“Water, energy and climate change nexus, prospective for the Syrian Arab Republic up to 2030”

Syrian National Report

Prof. Dr. Mohamad Kordab (Study Team Leader & Energy Expert), Dr. Maen Daoud (Water Expert)

Final version

Plan Bleu
UNEP/MAP Regional Activity Centre

Sophia Antipolis
August 2011

TABLE OF CONTENT

Key messages

Climate change is a reality in the Syrian Arab Republic (SAR), resulting in a significant decrease in precipitation during the last decades. This has led to the deterioration of surface water resources, groundwater reservoirs low filling rates, and its static levels depletion. This is reflected by a low agricultural intensification, and has incited an excessive use of groundwater resources.

Hydropower production has been significantly affected by climate change resulting in decreased volumes of water available for power generation and low water head in dams, which leads to energy consumption in the water sector approaches its energy production.

Climate change would limit the water supply in SAR by 19.2% according to IPCC A2 scenario and by 23.4% according to IPCC B2 scenario as a result , precipitation would decrease by 14.5% according to IPCC A2 scenario and by 29.5% according to IPCC B2 scenario while evaporation would increase by 5.3% according to IPCC A2 scenario and by 6.4% , in average, according to IPCC B2 scenario which lead to an intensification of water deficits in various basins of SAR and reducing the contribution of dams to irrigation and the potential contribution of artificial lakes to drinking water and irrigation during dry seasons(details are shown in part 1 & 2 of Chapter V).

Non-conventional water resources constitute a strategic component of future water policy. Treated wastewater reuse could locally increase the volume of water available for irrigation. However, these new technologies will not be enough to bridge the widening gap between supply and demand. Thus there is an urgent priority for the use of integrated management procedures (water demand management, water conservation, evaluation and economic instruments) of natural resources (water, energy).

Shifting to modern irrigation methods implies an increase of energy use. However, these techniques also help saving water and thus energy. The trend towards the available technological efficient options will lead to additional savings in energy and water, especially since the use of renewable energy (wind energy and solar energy) helps to reduce fossil fuel consumption to supply the pumping stations.

To control the optimal energy demand in SAR, a national energy strategy was developed in 2005-2010 for the aim of: (1) achieving energy security supply, (2) availability & accessibility of energy, (3) diversifying energy sources, and (4) enhancing energy efficiency in all sectors.

The optimal control of SAR energy demand and energy conservation & efficiency measures will lead to energy saving of 12% and the contribution of renewable energy in the national energy balance by 20% in 2030.

The projected investment for the production of electrical energy will require more water for thermal power plants cooling. This requires planning and more concerted action between water and energy sectors to prevent any worsening of the deficit in water.

The development of non-conventional water resources and the water demand management will increase the energy intensity consumption in the water sector, which should be recognized in the national energy demand plans.

In the phosphate mining sector the water requirement will be increased from 3.5-5.0 MCM/year at the present time to more than 30.0 MCM/year in 2030 (consumed water quantity is varied 1.0-3.0 m^3/Ton).

Abbreviations

W, E &CC	Water, Energy & Climate Change
SAR	Syrian Arab Republic
WR(s)	Water resource(s)
BCM	Billion Cubic Meter
MCM	Million Cubic Meter
Mtoe	Million Ton of Oil Equivalent
ET	Evapotranspiration
RS	Reference Scenario (water & energy)
AS	Alternative Scenario (water)
LS	Legal Scenario (water)
DN	Domestic Needs
DN RS	Domestic Needs in Reference Scenario
DN AS	Domestic Needs in Alternative Scenario
DN LS	Domestic Needs in Legal Scenario
UN	Urban Needs
UN RS	Urban Needs in Reference Scenario
UN AS	Urban Needs in Alternative Scenario
UN LS	Urban Needs in Legal Scenario
ESS	Energy Saving Scenario (Energy)
MRS	Modified Reference Scenario (Energy)
MESS	Modified Energy Saving Scenario (Energy)
P	Probability
SWL	Syrian Water Legislation
MoHC	Ministry of Housing and Construction
MoE	Ministry of Electricity
MW	Mega Watt
GW	Giga Watt
kWh	kilowatt-hour
GWh	Giga Watt-hour
DPMI	Directorate of Planning at Ministry of Irrigation
GCSAR	General Commission for Scientific Agricultural Research
PS	Pumping System
NEC	National Energy Congress
RE	Renewable Energy
EE & RE	Energy Efficiency & Renewable Energy
NG	Natural Gas
LPG	Liquefied Petroleum Gas

FO	Fuel Oil
HFO	Heavy Fuel Oil
INC -SY	Initial National Communication of Syria
IPCC	Intergovernmental Panel on Climate Change
GEEGT	General Establishment for Electricity Generation and Transmission
OAPEC	Organization of Arab Petroleum Exporting Countries
MOMR	Ministry of Oil and Mineral Resources
IEA	International Energy Agency
MADR on HS	Mean Annual Daily Radiation on Horizontal Surface
CCPP	Combined Cycle Power Plant
GT	Gas Turbine
CCGT	Combined Cycle Gas Turbine
WT	Wind Turbine
WF	Wind Farm
PV	Photovoltaic
CSP	Concentrators Solar Plant
ISCCS	Integrated Solar Combined Cycle Systems
GHGM	Green House Gas Mitigation
EE	Energy Efficiency
Kb/d	Kilo Barrels per day
LOPL	Loss of Peak Load
PEEGT	Public Establishment for Electricity Generation and Transmission
NERC	National Energy Reseach Center
GTZ	German Technical Cooperation
WSC	Water Specific Consumption of thermoelectric PP
NPV	Net Present Value
O&M	Operation & maintenance
LSDE	Low Speed Internal Combustion Engines
MSDE	Average Speed Internal Combustion Engines
FGD	Flue Gas Desulphurization
SCR	Selective Catalytic Reduction
ESP	Electrostatic Precipitators
PPP	Public Private Partnership
S P	Syrian Pound
IPP	Independent Power Producer
TOR	Terms of Reference
MENA	Middle East & North Africa

I. Introduction

1. Background, problematic and context

SAR experiences water scarcity. According to the Ministry of Irrigation reports (2008/09)[1], the renewable fresh water resources (FWRs) are estimated at nearly 11.770BCM/year, equivalent to about 526m^3/capita/years and close to the threshold of 500m^3/capita/year. This reveals a shortage in water resources and potential crisis in this field.

To realize socio-economic development and to meet the users' needs, Syria is committed to: (1) store and control WRs, (2) face WRs scarcity, (3) effective water distribution in order to insure water supplies for urban and agricultural needs and irrigation schemes development; and (4) build strong infrastructures & adequate institutions.

However, water sector faces several constraints and problems which, if not properly managed, could limit the economic & social growth that Syria is trying to achieve.

These constraints and problems are mainly related to limited water resources due to the impact of climate change that is now a reality and its consequences are already visible on the environment.(Clarification will be given in Part V, chapter 1 & 2).

WRs future development, based on high energy consumption such as: seawater desalination, reuse of treated wastewater and rational water use in agriculture (conversion to drip irrigation), will bring challenges to make the water sector compatible with energy sector developments. There is, therefore, a need to implement a work program to evaluate the current and future impacts of climate change, identify and quantify the costs of climate change and the interactions between water, energy and climate change, and identify appropriate solutions for adaptation to climate change.

2. Rationale and objective of the study

The objectives of this study are to:

- Review present water needs for energy production on the one hand, and energy needs for water production & pumping on the other hand;
- Review the works done by the SAR to evaluate future water needs for energy and energy needs for water, taking the “climate change” factor into consideration;
- Identify lacking data and information for evaluating water and energy present & future needs;
- Analyse water-energy-climate change nexus until 2030;
- Estimate investments to supply energy and water needs until 2030 (with/without taking the impacts of climate change into account);
- Participate in the exchange of experiences among the Mediterranean countries on water/energy/climate change.

[1] Babanov Bioter, 2009, Remarks on Irrigated Agricultural Plan for 2007-2008 & reevaluation of water resources , Ministry of Irrigation, Damascus, Syrian Arab Republic

3. Study development approach

3.1. Water Scenarios

To determine the growing demand for WRs and energy until the year 2030 in the SAR, the study is based on the content of the national available documents related to the Syrian national plans for WRs use and relevant water and energy policies, including the Initial National communication for the Syrian Arab Republic on Climate Changes. The growing demand for WRs was investigated through the following three scenarios:

3.1.1. Reference Scenario (RS), including:

- The growth rate of water demand in drinking & urban water uses is equal to the growth rate of population which is (2.45% during 2010-2015, 1.98% during 2015-2020, 1.65% during 2020-2025, and 1.35 during 2025-2030).
- Actual supply efficiency of drinking water is 69%. It is assumed that an increase of the supply efficiency by 0.5% annually reaching 82% at 2035,
- Actually, 83% of Syrian population is supplied with drinking water through the general water network, 13% is supplied by special water network isolated from the national water network, and the rest is supplied individually, by their own means, by wells & springs. It is assumed this situation will continue during the study period,
- The growth rate of demand on water for industrial needs, is 2.0% annually and will continue during the study period,
- Demand on water for irrigation needs will increase by 11% during the study period due to expansion of irrigated areas.

It is assumed that WRs are equal to that of average annual WRs at the beginning of the study period decrease gradually to a drought annual WRs at the end of the study period.

3.1.2. Alternative Scenario (AS):

It includes, in addition to assumptions adopted in RS supply efficiency of drinking water will be increased to reach 82% at 2022 instead of 2035 in RS that will be achieved by:

- Rationalizing water use and Water conservation and water efficiency measures in urban and in irrigation sectors by improving efficiency through the introduction of new technologies.
- Actual supply efficiency of drinking water is 69%. It is assumed that an increase of the supply efficiency by 0.5% annually reaching 82% at 2035,
- Raising the efficiency of WRs management in all economic sectors; and
- Capacity building of managers & technical staff of water utilities on water management in all sectors.

3.1.3. Legal Scenario (LS):

According to the Syrian water legislation of 31/2005, water demand management should be adopted to achieve the balance between the availability of water resources, in dry years (2.5 years/10 years) at supply probability P= 75%, and the demand on water for all purposes (achieving the balance principle between availability and demand as a fundamental principle of integrated WRs management) in this case the priority of water supply will be the following:

a) Water for urban needs including drinking water & water for tourism,

b) Water for energy generation,

c) Water for industry,

d) The remaining of WRs in addition to water drainage & treated of waste water treatment should be used for irrigation applying high efficiency techniques in irrigation systems.

It is assumed that the WRs are equal to that of a drought annual WRs for all the study period, taking into consideration that a drought year could be repeated every 4 years. In this case, water use efficiency for LS in all sectors will be the same as in AS.

The study team assumed that the climate variables values for climate change scenarios A2 and B2 are linked to their values in the reference series and base year with a linear relation during the period 2010-2039 due to lack of mathematical models by which these scenarios are calculated, so this change was adopted for the year 2030 linearly with time.

3.2. Energy scenarios

For the development of energy demand up to 2030 two scenarios were adopted by the National Energy Committee during the period 2005-2010, reference scenario (RS) & energy efficiency scenario(EES). These two scenarios were considered in the study of EE & RE Master plan prepared by (GTZ-NERC / Ministry of Electricity) end 2010. The study team has modified these two scenarios to be compatible with the eleventh five years plan in SAR and named them: modified reference scenario (MRS) & modified energy efficiency scenario (MEES):

3.2.1. Reference scenario (RS) assumptions

- The primary energy demand will increase by 4.9% starting from 25 (Mtoe) in 2005 arriving to 83.3 (Mtoe) in 2030 to meet the average final energy demand growth, which is 5.3% starting by 15.249 (Mtoe) in 2005 arriving to 55.6 (Mtoe) in 2030;
- Electricity generation will increase from 34.9TWh in 2005 to about 148.4TWh in 2030. The optimal expansion plan of RS shows an increase of installed capacity from 6200MW to 29600MW during the period 2005-2030. The new capacity addition is distributed to 14360MW for combined cycle power plants (CCPP), 12200MW for Heavy fuel oil (HFO) fired steam power plants, 900MW gas turbines (GT), 300MW wind turbines (WT)and 1600MW for two nuclear power plants that will enter the system in 2020 and 2025 with 600MW and 1000MW respectively. Other alternatives, like photovoltaic (PV) and concentrators solar power (CSP) are not competitive in the RS due to the high investment cost;
- Using wind farms to generate electricity in some promising windy areas in SAR and using solar PV power plants;
- Importing and exporting electrical energy through the electric grid interconnection according to the available capacity with neighboring countries which is 300MW in 2005 and 500MW in 2030;
- Importing NG through the Arab Gas Pipeline starting in 2008 by 2.74MCM per day;
- The nuclear option for electricity generation will start by 600MW power plant capacity during the period 2020-2025 then 1000MW power plant capacity during the period 2025-2030.

3.2.2. Energy Saving Scenario (ESS) assumptions

- Primary energy demand will grow at 4.6% annual rate (compared with 4.9% for the RS) and will increase from 25Mtoe in 2005 to reach to 76.3Mtoe in 2030 (compared with 83.9Mtoe for the RS) that means 7.7Mtoe saving in primary energy in 2030, a decline in the annual growth rate and improvement in energy efficiency, where the efficiency of final energy consumption will increase from 61% in 2005 to 67.4% in 2030;

- Enhance solar energy contribution to reach in 2030 to 35% of the total demand on thermal water heating in both domestic and service sectors;
- Take into account the contribution of mini hydro generation with additional capacity up to 200MW;
- Enhance the contribution of wind energy to 2000MW in 2030;
- Gradual reduction of transmission and distribution losses in the electric grid from present 22% to 12% in 2030;
- Activation procedures for energy conservation & efficiency to reduce the total final energy demand by 5% in 2030;
- Enhance the contribution of Photovoltaic power plants to 2000MW in 2030;
- The use of solar thermal electricity (CSP) up to 1000MW in 2030;
- Taking into account the availability of large quantities of NG from Akaz Iraqi field reach 5MCM per day in 2015 and then rise to about 10MCM per day in 2020;
- Adoption of the nuclear option for electricity generation after 2020 by one station every 5 years, the first 600MW capacity & the second 1000MW capacity;
- Increasing the share of NG power plants and in particular the combined cycle technology (CC);
- Considering future power plant candidates using liquefied natural gas (LNG).

3.3. Modified energy scenarios

Given the need to provide and secure imported fossil fuels to run power plants, which has become a burden on the national economy due to the difficulty to import and the high costs significantly, taking into account what has been adopted by the Eleventh Five Year Plan, the energy team of this study has modified the RS & ESS of the Syrian Master plan, prepared by (NERC-GTZ), by (1) using in both scenarios more RE power plants (wind, CSP, PV) (2) implementation of the pumping storage hydropower plant in Halabieh-Zalabieh on Euphrates River to meet peak load and improve the daily load factor of the Syrian electric system (3) using more coal fired steam power plants in order to diversify imported fuel., (4) maintaining, in the two modified scenarios, the expected demand for electrical energy of the mentioned Master plan study of EE & RE, (5) optimal operation of existing hydroelectric power plants in addition to the following assumptions:

3.3.1. Modified Reference Scenario (MRS) assumptions

The electricity demand in 2005 was amounted to 34.1TWh reached to 49.2TWh in 2011 and to 63.2TWh in 2015 with 6.5% annual growth.

The peak load demand in 2005 was amounted to 6008MW reached to 8507MW in 2011 and to 10931MW in 2015.

3.3.2. Modified Energy Saving Scenario(MESS) assumptions

The electricity demand in 2005 was amounted to 34.1TWh reached to 48.7TWh in 2011 and to 60.1TWh in 2015 with 5.4% annual growth.

The peak load demand in 2005 was amounted to 6008MW reached to 8422MW in 2011 and to 10931MW in 2015.

II. Energy needs for water from now until 2030

1. Country water resources, needs and deficit (current situation and trend until 2030)

The calculation of available WRs in SAR is based on estimations of renewable natural WRs by Ministry of Irrigation depending on: on rainfall and flows measurements thanks to the hydrological monitoring system present in Syria.

The above calculations are done based on runoff coefficients, groundwater recharge and other relevant data and parameters estimated by studying the four water basins[2] during the period prior to the hydrological year 1981-1982. Some of these coefficients and criteria were also modified based on development studies conducted in the years that followed and to date, whether by the National Company for Water Studies or in cooperation with international organizations (the Project of Integrated Orontes Basin Management in cooperation with the Dutch institutions, the project of Integrated Aleppo Basin Management in cooperation with the German institutions, the Project of the Development of Hydrological Monitoring System of Barada & Awaj and Coastal Basins in cooperation with JICA, etc.).

The amounts of controlled surface and ground water are determined as they linked with the degree of control in each of the basic hydrographical basins, in both surface and groundwater. The major uses at each basin level are distributed to meet the demand in all different uses: (1) water for drinking, domestic and urban uses, (2) water for industrial needs, and (3) water for irrigation and agriculture needs. The surplus of traditional water use in form of drainage effluent, urban, wastewater and industrial effluents, go back to the hydrological cycle (public waterways and groundwater aquifers).

These non-conventional resources are added to the total WRs to form as a whole amount, after deduction evaporation from water bodies, the available WRs at each basin level and at country level.

Country WRs (from fresh water sources or from non-conventional water/reused) are correlated with rainfall amounts as rainfall is the major element in the formation of Syrian water supplies as well as Syria's quota from shared international WRs, underlying the impact of climate changes on the amounts of available WRs for the study perspective until 2030.

1.1. Fresh water resources (natural renewable)

Fresh WRs consist of the surface flows of permanent rivers and temporary streams, groundwater springs not going to public waterways and groundwater aquifers exploited by wells. The country WRs are formed from internal resources (resources from flows in different catchments after rainfall and snow melting, forming surface water and contributing to groundwater aquifers recharge) and shared international resources (all international surface waterways or shared international aquifers).

WRs in Syria are distributed within seven water basins: Yarmouk basin (Upper Jordan), Barada & Awaji basin, Orontes basin, Coastal basin, Badia basin, Euphrates & Aleppo basin and Tigris & Khabour basin. Ministry of Irrigation's studies have stated that the average supply of renewable WRs (surface and groundwater), for long-term period, are estimated at about 9.03BCM/year, in addition to Syria's share of the Euphrates river in accordance with the protocols and agreement with riparian countries (SAR share is 42% of 500m^3/sec which flowing throw Syrian-Turkish border at Jarablus site), amounting to 6.627BCM/year which means that the long-term average annual water supplies are around 15.65BCM/year.

[2] The four water basins are: Barda & Awaj (Damascus water basin), Aleppo, Orontes and the coastal. This study was conducted in cooperation between the General Commission for Great Projects and Hydrobroket Institute – Moscow. The final report issued in 1984. The study was developed later to include all water basins.

The country water supplies, at a dry-year probability, are close to 13.42BCM/year calculated according to the reference time series for the period 1960 – 1990, of which the Euphrates River's supplies constitute more than 49%.

