effectiveness (results/objectives ratio). Forestry or energy policies and projects must be subject to this requirement. For so doing, procedures must be established, with possibility to include —in an appropriate manner—classical legal controls, voluntary certification and labelling procedures, sustainable development indicators.

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ABBREVIATIONS

AIFM : Association Internationale Forêts Méditerranéennes

CIHEAM : Centre International des Hautes Etudes Agronomiques

EFI : European Forest Institute

FAO : Food and Agriculture Organization of the United Nations

GIECC : Groupe International d'Etude du changement climatique

ITEBE : Institut des bioénergies

PAM : Plan d'action pour la Méditerranée

RED : rapport sur l'environnement et le développement du Plan Bleu (2005)

CHAPTER 10

Water for energy/energy for water and climate change in the Mediterranean

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AKNWOLEDGEMENT

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In the Mediterranean-rim countries, water resources are limited and unevenly distributed over space and time. Southern rim countries can count on only 13% of total resources. The Mediterranean countries' water demand, having doubled up within the second half of the twentieth century, is expected to increase by about 50 km3 by 2025 to reach some 330 km3/year, well beyond the renewable resource stock . Climate change will deepen the gap between water demand and the available resources.

Water and climate change: impacts on energy production

- Water is essential to the production of electricity. It is the "fuel" of hydroelectric power, but also the cold source of power stations. 13% of the electricity generated in the Southern and Eastern Mediterranean countries is hydroelectric, with the rest coming from power stations.
- The fight against climate change is one of the great challenges facing energeticians. Climate variability is the source of many hazards and has a very strong impact on almost all of the electricity production consumption cycle. Some countries have already registered a significant drop in their hydroelectric production due mainly to the decrease in the amount of surface water at the dams. The increased temperature of rivers may result in a significant decrease in electricity production in so far as the discharge temperature downstream power stations must not exceed a limit value.
- A good and long-term analysis of climate change impact on water flows and river temperatures is essential for the design and future management of electricity production plants. Thus, it is essential to continue to acquire knowledge on the availability of water resources and the factors that affect its quality.
- Improving the efficiency of existing hydroelectric plants and installing energy transfer stations by pumping are solutions under consideration to cope with the growth in energy needs. The development of micro-hydroelectric power plants, the links between hydro and wind energy and the potential of marine energy are other areas of investigation.

Water and climate change: impacts on energy consumption

- Energy needs for water will highly increase due to i) the increase in water demand, exacerbated by climate change, ii) the exploitation of increasingly remote water resources (deep groundwater resources, water transfers) and iii) the development of non conventional water production (desalination, reuse), notably as adaptation option to climate change and to face crisis situations.
- The current electricity needs for water production and mobilization represent 5% (for the North Mediterranean) to 10% (South and East) of the total demand for electricity. By 2025, this figure could reach 20% in the Southern and Eastern countries.
- The first response to the increasing demand for water and the growing pressures on resources is the development of water rational use policies, and this in the different using sectors.
- If the desalination techniques are now well controlled, their implementation requires large amounts of energy which are both costly (the cost of water produced through desalination of sea water would be at least twice higher than the one of conventional water, without taking into account the high capital costs) and potential sources of greenhouse gas emissions. The reuse of treated wastewater is a less costly solution in energy.
- Estimating the energy required for irrigation, the largest water consumer sector in the Mediterranean is essential to ensure the sustainability of irrigated agriculture. It requires to reinforce, at local level, the collection of data concerning the amounts of water withdrawn and used, as well as the various items of energy consumption.
- In the Mediterranean, the interactions between water and energy are very strong and vulnerable to climate change. This reinforces the need to develop strategies for integrated management of water resources and energy, with a prospective vision.
- In order to avoid any kind of development encouraging unsustainable patterns of production and consumption, the valorization of produced water and the possibilities for renewable energy development and measures for the rational use of energy for non conventional water production should be considered.

INTRODUCTION

Context

In the Mediterranean-rim countries, water resources are limited and unevenly distributed over space and time. Southern rim countries can count on only 13% of total resources. The Mediterranean countries' water demand, having doubled up within the second half of the twentieth century, is expected to increase by about 50 km3 by 2025 to reach some 330 km3/year, well beyond the renewable resource stock. Climate change will deepen the gap between water demand and the available resources.

At the same time, total commercial primary energy demand is expected to increase by 65% by 2025. In the Southern and Eastern Mediterranean countries (SEMC), in full development and where the population growth will be the strongest, the rates of increase in energy demand could be 4 times higher than those of the Northern Mediterranean countries (NMC). Here again, climate change will deepen the rift between demand and supply. Yet, energy consumption is today a major cause of global warming. In the Mediterranean, the rate of increase of CO_2 emissions is particularly high (with respect to the global average) because of the prevalence of fossil fuels as sources of energy. This is particularly true of Southern and Eastern Mediterranean countries.

The Mediterranean region has been earmarked as a climate change "hot spot", a zone where changes and inter-annual variabilities in mean temperatures and precipitation will be most felt. Extreme weather events will also be more common. All these pressures call for immediate action to manage water resources and hydrological risks.

The interactions between water, energy and climate change only add to this pressing need. The rise in water demand, made sharper by climate change, would induce a rise in energy consumption and, consequently, in greenhouse gases emissions. Part of the energy production rests, conversely, on the use of water resources (hydro-electricity, cooling of thermal power stations…) that are likely to decrease and thus to disturb, in particular, the production of electricity and the management of infrastructures (dams).

Objective of the chapter

This chapter will attempt to address the following questions:

What are the trends in energy needs related to water demand increases, and can they become key drivers of global energy demand?

Conversely, how much water will be needed to quench the thirst of the energy sector? What tensions are likely to arise around energy production and water resources?

How vulnerable is the "water-energy" system to the impacts of climate change?

What are the possible options to adapt the "water-energy" system to the constraints imposed by climate change without increasing GHG emissions?

Do such concepts as "water demand management", "energy efficiency" and "renewable energy" already apply to the "water-energy" system?

What are the best investment options and what are their costs?

information sources, methodology

In order to address these various questions, Plan Bleu and MEDITEP (Type II Initiative on sustainable energy in the Mediterranean) jointly organised, within the framework of their partnership on activities in matter of energy in the Mediterranean, a workshop on the topic "Water, energy and Climate Change" (Gammarth-Tunisia, 17 December 2007). The results of this workshop constitute the main source of information of this chapter.

Information related to the artificial production of freshwater through desalination of sea water or brackish water comes from a Plan Bleu regional study report « Water, energy, desalination and climate change in the Mediterranean » (Boyé, 2008).

<u>content of chapter</u>

This chapter consists of 2 parts. The first one focuses on water needs for energy production and the second one on energy needs for water production and mobilisation. Each party relies on the main findings and conclusions of thematic presentations by experts involved in the regional workshop, as well as on the issues and discussions among the participants.

Thus, this chapter is not intended to present an exhaustive analysis of the "water energy" system in the context of climate change in the Mediterranean, but describes the situation of some countries (France, Morocco and Egypt) and a few key sectors (hydroelectricity, desalination, water purification and irrigation)..

I. WATER NEEDS FOR ENERGY AND CLIMATE CHANGE, CURRENT AND PROSPECTIVE SITUATION

This part focuses on the themes of hydroelectricity, main source of renewable electricity, and cooling of thermo-electric (fossil and nuclear) power plants with an emphasis on France, Morocco and Egypt[1].

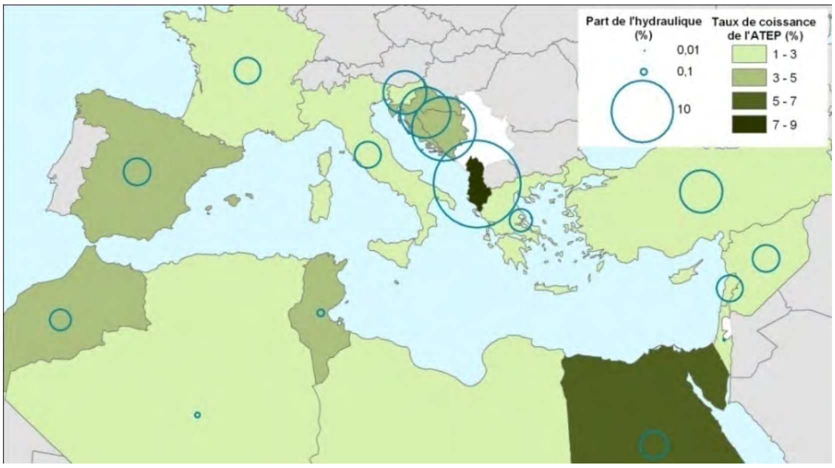
1. WATER, AN ESSENTIAL RESOURCE TO GENERATE ELECTRICITY

In the Mediterranean, the demand for electricity is soaring dramatically in the South and East: between 1970 and 2005, the final consumption of electricity has increased by 3 in the Northern Mediterranean countries, even though it was by 15 in the Southern and Eastern Mediterranean countries. If no action is taken to curb the demand for electricity in both North and South, the scenario of the Mediterranean Energy Observatory (OME) shows that this could lead to a doubling of electricity consumption of the SEMC by 2020.

Water is essential to the production of electricity. It even concerns almost all the means of production. It is the "fuel" of hydroelectric power, but is also the cold source of flame or nuclear power stations, wherever located near the sea or along rivers. In 2005, 13% of the electricity generated in the SEMC is hydroelectric (12% in the NMC), with the rest coming from gas, oil and coal power stations, respectively 60, 16 and 21% (in the NMC, the rates are 18, 7 and 18%, plus 40% for the nuclear and 5% for renewable energy)[2].

Figure 1 - Share of hydraulic in the energy balance in 2004

and growth of the total primary energy supply (1990-2004)



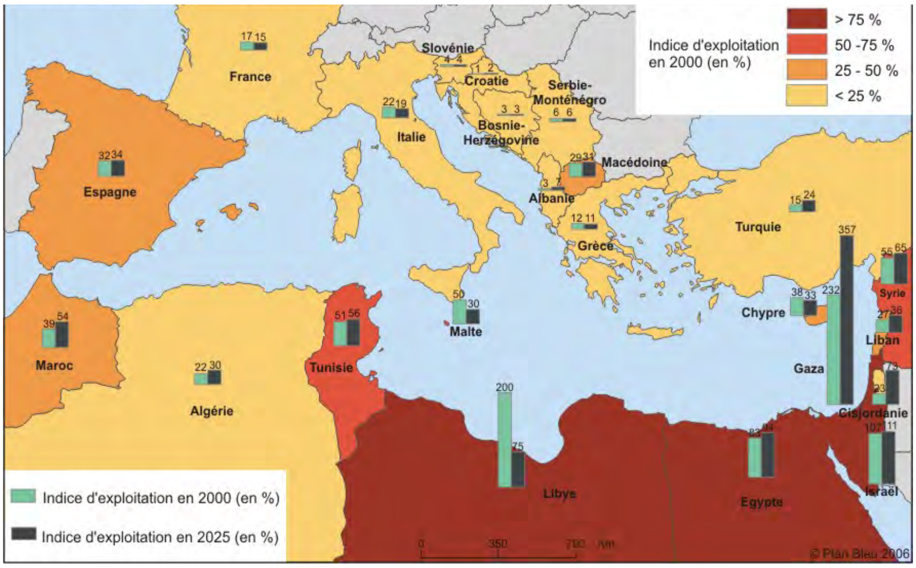
Sources: Plan Bleu, data: IEA

Today, the sharing of water resources has become more complex. To meet the increase in demand for water for all sectors of activity[3] and the need for better water quality in rivers and on the seafront, the regulatory and legislative environment has evolved. Meanwhile, severe hydroclimatic

1 It is based on the following presentations: Water needs for energy in the French Mediterranean region (Mr Bernard Mahiou, EDF), Dams and hydro-electricity in Morocco (Ms Laila Oualkacha, Secretariat of State in charge of Water and the Environment in Morocco), Current and prospective role of hydro-electricity in Egypt (Mr Adel Soliman, Sustainable Energy Users Association, Egypt).
2 Source of data: OME, 2007.
3 Refer to Blue Plan Note « Facing water stress and shortage in the Mediterranean » (Plan Bleu, 2006).

crisis (floods, heat waves, droughts…) have significantly marked resource availability and are warning signs, in the medium and long term, of even greater strains related to climate change impacts in the region. Today, in some countries, water withdrawals already near or even exceed the limit threshold of renewable resources. By 2025, the significant increase in pressures on water resources, gauged by the exploitation index of renewable natural water resources[4], highlights strong and sometimes alarming contrasts as regards the "future of water" (figure 2). New mitigation and adaptation policies are necessary and clearly demanded by Europe (Green Paper on climate change) and by the governments of various countries.

Figure 2 - Exploitation indices of renewable natural water resources, entire countries, 2000 and 2025



Source : Plan Bleu, J. Margat

The presentations have helped to highlight the fact that the fight against climate change was one of the great challenges facing energeticians and that it was even a priority challenge for climate "dependent" companies such as major electricity operators of the region managing significant hydroelectric capacity. Climate variability is the source of many hazards and has a very strong impact on almost all of the electricity production consumption cycle. Electricity consumption is, first of all, very sensitive to changes in air temperature. The production depends, in turn, greatly on the quantity and quality of the available water resources. Finally, the safety of the transportation and distribution network may be permanently affected by major climatic events (such as storms, sticky snow episodes…).