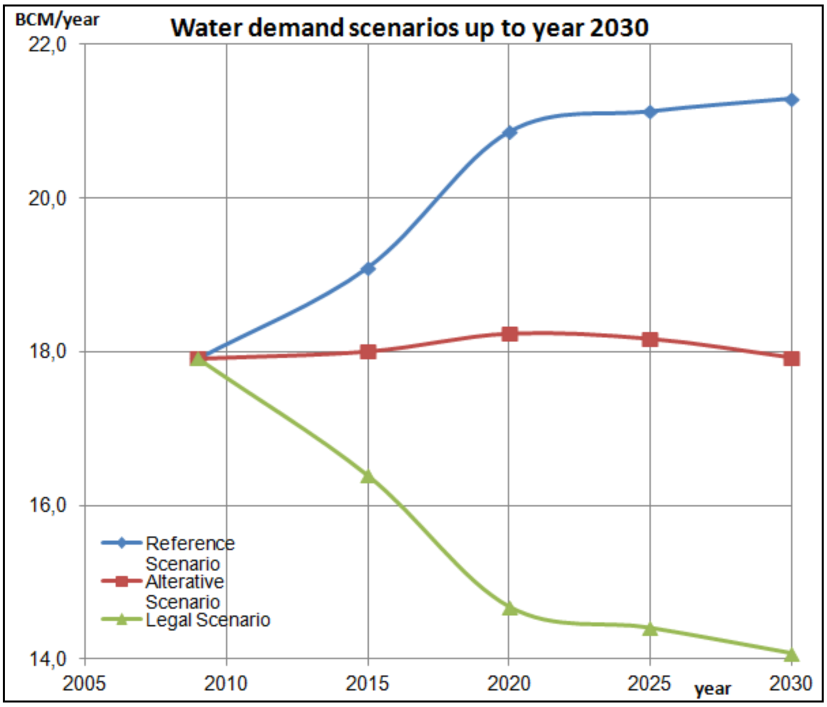
According to the Ministry of Irrigation's estimates for the hydrological year[3] 2007–2008 the water supplies was amounted to 8.88 BCM/year from internal water (surface and groundwater), in addition to 7.78 BCM/year from the Syria's quota (42%) from the Euphrates water passing the Syrian-Turkish border at Jarablus site, making the country WRs in this exceptional hydrological year about 16.662 BCM/year.

The various scenarios of water supply development in Syria assume that the supply of internal water sources until 2030 will be close to a dry-year supply with exploitation potential of about 1.25 BCM/year of water from the Tigris river (as a country share in accordance with agreements with the riparian States), which makes these resources about 14.67 billion m³/year only. Water demand in Syria is expected to decline by the effects of regional and global climate changes. Changes of overall demand until 2030 according to the adopted scenarios are shown in Figure 1and Box 1.

1.2. Fresh water needs in all consuming sectors

Irrigated agriculture in Syria is the largest consumer of available WRs, since its demand for water out of the overall demand for all sectors (drinking & domestic use, industry, agriculture, tourism and environmental use) is generally more than 85-88% of the overall water demand (not consumption nor withdrawals). The demand for drinking and domestic use (including tourism sector) accounts for 6-8% of overall demand for water.

Figure 1 - Changes of total water demand according to the adopted scenarios until 2030 (BCM)



Source: Dr M. Kordab, 2011

According to the declared governmental criteria and based on actual number of population and figures reported by the Ministry of Housing and Construction (MoHC), the domestic water demand in 2009 came to about 1.21BCM/year, whereas the irrigated agriculture demand reached to about 16.18BCM/year to cover the needs of irrigated areas planned to be exploited, and that arrived in the growing season 2008-2009

[3] Hydrological year is the duration of a calendar year starting from 1st October of the first year to 30 September of the second year

to 1.45 million hectares. Water needs for industry for the same year were about 519MCM/year. This means that the overall WRs demand for different economic sectors has reached 17.91BCM/year, noting that some governmental figures (Ministry of Agriculture and Agrarian Reform - MAAR) referred to 18.25BCM /year.

Box 1 - The total water demand is expected to change until the target year 2030 as follows:

1. **Reference scenario (As usual situation scenario)**: Steadily increase in overall water demand until the end of the study period according to estimates by the specialized governmental committees to reach about 19.09BCM/year in 2015, 20.86BCM/year in 2020, while lowering the pace of increase in overall demand to reach 21.13BCM/year in 2025 and more than 21.29BCM/year in 2030.
2. **Alternative scenario**: It is the inclusion of rationalization of WRs use, improvement of resources management efficiency and its distribution among all relevant economic sectors stated in the reference scenario, leading to an increase in the overall water demand in the first half of study period, at a slower pace, reaching about 18BCM/year in 2015, peaking at about 18.23BCM/year in 2020 and decreasing in the second half of study period to 18.17BCM/year in 2025, and down to 17.93BCM/year in 2030.
3. **Legal scenario**: It is correlated with the balance between the demand for resources and their availability, provided that the overall demand for WRs in all economic sectors not more than water supplies at a dry-year probability plus all effluents (reused water) in all concerned sectors. Continuing decline in overall water demand (once the marginal conditions of this scenario are met) is expected, where amounts of fresh water to be used for all purposes decline to about 16.39BCM/year in 2015, then decline rapidly to about 14.68BCM/year in 2020, and settle later at about 14.40BCM/year in 2025 and to less than 14.07BCM/year in 2030.

1.3. Fresh water deficit

Various challenges facing the national water sector, both internally and regionally (Syria's geographical location in a dry and semi-dry area, limited WRs versus demand, high population growth rates, inefficient use of water due to inadequate technologies of supply and distribution plus mismanagement, deterioration of water quality in different sources as a result of groundwater depletion and lack of surface water in most water basins, the of all these water sector-related administrative and institutional performance, and lack of awareness and water extension, all these play a key role in worsening water deficit, whether at basin level or at country level.

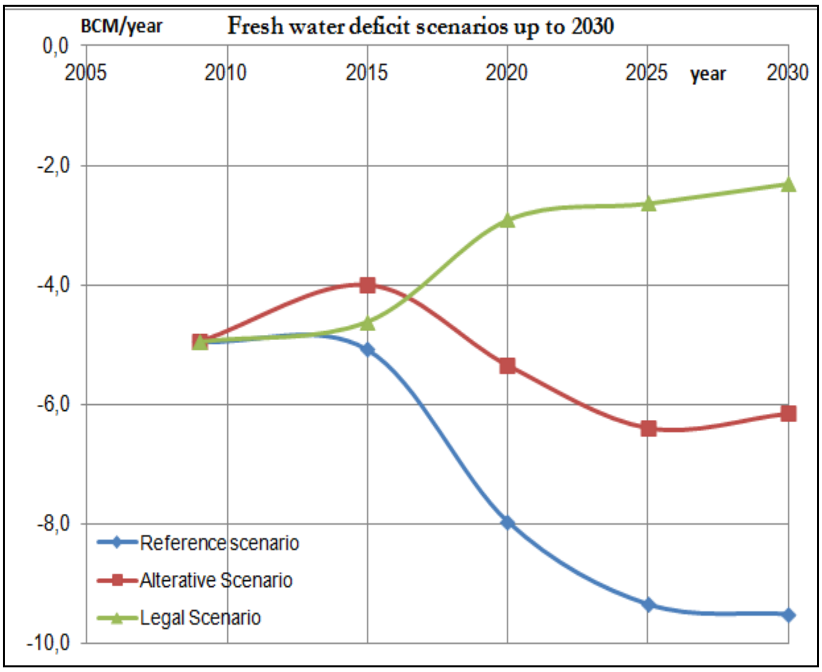
Low overall and sectoral efficiency of water uses affects the rational use of water and agricultural resources and energy, leading to deterioration of the overall revenue of different economic sectors. However, the overall deficit to meet the demand for fresh water (not used before) in an average year is about 4.54BCM/year, increasing in the dry years (at supply probability P= 75%) to 6.77BCM/year, whereas the deficit was about 4.95BCM/year in 2008-2009.

Non-conventional WRs (reused water: drainage water and treated wastewater) meet a large part of this deficit. Total non-conventional WRs (partially used in irrigation) were estimated at about 4.89BCM/year in 2008-2009, of which more than 975MCM from reused municipal water post-treatment (or without treatment) and discharged into the natural environment after use in non-agricultural sectors (wastewater effluent or industrial effluent), while the rest is agricultural drainage from irrigated lands.

Based on the different scenarios adopted in the study, Figure 2 shows the deficit in fresh water provision until 2030.

1) The deficit to meet the demand for previously unused fresh WRs will grow in the adopted reference scenario related to changing water demand according to the currently approach applied in calculating the increasing demand, for providing water to drinking purposes, domestic uses, industry, irrigation and other agricultural uses, from its current situation to reach 5.08BCM/year in 2015, 7.97BCM /year in 2020 and up to 9.36BCM /year in 2025, while low speed after this year to 9.52BCM/year in 2030.

Figure 2 - The deficit to meet fresh water according to different scenarios until 2030 (BCM)



Source: Dr M. Kordab, 2011

2) Notwithstanding the planned procedures in the alternative scenario, the deficit to meet demand for previously unused fresh WRs will continue to increase but at a slower pace. Calculations have shown that the deficit will reach 3.99BCM/year in 2015, rising to about 5.34BCM/year in 2020 and reaches its highest 6.40BCM/year in 2025, while declining in the remaining years of the study period to 6.16BCM/year in 2030.

3) Once the marginal conditions of legal scenario are applied, balance between available WRs at a dry-year supply probability and their demand is assumed to be reached, regardless of evaporation from water bodies, which means the need to consider overall deficit equal to zero at this assumption. The deficit to meet fresh water will gradually decrease to 4.62BCM/year in 2015 to settle after 2020 with a deficit of 2.91BCM/year, decreasing more slowly to 2.63BCM/year in 2025, and then to about 2.30BCM/year in 2030.

2. Country energy needs for water (current situation and trend until 2030)

Energy demand in the national water sector (ton of oil equivalent or kilowatt-hour) is distributed in this study, whether in agriculture (rain fed and irrigated) or drinking water and urban uses supply, to the following two categories:

- Energy Demand (electrical or diesel) to provide water necessary for irrigated agriculture.
- Energy Demand (electrical or diesel) in urban water supply sector (necessary for drinking and domestic uses), including wastewater and water reuse for different purposes.

2.1. Energy needs for "conventional" fresh water provision and supply (water pumping for irrigation, groundwater lifting, treatment of drinking water, etc.)

Energy Demand for fresh water provision from its conventional sources is changing according to water supply scenarios under the temporal target of the study (until 2030), starting from the essential demand calculated in the starting year 2008-2009 according to current situation as a basis point for different scenarios: reference, alternative and legal.

2.1.1. Energy demand in 2008-2009

This demand has been calculated for water provision for urban & rural uses and irrigated agriculture basically:

1) Energy demand for rural & urban uses provision:

Projects of water supply and provision for drinking and domestic uses have been expanded due to development of populated areas at national level. Supply networks often extended to areas far away from conventional drinking water sources, where human and economic activities grew up around. This contributed to increasing demand for energy whether to provide, discharge or treat this water according to the criteria that lead to conservation of human activities or environment to the minimum for the survival and development of human society.

Drinking water and waste water institutions consume about 0.4-1.0 kilowatt-hour (kWh) per m^3 of potable water, which is equivalent to pumping this water to an elevation ranging between 80-200m. The minimum energy density is achieved at water institutions that can, by virtue of geography and flat terrain, supply major part of consumers with water by gravity or with minimum energy consumption[4]. The relatively high energy density per water unity consumed is achieved in the geographically complicated areas or when the main sources are groundwater ones and require pumping from great depths, or when water is transported for long distances as is the case in water institutions of Damascus & Rural Damascus, Aleppo, coastal cities, Deraa and Suweida.

Given the assumptions adopted for actual consumption, drinking water amounts were estimated at 1.21BCM/year in 2008-2009, while the total energy used to provide water for drinking and domestic uses (average energy density at national level close to 0.85kWh/m^3) was estimated at about 1028.5GWh/year, noting that an essential part of this demand for energy is allocated to water transportation and water distribution as it will be discussed later.

The energy needed to provide water for industrial uses outside drinking water systems was estimated at about 207.6GWh/year (by adopting average energy intensity at national level close to 0.40kWh/m^3).

2) The demand for energy to provide water to irrigated agriculture sector

Though the planned irrigated area was about 1.5 million hectares in 2009, the actually irrigated areas were about 1.392 million hectares only, of which about 455 thousand hectares in State irrigation projects. To irrigate the implemented areas, about 13650-13950MCM of water was used in season in question[5].

Energy necessary for providing irrigation water to the actually cultivated areas was estimated according to the following basics:

- Energy necessary for providing 5.560BCM of irrigation water in State projects[6] (which based on surface resources/95% of these areas) was estimated at 1788.0GWh.
- Energy necessary for providing 6.305BCM of water for areas[7] irrigated thanks to wells, using electricity to lift water from wells was estimated at 785.66GWh.
- The remaining wells use diesel fuel, so the needed diesel amount is 204 280.9ton[8].

---

4 At water institutions of Homs and Hama cities: for systems, cities and towns supplied from Upper Orontes River's water intake. At water institutions of Raqqa and Deir Ezzor cities: for the systems of city centers and most affiliated towns.
5 According to GCSAR's estimates by comparing productivity and taking hydrological and climatic factors into consideration and deducting water abstracted for urban supply purposes.
6 According to figures by Directorate of Planning at Ministry of Irrigation.
7 According to demand plan of WRs for irrigation annually issued by Administration of Natural Resources Research at General Commission for Scientific Agricultural Research.
8 At average overall efficiency of pumping systems ηps = 0.475 and according to conversion coefficient between different energy loads adopted in the calculation of national energy balance, the diesel fuel amount is calculated as: P is gwd = 0.67x6305x103x100/367x0.475x11.86.

– Energy required to cover about 2.631 BCM of irrigated areas in the domain of surface water sources (rivers, lakes and springs) was estimated at about 17.49 GWh as electrical energy[9].

The remaining pumps use diesel fuel. The amount of energy required from diesel fuel (at average total efficiency of pumping systems $\eta ps = 0.42$) is equal to 19431.4 ton. Therefore, demand for energy loads to provide irrigation water is:

Electrical energy: 1788.0 + 785.66 + 17.49 = 2591.15GWh/year.

Diesel fuel: 204280.9 + 19431.4 = 223712.3 ton/year=223.7Kton/year

2.1.2. Development of energy demand until 2030:

In addition to what will be presented below, development of energy demand to provide water for irrigated areas in the agricultural sector is subject to basic assumptions associated with the scenarios adopted in item (Introduction, part 3-1). To the scientific papers of the national energy conference[10] were adopted to specify the base point for 2008 – 2009, namely:

1) Development of energy demand for urban & rural uses (including industrial water provision):

   a) The energy intensity used to cover water necessary for drinking and industrial supply in the reference scenario remains fixed all over the study period until 2030 at about 0.85 and 0.40kWh/m^3 for drinking water provision and industrial supply respectively.

   b) Energy intensity used decreases in the alternative and legal scenarios to provide drinking water gradually according to the pace that achieves water use rationalization and improves technical and administrative efficiencies in all economic sectors.

   c) Energy intensity gradually increases in the alternative and legal scenarios to provide industrial water as a result of the use of closed circuits and industrial water treatment, regardless of low water amounts used to attain specific revenue (profit).

Energy intensity necessary for drinking and industrial water supply for the different scenario, given in kWh/m^3 is presented in table 64 in study annexes.

2) Development of energy demand to provide water to irrigated agriculture sector

   a) Reference scenario: The contribution of irrigated areas in the domain of projects provided with water from surface water sources by gravity, surface by pumping, and pumping from groundwater aquifers remains fixed until the end of study period in 2030.

   b) In the alternative and legal scenarios: The contribution of groundwater sources to energy demand decreases with the corresponding decrease in water demand and improved efficiency of water irrigation provision.

   c) Legal scenario: Water amounts abstracted from groundwater aquifers by pumping for irrigation purposes don't exceed groundwater resources for a dry-year probability.

Energy demand in water sector changes until 2030 according to water demand scenarios as follows:

- **Reference scenario**
  - Energy demand to provide rural & urban uses:

    Given the assumptions adopted for the demographic/population coefficients and per capita share of drinking water (l/capita/day) estimated by Ministry of Housing until 2030, the energy required to provide drinking water and domestic & industrial uses until the end of study period is steadily forecasted to increase. It will reach 1139.5 and 229.2GWh/year in 2015, increase to 1304.2 and

9 Average lifting/head is 15 m.
10 National Energy Congress (NEC), March 2010, Damascus, Syria,

258.1GWh/year in 2025 and up to 1551.2 and 314.7GWh/year in 2030. This is achieved in the case of the stability of per capita share of water supplied and the persistence of supply efficiency of management in accordance with the current standards.

- Energy demand to provide water to irrigated agriculture sector

  With stability of WRs distribution rates to their different sources, conversion in the use of different technologies is equally made up to 2030. This means that the possible energy saving in this scenario to meet the demand on water for irrigation & agriculture sector would increase at 25% every five years. Therefore, total demand for energy of its key components in this scenario is expected to increase by the increase of demand for irrigation purposes (simplified). Amounts of electrical energy increases to meet irrigation water, and they reach about 3041.5GWh/year in 2015. Maximum demand is 3270.2GWh/year in 2020, and then the demand for electrical energy began to decrease gradually to 3236.8GWh/year in 2525 and to 3203.4GWh in 2030. Demand on equivalent energy of diesel fuel also increases in the same manner to reach 260162.6 ton/year in 2015, peaking at 275990.9 ton/year in 2020, and then decreases slowly to match the slight improvement in energy use and rationalization in this probability to 269928.3 ton/year in 2525 and to 263932.6 ton/year in 2030.

- **Alternative scenario**

- Energy demand to provide urban and rural uses:

  The alternative scenario, according to the assumptions referred to above, provides the possibility of saving 6.5-8.5% of electricity used in drinking water and urban water supply sector. Here, a steadily increase in demand for drinking water and domestic uses until the end of the study period is noticed, but at a slower pace than in the reference scenario. The demand to provide industrial water, that is until the middle of the second decade lower than that of the reference scenario is expected to become slightly higher than the rest of the years of the study period as a result of the increased density of energy use. The required energy will reach to 1088.8 and 224.6GWh/year in 2015, increased to 1182.8 and 262.9GWh/year in 2020, 1294.5 and 291.0GWh/year in 2025, and up to 1305.8 and 325.7GWh/year in 2030.

- Energy demand to provide water for irrigated agriculture:

  As a result of adopting the national programme of the rationalization of WRs use in the agriculture sector (mainly the programme of conversion into modern irrigation systems) and low water amounts used, the energy demand to provide water unit to the fields will increase by the use of techniques that need additional head in field supply systems estimated to 28-35m for sprinkler irrigation and about 18m for localized drip irrigation, while surface irrigation techniques need no additional head.

  It is also supposed to convert about 965 thousand hectares of irrigated lands to the use of more efficient irrigation techniques for water rationalization, according to the following:

  - 33.8 % of them use localized irrigation techniques (drip, vortex, spray, mini-sprinkler, etc.).
  - 37.0 % of them use sprinkler/spray (movable circular lateral, hand-moved, fixed, gun automated, etc.).
  - 29.2 % of them use improved surface irrigation techniques.

  Localized and sprinkler irrigation techniques are used at 70% in the domain of groundwater, 15% in the domain of surface water and at 15% in State irrigation projects. The rest of the areas are irrigated by traditional surface irrigation methods. Improved surface irrigation practices don't need additional energy within supply network. However, the use of such techniques saves irrigation water at 35% for localized irrigation, 25% for sprinkler irrigation and 20% for improved surface irrigation.