2. THE IMPACTS OF CLIMATE CHANGE ON ELECTRICITY PRODUCTION: FROM THE RETROSPECTIVE ANALYSIS

Retrospective analysis of the South of France shows that the already recorded rise in air temperatures had a direct impact on:

- snowfall which recent developments have led to significant consequence, already visible to the operation of a large pool at the head of valley like that of Serre-Ponçon, a displacement of available merged volumes and a more difficult seasonal reserve management (particularly in

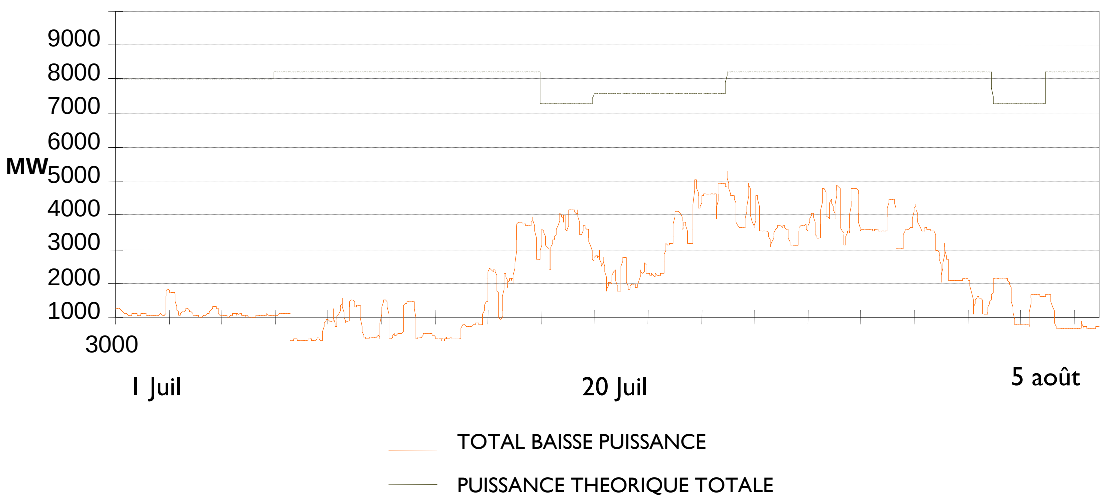
4 Indices nearing or exceeding 75% reveal very strong pressures exerted on water resources; ratios between 50 and 75% point significant medium-term risks of structural stress; indices between 25 and 50% indicate that countries may endure local or fluctuating stress.

ensuring the availability of water during the summer). It is thus necessary to move from an annual management to an interannual management of the retention level.

- the temperatures of the Rhone waters. The impact of the recent heat waves is very visible: in July 2006, temperatures above 27°C were measured at the outlet of Lake Geneva and in 2007, measured temperatures in April were consistent with those normally observed in mid-July. More generally, over the past 30 years, the Rhone River and its streams have seen their temperature increase significantly from +0.5 to +1.6°C depending on the measuring stations.

The increased temperature of rivers may result in a significant decrease in electricity production in so far as the discharge temperature downstream production sites (power stations) must not exceed a limit value - generally set at 28°C in France - regardless of the prevailing conditions upstream. During the summer of 2006, the power of some stations has been made temporarily unavailable as a result of these environmental constraints. At the peak of the sequence, the maximum power erasure has reached 5000 MW over the Rhone, which is considerable in terms of conditions of security and stability in the network.

Figure 3 - Reduced total power of nuclear power plants of the Rhone, July 2006



Source : EDF, 2007

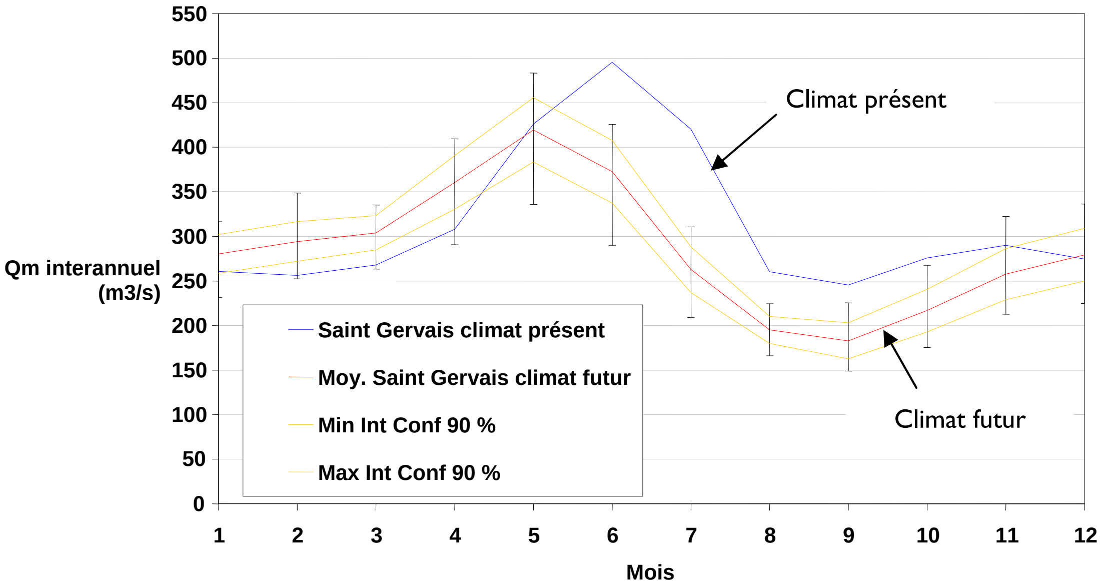
Morocco, which began in the 1960's the realization of a large number of dams, water and hydro-electric works to cope with the spatial and temporal variability of precipitation and develop its water and energy resources, has registered a significant drop of its hydroelectric production due mainly to the decrease in contributions in surface water at the dams. The national average for such contributions has, in fact, dropped by around 20% over the past 30 years under the impact of climate change and the change in rainfall. Loss of productive capital can also be explained by a lack of maintenance and the problems of siltation of dams.

Choices on the allocation of water between uses are increasingly needed, the supply of drinking water and irrigation get highest priority. The average production achieved in the past 20 years has fluctuated between 450 and 1500 million kWh, representing only about half the expected output (the average goal of energy production is 3200 GWh per year for the whole hydroelectric plants built until 2007). If hydroelectric power still plays a significant role in meeting the energy needs of the country (contributing to 8% of the national electricity production), the impacts of drought on this production have compelled the National Office of Electricity of Morocco to move towards the production of thermal energy and renewable energy.

3. TO PROSPECTIVE ANALYSIS: TOWARDS A REDUCTION OF MOBILISABLE HYDROELECTRIC POWER

In addition to the analysis of already recorded data, it is necessary to evaluate the impact of climate change on water resources, in the longer term. First, concerning stream flows, simulations conducted at the European level (from 2 different climate models) show that, in general, the countries of northern Europe will see a significant increase in the flow of their rivers and, inversely, the southern countries - including France - are expected to experience a decline in their flows on the order of 10%, decline even more pronounced on the Mediterranean shore. As for snowfall, which had already undergone a significant change over the past 20 years, the simulations in the French Alps showed a very significant deterioration in 2050 on the whole with less available stock in the form of snow and melting occurring almost one month earlier. Spring and summer flows will be changed consequently, just like the summer low flows which will be more stressful and more difficult to sustain.

Figure 4 - Flow evolution of the Isere at Saint-Gervais-le-Port



Source : EDF, 2007

Significant consequences should follow on the seasonal management of major hydroelectric reserves and the peak energy reserve, as well as a probable reduction of mobilizable hydroelectric power to be taken into account to set realistic targets for renewable energy in the long term. Similar results, and just as marked, occur when one examines the evolution of water temperatures under climate change.

In Egypt, hydroelectric production is entirely based on the exploitation of the Nile waters. The large uncertainties about the impacts of climate change on the development of water resources (though some studies estimate an increase of 30% in water resources in the catchment area of the Nile, others forecast a decrease of 20 to 70% of these resources by the year 2100) and on that of the Nile flow make it very difficult to estimate expected hydroelectric power[5].

[5] It would be necessary to develop studies related to the evolution of the Nile flow at the entrance of Lac Nasser.

4. WHAT ARE THE FUTURE PROSPECTS FOR THE PRODUCTION OF ENERGY FROM WATER, WHAT STRATEGIES TO PUT IN PLACE?

A good analysis of climate change impact on water flows and river temperatures is essential for the design and future management of electricity production plants. This is even more true that certain infrastructures (e.g. ERP - European pressurized reactor - for thermal power plants) are planned to operate at dates when climate change will be actually felt.

Today, the management of uncertain future climate from the past can take into account the risks due to the high variability of water resources quantity and quality. It guarantees the safe and optimized management of all the means of production. In the longer term, the potential impact of climate change on the availability and variability of water resources should be directly addressed, both in terms of quantity with regard to the availability of the resource and in terms of quality in relation to the impacts on the environment. This will include adapting the regulatory scheme applicable to thermal power plants (fossil and nuclear) according to the observed trend in river flows and temperatures resulting from climate change, while seeking the absence of significant impacts on biodiversity. The targets for renewable energy must also be adapted.

In Egypt, where hydroelectricity accounts for nearly 11% of total electricity supply in 2007 (estimated at 3.5% to 2025), national authorities are planning to cope with the growth in energy needs by:

- improving the efficiency of existing hydroelectric plants (improving water flows management, improving the equipment),
- installing Energy Transfer Stations by pumping (ETSP) which are a suitable solution for the countries where the use of wind energy is important and where load curves vary widely. The pumping turbining which allows, among other things, to manage peaks in demand, is an appropriate field of investigation.
- reconsidering the proposed transfer of seawater towards Quattara depression for hydroelectric power production (“hydro-solar" energy).

Actions may also be conducted in the framework of regional cooperation with other African countries (having not reached their full potential in terms of hydroelectricity) in order to meet the needs of the countries, and even to export electricity to Europe. With other countries, Egypt promotes the concept of a continent-wide electricity grid. It is currently implementing regional power cooperation and interconnection projects particularly with its southern neighbour riparian countries to the Nile basin. Several initiatives are under way (the Nile Basin Initiative, the New Partnership for Africa's Development and the Union of Producers, Conveyors and Distributors of Electrical Energy in Africa).

Workshop participants pointed to other areas of investigation or lines of thought, including:

- The development of micro-hydroelectric power plants,
- The links between renewable hydro and renewable wind energy,
- The potential of marine energy (currents, waves, thermal energy, tidal energy…), with the need to identify areas that may be concerned.

To complement these developments, it is essential to continue to acquire knowledge on the availability of water resources and the factors that affect its quality. This requires the strengthening of measuring and monitoring programs and continuing research efforts in the field of heat and rivers biology. This will include fostering trans-disciplinary studies (hydrology, climatology, biology, ecotoxicology, physical chemistry…) to better understand all the factors influencing the evolution of aquatic biodiversity and draw paths to the future. It will also be necessary to construct these adaptations in seeking the best possible scientific consensus, in particular through transfrontier actions and research programs (e.g. research programs on ecological impacts), which will enable to promote common knowledge and share all useful experience.

II. WATER ENERGY NEEDS AND CLIMATE CHANGE, CURRENT AND PROSPECTIVE SITUATION

This section presents a comprehensive review of energy needs for water in the Mediterranean and then goes over the details of the energy needs for water desalination, reuse of treated wastewater and irrigation[6].

1. THE CURRENT AND FUTURE ELECTRICITY NEEDS FOR WATER MANAGEMENT IN THE MEDITERRANEAN

A recent study[7] showed that the current electricity needs for water management (including pumping, drinking water treatment, wastewater treatment, desalination, transfers…) in the Mediterranean countries represent 5% (for the Northern countries) to 10% (for the Southern and Eastern countries) of the total demand for electricity (noting that electricity is the main source of energy used in the water sector).

While it has been extremely difficult to collect statistics on energy-related water use in all the Mediterranean countries, some information has been obtained for France (consumption of 15 TWh for water production in 2003, or about 3.5% of the national consumption of electricity), Israel (11.5% of the national consumption of electricity) and Tunisia (SONEDE having counted about 200 GWh in 2004 for the management of drinking water). The data collected were used to obtain orders of magnitude depending on the types of activities in the water sector and to extrapolate to similar situations.

The average electricity consumption for water varies greatly in the Mediterranean region. Based on the data collected, it was estimated in 2000 at 0.4 kWh/m^3 in France (where water is produced primarily in a conventional way) and 1.5 kWh/m^3 in Israel (where unconventional water production - seawater desalination, transfers - is important). To estimate the average amount of energy required in the Mediterranean, the following values have been retained for 2000: between 0.2 and 0.3 kWh/m^3 of water produced and processed in the Southern and Eastern countries (SEMC), 0.4 kWh/m^3 for the Northern countries (NMC). The results obtained are presented in the following table.

[6] It is based on the following presentations: Energy needs for water in the Mediterranean (Ms Houda Ben Jannet Allal and Mr Jean-Loup Rouyer, OME), Energy for water and wastewater treatment (Mr Michel Coeytaux, Veolia Water), Sea water desalination, renewable and nuclear energies (Mr Alain Maurel, consultant), Energy needs for irrigation in Egypt (Mr Mohamed Nour El Din, Ain Shams University, Cairo).