  Assuming the persistence of irrigated areas till 2030 parallel to the irrigated areas in 2008, the energy demand for irrigation water is correlated to the coefficient of increasing energy demand for different irrigation systems (State, ground, surface) equaling to:

  - 1.044 for State irrigation systems

- ♦ 1.665 in the domain of surface water sources
- ♦ 0.866 in the domain of groundwater sources

Thus, total energy amounts needed to provide irrigation water in case of conversion into modern irrigation technologies change as follows: Increasing demand on electrical power for providing irrigation water is slower than that of reference scenario to peak at about 2754.9GWh/year in 2015, and then it decline slowly to 2638.7GWh/year in 2020, 2578.0GWh/year in 2525 and 2488.9GWh/year in the target year 2030. Demand on energy equivalent to diesel fuel in the same manner to peak 235679.3 ton/year in 2015, decreasing to 222691.0 ton/year in 2020, and slowly in the next years (equal to improved energy use, rationalization, improved management, use of economic rationalization mechanisms in this possibility) to reach 214071.6 ton/year in 2025 and 205065.3 ton/year in 2030.

- **Legal scenario**
  - Energy demand to provide urban and rural uses:

Due to restructuring the institutions of drinking water and sewerage (e.g. Damascus and Rural Damascus, which represent 40% of institutions working in this sector of production and consumption), it is projected to lower the energy used to meet the demand by 4% of energy used in 2008 until the end of the second year of restructure, as a result of water sources exploitation of in a more efficient and integrated manner.

The use of economic and technical mechanisms for the WRs use rationalization of will result in an improvement in water supply efficiency at 0.5% annually until 2015 at the time when physical/financial and human potentials are available for implementation during the perspective five-year plans, which means low energy density required for the delivery of water unit consumed at 6.5% compared with its level in 2008. This figure is expected to be constant for the subsequent years.

The topographical situation of supplied areas and varied geographical elevations of water sources play a key role in the increase or provision of energy density at the time of drinking water provision and domestic uses. Optimally studying dividing supply areas according to areas of equal supply pressure at the beginning of sub-system, to topographic situation of each area, and considerations for providing optimal and appropriate water pressures for the exploitation and operation of systems economically and technically, the rate of energy density and energy consumed can be reduced to about 10-15% nationally from average rate of 0.8-0.85kwh/m^3, where the geographically elevated areas are supplied with water from high water sources, but the lower areas are supplied with water from sources of the lowest rise from the sea level.

The optimum use of the modeling of drinking water supply and domestic uses according to ring systems and the ideal choice of pumping units' capacity and discharge and their discharge enable more than 40% of separate sub-systems to reduce and rationalize energy use up to 25% of the total energy consumption.

Therefore, the development of total electrical power required, once the optimal exploitation of networks and their components in the legal scenario, will fall sharply below the figures listed above for the reference and alternative scenarios when drinking water especially in the first decade of the study period is provided. Despite the increase in energy demand to provide industrial water in the first half of the study period, but it becomes lower by about 11.6% end 2030. In this scenario, the quantity of energy required is expected to reach 1023.2 & 226.5GWh/year in 2015, up to 1135.1 & 259.1GWh/year in 2020, 1229.2 & 2277.8GWh/year in 2025, and 1240.5 & 287.8GWh/year in 2030.

– Energy demand to provide water to irrigated agriculture

The distribution of energy necessary for irrigation water provision changes by water basin and irrigation water provision source (State irrigation systems, groundwater and surface water). Due to the need to plan irrigated areas according to water renewal at a dry-year probability, the water demand for irrigated agriculture sector will be determined by the potentials for environmentally and economically safe use of available WRs, resulting in a reduction in final quantity of energy loads necessary for irrigation water provision.

The integrated evaluation of irrigation systems related to energy, economy and water under a number of criteria that take into account: (i) water amounts applied, (ii) use of different energy loads, and (iii) efficiency of the equipment and engines of energy consumption (including an evaluation of the impact of using and developing technologies and irrigation techniques applied at rehabilitated projects level) can reduce energy demand at the sectoral and national levels by between 6.3% and 11.5% especially when the pumping units in water supply systems are rehabilitated.

This leads to sector development and developing programmes for energy use rationalization by converting irrigated areas where irrigation techniques can be developed, firstly the domain of groundwater sources and then the State irrigation schemes.

With water deficit of total balances equal to zero in this scenario and stability of existing irrigated areas and based on the parameters mentioned above, water amounts needed for agricultural uses decrease, whereas water amounts abstracted from groundwater sources gradually declines to equal available groundwater resources in a dry year according to the reference hydrological chain. Water amounts abstract from surface sources are distributed to the rest projects by their contribution to other scenarios.

In this scenario, a rapid reduction in energy demand from its key components (electricity and diesel) to provide irrigation water is expected in the first decade, and it gradually slows in the second period of observation period. Reduction in demand on energy is lower when compared with that on diesel fuel. Needed energy amounts will reach 2574.5GWh /year in 2015 versus 161941.7 ton/year for diesel fuel. This demand decreases in 2020 to 2335.0GWh /year and 116246.0 ton/year. Despite gradual and continuous decline in demand on electrical energy over the remaining period, demand on diesel fuel will be more stable at 2257.8GWh /year and 105497.8 ton/year in 2025, and 2159.6GWh/year and 103130.3 ton/year in 2030.

Figure 3 and Figure 4 show the change of energy required for water provision in economic sectors according the scenarios of water demand change until 2030.

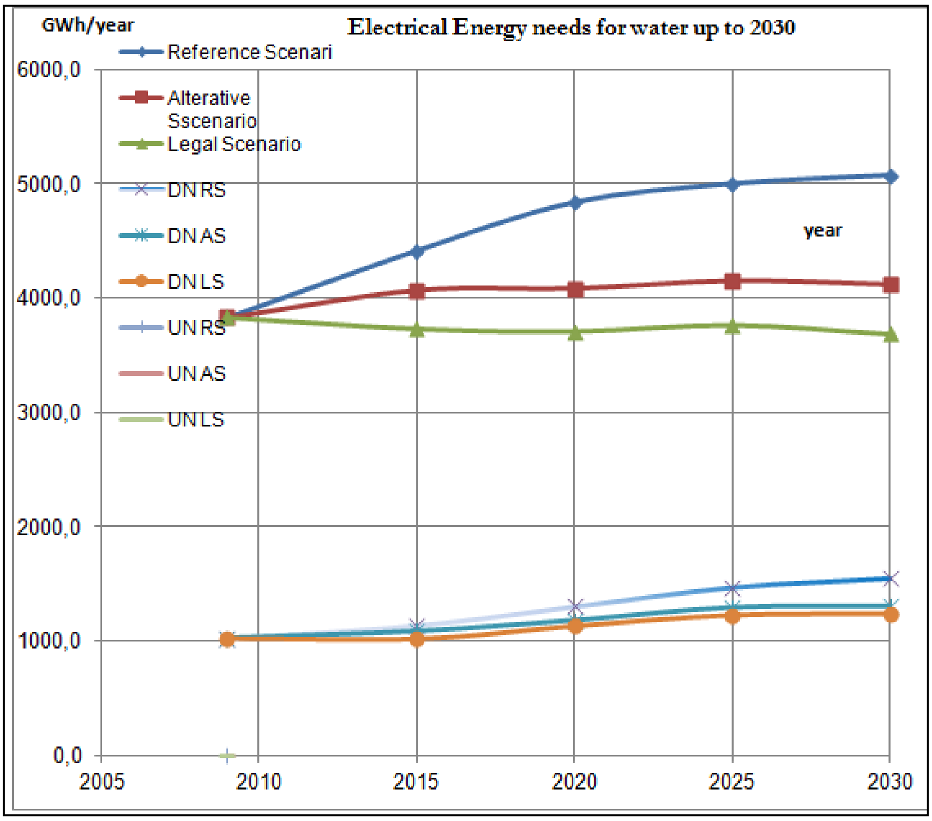
2.2. Energy needs for water (fresh and drainage) transportation and distribution

Portable water is generally conveyed from their different pumping fields and sources (surface water and groundwater) to varying-distance consumption centers, where water is conveyed from the Euphrates River to Aleppo city in pipes and channels with length more than 100km. The lengths of the main supply network of both Aleppo and Hama provinces and their affiliated cities and towns exceed 120km. The lengths of pipes and tunnels supplying Damascus city with water reach more than 200 km with discharge exceeding 200l/sec.

Water transportation among sub-basins, within the hydrological basin and different water basins requires relatively high energy density that may exceed 5.0kWh/m^3, distributed as follows:

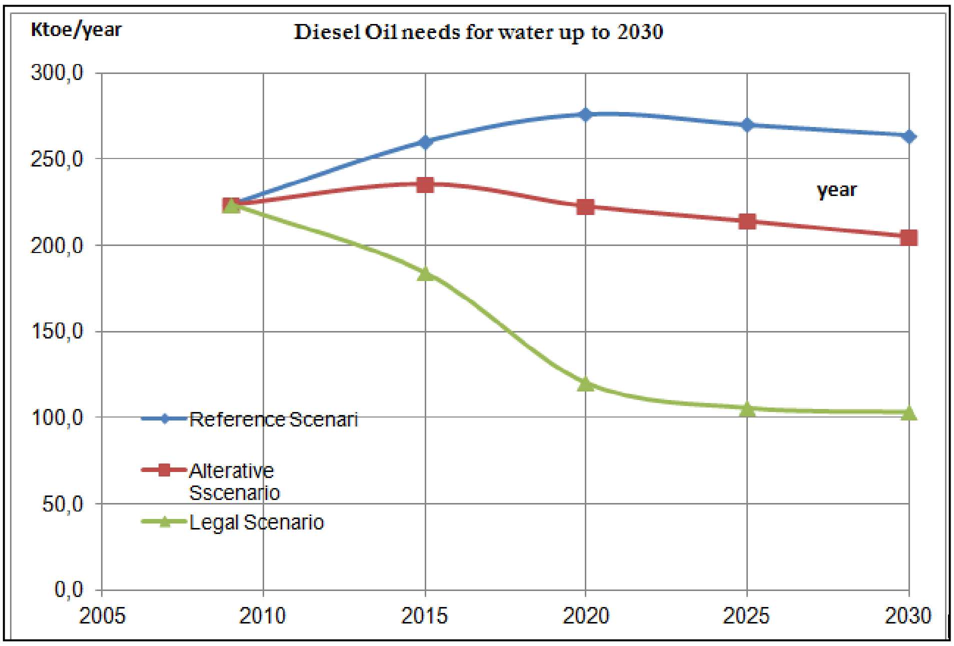
- 0.5 kWh/m^3 for water purification, filtration and treatment
- 1.1 kWh/m^3 for each lifting phase of 250m, equal to 4.0kWh/m^3
- 0.3 - 0.4kWh/m^3 in high-pressure pumping lines (pumping from surface intakes on lakes, rivers and dams and from groundwater fields according to topographical and hydrological situation of the intake.
- 0.1 - 0.3kWh/m^3 energy expenses for maintenance and technical staff.

Figure 3 - Electrical energy needs for water provision according to the scenarios of water changes until 2030



Source: Dr M. Kordab, 2011

Figure 4 - Diesel Oil needs for water provision according to the scenarios of water demand change until 2030



Source: Dr M. Kordab, 2011

The energy used to transport and distribute fresh water among basins accounts for around 42% of total energy used in the sector of drinking water supply and other urban uses. It accounted for about 432.0GWh/year in 2009 according to MoHC's estimates.

The energy used to transport and distribute water is expected to increase to approximately 45% of energy used under this item of reference scenario, while this percentage remains constant for both alternative and legal scenarios.

2.3. Energy needs for wastewater collection, treatment, discharge and reuse (in major water consuming sectors)

Treated wastewater in Syria constituted about 38% of total effluents of urban uses in 2009, concentrating in the large urban centers (Damascus, Aleppo, Homs and Hama) plus some less-populated urban communities (Salamiya, Herran al-Awmeed, Zabadani, etc.). The electrical capacity used to pump wastewater into urban systems and to treat water at these plants is estimated at about 45GW, provided by the national electrical network or from self-production as a result of treatment and use of the resultant gas at these plants.

A key part of water coming out from the tertiary treatment cycle is reused to irrigate appropriate crops by gravity flow (using energy for pumping in transportation process only), while composite capacity of 18 megawatt is used to reuse treated water in Damascus Ghouta (average discharge of 180-250 thousand m^3/day and manometric elevation up to 58m.

2.4. Energy needs for seawater or brackish water desalinization

The power currently used (in 2010) for brackish water desalinization is not more than 1.0 megawatt, while there is no sea water desalinization in Syria.

It can be confirmed that the energy demand for seawater and brackish water desalinization is related to options that can be implemented by the Syrian concerned bodies to meet the deficit in water demand for all purposes; therefore the assumptive estimation of these amounts still has different problems.

2.5. Other energy needs in the fresh and drainage water systems (which have not been covered before)

Energy uses to provide water to uses of public service nature (such as water needs for worship places estimated at 13.9MCM/year fresh water, water needs for education and professional, intermediate and high schooling installations estimated at 2.21MCM of potable water, water needs for hospitals and public health centers estimated at about 1.00MCM, water needs of tourism sector excluding the needs of restaurants estimated at 13.57MCM, fleet of vehicles, means of public transportation and national engineering machinery require about 3.09MCM of water, and so on). This is added to the energy needs to provide water for livestock watering at 180.0MCM of water used for watering and servicing livestock; the largest items in the field of unnoticed needs of energy to provide sufficient water to all uses.

Energy needs for the above items can be estimated based on the hypothesis of using equivalent energy intensity to provide water unit (as electrical power) for all public service uses and distribution of energy used to provide water for watering livestock at equal proportions for both calculated energy sources (electricity and diesel fuel). As these needs increase at the rate of increase in supposed population, demand for energy to provide water for public service uses increased from 28.7GWh in 2009, 31.8GWh in 2015, 36.4GWh in 2020, 41.1GWh in 2025, and peaking 43.3GWh in 2030. Demand on energy sources (electricity and diesel fuel) to provide water for water livestock will develop, according to these assumptions, from 14.4GWh and 1244.4 ton diesel in 2009 to 19.3GWh and 1378.7 ton diesel in 2015, 22.1GWh and 1577.9 ton diesel in 2020. As energy demand slows in case of stable capita share from meat produced at the present situation, it would reach 24.9GWh and 1782.2 ton diesel in 2025 and not more than 26.2GWh and 1876.7 ton diesel in 2030.

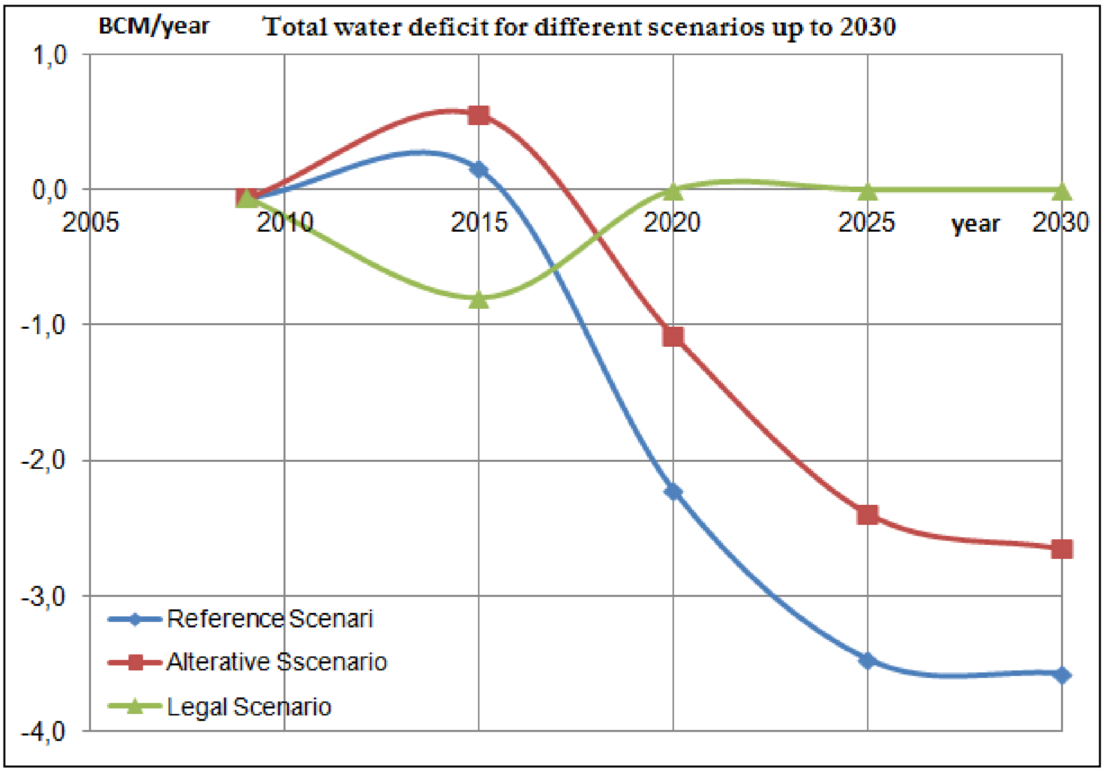
Moreover, the energy used for vertical drainage (from vertical drainage wells in the Euphrates basin) is considered as the largest item in the drained water system, where a capacity of 12.5MW is used in the Lower Euphrates to pump drainage water at heat 3.5-5.0m over a 10-month continuous interval every year.

3. Macro vision on water needs and deficits between 2030

The demand to meet water needs will noticeably change until 2030 once they are studied according to the three scenarios: reference, alternative and legal. Water needs steadily increase in the reference scenario to 21.291 billion m³, so the deficit in freshwater provision exceeds 9.52 billion m³/year. The total demand will reach its peak in the alternative scenario in 2020 up to 18.23 billion m³/year with a deficit in fresh WRs provision of nearly 5.34 billion m³. Despite the drop in overall demand in this scenario to 17.560 billion m³/year, the deficit in fresh water provision will reach 6.16 billion m³, noting steadily increase in overall water peaking 2.65BCM/year in 2030. In the legal scenario where the basic principles of balance between demand for resources and their availability, the total actual uses are expected to reduce to be equal to the national water supplies at a dry-year supply probability plus effluents (reused water) from all relevant economic sectors. In the legal scenario the uses reduce significantly to about 14.07BCM/year in the target year 2030, however the deterioration in overall expected WRs won't reduce the deficit in freshwater demand provision except to nearly 2.30BCM/year. Here, a rapid reduction in total deficit is noted until 2020 to be zero, and continues to be equal to zero in all years that have supplies corresponding to a dry-year supplies according to the reference climatic temporal series for WRs calculation (a 30 year-frequency 1960-1990).

Figure 5 shows the changes of water deficit (to meet water demand for all different purposes) according to the studied scenarios.

Figure 5 - Changes of water deficit (to meet water demand for all purposes) according to the studied scenarios



Source: Dr M. Kordab, 2011

III. Water needs for energy from now until 2030

1. Country energy available resources and forecasted demand (current situation and trend until 2030)

A strategic goal of the Syrian Arab Republic (SAR) is to promote Syrian's energy security through affordable, reliable and clean energy.

1.1. Available energy resources

Syria possesses a good potential of energy resources of both conventional (oil and natural gas) and renewable energy (RE) (solar, wind and hydro). The following items review the actual status of oil & natural gas, the actual status of electricity as well as the status of renewable energy in SAR.

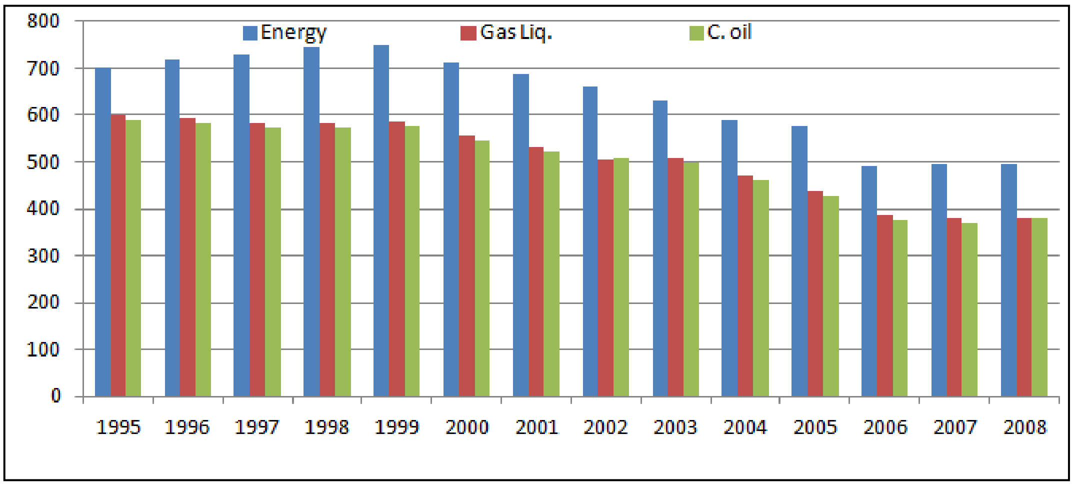
1.1.1. Actual statues of oil & natural gas sector

Oil and natural gas (NG) sector, is a main governmental one, where public authorities hold the bigger role in the production, transportation, refining and distribution of primary energy sources, with partial participation of some foreign companies in oil and gas exploration and production through sharing contracts with the government. Private sector is the local distributer of oil derivatives via fuel stations.

Oil and NG are the main energy resources in Syria. The geological reserves are estimated at the end of 2008 at about 24.869 billion barrels of oil and condensate and about 698.610 billion m^3 of NG. The estimated quantities of recoverable oil production was about 7.151 billion barrels, about 4.8 billion barrels produced until the end of 2008, the remaining reserves for production amounted to 2.4 million barrels. The estimated amount of produceable NG was about 284 billion m^3 about/125.249/billion m^3 of which were produced until the end of 2008.

Oil production began to decrease gradually in Syria after 1995. That decreased from 27.37 million tons in 2000 to 19.33 million tons in 2007. It has been possible to maintain the same rate in 2008 and 2009.

Figure 6 - Energy, crude oil and gas liquids production for the period 1995-2008(Kb/d)

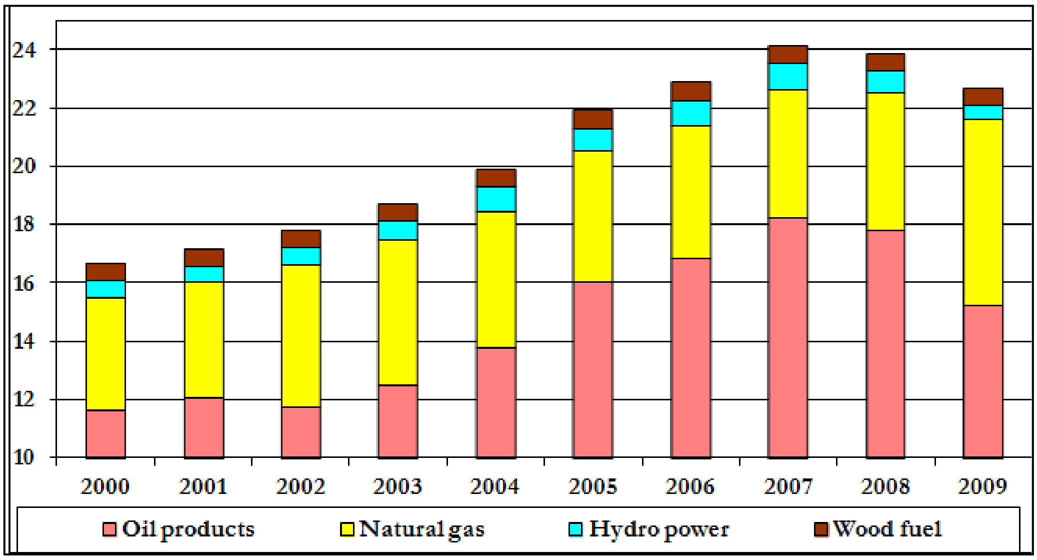


Source: OAPEC statistical Reports (2001-2009)

The crude oil production was 460kb/day in 2004 and about 400kb/day in 2006. Production and exports are expected to decrease while consumption continues to increase. Figure 6 shows Energy, crude oil and gas liquids production for the period 1995-2008 in SAR. It shows that crude oil production decreased steadily since 1996 while liquids from gases increased slightly due to the increase in production of natural and associated gas[11]. NG Production started to increase in the 90's and jumped to a higher level at the end of 90's.

Figure 7 shows primary energy consumption in SAR during the period 2000-2009 more details are illustrated in Table 67 in study annexes. Energy consumption in Syria sharply increased during the period 2003-2007, the energy demand reached 24Mtoe in 2007, but as a result of different actions has been taken for energy conservation such as adjusting electricity & diesel prices and reducing the diesel smuggling the energy demand decreased in 2008 and reached to about 22.6Mtoe in 2009. Table 1 shows distribution of primary energy consumption at different sectors in 2008[12].

Figure 7 - Primary Energy Consumption during 2000-2009 (Mtoe)



Source: Syrian Energy Balances for the years 2000-2009

Table 1 - Distribution of Primary Energy consumption at different sectors in 2008

Sector	Total (Ktoe)	%
Agriculture	918	3.85
Oil & Gas Sector	1668	7.00
Electricity Sector	9316	39.10
Transformation Industrial Sector	1941	8.15
Build. & Construction, Commercial and Governmental Sectors	912	3.83
Transport Sector	4791	20.11
Residential Sector	4282	17.97
Total	23828	100

Source: Strategic Plan for oil & gas sector in Syria, 2010, Ministry of Oil and Mineral Resources

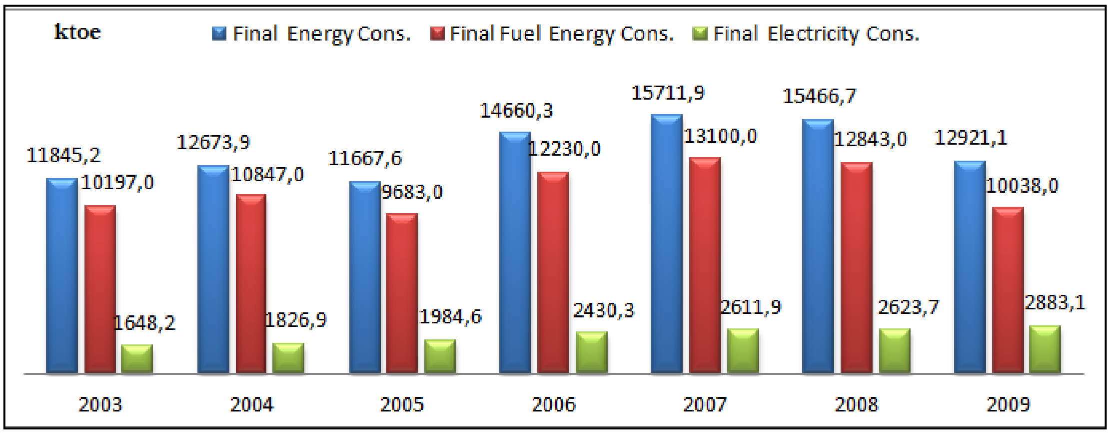
The pattern of primary energy distribution in SAR in 2008 shows that the electricity generation sector is the largest consumer of primary energy it consumed 39.1%, followed by the transport sector 20.1%, the domestic sector up to 18% and the transformation industry, extraction and refining sectors consumed 15.15%. Figure 8 shows Final Energy, Final Fuel & Final Electricity Consumption during the period 2003-2009 The final energy consumption reached to about 15.712Mtoe in 2007 decreased to 12.92Mtoe in 2009. Final energy consumption is distributed 72.1% oil product (oil derivatives), 10.3% natural gas, 2.8% traditional fuel, and 15% was transformed into electricity.

---

[11] OAPEC statistical Reports (2001-2009)

[12]Strategic Plan for oil & gas sector in Syria, 2010, Ministry of Oil and Mineral Resources

Figure 8 - Final Energy, Final Fuel & Final Electricity Consumption during 2003-2009 (Ktoe)

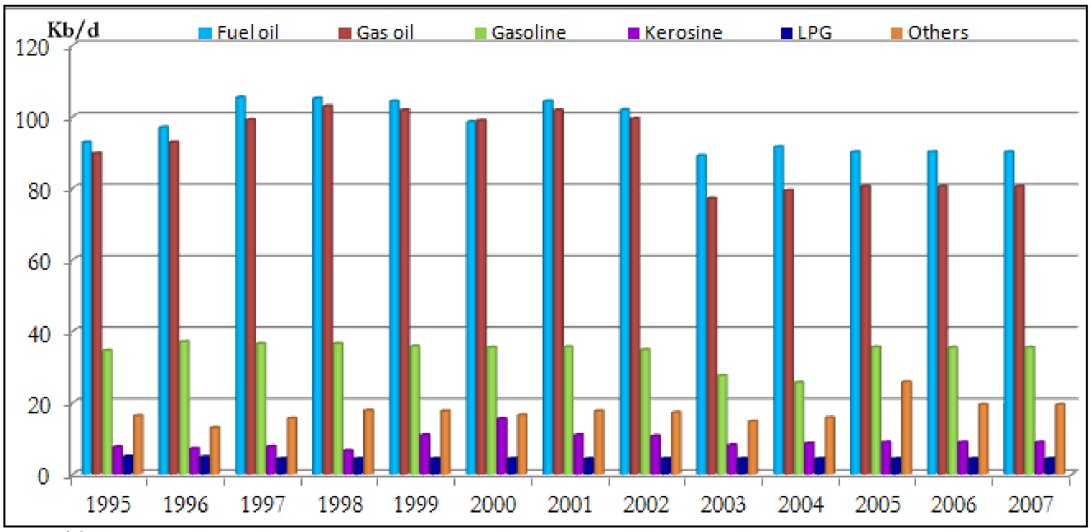


Source: Syrian Energy Balances for the years 2003-2009

There are two refineries in Syria. The first is Homs refinery with 5.7 million tons/year capacity. It operates on a mixture of 60% heavy crude oil & 40% light crude oil. The second is Banias refinery with 6 million tons/year capacity. It operates on a mixture of 60% light crude oil and 40% heavy crude oil. Crude oil used in 2008 for Refineries was around 11.72 million ton[13]. The produced derivatives in the two refineries are distributed to 40% fuel oil (FO), 32 % Diesel Oil (DO), 18% gasoline, naphtha, kerosene and LPG and 10% asphalt, coke and other heavy products. The oil derivatives produced are not sufficient for domestic uses, so a large quantity of diesel oil and fuel oil were imported. (The diesel and fuel oil domestic production was about 4 million tons in 2008, while the total consumption exceeded 7 million tons).

Figure 9 presents the evolution of oil products consumption during the period 1995-2007. It is obvious that fuel oil, gas oil and gasoline are the main consumption oil products in Syria. Fuel oil is the main fuel for electricity generation, while gas oil is being used in domestic, services and transport sectors.

Figure 9 - Evolution of oil products consumption in SAR during the period 1995-2007



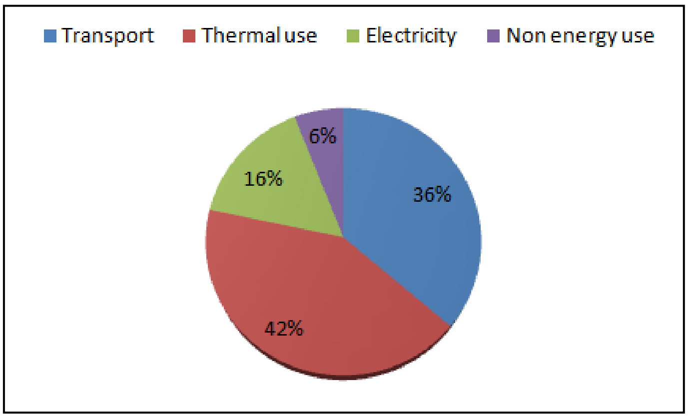
Source: Dr M. Kordab, 2011

Actual energy conversion technologies rely mainly upon combustion of fossil fuels. This is generally either used directly, but more often for generating electricity or for transport. This sector includes two main combustion-related activities, namely stationary combustion and transport. Stationary combustion

[13] Ministry of Oil and Mineral Resources, 2010, Strategic Plan for oil & gas sector in Syria

practically includes all energy-consuming activities, except those of the transport sector in addition to petrochemicals and fertilizers.

Figure 10 - Distribution of Final Energy Consumption into different services in 2008



Source: INC- SY, GHG Mitigation Analysis in the Power Generation Sector

Thermal use share of final energy consumption was high (42%) followed by the transport sector's share was (36%), as shown in Figure 10.

It is important to mention that the level of crude oil production is maintained at an average annual production 380 thousand barrels /day and the NG production is increased from 20 million m^3/day to 21 million m^3/day. The level of the refining capacity of Homs and Banias refineries are maintained at 230 thousand barrels/day. Importing fuel oil started in 2006 by 620 thousand tons, increased in 2007 to 2158 thousand tons and to 2856 thousand tons in 2008.

1.1.2. Actual status of Electricity Sector

Electricity in Syria is still produced by the government sector, where the public authorities assume the overall production, transmission and distribution processes. Ministry of Electricity Plays a key role in the production process (through the General Establishment for Electricity Generation and Transmission) to meet about 85% of the total demand for electricity during the period 2000-20010 , while the rest of actors (the General Establishment for Euphrates Dams, Ministry of Oil & Mineral Resources and Import) are contributing at about 15% . But their contribution is declining by electricity demand growing and limited hydropower resources.

Unprecedented temperatures rise in some summer months has led to the emergence of a peak load in Summer time similar to Winter peak load, with negative impact on the performance of thermal power generation plants leading to lower efficiency and available capacity at a critical time the system needs to generate more to meet the overload air-conditioning and water pumping.

Electricity Demand, Peak Load and Installed Capacity

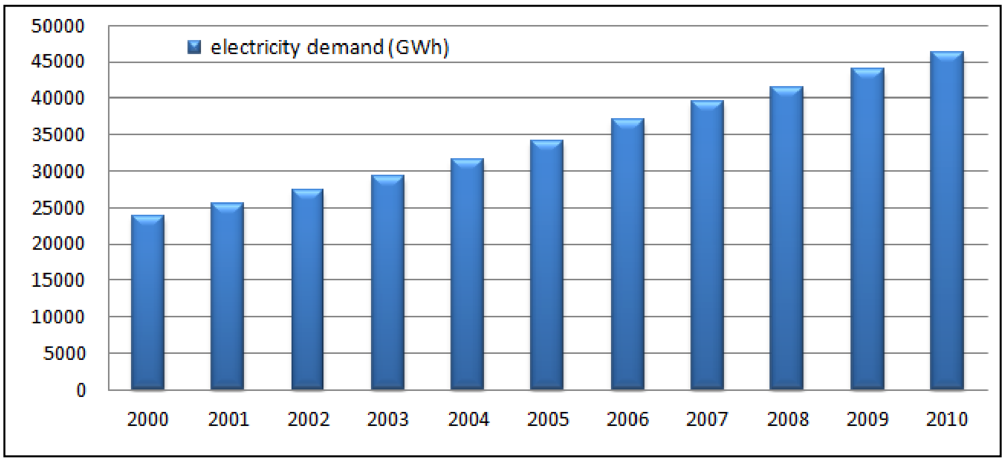
To face the increased demand, the electricity generation increased during the period 2000-2010 from 23874GWh in 2000, to 41373GWh in 2008 and to 46195GWh in 2010 as shown in Figure 11[14], with 7.1% annual growth rate. The electricity per capita arrived to about 2037kWh in 2007 and to 2086kWh in 2008. However, the daily demand for electricity during winter (winter peak) and summer (summer peak) exceeding the average daily demand for electricity during the full year.

During the period 1994-2009 the peak load demand grew from 2474MW to 6900MW showing an average growth rate of 8.2%. To cope with both peak load and electricity demand increase the available installed capacity increased from 3600MW to 6250MW (Figure 12). The reserve margin was more than 30% in the

[14] Ministry of Electricity, 2003-2007, Technical Statistical Reports

year 2000, decreased after that gradually and the system has shown deficient in the installed capacity in 2006 and 2007 that caused in real power shortages during the peak time. Figure 13 presents the distribution of available installed capacity by generation type in 2008. It should be noted that the total installed capacity in 2008 arrived 7518MW of which only 6250MW was available.