[7] Rouyer, J.-L., Morel, J. (2007). *De l'énergie pour l'eau dans le bassin méditerranéen*. Report prepared for the Hydrotop Conference, France.

Table 1 - Water and electricity demands in 2000 and 2025

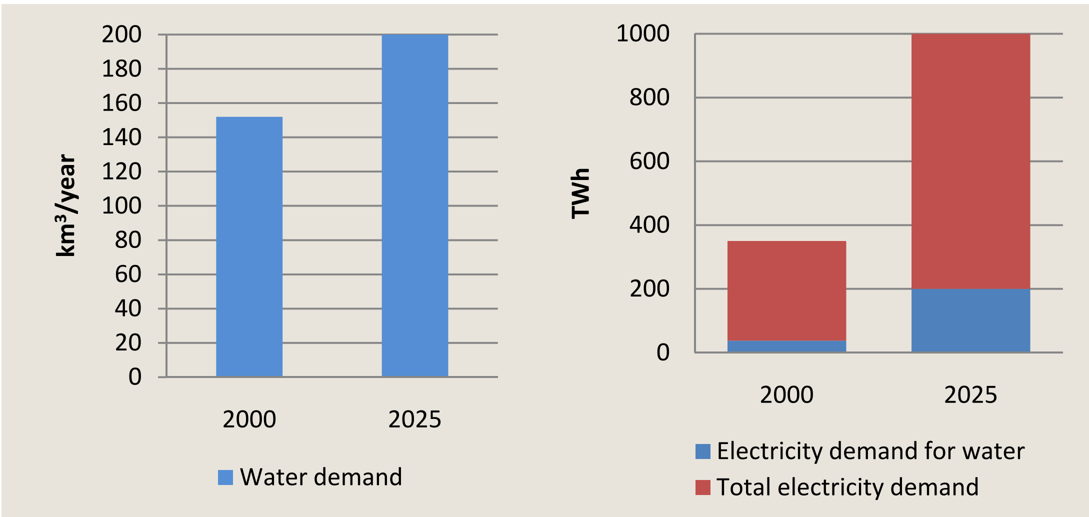
	NMC		SEMC		Total Mediterranean	
	2000	2025	2000	2025	2000	2025
Water demand (km³/an)	138	133	152	200	290	333
Electricity demand (TWh)	1150	1800	350	1000	1500	2800
Electricity demand for water (TWh)	55	93	30 à 45	200	85 à 100	293
% electricity for water	4,8	5	8,5 à 13	20	5,6 à 6,7	10

	PNM		PSEM		Total Méditerranée	
	2000	2025	2000	2025	2000	2025
Demande en eau (km³/an)	138	133	152	200	290	333
Demande en électricité (TWh)	1150	1800	350	1000	1500	2800
dont pour l'eau (TWh)	55	93	30 à 45	200	85 à 100	293
% électricité pour l'eau	4,8	5	8,5 à 13	20	5,6 à 6,7	10

Sources : Jean Margat (Plan Bleu), Jean-Loup Rouyer (OME)

Figure 5 - Water and electricity demands in 2000 and 2025

in the Southern and Eastern Mediterranean countries



Sources : Jean Margat (Plan Bleu), Jean-Loup Rouyer (OME)

According to the projections of Plan Bleu (baseline scenario), water demand may increase by a further 43 km3 by 2025[8], essentially in the Southern and Eastern countries (notably in Turkey and Syria), mainly because of the demographic growth. Agriculture is expected to remain the main water user in volume.

The increase in water demand, exacerbated by climate change, will inevitably lead to an increase in energy requirements for water production and mobilization. Meeting water demand will also rely on the exploitation of resources, increasingly energy costly (withdrawals of deep groundwater resources, transfer of increasingly remote water resources, desalination of seawater…).

[8] Refer to Blue Plan Note « Facing water stress and shortage in the Mediterranean » (Plan Bleu, 2006).

Thus, by 2025, electricity consumption for 1 m^3 of mobilized water could be in the order of 1 kWh for the SEMC and 0.7 kWh for the NMC. At this horizon, electricity needs for water management in the Mediterranean would be in the range of 5% (for the Northern countries) to 20% (for the Southern and Eastern countries) of the total electricity demand (Rouyer, 2007).

It should be noted that these global estimates (by major geographic regions), and taking into account only electric energy, are loaded with uncertainties and do not indicate whether some countries (or some territories within the countries) will be more forced than others by large increases in their electricity needs for water. It would be necessary to specify the estimates for each country and complete the analysis by the consumption of fossil fuels for water management.

2. WHAT SOURCES OF ENERGY TO DESALINATE WATER?

Desalination techniques are well controlled since, to date, the total installed capacity at the global level exceeds 40 million m^3/day. Some Mediterranean countries have already substantial installed capacity (see Table 3). The total installed capacity for the Mediterranean region could grow sixfold by 2030 to reach 30 million m^3/day.

Table 2 - Desalination in the Mediterranean countries

Countries	Installed capacity	Projects scheduled	Remarks
Algeria	600 000 m³/d	2 300 000 m³/d (2009)	Water supply for major urban centres
Cyprus	10 000 m³/d	Ongoing enlargement	
Egypt		Projects in isolated areas (Sinaï, Red Sea)	Use of wind energy
Israel	800 000 m³/d		320 000 m³/d in Ashkelon (reverse osmosis plant)
Libya	1 000 000 m³/d (distillation)	Nuclear desalination Project	
Malta	150 000 m³/d		60% of drinking water supply
Morocco	20 000 m³/d	150 000 m³/d (3 plants)	
Spain	2 500 000 m³/d	Many ongoing projects for agriculture (greenhouse vegetables)	The only Mediterranean country to use desalinated water for agriculture
Tunisia	100 000 m³/d	250 000 m³/d (5 plants)	A desalination project with renewable energy

Source : Plan Bleu, Boyé, 2008

If the desalination of sea water or brackish water is one of the possible adaptation response to the increasing water stress and shortage in some Mediterranean countries, it is not, per se, a sustainable development option. Its implementation requires large amounts of energy (heat or electricity) which are both costly and potential sources of greenhouse gas emissions.

In fifty years, the various processes have made considerable progress in terms of energy consumption. Thus, there exists on the market multiple effects distillation facilities, which require about 250 MJ/m3 (~ 60.103 kcal/m3) of low level thermal energy (~ 100°C) over 2 to 3 kWh of electric energy for the recirculation of seawater. The process of reverse osmosis, for its part, through the establishment of energy recovery systems and much more efficient membranes, requires only 3 to 4 kWh of electricity per m3 of water. When the primary energy fuel is available, energy consumption is of the order of 1 kg of heavy oil (10000 kcal/kg or 42 MJ/kg) for 1 m3 of water with reverse osmosis (with energy recovery) and about 3.5 kg of heavy oil for distillation.

Desalination techniques do not depend on primary energy source. Thus, the use of nuclear energy, planned for high capacity desalination units, does not have specific technology desalination. It is an integrated complex where the nuclear reactor and the desalination plant are built on the same site. In the case of reverse osmosis, which only needs electric energy, no coupling problem arises. Thus, a standard reactor of 900 MW could produce more than 5 million m3/day of freshwater. If nuclear energy has a number of benefits (in terms of preservation of fossil resources, reducing emissions of greenhouse gases, price stability…), countries wishing to use it must cope with the high cost of initial investment as well as the problem of public acceptance (including security and the future of nuclear waste). They must also put in place an adequate administrative and regulatory system.

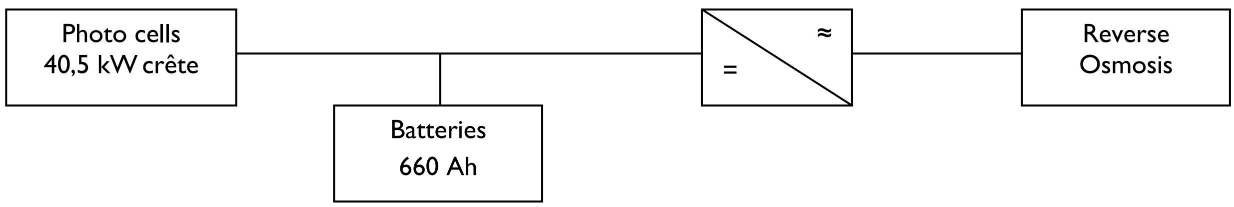
Renewable energy (solar and wind energy) can be used to power small desalination units in isolated locations. Using the sun's energy to distill sea water is not, in fact, a new idea. "Greenhouse" distillation system is the oldest and simplest process of desalination, but whose potential remains limited. Productivity may not exceed 4 to 5 litres of fresh water per square meter of still surface per day and it happens that we quickly have very significant greenhouse surfaces.

Another possibility is to use renewable energies with conventional high productivity desalination processes: multiple effects distillation associated with solar collectors; reverse osmosis is associated with either solar cells or air generators. However, the development of these processes faces two problems:

- the high cost of investments relating to both the energy source and the high productivity desalination plant (hence the use of very high energy performance desalination processes);
- the discontinuous and random character of renewable energy (regular day / night alternance for the solar, weather risks for the solar and wind energy), which implies a more or less important energy storage (in batteries for small capacity units, by connection to a power grid for capacity units ≥ 1 000 m3/d).

Figure 6 - Solar desalination unit (photovoltaic and reverse osmosis)

in the village of Ksar Ghilène, Tunisia



Desalination Unit	Operation conditions		Cost of produced water
Salinity of brack water: 4.5 g/l Capacity of the reverse osmosis unit: 2 m³/hr Conversion Rate: 70% Power Requirements: 3.57 kW Energy use: 1.7 kW/ m³	Summer 35 kWh/d i.e. 15 m³/d (7,5 h/d*2 m³/h)	Winter 16 kWh/d i.e. 7,5 m³/d (3,75 h/d*2 m³/h)	5.6 €/m³ (compared with 8.5 €/m³ for the trucking)

Source : Maurel, 2007

Desalination, a costly solution to face crisis

The industrial production of freshwater through desalination of sea water or brackish water is a growing non-conventional resource in the Mediterranean[9]. Initially developed in situations of insular isolation (Malta, Balearic Islands, Cyprus…) and coastline situation (Libya), notably to respond to the needs of the tourist sector with high season peaks, it is today expanding quite rapidly all around the Mediterranean. It represents up to 60% of drinking water supply in Malta. Algeria - which benefits from cheap energy - has clearly chosen the option of desalination to supply major urban centres (such as Alger, Oran or Skikda) with drinking water. Spain, ranking in fourth position globally, has the characteristic of allotting a significant portion of the desalinated water to the agriculture sector for the production of "off-season" greenhouse vegetables intended for exports. In Cyprus, desalination - for domestic use - contributes to face up to successive droughts situations and to minimize drinking water rationing measures…

Large-scale desalination is a large power consuming, greenhouse gas emissions producing and costly option. The cost of water produced through desalination of sea water would range from about 0,4 to 0,6 €/m3 (and from 0,2 to 0,3 €/m3 for the desalination of brackish water) for large scale plants, i.e. approximately twice higher than the one of conventional water and 1,5 times higher than the one of water treated to be reused, and this without taking into account the high capital costs. These costs are higher for smaller, lower performance or old plants, and obviously very sensitive to the cost of energy which differs according to the countries. It is also worth underlining the negative impacts of desalination on the local environment: the usual impacts of infrastructures on the coastline, but also the ones linked to the brine discharge in the natural medium (which can affect the aquatic ecosystems and water quality).

Thus, certain criteria should be observed before developing or financing any desalination project:

- Use of the desalinated water only for the water supply of populations,
- Justification of the need for and the opportunity of the desalination project (in regards to the other existing alternatives for the supply in freshwater),
- Choice of an operation method maximising avoidance of the negative impacts (minimizing energy consumption, encouraging the use of carbon imprint-free energies, minimizing the impacts on the local environment…),
- Implementation of a plan of environmental management of effluents (brines),
- Integration of significant fringe benefits in terms of employment, development of industrial sectors, creation of services enterprises, etc.

Source : Plan Bleu, Boyé, 2008

3. THE REUSE OF TREATED WASTEWATER: A LESS ENERGY DEMANDING SOLUTION

The comparative analysis of 3 applications (desalination of brack water, the treatment of urban waste water and reuse of treated wastewater) has helped to highlight the following conclusions:

- The desalination of brack water (containing 1 to 10 g/l of salt) consumes less energy than the desalination of sea water (1.5 kWh/m3 instead of 4 kWh/m3 for sea water) as far as brackish waters are of good biologic quality, contain little suspended solids (hence simplified pre-treatment) and have an osmotic pressure lower than sea water. The rate of use of desalinated brack water is high (~ 90%), but the elimination of salty residue remains problematic.

- The energy criterion is an additional criterion for assessing the purification processes of urban waste water. Traditionally, energy recovery from sludge allows the achievement of a coverage rate of the needs in the order of 60%. Energy autonomy from sewage treatment plants is feasible in the short term.

- The reuse of treated wastewater requires low energy consumption (~ 1 kWh/ m3) compared to desalination (seawater or brack water) and the import of water if the distance is over 60 km. It is also a better way to preserve the resource.

[9] In 2000, these resources approached 0,4 km^3 per year in the entire Mediterranean basin (Algeria, Cyprus, Egypt, Israel, Libya, Malta, Morocco, Spain, Syria, Tunisia).