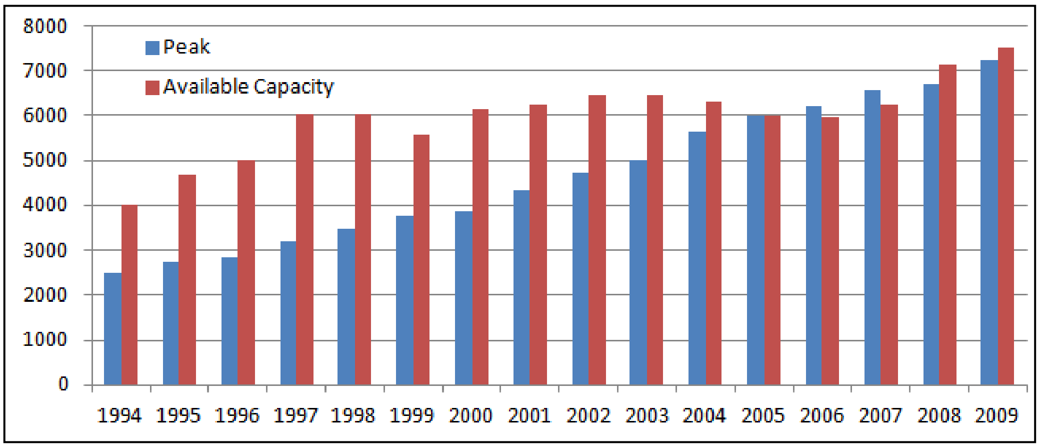
Figure 11 - Development of electricity demand for the period 2000 - 2010



Source: Syrian Ministry of Electricity, Electricity Statistical Report

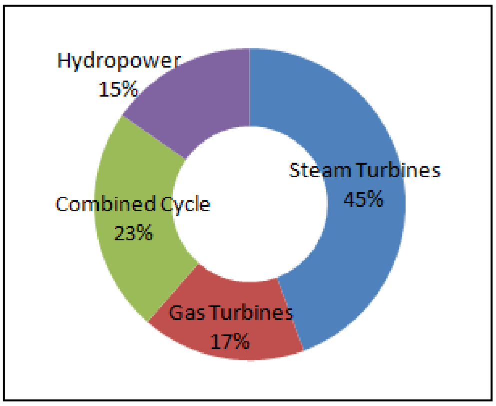
Installed Capacity and Peak Load

Figure 12 - Peak load and available installed capacity 1994-2009



Source: Syrian Ministry of Electricity, 2000-2010 Electricity Statistical Reports

Figure 13 - Distribution of installed capacity by type of generation in 2008

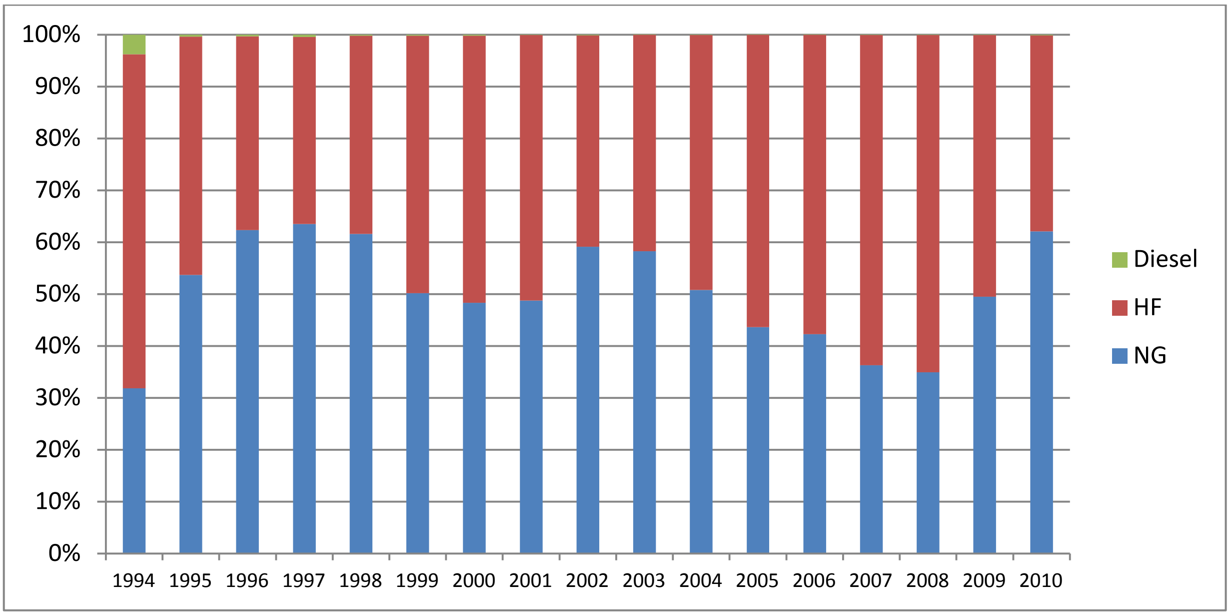


Source: Syrian Ministry of Electricity 2009, Electricity Statistical Report

Fuel Consumption Development in the Generation Sector

Due to the limited generation of hydro power the increased electricity demand lead to steadily increase of fossil fuel for generation purposes represented mainly by heavy fuel oil (HFO) and natural gas (NG). During the period 1994-2010 the share of hydro power generation fluctuated between 10% and 19% following the water availability in the Euphrates River. Thus, over the whole period the share of thermal generation exceed 80% and arrived in 2007 more than 90%. Hence, the fossil fuel consumption in the electricity generation –consisting of HFO, NG and small amounts of Diesel. Following the available domestic NG its share in the fuel mix fluctuated significantly; it increased from 32% in 1994 to 60% in 1997, decreased to 48% in the year 2000 and increased again to 59% in 2002 and to 36% in 2010 as shown in Figure 14.

Figure 14 - Development of fuel consumption for electricity generation (%)

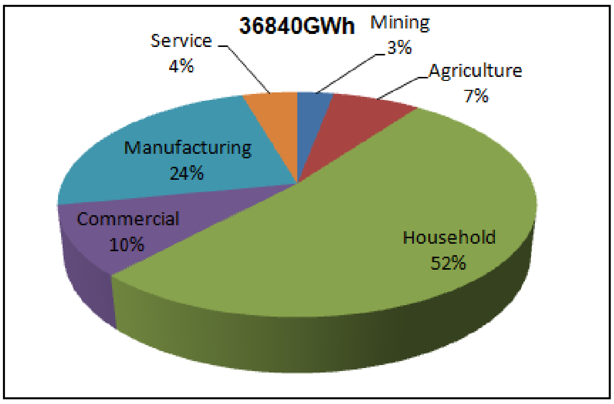


Source: Syrian Ministry of Electricity, 2000-2010, Electricity Statistical Reports

Final electricity consumption

Figure 15 shows the distribution of electricity consumed in different consuming sectors in 2008. The domestic (household) sector is the largest consumer of electrical energy as it consumes 52% of the total electric energy followed by the industrial sector 24%.

Figure 15 - Sectoral consumed electricity distribution in 2008



Source: Syrian Ministry of Electricity, 2009, Electricity Statistical Report

1.1.3. Potential of Renewable Energy Resources in Syria[15]

The SAR is geographically situated between 32.3° and 37° latitude north of the Equator line and between 36° and 42.5° longitude lines east of Greenwich line. It enjoys a huge and unlimited source of solar energy, in addition to a considerable potential of wind energy, which can be of great value for many applications.

Solar Energy Resources

The average global horizontal solar radiant flux in Syria is approximately 5kWh/m^2/day or 1.8MWh/m^2/Year. The average daily radiant flux varies from 4.4kWh/m^2/day in the mountainous areas in the west to 5.2kWh/m^2/day in the desert regions. The annual sunshine hours also vary between 2,820 to 3,270 hours/year. Table 2 presents the Mean Annual Daily Radiation (MADR) on Horizontal Surface (Wh/m^2) at 18 Meteorological Stations in Syria.

Table 2 - Mean Annual Daily Radiation (MADR) on Horizontal Surface (HS) at 18 Meteorological Station in Syria(Wh/m^2)

Station	MADR on HS (Wh/m^2/day)	Station	MADR on HS (Wh/m^2/day)
Damascus (Mezzeh)	5179	Idleb	4852
Damascus (Airport)	5106	Aleppo	4792
Kharabo	5134	Messelmyeh	4696
Daraa	5079	Jarablus	4610
Sarghaya	4863	Raqqa	4870
Palmyra	4985	Der Ezzor	4810
Homs	4886	Hassakah	4695
Hama	4926	Kamishleh	4572
Jableh	4950	Idleb	4852
Lattakia	4516	Aleppo	

Source: Dr M. Kordab, 2011

Wind Energy Resources

Wind is a promising source of renewable energy for electricity generation and for water pumping. The surveys show that more than 4000 multi-bladed wind mills have been installed in the past few decades in different regions of Syria for water pumping.

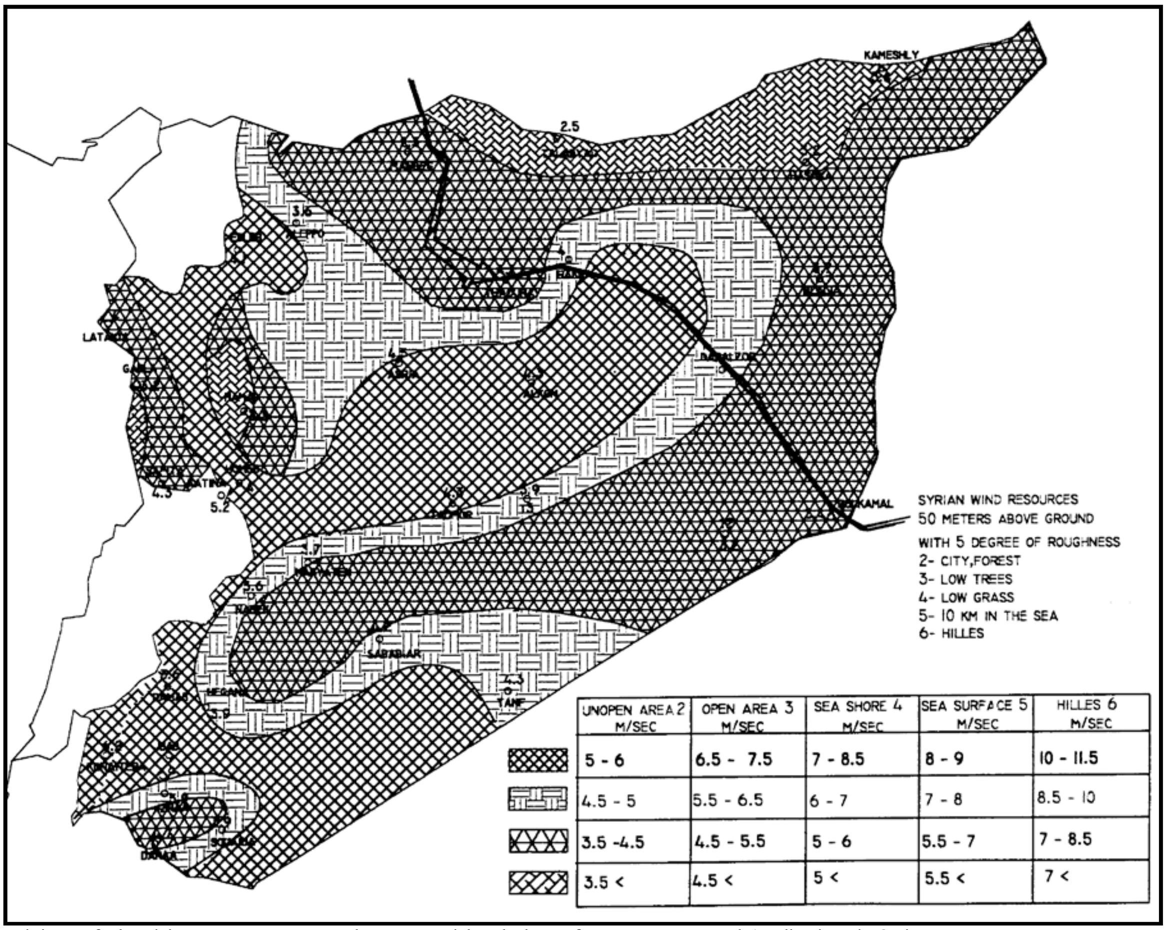
Figure 16 shows the wind map of Syria in which Syria is divided into four main regions depending on the wind speed. The first region (south and middle of Syria) enjoys wind speed in access of 11.5m/s and the other regions have wind speed in the range of 3.5-10m/s.

Biomass Resources

Animal and agricultural wastes are important products of rural areas in Syria. Cow dung, poultry droppings and human waste in addition to wood and vegetable debris form the main source of biomass in Syria. The theoretical biomass potential in Syria has been estimated as 25.8 million tons per year, which is split between all sources as shown in the Figure 17. Over 60% of the total biomass potential is derived from the agricultural sector.

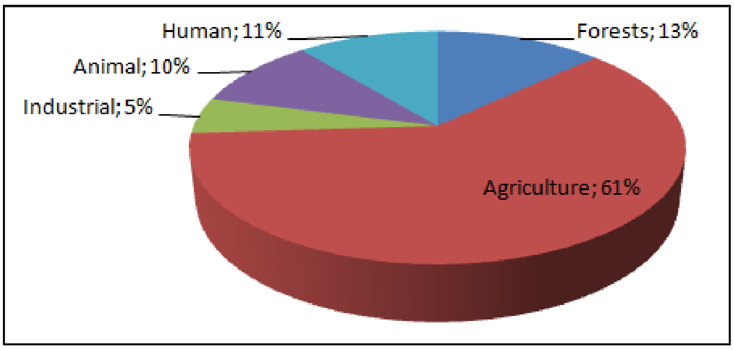
[15]:Ministry of Electricity, 2001, RE Master Plane, Potential and Plans of R E Resources and Applications in Syria

Figure 16 - The Wind Map of Syria



Source: Ministry of Electricity, 2001, RE Master Plane, Potential and Plans of R E Resources and Applications in Syria

Figure 17 - Biomass Resources in Syria



Source: Ministry of Electricity, 2001, RE Master Plane, Potential and Plans of R E Resources and Applications in Syria

Hydro Power Resources

Generation of electricity from Al-Thawra Dam (840MW) and Teshreen Dam (630MW), both on the Euphrates River, provide around 90% of the hydro-electric supply. The Al-Baath Dam on the Euphrates (81MW) and 5 other small hydro plants make up the total of 1551MW installed.

These stations provided between 2119 GWh in 2001 and 4247 GWh in 2003, depending on availability of water in the Euphrates River as shown in the Table 3. These amounts are between 7% and 13% of electrical energy production. There are small hydropowers potential in the coastal area in Syria.

Techno-economic Studies currently under way note the possibility to build a hydropower plant in the region of Halabieh Zalabieh on the Euphrates River with 85MW, and a pumping storage power plant with 1000MW.

Table 3 - Total electricity generated & hydro electricity generated during the period 2000-2008

2000	2001	2002	2003	2004	2005	2007	2008
25218	26714	28014	32077	34935	37505	38645	41023
2503	2119	2501	4247	3445	3994	3526	2872
9.93%	7.93%	8.93%	13.24%	9.86%	11.43%	9.12%	7%

Source: Dr M. Kordab, 2011

Geothermal Energy Resources

The geothermal energy potential in Syria has been evaluated with the consequent identification of the resources presented in Table 4. This data, which identifies various opportunities, shows that one of them, Aleppo, may assume an interesting role in energy production, particularly if associated with the exploitation of water and residual heat for agricultural purposes.

Table 4 - Geothermal Resources in Syria

Name of the well	Location	Surface Temperature ºC	Water Discharge m^3/hour
Aldbayat – Sukneh	Palmyra central region	61	42
Abourabah – Quareten	Palmyra central region	50	Dry air
Almauh Swamp	Palmyra central region	45	320
Alyadude	Daraa-South region	44	7.72
Raas Alain	North East region	40	31.3
Alsfera	Aleppo-North region	38	980

Source: Ministry of Electricity, 2001, RE Master Plane, Potential and Plans of R E Resources and Applications in Syria

Shale oil

There are few places in SAR containing shale oil in the southern area of Syria. The estimated reserve is about 65Mtoe[16].

1.2. Energy demand forecast in Syria until 2030

1.2.1. Future status of Energy & Electricity in SAR

The data of Ministry of Oil and Mineral Resources of SAR shows limited available fuel oil locally. The estimated fuel oil output of Homs and Banias refineries is up to 3.8 million ton. New refineries will produce light products instead of needed fuel oil for electricity sector. Consequently high amounts of imported fuel oil are expected by 2030 and will increase in case of retirement of Homs or Banias refinery.

Table 5 and Figure 18 show the distribution of available clean natural gas per day. The NG production would stabilize at 28MCM per day plus 6MCM per day confirmed to be imported. If the industrial, transport and oil sectors would consume 12.3MCM per day, 22MCM per day should remain to electricity generation. It is planned, at least until 2030, to continue providing this NG amount to the electricity sector, with possibility to import 13.5MCM per day from the region that could increase if the Iraqi NG exported via Syria.

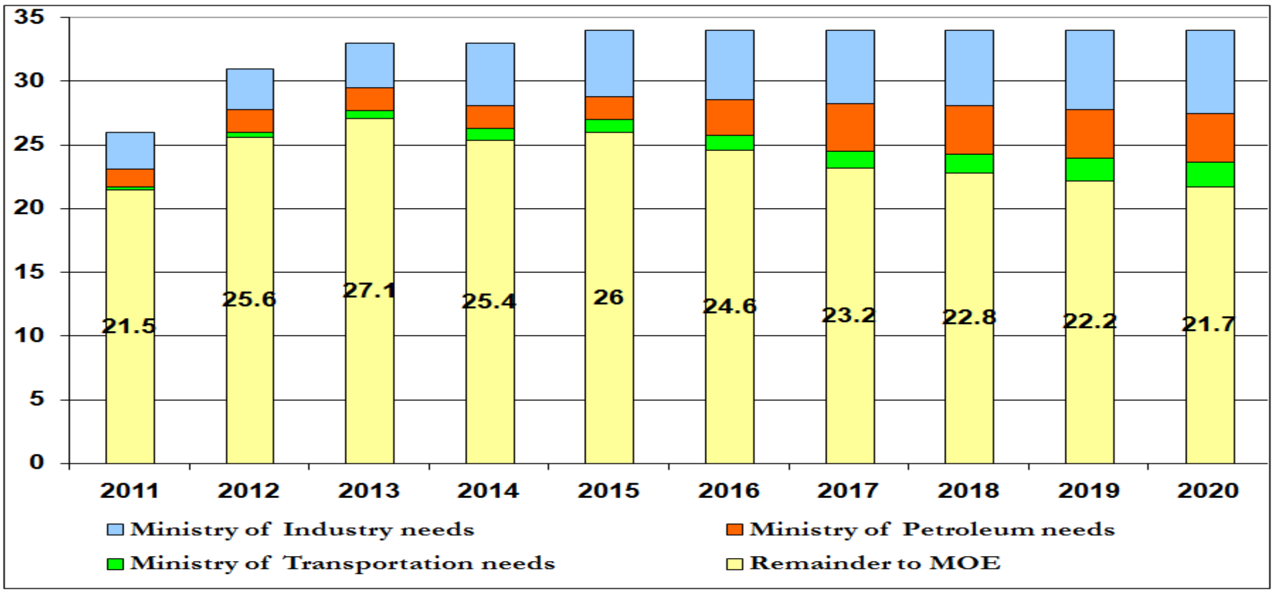
[16] Ministry of Electricity, 2001, RE Master Plane, Potential and Plans of Renewable Energy Resources and Applications in Syria

Table 5 - Available NG Distribution to main consumers in SAR during the period 2010-2020

(MCM/Day)	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Available clean natural gas	28	28	28	28	28	28	27	27	27	23	18
Confirmed Imports NG (confirmed)	6	6	6	6	6	6	6	6	4	3	2.5
Tot. with confirmed imp.	34	34	34	34	34	34	33	33	31	26	20.5
Min. of Transportation needs	2	1.8	1.5	1.3	1.2	1	0.9	0.6	0.4	0.2	0
Min. of Petroleum needs	3.8	3.8	3.8	3.8	2.8	1.8	1.8	1.8	1.8	1.4	1.2
Min. of Industry needs	6.5	6.2	5.9	5.7	5.4	5.2	4.9	3.5	3.2	2.9	2.6
Remainder to MOE	21.7	22.2	22.8	23.2	24.6	26.0	25.4	27.1	25.6	21.5	16.
Imported NG conf.)	13.5	12.5	12.5	11.5	11.5	12.5	9.5	7.5	7.5	4.5	0

Source: Ministry of Oil & Mineral Resources, , 2010, Strategic plan for NG production 2010-2025, Saidnaya WS

Figure 18 - Available NG Distribution to main consumers in SAR during the period 2010-2020



Source: Ministry of Oil & Mineral Resources, 2010, Strategic plan for NG production 2010-2025, Saidnaya WS

1.2.2. Regional cooperation on Energy

Regional cooperation in the field of energy is expected to lead to complementary projects as follows:

- Strengthen the capacities of the national electric grid, thereby increasing the capacity of the regional electric interconnection on AC & Dc high voltage.
- The establishment of NG pipelines to link Gulf countries to Europe, or to link Iraq with Syria and Iran.
- Activating crude oil pipelines between the region countries and promote the establishment of new lines.
- Strengthen the infrastructure capacity of the Syrian ports to import additional quantities of fuel oil, liquefied NG and coal.

The evolution of energy demand in Syria has been forecasted by a study executed by the National Energy Committee in SAR and presented in the National Energy Congress held in Damascus Syria, 13-14 March 2010. According to the economic, social and technical development in Syria and in view of national energy resources and available techniques of energy conversion options taking into account the import and export potential, the following assumptions were taken into consideration:

- Achieving energy security,

- Determining the fuel prices by official intervention, taking into account the market impact on prices of energy sources,
- Governmental support to some forms of energy carriers (such as gasoil & electricity),
- Introducing energy efficiency policies,
- Interaction between energy sector and other development sectors,
- Diversification of energy sources.