4. ENERGY REQUIREMENTS FOR IRRIGATION

Agriculture is the main water-consuming sector in the Mediterranean. In 2000, it accounted for 64% of total water demand (45% in the North and 82% in the South and East). According to the projections of Plan Bleu, water demand for agriculture may increase by a further 32 km3 by 2025, essentially in the Southern and Eastern countries. These projections reinforce the necessity to improve the efficiency of irrigation water transport and use (through, notably, the implementation of water and energy saving equipments and technologies).

Because of the increase of both the demand for irrigation water and energy costs, it is important to estimate the energy required for irrigation to ensure the sustainability of irrigated agriculture. In the regional study conducted by Rouyer and Morel (2007), the energy required for 1 m3 of water for irrigation is estimated at 1kWh (for the collection, transport and irrigation in the plot).

In the case of Egypt, for example, large amounts of energy are required to:

- gravity irrigation of ancient lands in the Nile Valley and Delta. For this traditional irrigation based mainly on the use of diesel pumps to bring water from the Nile up to 1.5 to 2 m, the energy requirements are estimated between 10,000 and 32,000 kWh/ha/yr (Goosens and Bonnet, 2001);
- irrigation of new reclaimed lands (mostly in the desert) based on pressurized canal systems (sprinkling, drop irrigation) and depending primarily on groundwater. Most of the pumps used to operate the groundwater (to a depth of 50 to 300 m) are electric pumps;
- pumping drainage water for disposal or reuse (6 billion m3 of water drainage are reused every year to provide additional irrigation water);
- water renewal in fish farms..

In the case of traditional irrigation, projects substituting individual small diesel pumps for collective pumping stations upstream irrigation canals aim at improving the efficiency of water use and reducing energy consumption. Additional significant energy savings could be obtained by electrification of these pumps.

The estimation of current and future energy requirements for irrigation is very difficult because of the lack of reliable data at the local level for these various items of energy consumption. It requires further data on the quantities of water drawn for irrigation and drained, the energy consumed for operating the pumps, the establishment and operation of fish farms, and so on.

5. OTHER OPTIONS TO EXPLORE FOR A SUSTAINABLE FRESHWATER PRODUCTION

There is a wide range of resource management methods - not yet sufficiently explored - that would make it possible to increase the exploitable potential of renewable natural resources at the lowest possible energetic, economic and environmental cost. Some options developed for the arid countries (artificially recharging the water tables, dividing up regulatory works upstream of catchment areas, water and soil conservation…) merit consideration in detail in all countries, although they often call for innovations covering a wide spectrum (hydro-geology, hydrology, agronomy, study of soils…).

Other options, such as harnessing coastal or underwater freshwaters, are beginning to be explored in the Mediterranean (La Mortola in Italy, Menton in France). The production of fresh water from underwater sources requires very few energy consumptions (since fresh water goes up naturally to the surface) and doesn't imply any organic or mineral discharge. The cost of water coming from underwater sources would be up to 10 times lower than the one of water produced through desalination of sea water.

III. CONCLUSIONS

Within a context of rising trend in demand for water and power supply, the countries bordering the Mediterranean are faced with a number of challenges: manage sustainably water and limited energy resources, provide access to safe drinking water and electricity to unserved populations and encourage users to saving behavior. These challenges are all the more important as tensions over resources are likely to be exacerbated by the effects of climate change. The expected temperature increase and the decrease in precipitations would lead to both a reduction in resources and an increase in water demand. They would equally create a drop in the production of electricity (hydroelectricity, thermal power plants) and increased demand for energy for the production and mobilization of water (electricity demand for water production already represents nearly 10% of the total demand for electricity in the South and East of the Mediterranean).

Factors to be taken into account when choosing investments to be carried out in the water-energy sector are as follows (see Table 1):

The first response to the increasing demand for water is the development of demand management policies likely to reduce losses and misuses, to manage water resources equitably while ensuring that the different uses are satisfied. Similarly, the initial response to the increasing demand for energy is a better demand side management (energy efficiency), which offers a very significant potential in the countries of southern and eastern shores of the Mediterranean in particular.

Moreover, in some countries, an increase in the supply of water, to organize through better resource management (increase in the exploitable potential, pollution control…) or via non-conventional forms of water supply, is also necessary. Similarly, the increase in the supply of energy in the Mediterranean is and will be necessary, while diversifying energy mix through renewable resources (solar and wind) and promoting sustainable energy development.

The desalination of seawater or brack water is thus one of the possible answers to adapt to the increasing scarcity of water resources in some Mediterranean countries. However, if the desalination techniques are now well controlled, their implementation requires large amounts of energy which are both costly and potential sources of emissions of greenhouse gases. The reuse of treated wastewater is a less costly solution for energy and more "virtuous" for the preservation of the resource. In order to avoid any kind of development encouraging unsustainable patterns of production and consumption, we should consider the valorization (uses and management) of desalinated water and the possibilities for renewable energy development and measures for the rational use of energy for desalination.

In the arid and sparsely populated countries in the South and East of the Mediterranean, the supply of decentralized solar electricity is already a reality (Maghreb, Egypt…). The declining trend in the cost of photovoltaic cells and the increase of that of fossil fuels should encourage the development of renewable energy in these arid rural regions, but also gradually in the densely populated coastal urban and peri-urban areas.

In the Mediterranean, the interactions between water and energy are very strong and extremely vulnerable to climate change. This reinforces the need to develop strategies for integrated management of water resources and energy, with a prospective vision. Morocco has, in this sense, developed an adaptation strategy of the "water-energy" system to climate change.

Table 3 - Adaptation of "water-energy" to climate change in Morocco

Strategies for sustainable and integrated water resources management	Development strategies in the energy sector
• Integrating the climate change factor into national planning of water resources, • Integrated management of conventional and nonconventional water resources (desalination, reuse…), • Implementation of a national strategy to save water that promotes water demand management, installation of water-saving equipment, • Implementation of appropriate water governance (decentralization, consultation and participation of stakeholders), • Introduction of a cost recovery system consistent with the funding requirements of the sector, • Adoption of an adequate institutional and regulatory framework.	• Seek the cheapest kWh : rational use of energy, development of operational performance, encouragement to private investment, adoption of appropriate tariff structures, • Diversification of sources of supply: practical mix between different types of fuels and their origins, development of renewable energy (solar, wind and water), introduction of new environment-friendly technologies, continuation of studies for the use of electronuclear energy for the production of energy, • Attendance of the National Office of Electricity at international forums to valorize the know-how and exchange of experiences.

Source: Secretariat of State in charge of water and the environment in Morocco, 2007

Among the lines of investigation to explore or investigate, the speakers and participants at the workshop highlighted the following points:

- Improve the production and collection of data on water needs for energy and energy needs for water in the countries (consolidate orders of magnitude, develop country-by-country analyses…),
- Continue or develop, country by country, prospective studies on the evolution of water and energy resources and demands, integrating the "climate change" factor,
- Further analysis of the issue of sea water and brack water desalination, and especially the future of renewable energy and energy efficiency in the global supply of energy for desalination,
- Study the potential offered by pumping turbine, micro-electricity and tidal energy,
- Continue the exchange of experience on the links between water, energy and the environment (including the climate change factor) among Mediterranean countries, within the framework of regional cooperation.

CHAPTER 11
Cross-cutting challenges : energy/tourism, cities/energy and climate change

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Tourism

Tourism, both national and international, is a major activity for most of the 21 countries of the Mediterranean basin. Indeed, they receive over 30% of international tourism, which represents a major source of foreign currency. The most attractive countries of the Southern and Eastern rims of the Mediterranean are Turkey, Egypt, Tunisia and Morocco, which received in 2005 respectively 20, 8.2, 6.4 and 5.8 million international tourists.

However, this sector is quite vulnerable to climate change. The Northern and Eastern Mediterranean rims stand out, especially in view of the forecasts of increased frequency of droughts and heat waves potentially affecting directly tourism frequentation. Low lying coastal areas are particularly exposed. In Tunisia, for instance, where 90% of the accommodation capacity is located on the coast, the Gulf of Gabès seems to be quite vulnerable. The same applies to the Mediterranean coast of Egypt, where domestic tourism reports a rapid development. The aggravation of natural resources scarcity (such as water), to which tourism contributes, is also a factor which could affect negatively tourism activities.

It is also proven that the contribution of tourism to global CO2 emissions is about 5%, of which three quarters must be ascribed to transport (Céron, 2007). The continuation of the trends observed (business-as-usual scenario) reveals that the growth of tourism could generate GHG emissions likely to reach 152% by 2035 (Céron, 2007), thus playing a major role in the aggravation of climate change, itself causing, in fine, great economic losses in this sector.

In terms of adaptation, the tourists themselves will probably reconsider the choice of their destination as the climate conditions deteriorate in the Mediterranean destinations.

However, the shift of the tourism activity to less exposed zones is not always possible, in particular for the small local operators strongly attached to a given location. To mitigate such losses, it seems necessary to anticipate the future impacts within the current investments, which requires climate information that is not always available (vulnerability maps) (Billé, 2007).

The eliciting of solutions is currently focused on adaptation options that are low CO2 emitter, such as:

- establishment of the facilities in areas not exposed to variations of sea level and to increased frequency of extreme events,
- tourism offers that minimise water and land wastages,
- environmental management and energy efficiency in tourism facilities (buildings in particular), thus allowing, at the same time, to cater for the comfort needs of tourists and to reduce GHG emissions,
- better control over air transport, a highly GHG emitting sector, by acting—for instance—on the frequency of departures, especially for very long routes. It requires a change in the mindset, in the travel culture, of the future generations.

Urban areas

Cities and urban areas are, quite rightly, considered as sites of high carbon dioxide emissions into the atmosphere (housing and buildings, transport, industry). At the same time, climate change brings a “natural” risk dimension to bear on cities. Their future, thus, constitutes a major stake.

In the whole of the twenty one riparian countries of the Mediterranean, the urban population—living in conurbations of over 10 000 inhabitants—passed from 94 million in 1950 (44% of the population) to 274 million in 2000 (64%). The Southern and Eastern Mediterranean Countries (SEMCs) report an accelerated urbanization (74% of the population of the SEMCs would be urban by 2025), owing to a still steady demographic growth, interurban migrations, as well as a rural migration which continues to prevail in certain countries.

By 2025, the urban population is likely to exceed 243 million in the SEMCs (representing 74% of the urban population of 2025 and 100 million more than in 2000).

These evolutions, associated with urban development patterns that are hardly under control, in particular on the socio-spatial level, exacerbate the vulnerability of Mediterranean cities vis-à-vis the impacts of climate change.

Owing to the very nature of the urban structure, local warming is more exacerbated in the city than in the surrounding country. In the Mediterranean, the unregulated, high-density housing areas, are particularly exposed to extreme events (floods, landslides) whose frequency and intensity are likely to increase in the future. Cities located in very low-lying coastal areas and in delta zones will have to contend with the rise in sea level. The city of Alexandria, but also the cities of Rosetta and Port Saïd, are particularly vulnerable: a rise in sea level by 50 cm is likely to entail the loss of 200 000 jobs and incur the loss of 30 billion dollars in farmland and housing infrastructures (business-as-usual scenario) (El Raey, 2007).

Apart from the displacement of the populations of low-lying coastal areas to higher altitude areas or the installation of efficient coastal protection, which could take between 20 and 30 years, the building and the transport sector are huge area of potential action.

The construction and transport sectors account for the most significant energy consumption rates in urban environment, together with the most GHG emitting sectors.

The construction sector (residential and tertiary) holds a quite high potential of energy efficiency and of recourse to renewable energies. Those options in this sector are at same time adaptation and mitigation action (e.g.: better insulation of buildings against heat wawe). It justifies to give it a priority. The tapping of this potential is met with two major difficulties: the first one involves the stock of new housing units and relates to the difficulty of introduction of the known technical solutions in a market characterized by a large portion of self-construction; the second one involves the stock of existing and old dwellings—which is quite considerable in the Mediterranean—and relates to the difficulty of improving and replicating, on a significant scale, the renovation and rehabilitation techniques.

The urban transport sector raises more daunting problems than those related to construction. The increase in power consumption is quite rapid in the underlying scenarios. In the emissions stabilisation strategies, two main pathways are explored: on the travel supply side, this involves the development of public transport networks and modal transfer policies; on the travel demand side, the solutions belong in the urban policies combining functional mixes and land cover densities, in order to contain urban sprawl. This is admittedly a more difficult course of action, though not the less urgent..

INTRODUCTION

Objectives of the chapter

This chapter aims at a better understanding of the impact of climate change on the tourism sector and on urban areas in the Mediterranean, as well as at considering this issue from a energy-focused perspective.

It does not purport to be exhaustive with regard to the topics addressed. What it rather seeks to do is to offer pathways of reflection on the vulnerabilities and the possibilities of action based on the experiences accruing in some Mediterranean cities or countries and on analyses of the situation of the tourism sector in certain countries of the region.

Information sources

This chapter draws, in part, upon the information disseminated during the two roundtables (one on cities, the other on tourism) organised by Plan Bleu at ENERGAIA, on 6 and 7 December 2007, which offered an opportunity to present the experiences and the reflections obtaining in some countries of the region (Egypt, France, Morocco, Turkey). It also draws upon the recent works conducted by Plan Bleu (cf. References), as well as upon the relevant available literature.

Contents of the chapter

This chapter is divided into two sections. The first section offers an overview of the situation of urban areas, while the second focuses on the tourism sector. They present the vulnerability of these areas and of this sector to climate change and highlight the twofold nature of these issues when considered from the energy perspective (mitigation versus adaptation).

I. TOURISM AND CLIMATE CHANGE

The Mediterranean countries are set to be soon faced with difficulties related to climate change, characterized by an increase in temperature, a reduction in rainfall, a rise in sea level and a greater occurrence of extreme events.

Tourism is one of the sectors most exposed to the climate. The economic losses anticipated for the region will thus be all the higher as this activity has a significant weight in the aggregate income of most of the economies of the Mediterranean region.

However, the relation between climate and tourism is complex and remains difficult to grasp. It calls for special attention insofar as it relates to an activity sector being at once highly vulnerable and a major GHG emitter.

In this regard, the issue to be addressed is necessarily dual: it involves the aspect related to the impact of tourism on climate change, which refers to the stakes pertaining to the reduction of GHG emissions, and the aspect related to the impact of climate change on tourism, which refers to the stakes pertaining to vulnerability and adaptation. However, these two aspects of the issue of "tourism and climate change" are partly interrelated, with the mechanisms of adaptation to climate change being also likely to be CO_2 emissions saving.

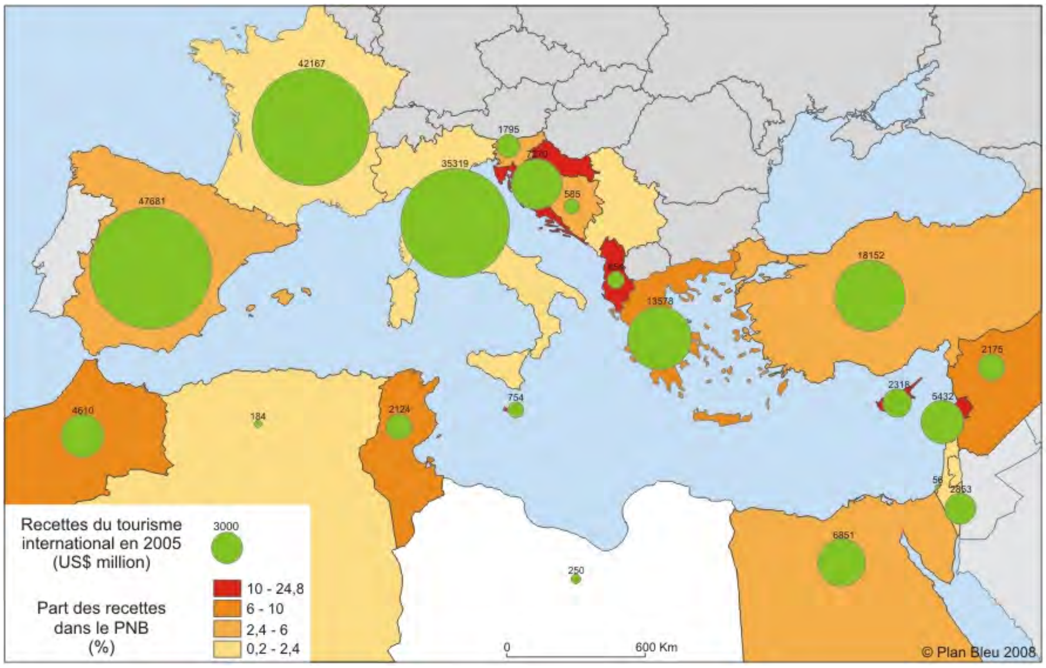
After briefly recalling the importance of tourism in the Mediterranean, we will see the extent to which the evolution of this sector follows a non sustainable trend in this region, particularly in view of the adverse impacts it generates in terms of GHG emissions, as well as in view of the loss of attractiveness of the region owing to climate variability. This will help us to highlight the need for the enforcement of adaptation measures likely to generate net social benefits, even if the climate variability proves to be different from that which was anticipated ('no-regrets policies'), and which could be compatible with the mitigation objectives. We will propose, in this regard, pathways of reflection concerning the main action levers likely to help address the twofold issue of tourism and climate change.

1. TOURISM AND CLIMATE CHANGE: WHAT LINKS ?

1.1. Tourism: A major activity in the Mediterranean

Tourism, both national and international, is a major activity for most of the 21 countries of the Mediterranean basin. Indeed, they receive over 30% of international tourism, which represents a major source of foreign currency (Figure 7). The growth of this sector has ranged since the beginning of the present decade between 3 and 4% per year. In Turkey, for instance, this amounted to 17 billion dollars of earnings in 2006. In this same country, 20% of exports, on average, are generated by tourism which employs 3 million people (Tosun, 2007).

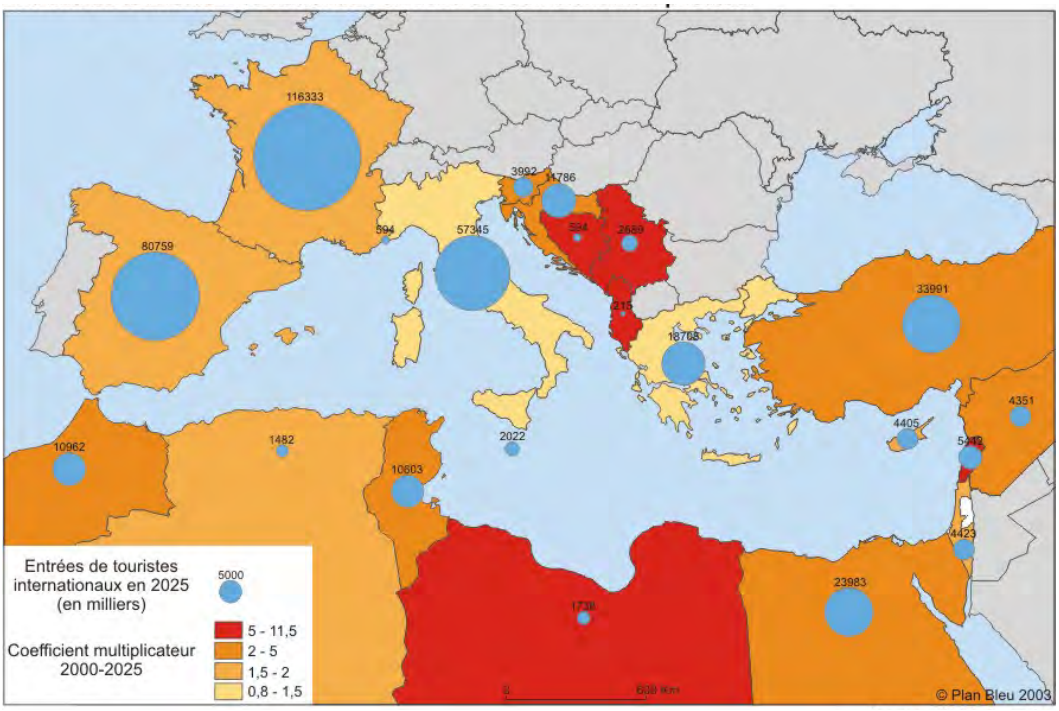
Figure 1 – International tourism receipts and their importance fot the GNP in 2005



Source : OMT / WTO, Compendium 1980-1983 à / to 2007 ; OMT / WTO Fait saillants du tourisme, édition 2007 ; Plan Bleu

The most attractive countries of the Southern and Eastern rims of the Mediterranean are Turkey, Egypt, Tunisia and Morocco, which received in 2005 respectively 20, 8.2, 6.4 and 5.8 million international tourists. This phenomenon is set to intensify in the coming years, since—for the countries of the basin as a whole—, the projections for the time frame 2025 highlight a significant increase in international tourist entries, especially in the countries which are currently among the region's least attractive ones (Plan Bleu, 2005) (Figure 2).

Figure 2 – International tourism entries in 2025



Source : OMT, Plan Bleu

1.2. … which contributes to climate change …

The development of tourism follows today a trend that is fraught with adverse environmental impacts of several orders: degradation of the ecosystems, wastage of water resources, and—above all—an increase in GHG emissions.

On the latter point, it is proven that the contribution of tourism to global CO2 emissions is about 5%, of which three quarters must be ascribed to transport (Céron, 2007). The continuation of the trends observed (business-as-usual scenario) reveals that the growth of tourism could generate GHG emissions likely to reach 152% by 2035 (Céron, 2007), thus playing a major role in the aggravation of climate change, itself causing, in fine, great economic losses in this sector.

1.3. … and which bears (will bear) the brunt of its adverse impacts

The impacts of climate change on tourism may be divided into four types (Billé, 2007; Ceron, 2007):

- direct climate impacts: increased variability of the climate, hence more difficult conditions for the exercise of the activity; change in comfort, health and safety conditions; extreme events (storms, floods, heat waves, etc). Local "improvements" are not to be excluded: lower rainfall, extension of the summer period;
- indirect impacts via environmental change. For instance, a reduction in availability of the water resource—especially in the summer—is envisioned in several Mediterranean areas and may have varied impacts on the tourism sector through problems of access to drinking water, water activities, alteration of attractive natural and agricultural landscape. The expected rise of sea level, associated with other natural phenomena, or ones of anthropogenic origin, also constitutes a threat to a number of coastal tourism resources, ranging from infrastructures to beaches;
- indirect impacts of emission mitigation policies, in particular on transport costs and features. According to the objectives to be set by our societies and the measures which they will take in the years to come, these impacts could prove to be largely higher for tourism than those due to climate change itself;
- the consequences of the global impacts of climate change on the societies: way of life, economic growth, political stability, etc. Herein lie the greatest uncertainties and the most complex interrelationships, tourism being dependent on numerous other sectors.
- In combination, these four types of impact contribute towards putting into question the attractiveness of the destinations. In the Mediterranean, where the main tourist flow currently goes from Northern Europe to the Mediterranean basin, the possible impacts on the destinations are numerous (Table 1).

Table 1 - Expected impacts of climate change on Mediterranean tourism destinations

Changement climatique sur le lieu d'origine	Changement climatique sur le lieu de destination	Implications pour la destination	Réactions possibles du marché
-Hivers beaucoup plus doux et humides -Etés plus chauds et secs -Etés mieux garantis	-Hivers plus doux et humides -Etés beaucoup plus chauds et secs -Changements plus marqués dans l'Est de la Méditerranée -Augmentation de l'indice de chaleur -Plus de jours au dessus de 40°C -Paysages plus arides -Impacts de la hausse du niveau de la mer accentués par la faiblesse des marées	-Sécheresses et risques d'incendies plus sévères -Accentuation du manque d'eau -Exposition personnelle accrue à la chaleur -Dégradation des plages et pertes d'habitats dus à la hausse du niveau de la mer -Vulnérabilité à davantage de maladies tropicales (ex: malaria) -Plus d'inondations éclairs -Faible qualité de l'air dans les villes	-L'amélioration des étés du Nord de l'Europe génère plus de vacances domestiques -Incitation moindre à des vacances estivales sur la Méditerranée -Incitation accrue pour des vacances méditerranéennes pendant les saisons intermédiaires -Incitation accrue pour les sudistes à voyager vers le Nord

In Turkey, for instance, 42% of the total flows take place during the summer months (Tosun, 2007). However, several climate scenarios predict summer temperatures above 40° in the years to come. The impacts of the climate on the environment and on society would increase considerably and would induce a loss of attractiveness of the country in matter of tourism. Over the longer term, this situation could be worsened by the rise in sea level which would entail losses of tourism accommodation facilities and equipment. Besides, currently reputed beaches would be inundated. The future loss of tourists in Turkey in the summer period is estimated on average as 45% within the thirty coming years compared with today.

More generally, to each of the four types of impacts there correspond several forms of vulnerability—varying according to the areas and the tourism practices—and which call for the following elements of reflection:

- For the direct impacts of climate change, the identification of the "hot spots of tourism and climate change" on global level cross-compiles the WTO figures of tourist flows and the IPCC analyses on climate change. The Northern and Eastern Mediterranean rims stand out, especially in view of the forecasts of increased frequency of droughts and heat waves: these hot spots are particularly vulnerable to direct climate impacts.
- The vulnerability to the indirect impacts of a climate change is multidimensional, but—quite obviously—low lying coastal areas are particularly exposed. In Tunisia, for instance, where 90% of the accommodation capacity is located on the coast, the Gulf of Gabès seems to be quite vulnerable. The same applies to the Mediterranean coast of Egypt, where domestic tourism reports a rapid development.
- The average tourist is a great consumer of resources: he consumes in particular much water (food, bath, swimming pool, cleaning, garden, golf course, etc), and this, in seasons of little availability. Tourism thus competes with local uses (household consumption, agriculture, industry, etc), adding to the vulnerability of the area where it is established—and, hence, its own area. In Turkey, for instance, the daily consumption in the tourism industry amounts, on average, to 400 litres of water per person, while the country's residents use only 70 litres of it (Tosun, 2007).

2. IDENTIFICATION OF ADAPTATION ACTIONS

2.1. What possible « sustainable » adaptations?

To promote sustainable tourism in the Mediterranean in a context of climate change, several adaptation measures may be envisioned. To date, there is hardly any country in the region that anticipates the impacts of climate change on tourism and that takes measures to mitigate the future costs related thereto. It is worth pointing out, however, that tourism in the Mediterranean is at present (therefore, in a non climate change context) very scarcely responsive to the criteria of sustainable development, as attested by the guidance and actions recommended by the Mediterranean Strategy for Sustainable Development (MSSD). Consequently, the riparian countries are faced with a twofold challenge: (i) regulate and direct the tourism activity towards a greater sustainability (economic, societal and environmental), while seeking simultaneously (ii) to anticipate the impacts of climate change and take measures to mitigate the costs related thereto. The task is gargantuan.