In order to evaluate the impact of adaptation measures in future energy supply policies on GHG emissions, two energy supply scenarios were chosen: a business-as-usual reference scenario (RS) and energy saving scenario based on the enforcement of sharing renewable resources (ESS).

The development trend refers to the Reference Scenario (RS) reflects the baseline development in formulating future optimal expansion plan of generation sector under a set of limits and constraints that reflect the technological features of available, committed and future power plant candidates, availability of domestic fuel resources and import & export possibilities. The second is the energy saving Scenario (ESS) that focuses on introducing policy measures in term of energy saving & energy efficiency and clean energy technologies. These two scenarios were adopted by the National Energy Committee and presented at the National Energy Congress held at Damascus on March 2010, and also are used in the study of EE & RE Master plan prepared by (GTZ-NERC of the Ministry of Electricity) end 2010, the two scenarios introducing in the Syrian Power System 2 Nuclear power plants with 1600MW capacity, one 600MW to be installed during 2020-2025 and the second 1000MW to be installed during 2025-2030. But, after the Japanese Nuclear disaster of Fukushima, the Syrian trend go forward to exclude the nuclear option, that is why we adopted in this study two modified scenarios (Modified reference scenario MRS & Modified energy saving scenario MESS) including the same assumptions except the nuclear ones.

1.2.3. Energy demand forecast according to the Reference Scenario (RS)

The main assumptions of this scenario are the following:

- Adoption of official data on oil and NG reserves and production, Gasoline will share by 25% and diesel by 75% of the fuel consumed in the transport sector in 2005, and maintain a fixed share for gasoline during the study period while the diesel share will decrease in favor of NG in the subsequent years,
- 14.5% of final energy demand for thermal uses will be covered by liquefied natural gas (LNG), 20% by FO, while the share of NG will grow from 3.5% in 2005 to 8.6% in 2015 and then decrease to 4.1% in 2030 as a result of decline in NG production The nuclear option for electricity generation will start by 600MW power plant capacity during the period 2020-2025 then 1000MW power plant capacity during the period 2025-2030,
- Using wind farms to generate electricity in some promising windy areas in SAR and using solar PV power plants,
- The power plants reserve margin will be 5% in 2010 and 10% later,
- Importing and exporting electrical energy through the electric grid interconnection according to the available capacity with neighboring countries which is 300MW in 2005 and 500MW in 2030,
- Importing NG through the Arab Gas Pipeline starting in 2008 by 2.74MCM per day,
- The primary energy demand will increase by 4.9% starting from 25 (Mtoe) in 2005 arriving to 83.3 (Mtoe) in 2030 to meet the average final energy demand growth, which is 5.3% starting by 15.249 (Mtoe) in 2005 arriving to 55.6 (Mtoe) in 2030.

The results of the reference scenario conclude to the continued reliance on fossil fuels (oil and NG), to meet the needs of primary energy where the demand on primary energy will increase more than 3.3 times, and the share of crude oil and oil products will decrease from 65.5% in 2005 to 60.2% in 2010 and then will increase to 81.3% in 2030, while the share of NG, including LNG will increase from 30% in 2005 to 35.4% in 2010 and then decline gradually to reach 13% in 2030. The share of wind energy and hydropower will decrease from 2.6% to 0.6% in 2030, while the share of solar water heating in the domestic and services sectors will increase to 0.6% in 2030. Nuclear energy will also contribute by 3.5% in 2030.

According to the Strategic Plan for oil & gas sector in Syria[17], the expected crude oil production has been forecasted during the period 2010-2030 as shown in Table 6.

Table 6 - Oil production forecast in Syria during 2010-2030

Year	Production Million ton	Year	Production Million ton	Year	Production Million ton
2010	18.80	2017	16.60	2024	12.55
2011	19.15	2018	16.05	2025	12.15
2012	19.00	2019	15.45	2026	11.70
2013	18.65	2020	15.00	2027	11.40
2014	18.20	2021	14.30	2028	11.05
2015	17.80	2022	13.55	2029	10.75
2016	17.35	2023	13.00	2030	10.50

Source: Ministry of Oil and Mineral Resources, 2010, Strategic Plan for oil & gas sector in Syria

The Table 6 shows the decline of oil production in Syria from 18.8 million tons in 2010 to 10.5 million tons in 2030, exporting oil will be stopped and Syria is expected to import oil and its derivatives in 2020, with increased imports from 22% in 2005 to reach 70% in 2030. By 2015 it is expected to import 5.7 million tons of crude oil and by 2020 the amount of imports of crude oil & derivatives will reach 28 million tons.

Table 7 Forecasted NG needed, NG produced locally, NG imported and NG deficit during the period 2010-2030. NG deficit started in 2010 by 10MCM/d which decreases to zero in 2012 & 2013 then will increase to 10MCM/d in 2017, to 15MCM/d in 2020, to 32MCM/d in 2025 and to 53MCM/d in 2030.

Table 7 - Forecast of NG needed, produced (Prod.), imported (Import.) & NG deficit in Syria during the period 2010-2030 (MCM/day)

Year	NG needed	NG Prod.	NG Import	NG Deficit	Year	NG needed	NG Prod.	NG Import	NG Deficit
2010	33	18	2	13	2021	65	28	19	18
2011	36	23	7	6	2022	68	26	19	23
2012	38	23	11	0	2023	71	26	19	26
2013	40	27	13	0	2024	75	25	19	31
2014	45	27	15	3	2025	77	24	19	32
2015	47	28	18	1	2026	82	24	20	38
2016	51	28	18	5	2027	84	24	21	39
2017	55	28	17	10	2028	86	24	16	46
2018	57	28	19	10	2029	90	24	17	49
2019	60	28	18	14	2030	95	24	18	53
2020	62	28	19	15					

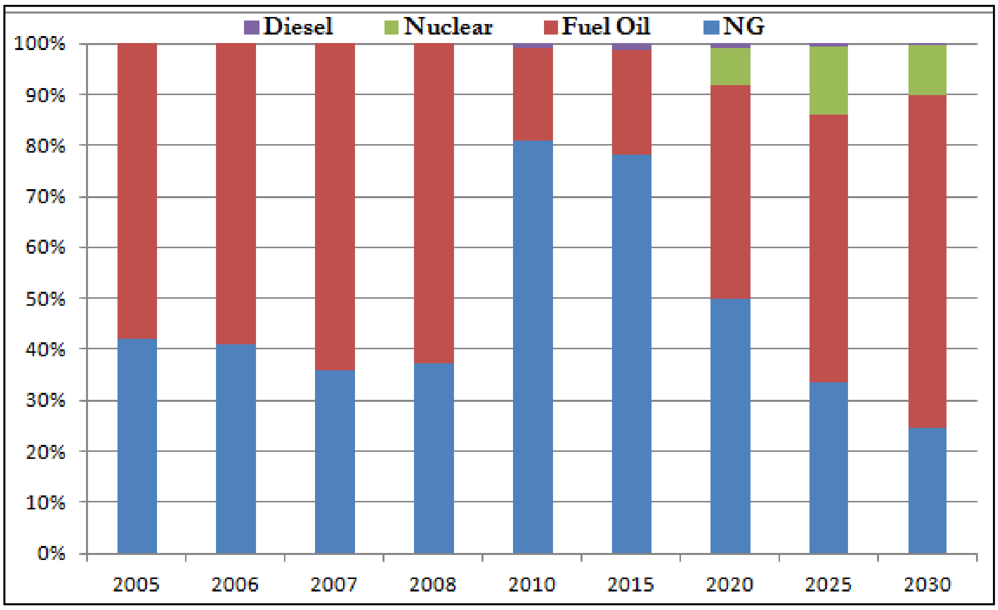
Source: Ministry of Oil and Mineral Resources, 2010, Strategic Plan for oil & gas sector in Syria

[17] Ministry of Oil and Mineral Resources, 2010, Oil and NG Strategic Plan up to the year

1.2.4. Expansion Plan of Generation System according to RS

According to RS the electricity generation will increase from 34.9TWh in 2005 to about 148.4TWh in 2030. The optimal expansion plan of RS shows an increase of installed capacity from 6200MW to 29600MW during the period 2005-2030. The new capacity addition is distributed to 14360MW for combined cycle (CC), 12200MW for Heavy fuel oil (HFO) fired steam power plants, 900MW gas turbines (GT), 300MW wind turbines (WT) and 1600MW for two nuclear power plants that will enter the system in 2020 and 2025 with 600MW and 1000MW respectively. Other alternatives, like photovoltaic (PV) and concentrators solar power (CSP) are not competitive in the RS due to the high investment cost[18].

Figure 19 - Development of fuel share for electricity generation (RS)



Source: Dr M. Kordab, 2011

The increase in electricity generation will boost the future fuel demand for generation purposes. The fuel demand will grow by an average annual of 5.8% from 7 Mtoe (distributed to 58% HFO and 42% NG) to 11 Mtoe in 2015 (distributed to 78.3% NG, 20.4% HFO and 1.3% diesel), arriving to 30 Mtoe in 2030 (distributed to 24.6% NG, 65.2% HFO, 9.7% nuclear and 0.5% diesel) as presented in Figure 19. The electricity generation by fuel type shows that the share of NG will increase to a maximum of 83% in 2017 and decline later to 31% in 2030. The decreased NG availability will be compensated by HFO and nuclear.

1.2.5. Energy demand forecast according to the energy saving scenario[19] (ESS)

Because of the limited quantities of NG production of national sources available in the future and those expected to be imported (via the Arab Gas Pipeline) forecast has shown that the optimum expansion system for power generation will be shifted dramatically after 2015 to rely on fuel oil. Fuel oil quantities required for generation only would amount to about 14 million tons in 2020 and then increase to 28 million tons in 2030.

However, there are significant limitations on the provision of such quantities in the future locally on the one hand, where local production will be reduced to 3 million tons per year and the difficulty of importing of non-availability in the global markets on the other hand.

---

[18] The National committee for Energy Studies, March 2010, Energy Demand in Syria for the period 2005-2030, National Energy Congress, Damascus, Syria

[19] The same previous reference

Based on the above other alternatives should be relied on, including energy conservation & efficiency and raising the reliance on renewable energy for electricity generation. The following assumptions are adopted for the energy saving scenario (ESS):

- Enhance solar energy contribution to reach in 2030 to 35% of the total demand on thermal water heating in both domestic and service sectors,
- Take into account the contribution of mini hydro generation with additional capacity up to 200MW,
- Enhance the contribution of wind energy to 2000MW in 2030,
- Reduce the total losses (technical and otherwise) in transmission and distribution networks to 12% in 2030,
- Activation procedures for energy conservation & efficiency to reduce the total final energy demand by 5% in 2030,
- Enhance the contribution of Photovoltaic power plants to 2000MW in 2030,
- The use of solar thermal electricity (CSP) up to 1000MW in 2030,
- Taking into account the availability of large quantities of NG from Akaz Iraqi field reach 5MCM per day in 2015 and then rise to about 10MCM per day in 2020,
- Adoption of the nuclear option for electricity generation after 2020 by one station every 5 years, the first 600MW capacity & the second 1000MW capacity.

By analyzing the results of the energy saving scenario (ESS) it is concluded that the final energy demand will increase from 15.2Mtoe in 2005 to 52.9Mtoe in 2030 (compared with 55.6Mtoe of the RS) with 5.1% annual growth rate (compared with 5.3% for the RS).

Primary energy demand will grow at 4.6% annual rate (compared with 5% for the RS) and will increase from 25Mtoe in 2005 to reach to 76.3Mtoe in 2030 (compared with 83.9Mtoe for the RS) that means 7.7Mtoe saving in primary energy in 2030, a decline in the annual growth rate and improvement in energy efficiency, where the efficiency of final energy consumption will increase from 61% in 2005 to 67.4% in 2030.

The results indicate that SAR will continue depending on fossil fuels (oil and NG) to meet the needs of primary energy, but the crude oil and oil derivatives share will decrease from 65.5% in 2005 to 58.4% in 2010 before returning to increase to 73.2% in 2030 (compared with 81.7% for the RS). The NG share (including LNG) will increase, from 30% in 2005 to 37% in 2010 , benefiting from the increased production expected for the NG during this period, but they tend to decline after that to reach about 18% in 2030 (compared with 13% for the RS).

The share of renewables (water and wind) will drop slightly during the study period from 2.6% to 2.1% (compared with the sharp decline to 0.6% for the RS) by 2030. While the contribution of solar water heating in both domestic and services sectors will rise to 1.7% of primary energy in 2030 (compared with 0.6 for the RS). Nuclear generation will start at 2020 and their share will be 3.8% of primary energy at 2030.

Crude oil production will fall by 2015, exporting oil will stop and begin of importing about 5.7 million tons per year (compared with 12.7 million tons, for the RS) to reach to 6.7 million tons in 2020 (compared with 13.7 million tons, for the RS) in addition to 4.2 million tons of diesel and 14.6 million tons of fuel oil.

1.2.6. Expansion Plan of Generation System according to ESS

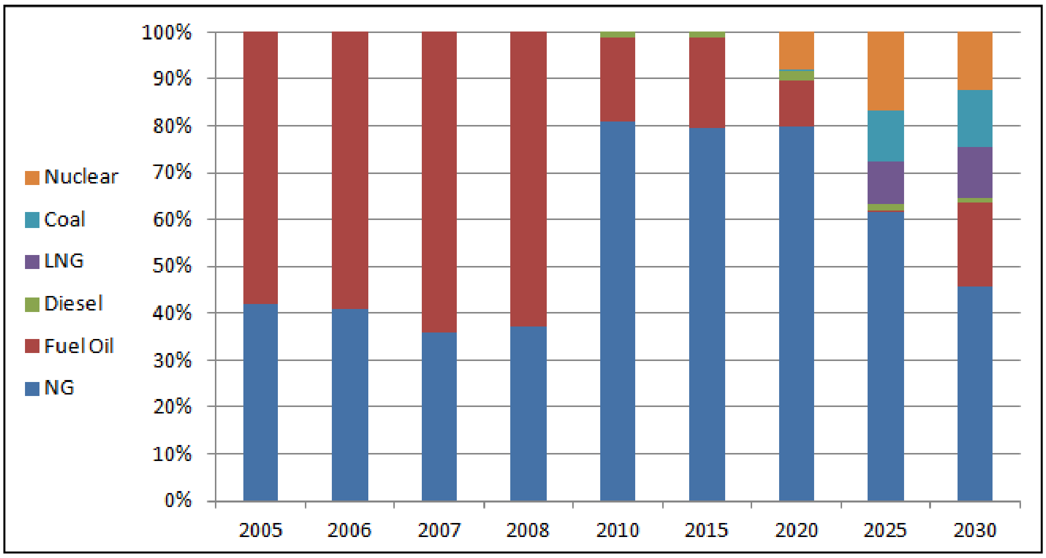
ESS scenario adopts a future energy policy that focus on environmental requirements by increasing the share of renewables and other clean technologies in the future supply mix. It aims at exploring the possibility of increasing supply security by reducing the dependency on fossil fuel and limiting the GHG emission at the same time. EES offers the possibility to assess the cost of such GHG abatement policy in the power sector by comparing its results with those of RS. The proposed measures in this scenario cover wind, PV, CSP and soft solar for thermal application according to following assumptions:

- Encouraging the introduction of renewables by imposing predefined total installed capacities of 2000MW for wind, 2000MW for PV and 1000MW for CSP over the study period,
- Increasing the share of NG power plants and in particular the combined cycle technology (CC),
- Considering future power plant candidates using liquefied natural gas (LNG),
- Allowing the introduction of nuclear option after 2020,
- Gradual reduction of transmission and distribution losses in the electric grid from present 22% to 12% in 2030.

The optimal expansion plan of ESS shows that the installed capacity will reach 32360MW in 2030. The new capacity addition is distributed to 16500MW for CCPP, 2100MW LNG fired power plants, 2600MW for HFO fired steam power plants, 3100MW GT, 1600MW for two nuclear power plants, 1500MW coal fired power plants, 2000MW for Wind Farms, 2000MW for PV and 1000MW for CSP. The expected share of installed renewables will arrive about 15% in 2030. It is noticeable that the share of renewables in this year will exceed the share of HFO that will amount to 8% only. The total installed capacity of EES is higher than that of RS due to the increased share of renewables with their low availability factors. Following the above results the achieved structure of the generation system for ESS show more diversity in type of generation and increased contribution of CC. Besides, the share of the installed renewable will arrive 15% in 2030 compared to 1% for RS.

The fuel demand will grow by an average annual of 4.7% from 7Mtoe (distributed to 58% HFO and 42% NG) to about 23Mtoe in 2030 (distributed to 46% NG, 29% HFO, 11% LNG and 13% nuclear) as presented in Figure 20.

Figure 20 - Distribution of fuel shares for electricity generation (EES)



Source: State Ministry for Environmental Affairs, April- 2010, SYRIAN Initial National Communication

Table 8 shows the evolution of primary energy demand, imported energy, imported fuel oil and NG for RS and ESS while Table 9 & Figure 21 shows a comparison of the forecasted electricity generation for the two Scenarios up to 2030.

Table 8 - Evolution of Primary Energy demand, Imported Energy, Imported Fuel oil and NG for the two Scenarios (Mtoe)

	Import NG		Import Fuel Oil		Imported Energy		Primary Energy	
	EES	RS	EES	RS	EES	RS	EES	RS
2005	3.82	3.82	4.88	4.88	5.48	5.48	25.07	25.07
2007	3.63	3.63	5.36	5.36	7.09	7.10	26.70	26.70
2010	5.47	5.47	4.29	4.93	7.39	8.79	28.94	30.39
2015	7.60	5.97	7.20	10.43	13.63	16.31	38.76	41.31
2020	7.87	4.62	11.57	17.93	24.49	29.14	48.35	52.55
2025	7.19	3.94	17.47	24.85	35.12	41.40	60.81	66.13
2030	6.85	3.60	25.60	34.70	49.57	58.23	76.33	83.3

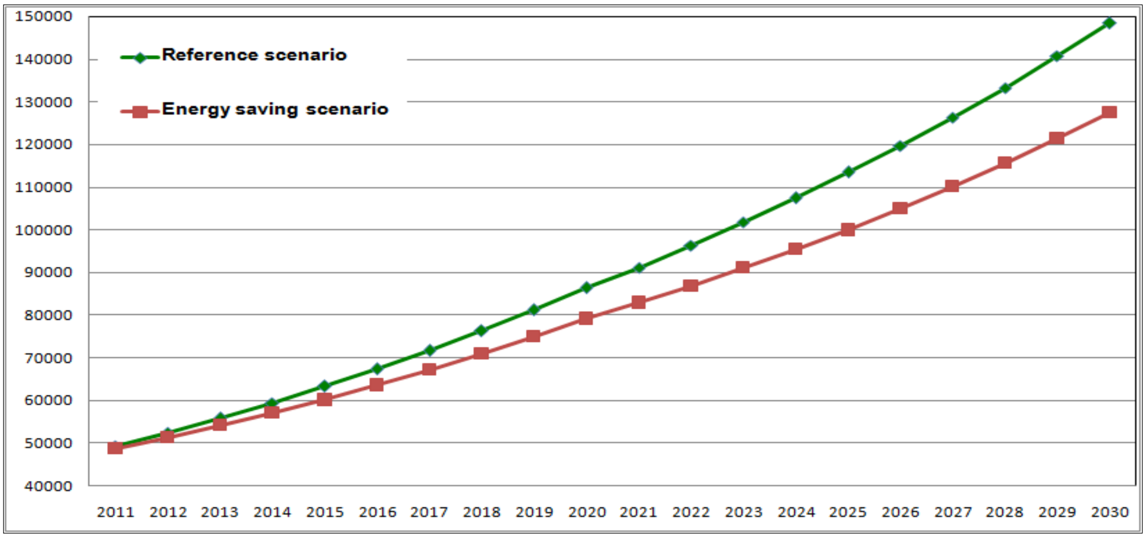
Source: The National committee for Energy studies, March 2010, Energy Demand in Syria for the period 2005-2030, National Energy Congress, Damascus, Syria

Table 9 - Forecasted electricity & installed capacity[20] up to 2030 (MW) for the two Scenarios

	Reference scenario(RS)				Energy saving scenario(ESS)			
	TWh	Av. Gr%	MW	Av. Gr%	TWh	Av. Gr%	MW	Av. Gr%
2010	46.3		7500		46.1		7500	
2015	63.2	6.5%	12000	9.8%	60.1	5.4%	11400	8.7%
2020	86.3	6.4%	15500	5.2%	79.1	5.6%%	14200	4.5%
2025	113.4	5.6%	20500	5.7%%	99.9	4.8%	18000	5%%
2030	148.4	5.5%%	27000	5.6%	127.5	5.0%	23200	5.2%%

Source: Ministry of Electricity (NERC) and (GTZ) – 2010, Master plan for E E and R E (MEERE)

Figure 21 - Forecast of Electrical Energy Demand up to 2030 (GWh) for the two scenarios of NERC-GTZ Master Plan



Source: Ministry of Electricity (NERC) and (GTZ) – 2010, Master plan for E E and R E (MEERE)

[20] Ministry of Electricity -National Energy Research Centre (NERC)And (GTZ) -2010 , Master plan for Energy Efficiency and Renewable Energies (MEERE)

1.2.7. Expansion Plan of Generation System according to the eleventh five years plan 2011-2015

Given the need to diversify the Syrian electrical generation system and to expand its capacity taking in consideration the difficulty of primary energy resources availability, especially natural gas and nuclear fuel, the energy team of this study has modified the RS & ESS of the Syrian Master plan prepared by (NERC-GTZ) using in both scenarios more RE power plants, implementation of the pumping storage hydropower plant in Halabieh-Zalabieh to meet peak load and improve the daily load factor of the Syrian electric system and to use more coal fired steam power plants in order to diversify imported fuel. In the two modified scenarios the expected demand for electrical energy of the Master plan study of EE & RE, mentioned above, is maintained, these two new scenarios are: Modified Reference Scenario (MRS) & Modified Energy Saving Scenario (MRS).