In terms of adaptation, the tourists themselves will probably reconsider the choice of their destination as the climate conditions deteriorate in the Mediterranean destinations.

Among travel agents, the adaptation will also probably require the choice of new destinations for the offer of tourism travel and holidays.

However, the shift of the tourism activity to less exposed zones is not always possible, in particular for the small local operators strongly attached to a given location. Accordingly, in the countries concerned by a change in climate conditions causing tourism stays to be uncomfortable (for example, with temperatures above 40°), many small and medium-sized enterprises (SMEs) of the hotel sector, as well as all tourism related activities (catering, leisure, etc), could incur significant losses, likely to have an impact on the economy as a whole (Ceron, 2007). To mitigate such losses, it seems necessary to anticipate the future impacts within the current investments, which requires climate information that is not always available (vulnerability maps). (Billé, 2007).

The environmental management of tourism facilities, with the involvement of the tourists (e.g.: water and energy saving, rainwater collection systems, reuse of treated wastewater, adapted design and architecture), based on incentive financial measures, constitutes an adaptation measure that could be envisioned by the countries. However, so that these measures can be accepted by the operators, they should subsequently generate operation saving.

The diversification of the tourism offer in the Mediterranean is equally promising in a context of climate change. Seaside tourism (sun, sand and sea)—being dominant in the Mediterranean—is particularly vulnerable to climate change (coastal erosion and rise in sea level). The stake is, therefore, not only to develop less climate sensitive activities or, in any case, activities with differentiated climate sensitivities, but also less resource demanding activities (Billé, 2007).

The reduction of seasonality, via a better distribution of tourist arrivals throughout the year, constitutes another adaptation measure, helping avoid, for instance, the heat wave periods of the summer season.

Yet, a sustainable development scenario requires, at the same time, maintaining tourism, mitigating the vulnerability of the countries to the climate, as well a reducing GHG emissions.

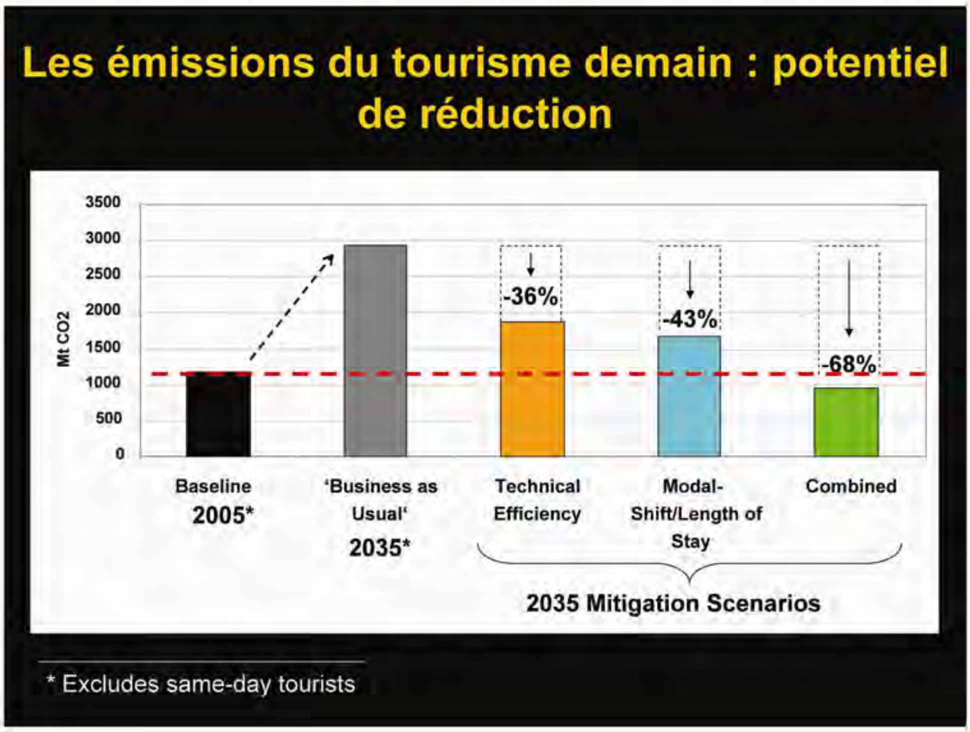
2.2. Which options for emission reduction scenarios for the time frame 2035?

On global level, two major options for 30-year scenarios have been considered:

- a high technology option with energy efficiency gains of 50% for aircraft and of 2% for the other sectors;
- an option combining modal transfer and increase of stay period, with a boost of train and bus transport by 2.4% to 5% per year and an increase in stay time by 0.5% per year.

For the time frame 2035, the "Technological Efficiency" scenario, compared with the "business-as-usual" scenario, offers a reduction of emissions of 36%; on the other hand, the "Modal transfer and length of stay" scenario reduces emissions by 43%. The scenario combining both options allows, therefore, a large scale reduction (68%) in such a way that the emissions would range within a level less than that of 2005 (Figure 1) (Céron, Dubois, 2008)

Figure 3 - Tourism emissions scenarios for the time frame 2035



Source : Céron, Dubois, 2008

2.3. A few possible action levers ?

In order to achieve these objectives, several action levers could be put to the task. Rather, it would be more judicious to speak of a combination of levers to be activated simultaneously, the objective being twofold (to adapt and to reduce emissions) and the tourism sector being completely cross-cutting.

Even though the contribution of technology remains limited, the gains generated by technical progress are not to be neglected, especially with regard to the energy efficiency of the means of transport and of construction.

Moreover, the State can contribute to financing the infrastructures necessary to allow limited recourse to air transport (financing railroads, for instance…); train and bus being the means of transport to be granted precedence, such as illustrated by the case of France (Table 2).

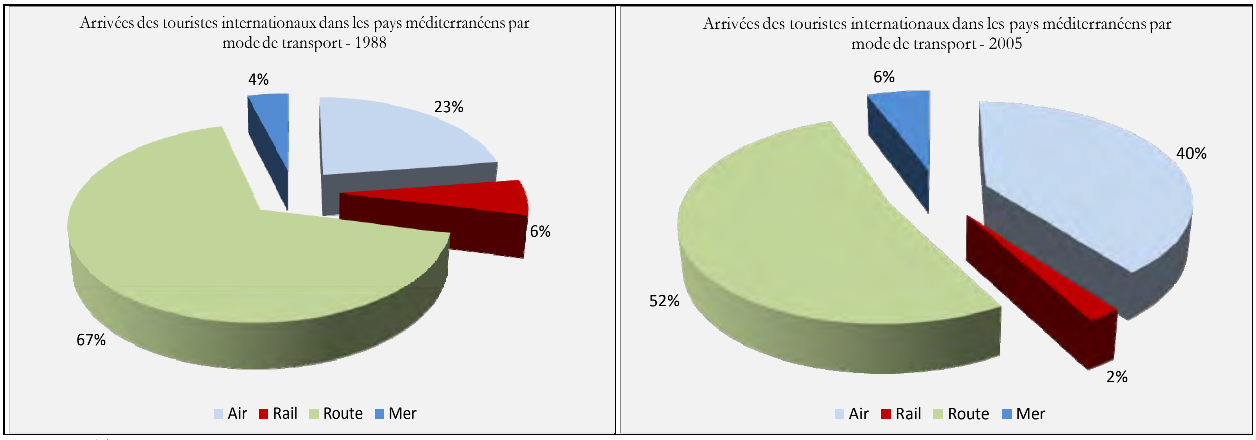
Table 2- GHG emissions and distances covered according to the various modes of transport in France

	Emission moyenne par séjour (en kg)	Distance moyenne par séjour (en km)
Avion affaires	3731	5384
Avion éco	1252	5188
Camping-car	134	672
Minibus	78	993
Voiture	77	588
Moto	67	564
Bateau	57	1211
Autocar	51	1258
TER	14	362
Train Corail	10	759
Train TGV	3	1033

Source. Direction des études économiques et de l'évaluation environnementale, (Department of Economic Studies and Environmental Assessment) 02/ 2008

In the Mediterranean, arrivals of international tourists by rail reported a decrease by 6 to 4% over the period 1988-2005, while those by air increased from 23 to 40% (Figure 4). The reduction of GHG emissions due to tourism undoubtedly requires reversing this trend. The improvement of the energy efficiency of road transport (public and individual) also remains a worthwhile course of action in matter of reduction of GHG emissions, the road being still the most used transport mode (52%) in 2005.

Figure 4 - Arrivals of international tourists in the Mediterranean countries by transport mode



Source : WTO ; Plan Bleu 2008

A highly effective action lever would lie in price level (Fotiou, 2007). Tourism gives rise to negative externalities: it produces GHG emissions likely to impact the climate, the ecosystem, people's health, as well as cause degradation to the environment and society. If these externalities were factored by the market prices, investor decision-making and consumer behaviour would become more in line with the objectives of sustainable development. This is why it is important that tourists should pay for the damage due to them. That would make it possible, on the one hand, to finance the repairs and would, on the other hand, serve as an incentive system towards limiting emissions and degradations. It would be possible, in this regard, to consider the introduction of high and dissuasive air taxes, for instance.

Another key point—likely to make the countries aware of the problems caused by tourism and to induce them to adopt preventive and adaptation measures—consists in reducing the information asymmetries (Fotiou, 2007). Indeed, the anticipated costs must be known by all people, in all the countries, in order to help them channel their decisions in an optimal way.

Moreover, more precise information is necessary: a step must be taken to move from the climate, as a broad concept, to "what the weather is like", i.e. to translate the models output parameters (rainfall, mean and maximum temperatures) into indicators that are closer to what is felt by the tourists in order to effect a change in the decisions of both tourists and operators. This requires a reinforcement of research and a scientific extension effort (Céron, 2007).

Lastly, to help this scenario materialise requires a change in the mindset, in the travel culture, of the future generations. Tourists might prefer activities closer to their home, which is likely to be induced via an improvement of the living environment (Céron, 2007). Departures would be less frequent and stays would be longer, and it would be possible to compensate for this reduced mobility by an increase in proximity trips.

II. URBAN AREAS, ENERGY AND CLIMATE CHANGE

Grasping climate change issues requires an appreciation of the local impacts of global changes, with significant regional differentiations and complex retroactions.

Cities and urban areas are, quite rightly, considered as sites of high carbon dioxide emissions into the atmosphere (housing and buildings, transport, industry). At the same time, climate change brings a "natural" risk dimension to bear on cities. Their future, thus, constitutes a major stake.

1. URBAN AREA AND CLIMATE CHANGE: WHAT LINK?

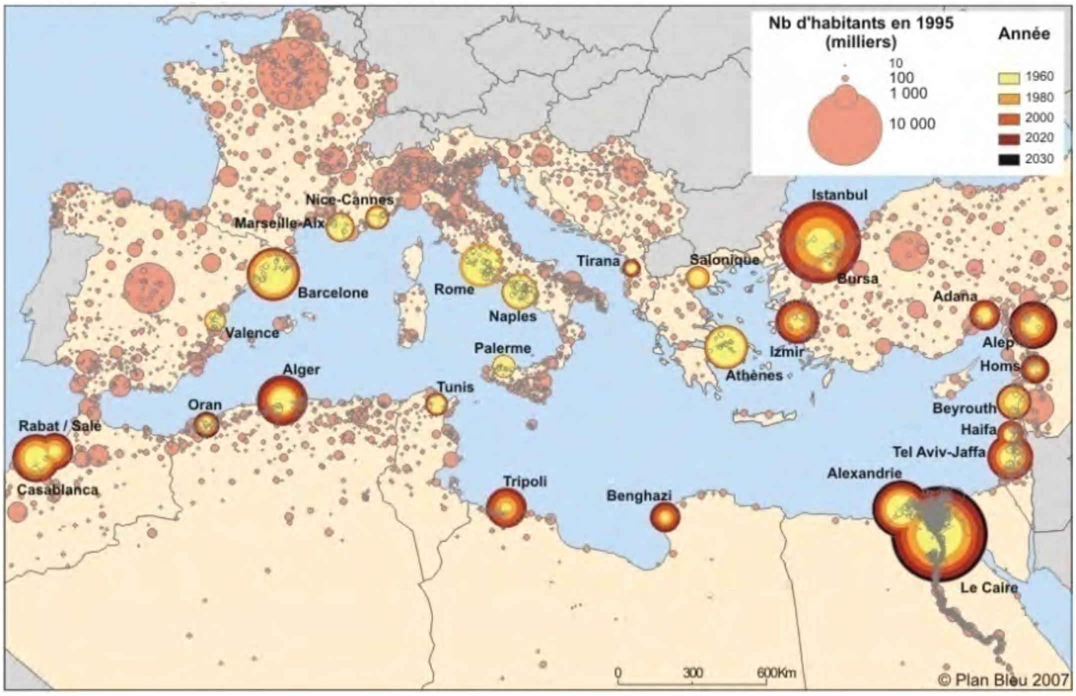
1.1. An increasingly urban population

In the whole of the twenty one riparian countries of the Mediterranean, the urban population—living in conurbations of over 10 000 inhabitants—passed from 94 million in 1950 (44 % of the population) to 274 million in 2000 (64 %). The Northern Mediterranean Countries (NMCs) today report quite moderate growth patterns (0.7 % for 1970-2000) which are set to continue into the future, while the Southern and Eastern Mediterranean Countries (SEMCs) report an accelerated urbanization (3.6 % for 1970-2000) which poses huge challenges in terms of sustainable development.