The following assumptions are adopted:

- The electricity demand in 2005 was amounted to 34.1TWh reached to 46.1TWh in 2010 with 6.2% annual growth,
- The peak load demand in 2005 was amounted to 6008MW reached to 7843MW by the end of 2010 with 5.5%.annual growth.

Table 10 shows the forecast of demand on electricity and peak load for both scenarios up to 2015.

Table 10 - Forecast of Demand on Electricity & Peak Load up to 2015

		2011	2012	2013	2014	2015
Electricity Demand (GWh)	MRS	49183	52365	55753	59360	63200
Average annual growth on electricity demand %		6.5%	6.5%	6.5%	6.5%	6.5%
Electricity Demand (GWh)	MESS	48691	51322	54096	57019	60100
Average annual growth on electricity%		5.4%	5.4%	5.4%	5.4%	5.4%
Peak Load Demand (MW)	MRS	8507	9057	9643	10267	10931
	MESS	8422	8877	9357	9862	10395

Source: Calculation of the Energy Team of this Study

Given the need to provide and secure imported fossil fuels to run power plants, which has become a burden on the national economy due to the difficulty to import and the high costs significantly, taking into account what has been adopted by the Eleventh Five Year Plan as follows:

1) Exploitation of all expected hydroelectric power sources by:
   - Optimal operation of existing hydroelectric power plants,
   - Completion of the study, bidding, contracting and securing the necessary funding for the pumping storage hydro- power plant project at Halabiya – Zalabiya,
   - Update the assessment of water resources for mini and medium-sized hydroelectric power plants.
2) Exploitation of renewable energy resources for electricity production by:
   - Implementation of wind farms,
   - Implementation of Solar thermal power plants (CSP) & Solar photovoltaic power plants,
   - Preparation of studies needed to use shale oil and coal to generate electricity.

Meet the peak load demand:

- Demand on electric power increases in summer because of air-conditioning in domestic, commercial and service sectors, and affected the performance of thermal generation power plants in general and gas turbine in particular. High temperature in summer leads to a decrease available power of thermal power plants. In addition to the low availability of hydro power plants as well as the low amount of hydroelectric generation due to scarcity of water resources.

- In order to study the real need of the future power plants for the period 2011 - 2015, available power of electric power plants in summer in the Syrian system was considered (including power units that have recently developed such as expanding Teshrin thermal power plant by Combined cycle and expanding Banias power plant by two gas turbines) as illustrated in Table 11.

Table 11 - Expansion of Syrian Electric Power Plants during 2011-2015

	2011	2012	2013	2014	2015
Steam turbines Power Plant	3125	3125	3125	3125	3125
Gas turbines Power Plant	744	744	744	544	538
Combined cycle Power Plant	2710	2710	2710	2710	2710
Hydro Power Plant	440	440	440	440	440
Available existing capacity	7019	7019	7019	6819	6813

Source: Calculation of the Energy Team of this Study

The capacity needed to meet the peak load demand has been calculated with 5% reserve margin only in order to avoid excessive investment costs for MRS & MESS as shown in Table 12.

Table 12 - Needed Capacity & peak load up to 2015 for both scenarios

		2011	2012	2013	2014	2015
Peak load demand on (MW)	MRS	8507	9057	9643	10267	10931
	MESS	8422	8877	9357	9862	10395
Needed capacity to cover peak load (MW)	MRS	8932	9510	10125	10780	11478
	MESS	8843	9321	9824	10355	10915

Source: Calculation of the Energy Team of this Study

An extensive assessment on power generation projects under construction, under contract, under study or under call for bidding has been developed. These projects, which will use conventional fuel or renewable energy resources, will be implemented either by public sector or by private sector according to BOO, BOT or BOOT. Some of these projects will contribute to the peak load as shown in Table 13, and some will not contribute to the peak load, such as WFs, PVs with total installed capacity 58MW in 2015, 118MW in 2020, 178MW in 2025 and 388MW in 2030 and would be executed by public or private sectors in Qatineh, Gabageb (Deraa), Hejaneh and Sukhneh.

Table 13 - Public & Private Power Generation projects will contribute to the peak load

(MW)	2011	2012	2013	2014	2015
Public sector	150	550	1750	2760	3160
Tishreen extension ST			200	400	400
Der-Ali extension CC power plant		250	500	750	750
Jandar extension CC power plant	150	300	450	450	450
Swedieh CC power plant				300	450
Deir-ezor CC power plant			250	500	750
Nasrieh extension CC power plant			350	350	350
CSP				10	10
Private sector	0	0	150	300	450
Nasrieh private CC power plant			150	300	450
Total (1)	150	550	1900	3060	3610

Source: Calculation of the Energy Team of this Study

Power generation deficit

The expected deficit in power generation during the period 2011-2015, will result by comparing the sum of available capacity and new projects with the power needed to meet the peak load (PV & WFs projects should be deleted as they are not contributing to peak load), would be as Table 14:

Table 14 - Power Generation Deficit for the period 2011-2015

(MW)	2011	2012	2013	2014	2015
Capacity of new projects	153	608	2018	3238	3998
Capacity of existing PP	7019	7019	7019	6819	6813
Total capacity (new + existing)	7172	7627	9037	10057	10811
Demand on peak load (MW)	8507	9057	9643	10267	10931
Annual deficit	1338	1488	724	388	508

Source: Calculation of the Energy Team of this Study

Noting that this deficit indicates lower reliability to meet the electrical peak load and taking in consideration the possibility of importing electricity from neighboring countries when needed. Covering this deficit leads to a critical balance between supply and demand, while there is a need to additional 5% of capacity as a reserve.

1.2.8. Power generation expansion during the period 2011-2030, including Eleventh Five Year Plan

Expansion of Installed capacity and peak load according to modified scenarios

In this scenario the electrical energy adopted in the RS of the Masterplan study (NERC-GTZ) is maintained, but when forecasting the peak load has been assumed that the application of load management effectively will be reflected directly on the improvement of the annual load factor to achieve 80% in 2030, which leads to 21176MW for MRS and 18193MW for MESS peak load in 2030 instead of 27000MW for RS & 23200MW for ESS, where annual load factor was 66%. This can be justified by allowing a low probability of loss of peak load (LOPL) up to three days in the year, which usually can be accepted in the economic studies in terms of ease heavy investment to expand the sector. Table 15 & Table 16 show the electricity demand and the peak load demand during the period 2011-2030 for the MRS & MESS.

Table 15 - Demand on Electricity & peak load up to 2030

		2011	2015	2020	2025	2030
Electricity Demand (GWh)	MRS	49183	63200	86300	113400	184400
Average annual growth on electricity demand %		6.5%	6.5%	6.4%	5.6%	6.5%
Electricity Demand (GWh)	MESS	48691	60100	79100	99900	127500
Average annual growth on electricity%		5.4%	5.4%	5.6%	4.8%	5.0%
Peak Load Demand (MW)	MRS	8507	10931	14074	17260	21176
	MESS	8422	10395	12900	15205	18193

Source: Calculation of the Energy Team of this Study

- Referring to Table 10 & Table 19 the peak load demand in 2015 will be:
  - 12GW for RS, 11.4GW for ESS, 10.931GWH for MRS & 10.395GW for MESS
- The peak load demand in 2020 will be :
  - 15.5GW for RS, 14.2GW for ESS, 14.074GWH for MRS & 12.9GW for MESS

- The peak load demand in 2025 will be :
  - 20.5GW for RS, 18GW for ESS, 17.26GWH for MRS & 15.205GW for MESS
- The peak load demand in 2025 will be :
  - 27GW for RS, 23.2GW for ESS, 21.176GWH for MRS & 18.193GW for MESS

Available Power Generation in the Syrian Power System up to 2030

shows available power generation capacity after retirement of power generation units during the period 2011-2030 for both scenarios.

Table 16 - Available power generation capacity during 2011-2030 for MRS

	2011	2015	2020	2025	2030
Available existing Steam turbines P P	3125	3125	2600	2480	2470
Available existing Gas turbines P P	744	538	508	280	280
Available existing Combined cycle P P	2710	2710	2670	2590	1980
Available existing Hydro turbine P P	440	440	440	440	440
Available existing capacity	7019	6813	6218	5790	5170

Source: Calculation of the Energy Team of this Study

While Table 17 shows peak load demand and needed capacity to cover the peak load with 5% reserve for both MRS & MESS:

Table 17 - Peak Load and Needed Capacity during 2011-2030 for MRS & MESS

		2011	2015	2020	2025	2030
Peak Load Demand (MW)		8507	10931	14074	17260	21176
Needed Capacity to cover Peak Load Demand (MW)	MRS	8932	11478	14777	18123	22235
	MESS	8843	10915	13545	15966	19103

Source: Calculation of the Energy Team of this Study

Table 18 shows available existing power generation capacity without retirements, under contracting, under contraction and under bidding power generation projects as well as power generation capacity to be installed during the period of study for both MRS & MESS

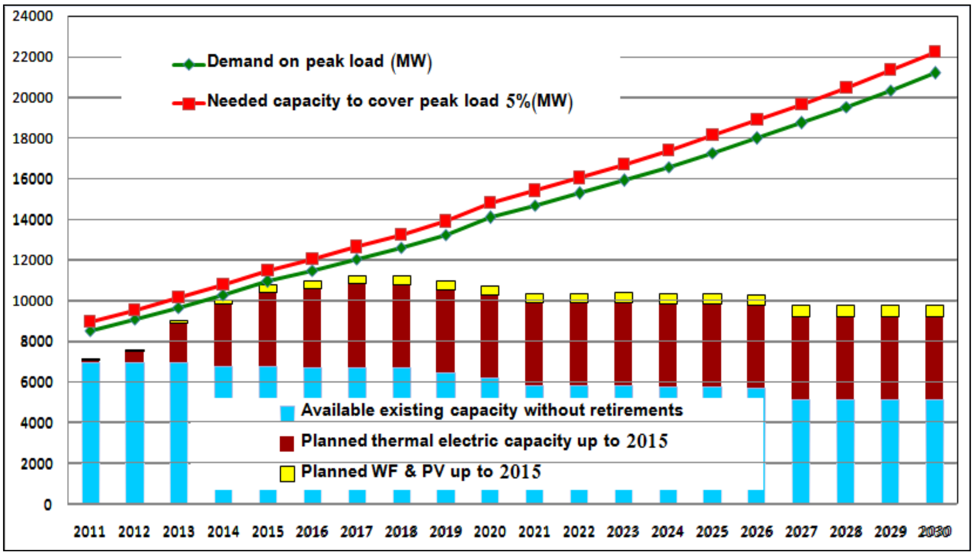
Table 18 - Available, planned and needed power capacity for MRS & MESS up to 2030

		2011	2015	2020	2025	2030
Existing capacity without retirements		7019	6813	6218	5790	5170
Planned thermal capacity up to 2015		150	3610	4110	4110	4110
Planned wind farms (WF) up to 2015		-	350	350	350	350
Planned Photovoltaic's (PV) up to 2015		3	38	38	38	38
Deficit or needed capacities to be added	MRS	1763	1055	4499	8323	13105
	MESS	1674	492	3217	6066	9823

Source: Calculation of the Energy Team of this Study

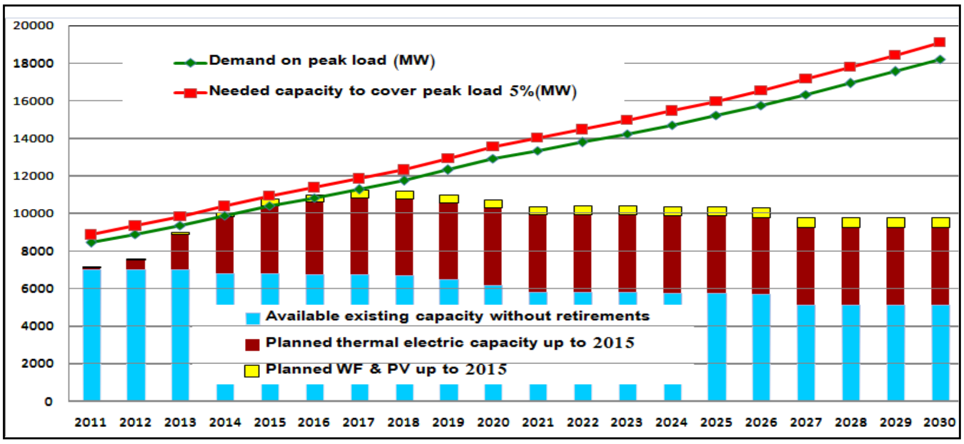
Figure 22 & Figure 23 show available existing capacity, planned thermal power generation & wind farms and PV systems to be installed up to 2015 and power generation capacity to be installed to cover peak load for MRS & MESS.

Figure 22 - Power Generation to be installed to cover the Peak Load for the MRS up to 2030



Source: Calculation of the Energy Team of this Study

Figure 23 - Power Generation to be installed to cover the Peak Load for the MESS up to 2030



Source: Calculation of the Energy Team of this Study

It was found that the electrical system needs to expand generation capacity at the end of the study period in the MRS by 17900MW and 14300MW in the MESS to meet the demand for peak load.

Table 19 - Expansion of power generation up to 2030 for MRS

(MW)	2011	2015	2020	2025	2030
Public sector expansion projects:	0	0	2550	5400	10900
CSP			1000	1000	1000
Pumping storage hydro-pp (Halabieh-Zalabieh)			1000	1000	1000
Wind farms				1000	2000
New HFO fired steam power plants			300	900	2400
New CC power plants	0	0	250	1500	4500
Private sector expansion projects:	0	0	3500	7000	7000
CSP with water desalination			1000	1000	1000
2nd CSP				1000	1000
Wind farms			1500	2000	2000
PV				1000	1000
Coal fired Power plant No./1/			1000	1000	1000
Coal fired Power plant No./2/				1000	1000
Total	0	0	6050	12400	17900

Source: Calculation of the Energy Team of this Study

It is estimated that the public and private sector would contribute to the Syrian electric system by new RE power plants (wind farms: 2000MW by each sector, CSP: 1000 MW by public Sector & 2000MW by private sector, PV: 1000MW by private sector, 1000MW Pumping storage hydro-pp by public Sector). Two Coal fired Power plants would be implemented by private sector, while 4500MW CC power plants and 2400MW HFO fired steam power plants would be implemented by public sector.