By 2025, the urban population is likely to exceed 243 million in the SEMCs (145 million in 2000) and to be in the order of 135 million in the NMCs (129 million in 2000). A sizeable third of this growth will take place in Mediterranean coastal areas (Plan Bleu, 2005).

With the urbanization and the fall in fertility reported in the SEMCs, the family pattern changes, the size of the households is reduced, the number of households increases at a higher pace than that of demographic growth, and demand on housing becomes more massive. For example, the housing deficit stands at 1 million in Morocco, and the additional needs are estimated as between 100 000 and 125 000 housing units per year (Guerida, 2007).

Figure 5 – Population in Mediterranean cities



Source Source : Plan Bleu, after Géopolis 1998 and UN Population Division. World Urbanization Prospects: The 2005 Revision

In the coastal areas, the population is likely to reach 174 million inhabitants by 2025 (143 million in 2000), of which 90 million in coastal cities. To these, there must be added the seasonal tourist flows, which can double up the number of inhabitants on the coastline during the peak periods. These demographic and tourism trends induce a high growth of infrastructures and equipment on the coastline, thus translating, in fine, into an increasing artificialisation of the coasts and a more acute vulnerability of the ecosystems and coastline landscapes (Plan Bleu, 2005).

1.2. Vulnerability of urban areas and adaptation to climate change

The impacts of climate change on urban areas and the constructed space relate mainly to temperature increases, extreme hydro-meteorological events and sea level rises.

Owing to the very nature of the urban structure, local warming is more exacerbated in the city than in the surrounding country. Heat waves are more marked there, being intensified by the reduced area of green spaces and the low evapotranspiration of the vegetation, with dreadful impacts on health, the economy and the environment: increased mortality among the vulnerable population groups (old people), reduction in the comfort of city-dwellers and their productivity—as well as that of the urban economy—, peaks of demand on the installation of air-conditioning and peaks of power consumption, with an increase in global warming. In 2003, the heat wave that had struck Europe claimed a toll of over 30 000 deaths; in the future, the impacts of very hot summers and more frequent heat waves will be heavy in the Mediterranean cities.

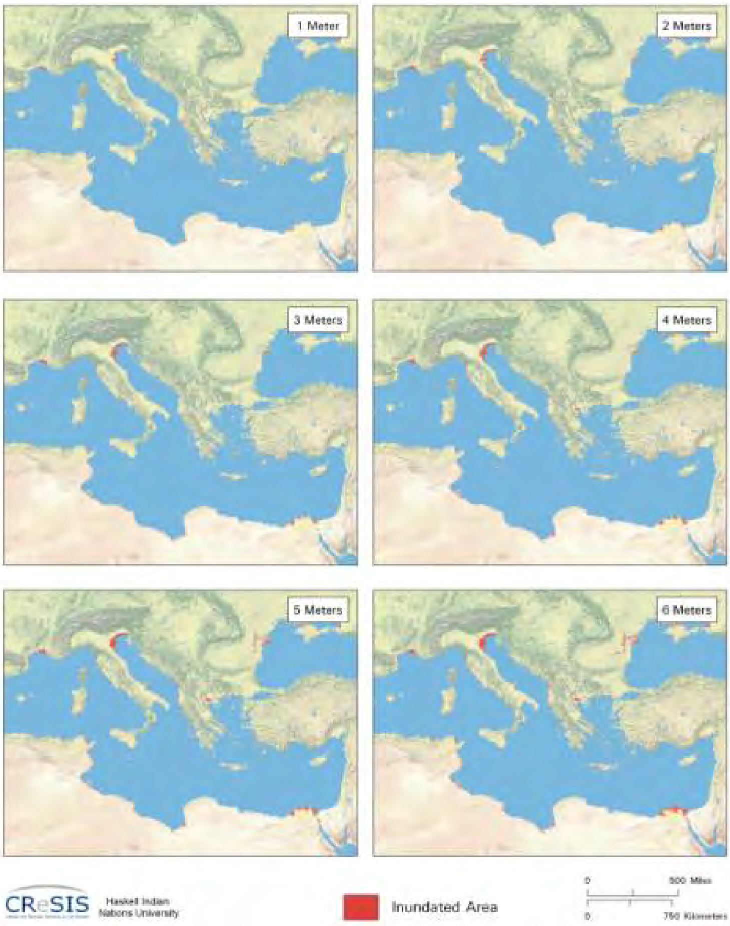
The climate models predict a substantial increase in urban vulnerability to hydro-meteorological disasters. In the Mediterranean, the unregulated, high-density housing areas, are particularly exposed to extreme events (floods, landslides) whose frequency and intensity are likely to increase in the future. Between 1975 and 2001, out of 480 extreme events which had occurred in the Mediterranean, the countries reporting the heaviest toll in terms of victims were Turkey, Italy, Algeria, Greece and Egypt. Catastrophic floods attendant upon violent rainfall, and further aggravated by deforestation and construction on slopes, constitute a major risk for a great number of Mediterranean cities in Spain, France, Italy, Algeria, etc. The floods that struck Algiers in 2001 (920 dead, 50 000 disaster victims) and other very fatal disasters of the same type, regularly highlight the deficient application of town planning and construction rules, thus accentuating the vulnerability of cities (Plan Bleu, 2005).

Cities located in very low-lying coastal areas and in delta zones will have to contend with the rise in sea level (Figure 2). A rise in sea level by 1 metre[1] would affect 6% and 10% of the total population in Tunisia and in Egypt, respectively (Figure 6). More significant exposures of the infrastructures to the action of the waves (erosion) and coastal storms are among the most serious impacts.

In Egypt, the financial impact could claim as much as 7% of GDP—loss of 13% of farmland, loss of habitat, biodiversity and water resources, as well as adverse impacts on health (Figure 7). The city of Alexandria, but also the cities of Rosetta and Port Saïd, are particularly vulnerable: a rise in sea level by 50 cm is likely to entail the loss of 200 000 jobs and incur the loss of 30 billion dollars in farmland and housing infrastructures (business-as-usual scenario) (El Raey, 2007).

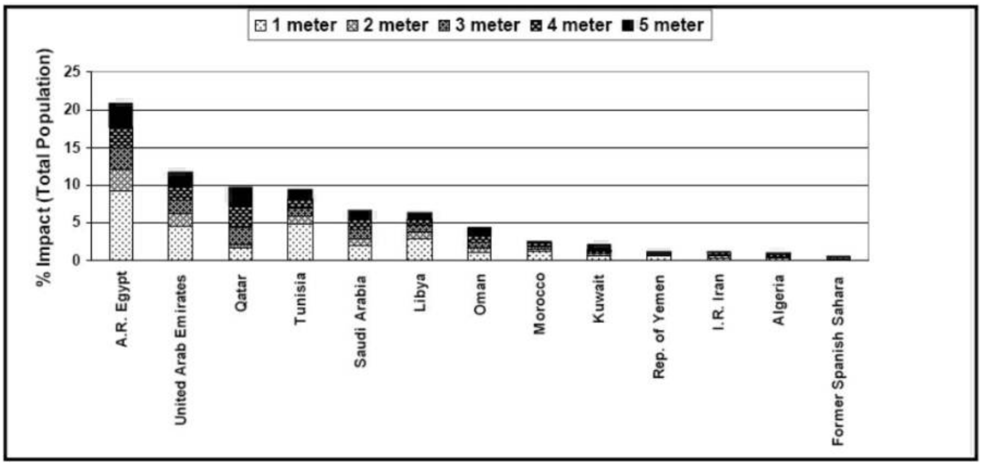
As regards adaptation, the displacement of the populations of low-lying coastal areas to higher altitude areas is considered, but the implementation of such an alternative would be quite difficult. Another possibility is the installation of efficient coastal protection, which could take between 20 and 30 years. All things considered, it is necessary that adaptation should become a priority for the public authorities as of now, so that it can make a difference tomorrow.

Figure 6 - Impact of sea level rise in the Mediterranean



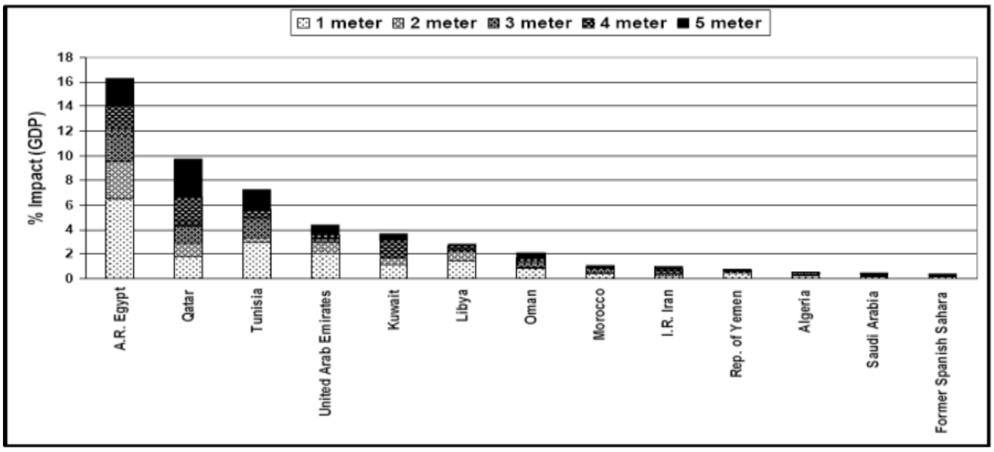
1 It is worth pointing out, however, that the climate models predict a rise in sea level, on certain banks, ranging between 30 and 60 cm for the time frame 2100 and that knowledge on the matter for the Mediterranean is still quite incomplete. For further details, cf. Chapter 1 of Part 1.

Figure 7 - Impact of sea level rise on the population of the countries of the MENA region



Source. El Raey, 2007

Figure 8 - Cost of sea level rise in the countries of the MENA region (in % of GDP)



Source. El Rey, 2007

2. IDENTIFICATION OF ACTION FOR ADAPTATION

2.1. Energy saving and strategies of mitigation of climate change

Energy is consumed mainly in the cities. There is a lack of data to quantify this consumption, but it is known that, in the Northern Mediterranean Countries (NMCs), the growth of final energy consumption is due, above all, to the transport sector, which accounted for about a third of the total in 2005, as against approximately 20 % in 1970. In the Southern and Eastern Mediterranean Countries (SEMCs), it is the residential/ tertiary sector which ranks first in the consumption list (nearly 40 %) and which currently reports spectacular increase (annual growth by about 5 % between 1971 and 2005).

On global level, the cities generate approximately 75% of GHG emissions. The most significant consumption in urban areas is due to buildings and transport, two of the highest GHG emitting sectors.

Transport is the key sector when it comes to reducing the consumption of fossil energies and reducing GHG emissions. Nevertheless, effecting a medium-term change in this regard is deemed to be more difficult than in buildings. The building sector has a potential of energy saving considered to be also quite significant; it is the sector where such saving becomes the more accessible in the medium term.[2]

2.2. Building, a sector with a high energy saving potential

The building sector is a heavyweight energy consumer. In Europe, it represents the top sector in the consumption of electricity, and ranks second in the consumption of fossil energies (after transport).

The energy consumption of buildings—residential, administrative and commercial—depends mainly on the features of the natural environment. The energy needs of buildings can be reduced by a well insulated construction, designed according to the rules of bio-climatic architecture. The historical sites of Rome, Venice, Florence, Athens, Barcelona, Marseilles, Istanbul, or the medina of Arab cities, offer examples of the "bio-climatic" city whose construction had been guided by a concern to save energy and by architectural principles that are now freshly capitalised, such as:

- orientation chosen to capture the sun in the winter and to reduce heat inflows in the summer;
- insulation of walls and roofs, reduction of heat losses;
- minimising the need for cooling (ventilation, outside shade, colours, solar protection of window panes, walls and roofs);
- inside lighting, taking into account the specific luminosity in the Mediterranean.

With the massive use of fossil energies, it is the glass and steel skyscraper international architecture—nonviable without air conditioning or heating—that has developed everywhere, including on the rims of the Mediterranean. The very recent, planet-wide ecological concerns induce a return to the principles of bio-climatic architecture, whose potential can be scaled up in the wake of current technologies.

As regards heat insulation and lighting, dedicated technical solutions are available to reduce the energy consumption of buildings: preliminary sunshine study, use of available solar energy (under the form of light or of heat) while avoiding summer overheating, heat insulation, night ventilation…, for the stock of new housing units. The difficulty lies in building such housing units at a cost (or with a financing) accessible and at a sufficiently substantial pace so that the results can be significant in energy terms.

In the Mediterranean, considering that 30 to 60 % of the housing stock in the cities of the SEMCs (as well as in the cities of the EACs (Eastern Adriatic Countries)) belongs in the unregulated housing sector, the problem lies in the ways of promoting the penetration or the reintroduction of the techniques of bio-climatic architecture in the construction market, which also requires a proper grasp over the socio-economic processes that govern such a market, both formal and informal. In Morocco, for instance, 80 % of house building is done via self-construction; significant programmes of energy efficiency and building promotion have recently been set up (box 1).

[2] Besides, the development of new energies and of energy efficiency can be regarded as an economic opportunity and can generate many new jobs, in particular in the buildings sector.

box 1 - Buildings, energy efficiency and urban upgrading in Morocco

Morocco is in process of implementing a energy efficiency programme in buildings (programme of the Ministry of Housing, Ministry of Tourism, Ministry of Health and Ministry of National Education) based on thermal regulations involving architectural design, construction materials and electro-mechanical systems (e.g.: air-conditioning or heating, specifications approach). This initiative belongs within the framework of a national programme assigned an objective of 10 % renewable energy use for the time frame 2012.

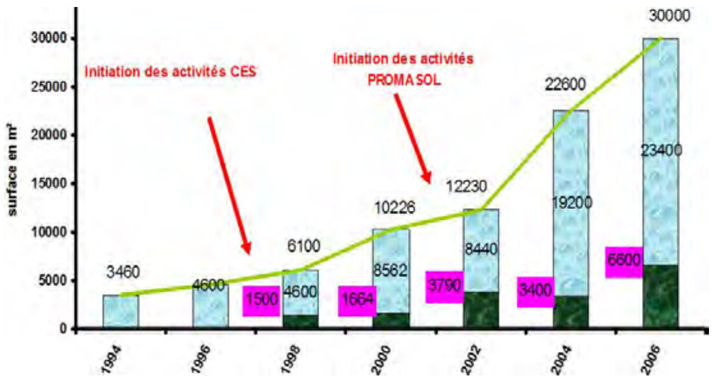
In order to meet the objectives of urban development and housing needs, a programme to promote the construction sector has been set up: 100 000 new housing units were put on offer in 2005, as against 30 to 40 000 on average as of 2002. For the five coming years, the programme envisions to reach 150 000 to 200 000 new housing units per year, a necessary objective to meet the demand.

Besides, a urban upgrading programme dedicated to the elimination of shantytowns involves about 750 000 households and a similar number of housing units in state of disrepair, generally in major cities. Finally, the country needs to lay down a new town planning code which would identify the areas to be set out for urbanisation.

As for the existing housing units and the old buildings (their portion is difficult to quantify[3]) however, the restoration and renovation will require considerable efforts to make dedicated products available to the reconstruction market. In view of the size of the stock of existing buildings in the Mediterranean and the low level of their energy performance, the project of the Institut du Bâtiment Méditerranéen - IB Med (cf. networks list in References below), dedicated to enhancing rehabilitation practices, stands as a promising initiative.

"Solar hot water" also presents a significant potential of reduction of energy consumption in the Mediterranean region. Although much progress remains to be achieved in this regard, several riparian countries are already tapping these energy solutions. Programmes have been initiated in Morocco[4] (Figure 9) and in Tunisia to promote the solar water heating market. In Turkey, Greece and Cyprus, the roofs of city buildings are often used for this type of installations.

Figure 9 - Installation of solar water heaters in Morocco (in m²)



Source. Berdaï, 2007

The actions implemented remain, however, quite limited in view of the opportunities offered by the region's exceptional sunshine. Besides, in the Southern and Eastern Mediterranean Countries (SEMCs), the initiatives generally rest with the public authorities on national level and not with the cities themselves, owing to the latter's low administrative, and especially technical and financial, capacities.

On the northern rim of the Mediterranean, the conurbation of Montpellier provides an example of a more thought-out attempt at energy efficiency (Box 2) and urbanization, with the set up of a "eco-quarter" characterized by an efficient management of energy, water, waste and development of public transport.

[3] Concerning France, 2/3 of the existing housing units were built before 1974, that is prior to any prescription related to energy performance.
[4] Morocco also boasts a success story as regards photovoltaic solar energy in rural environment and the conservation of the firewood resource. The energy efficiency programme in buildings is set to foster decentralised penetration of renewable energies in cities.

box 2 - The experience of the conurbation of Montpellier (Hérault), 470 000 inhabitants

In 1985, the creation of a energy service, now comprising 21 employees, allowed the inception of a energy efficiency programme:

- Engineering consultancy for the design of energy installations (3 persons),
- Maintenance service for operation and control of the 311 boiler rooms (16 persons),
- Energy management service for monitoring consumption and bills, as well as for pricing optimisation (2 persons).

"Town-planned" Montpellier

A strong political will to restore urbanisation balance in Montpellier was marked by:

- Creation of the Antigone and Port-Marianne districts, near the town centre, in order to bring housing sites closer to the workplace.
- Fitting out a large pedestrian area in the town centre, in order to significantly reduce car traffic.
- Creation of 54 km of cycle tracks.
- Laying, in 2000, a first tramway line of 15 km.
- Besides, a deployment agreement with EDF-GDF (Electricity Utility + Gas Utility) on the Port-Marianne district promotes the use of natural gas as a substitute for electric heating.
- Creation of a "eco-quarter".

"Productive and distributive" Montpellier

- Distribution of heat (50 000 MWh) and cold (18 000 MWh) via the heating and cooling Montpellier network (RMCC), regulated by a mixed-economy company of the city of Montpellier (SERM).
- Use of Cévennes coal and of natural gas in the RMCC.
- Setting up, in autumn 1996, a natural-gas-fired co-generation plant onto the RMCC.
- Equipment of public buildings with photovoltaic and solar thermal (in 2005, installation de 1600 m² de captors producing 129 000 kW).
- Extraction of biogas from the old land fills for over 25 years, which is made use of on site.

"Consumer" Montpellier

Municipal buildings:

- Consistency between the design of buildings, the operation of the energy installations and the management of energy expenditure, in order to ensure best overall cost.
- Actions for the control of power demand.
- Remote management of boiler rooms.

Street lighting:

- \- Modernisation of the 17 000 lighting points by high-output appliances.

Energy management:

- \- Pricing optimisation on a yearly basis.
- \- In-house: memoranda to raise awareness among municipal staff as to the need for heating and power saving in buildings, as well as for better design of energy installations during the rehabilitation or the construction of municipal equipment.
- \- Outreach: information on the actions of the city of Montpellier in matter of energy saving, on the stakes of energy efficiency, and on pricing optimisation of EDF (Electricity Utility) subscriptions.

Results and projects:

On the whole, between 1985 (date of establishment of the energy service) and 1999, energy efficiency actions helped cut down by 53.5 % the energy bill of municipal buildings. Since 2005, the return on the investment made in this field has been of 64 000 euros per year. To these, there must be added the earnings obtaining from the recycling of wastes (35 000 euros per year). A programme with an amount of 2 million euros has been incepted with a view to equipping both old and new buildings with 3200 m² of heat or photovoltaic captors allowing the production of 590 000 kW of heat or electricity based on avoiding the disposal of 100 tons of carbon dioxide.

Objective: Reduction by 20% of energy consumption on current or future equipments.

Source: J. P. Mourre, 2007 and information derived from http://www.sortirdunucleaire.org/

2.3. Transport and land use

The future of the energy consumptions of the transport sector is a greater cause for concern; their increase seems to be more rapid in the underlying scenarios. The determining factors are more difficult to impact by public policies.

On a global level, between 1990 and 2004, CO2 emissions of the transport sector increased by 36.5 %; the growth of the emissions due to road transport stood at 29 % in industrialized countries and 61 % in transition economies and developing countries. Three quarters of the emissions (76 %) are generated by road transport, in particular cars, commercial vehicles, light vans (GTZ 2007, according to IEA 2006), but figures are still lacking to show the relative share of urban transport in this total.

Three courses of action are nowadays explored to reduce CO2 emissions due to transport. The first two aim at making the urban transport offer more environment friendly; their impact on the reduction of emissions depends on the following factors: number of vehicles, level of congestion, driver behaviour (speeds), state of the vehicle fleet, type of fuel.

The improvement of the energy efficiency of vehicles and the shift to less carbonaceous fuels are conducive to a reduction of local air pollution (cf. the Egyptian policy of conversion of the vehicle fleet to natural gas). In spite of their interest, these are so-called "end of the pipe" policies; all studies concur to the fact that they will not be enough to achieve the goals of stabilization of GHG emissions.

The second course of action, that of modal transfer to less polluting modes, requires vigorous policies of development of public transport (infrastructures of mass transport, subsidies to operation…), together with concurrent measures aimed at limiting the use of the private car (paying parking in the city centre, urban toll…).

In the Mediterranean, tram construction and projects, for instance, have multiplied over the past few years (Alicante, Valencia, Barcelona, Montpellier, Marseilles, Nice, Rome, Naples, Palermo, Athens, Cairo, Tunis, Algiers, Constantine, Oran, Rabat…), with some examples of reduction in congestion, in energy consumption and in polluting emissions in the central areas of cities. However, problems of traffic outside of the city centre have worsened.

Lastly, as the development of mass transport can cause urban sprawl and increase the use of the car on the outskirts of cities, the third type of measures aims at cutting down the demand on motorized travel, by acting on the urban structure, on the space organization of cities, the latter exerting a strong influence on the travel demand and energy consumption of the transport sector. This consists particularly in control over urban sprawl and on the transport demand via cross-planning of the city and transport, by preserving compact urban structures and by organizing the city in such a way as to generate less travel, especially of the motorized type.[5] In other words, it consists in pursuing the "city of short distances".

The actions in this field involve the very long term future; this, accordingly, confers upon them a certain urgency. Yet, they are very difficult to implement, as the urban structure is largely governed by the operation of powerful land property and real estate markets. Nevertheless, it is possible to somewhat induce a shift in trends based on development and town planning schemes (urbanization areas, functional mixes, land use density), alongside with the activation of inner city housing.

5 The cross-planning of the city and transport has recently been introduced in industrialized countries (The Netherlands, Great Britain, Norway…) and in developing countries (Brazil, Singapore…) in order to contain the excessive use of the car. Emphasis is laid on densifying the urban fabric, in particular around public transport stations and connection points.

2.4. Pathways of reflection for further consideration

The southern Mediterranean countries experience an accelerated urbanisation (74% of the population of the SEMCS would be urban by 2025). This first section has addressed the anticipated impacts of climate change on urban areas and highlighted their increasing vulnerability to global warming, extreme hydro-meteorological events and sea level rises.

The strategies of adaptation to climate change and those aimed at mitigation have been considered in view of their more or less great difficulty of implementation.

With the large-scale demand on housing in the southern Mediterranean, the construction sector (residential and tertiary) offers a very high energy saving potential. Technical solutions are known enough to allow hope for some progress in the medium term. The major difficulties are two-pronged:

- on the one hand, how to foster the penetration or reintroduction of the technical solutions in the market of new housing when between 30 and 60 % of the housing stock of the cities of the Southern and Eastern Mediterranean Countries (SEMCs) (and also of the Eastern Adriatic Countries (EACs)) belongs in the unregulated and self-construction housing types;
- on the other hand, considering the sizeable stock of existing and old buildings in the Mediterranean, how to improve and extend renovation and rehabilitation practices to achieve significant energy objectives.

In the urban transport sector, two major courses of action for progress have been mentioned. The first one consists of:

- actions on the urban transport supply side, in order to mitigate impacts on the local and global environment, particularly via public transport and modal transfer promotion policies;
- policies aimed at acting on the travel demand at source, via a space organisation of the city which generates less travel; these are solutions in terms of urban policies, combining functional mixes and densities in order to contain urban sprawl.

The second course of action is certainly the more difficult, as the determining factors of demand are too complex to be influenced by public policies. This course of action is, nonetheless, inescapable if the prevailing trends are to be inverted. Both reflection and action in this regard are all the more urgent.

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A few professional networks and projects

Energie Cités. Counting not less than 150 members from 24 countries, representing over 500 cities, Energie-Cités is the association of European local government for a sustainable local energy policy.

MEDENER. Association of national energy efficiency agencies of Mediterranean countries.

UMAR (Union of Mediterranean Architects). Founded in 1994 in Rabat, UMAR gathers the national organisations representative of the architects of the Mediterranean basin riparian countries: 18 countries from around the Mediterranean are represented in it. UMAR has signed a partnership agreement with the international association SD-MED (Association for cooperation in development and sustainable construction in the Mediterranean).

IB Med. The Provence Alpes Côte d'Azur Region (France) launched, in late 2006, a pre-feasibility study with a view to creating a Mediterranean Building Institute. The project is supported by seven organisations (PUCA, ANAH, ADEME, Caisse des Dépôts et Consignations (Deposits and Consignments Fund), UMAR). A IB Med call for projects was launched in order to complement the body of available knowledge in the field of housing and town planning in Mediterranean areas, as well as to facilitate the mainstreaming of sustainable development objectives in buildings and urban land use planning projects. In view of the sizeable stock of existing buildings and of their poor energy performance, the option selected was to focus on improving the rehabilitation practices.

EnviroBAT. The EnviroBAT - Méditerranée association aims to promote and enhance the environmental quality of building and land use planning operations in the Mediterranean region.

Supported by the PACA (Provence Alpes Côte d'Azur) Region and ADEME, it groups the actors of the entire land use planning – building sector: project owners, local government, architects, consultancies, professionals, contractors, landscape architects, town planners ...

MED-ENEC. Mediterranean project of energy efficiency and the use of solar energy in the building sector in the Mediterranean.