Table 20 - Available & new power generation capacity up to 2030 for MRS

Label	2011	2015	2020	2025	2030
Available capacity & planned up to 2015	7172	10811	10766	10388	9818
New HFO fired ST power plants	0	0	300	900	2400
New coal fired ST power plants	0	0	1000	2000	2000
New CC power plants	0	0	250	1500	4500
CSP	0	0	2000	3000	3000
Pumping storage hydro-pp	0	0	1000	1000	1000
WF	0	0	1500	3000	4000
PV	0	0	0	1000	1000
Total	7172	10811	16816	22788	27718

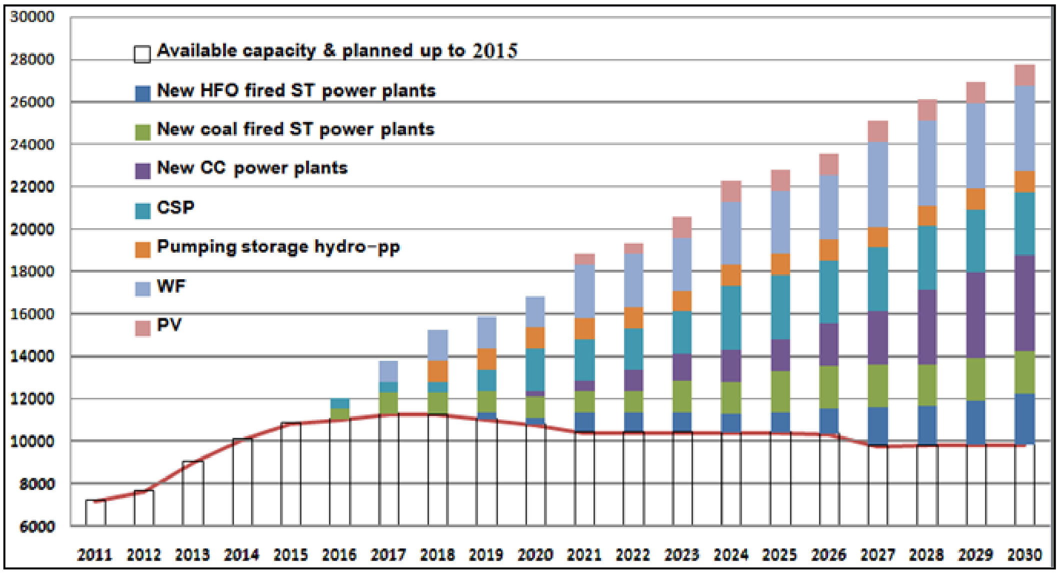
Source: Calculation of the Energy Team of this Study

Table 21 - Contribution of Public & Private Power Sectors to new Generation PP for both Scenarios up to 2030

(MW)		2011	2015	2020	2025	2030
Available capacity & planned up to 2015		7172	10811	10766	10388	9818
New public power sector plants	MRS	0	0	2550	5400	10900
	MESS	0	0	1350	3050	7800
New private power sector plants	MRS	0	0	3500	7000	7000
	MESS	0	0	3400	6100	6500
Total	MRS	7172	10811	16816	22788	27718
Total	MESS	7172	10811	15516	19538	24118

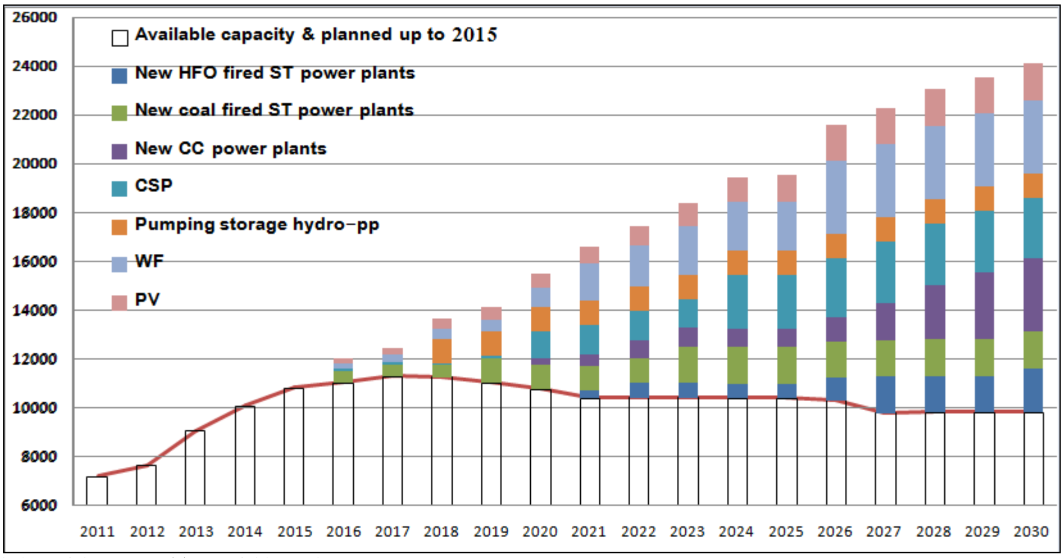
Source: Calculation of the Energy Team of this Study

Figure 24 - Available & new power generation capacity Forecast up to 2030 for MRS



Source: Calculation of the Energy Team of this Study

Figure 25 - Available & new power generation capacity Forecast up to 2030 for MESS



Source: Calculation of the Energy Team of this Study

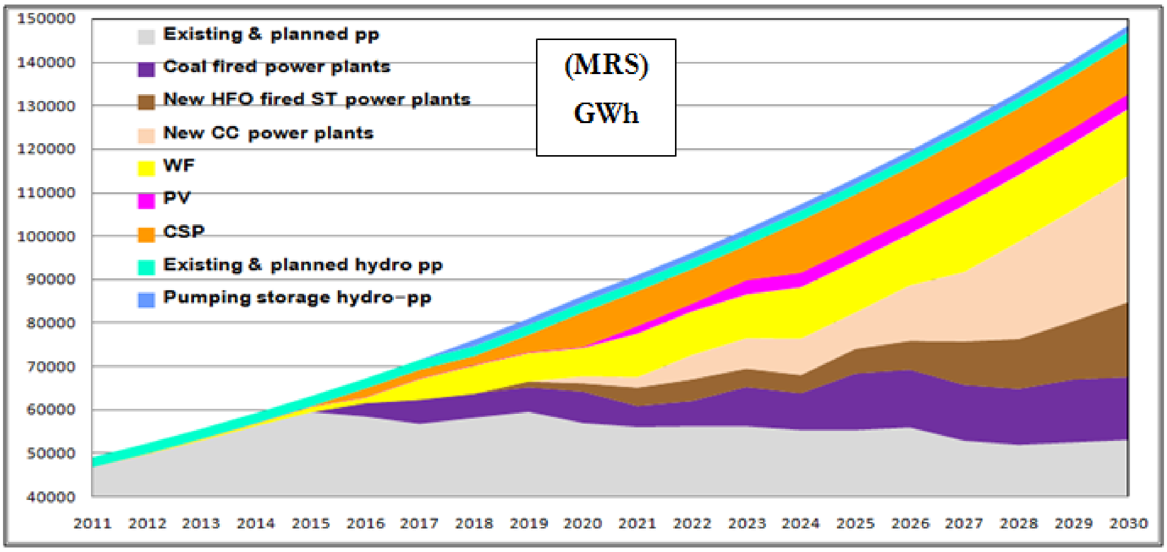
It is estimated that the public sector would contribute to the Syrian electric system by 10900MW new power plants for MRS & by 7800MW for MESS and the private sector would contribute by 7000MW for MRS & by 6500MW for MESS.

Table 22 - Electrical Energy Generated according to type of generation for both scenarios

GWh		2011	2015	2020	2025	2030
Existing & planned pp	MRS	46854	59476	56938	55335	53092
	MESS	46362	56376	56315	54967	52838
Existing & planned hydro pp	MRS	2320	2345	2300	2300	2300
	MESS	2320	2345	2300	2300	2300
Pumping storage hydro-pp	MRS	0	0	1460	1460	1460
	MESS	0	0	1460	1460	1460
Coal fired power plants	MRS	0	0	7200	12966	14400
	MESS	0	0	6496	10800	10800
New HFO fired ST power plants	MRS	0	0	2023	5760	17280
	MESS	0	0	0	3594	11272
New CC power plants	MRS	0	0	1600	8400	29039
	MESS	0	0	2000	6000	22000
WF	MRS	0	1225	6475	11725	15225
	MESS	0	1225	4025	8225	11725
PV	MRS	9	114	264	3414	3564
	MESS	9	114	2064	3714	5064
CSP	MRS	0	40	8040	12040	12040
	MESS	0	40	4440	8840	10040
Total	MRS	49183	63200	86300	113400	148400
	MESS	48691	60100	79100	99900	127500

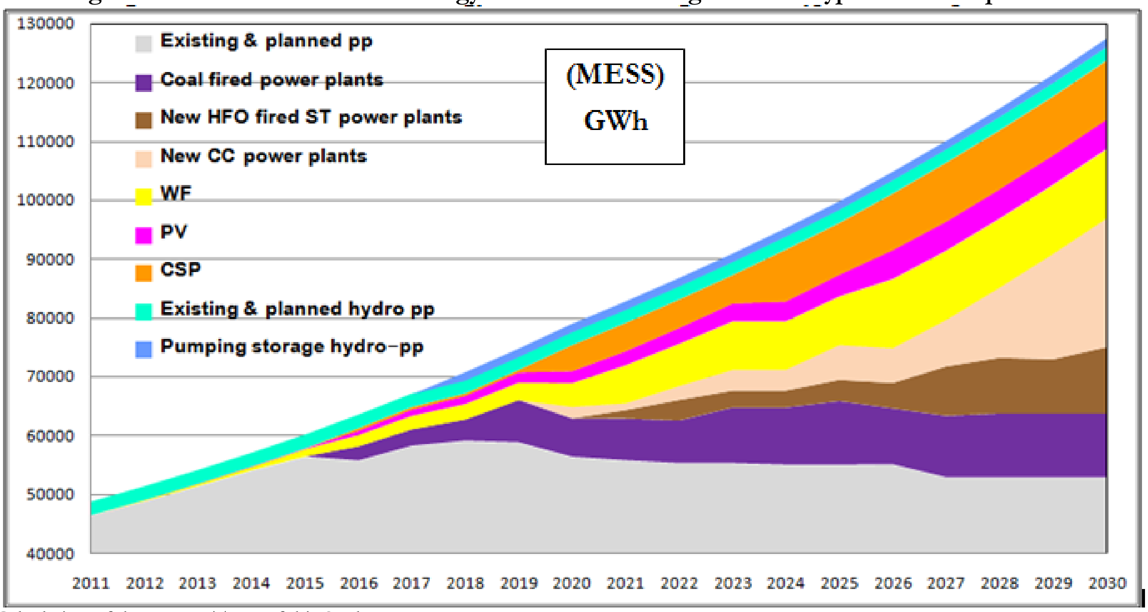
Source: Calculation of the Energy Team of this Study

Figure 26 - Forecast of Electrical Energy Generated according to PPs type for MRS up to 2030



Source: Calculation of the Energy Team of this Study

Figure 27 - Forecast of Electrical Energy Generated according to the PPs type for MESS up to 2030



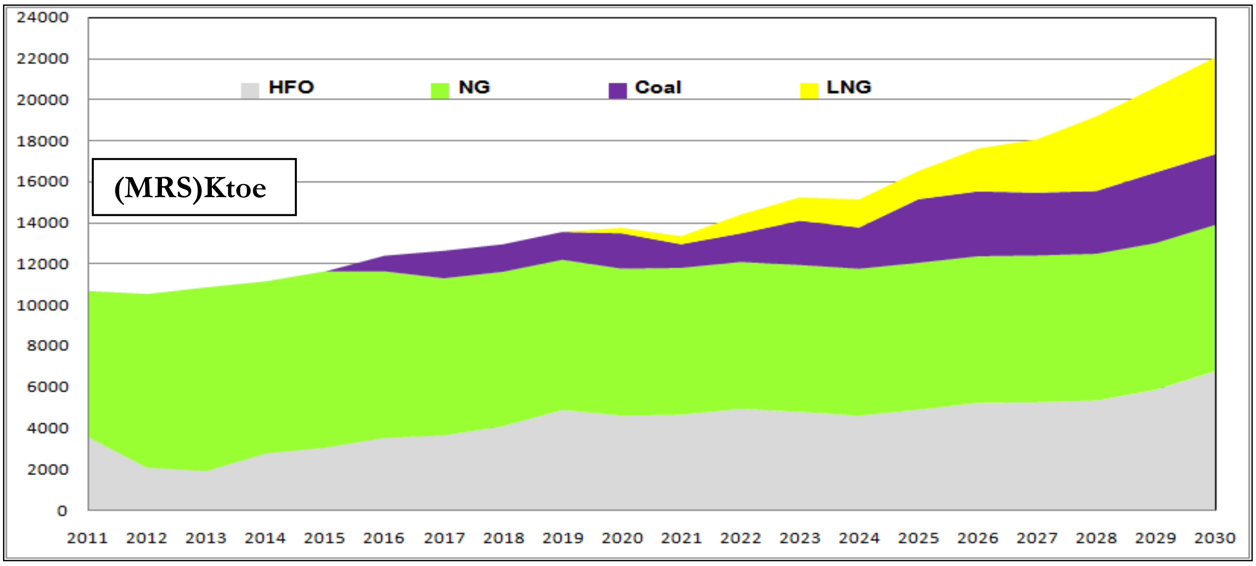
Source: Calculation of the Energy Team of this Study

Table 23 - Fossil fuel needed for thermal power plants up to 2030 for both scenarios

Label		2011	2015	2020	2025	2030
Needed HFO (Ktoe)	MRS	3608	3080	4632	4918	6778
	MESS	3608	2573	4066	4393	5504
Needed coal (Ktoe)	MRS	0	0	1728	3112	3456
	MESS	0	0	1559	2592	2592
Needed NG (Ktoe)	MRS	7063	8541	7128	7128	7128
	MESS	7063	8541	7128	7128	7128
Needed LNG (Ktoe)	MRS	0	0	259	1361	4704
	MESS	0	0	324	972	3564
Total (Ktoe)	MRS	10671	11621	13748	16520	22067
	MESS	10671	11114	13078	15085	18788

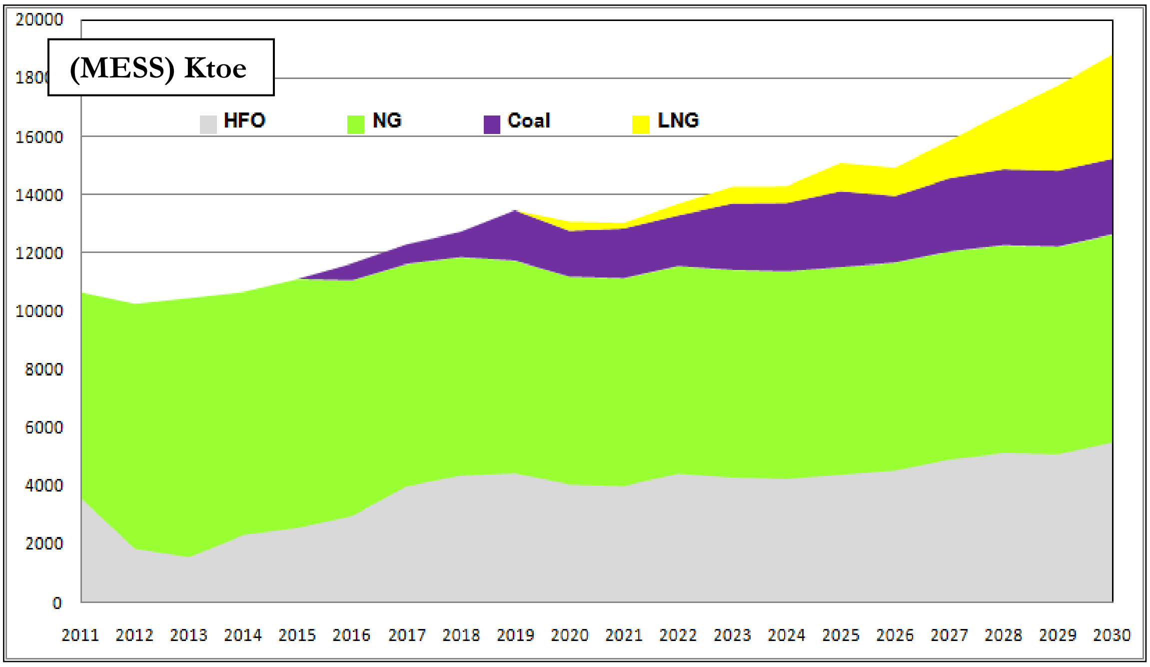
Source: Calculation of the Energy Team of this Study

Figure 28 - Fossil fuel needed to fire thermal power plants up to 2030 for MRS



Source: Calculation of the Energy Team of this Study

Figure 29 - Fossil fuel needed for thermal power plants up to 2030 for MESS (Ktoe)



Source: Calculation of the Energy Team of this Study

2. Country water needs for energy (current situation and trend until 2030)

Water is an integral element of energy resource development and utilization. It is used in energy-resource extraction, refining & processing, and transportation. Water is also an integral part of electric-power generation. It is used directly in hydroelectric generation and is also used extensively for cooling and emissions scrubbing in thermoelectric generation. Therefore, SAR should carefully consider energy and water development and management so that each resource is used according to its full value. Since new technologies can reduce water use, there will be a great incentive for their development. Given current constraints, many areas of the country will have to meet their energy and water needs by properly valuing each resource.

2.1. Water needs for the electricity supply sector (hydroelectricity & thermal power stations cooling - fresh water only)

Water is used in electric power generation. The energy sector can impact water quality via waste streams and air emissions that may affect downwind watersheds. Table 24 shows the connection between the electric power generation and water availability and quality[21].

Table 24 - Connections between Electric Power Generation and Water Availability and Quality

Energy Element	Connection to Water Quantity	Connection to Water Quality
Thermoelectric fossil)	Surface water and groundwater for cooling** and scrubbing	Thermal and air emissions impact surface waters and ecology
Hydroelectric	Reservoirs lose large quantities by evaporation	Can impact water temperatures,quality, ecology
Solar PV and Wind	None during operation; minimal water use for panel and blade washing	

*Impaired water may be saline or contain contaminants, **Includes solar steam-electric plants
Source: Dr M. Kordab, 2011

2.1.1. Water needs for Hydroelectricity

Hydroelectric power is an important component of the Syrian Electricity Generation. There are three hydropower generations in SAR with total installed capacity 1551MW generated about 2603GWh in 2010 as shown in Table 25. The hydropower plants are installed in Syria on the Euphrates River, they operate as run-of– river plants, as 58% of Euphrates River water is the share of Iraq, should pass to Iraq, so the plants operate by the transit water. They need from the Syrian water share of Euphrates River, only the evaporation from surface water of dams of hydropower station.

Table 25 - Installed Hydro Power Generation Capacity and electricity produced in 2010

Station	Total capacity installed (MW)	Total Electricity produced (MWh)
Al Thowra Hydro	840	1580
Teshrin Hydro	630	850
Al Baath Hydro	81	173
Total Hydro	1551	2603

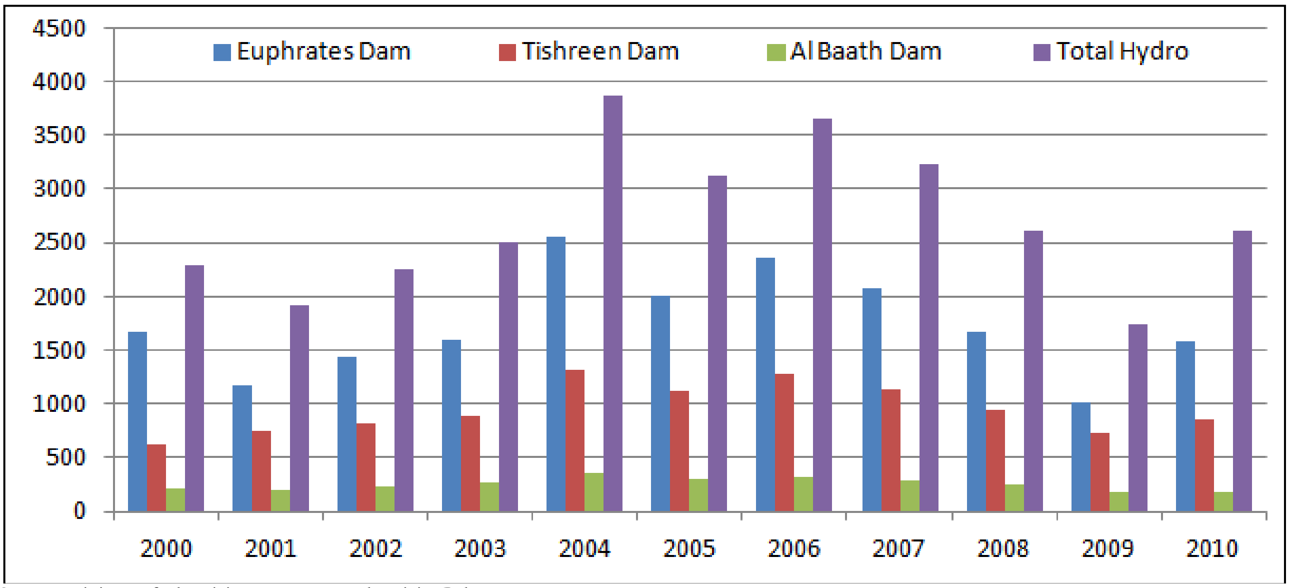
Source: Ministry of Electricity, Electricity Balances 2000-2010

Hydroelectric power production varies greatly with the amount of water available, depending upon weather patterns and local hydrology, as well as on competing water uses, such as flood control, water supply, recreation, and in-stream flow needs as shown in Figure 30, while Figure 31 shows the ratio of hydroelectric production of total electric production during the period 2000-2010.

Hydroelectric power plays an important role in stabilizing the electrical transmission grid and in meeting peak loads, reserve requirements, and other electric energy needs as it can respond very quickly to changing demand. Hydroelectric plant design and operation is highly diverse. Projects vary from storage reservoirs to run-of-river projects that have little or no active water storage. However, reservoir operation can shift water releases in time relative to natural flows.

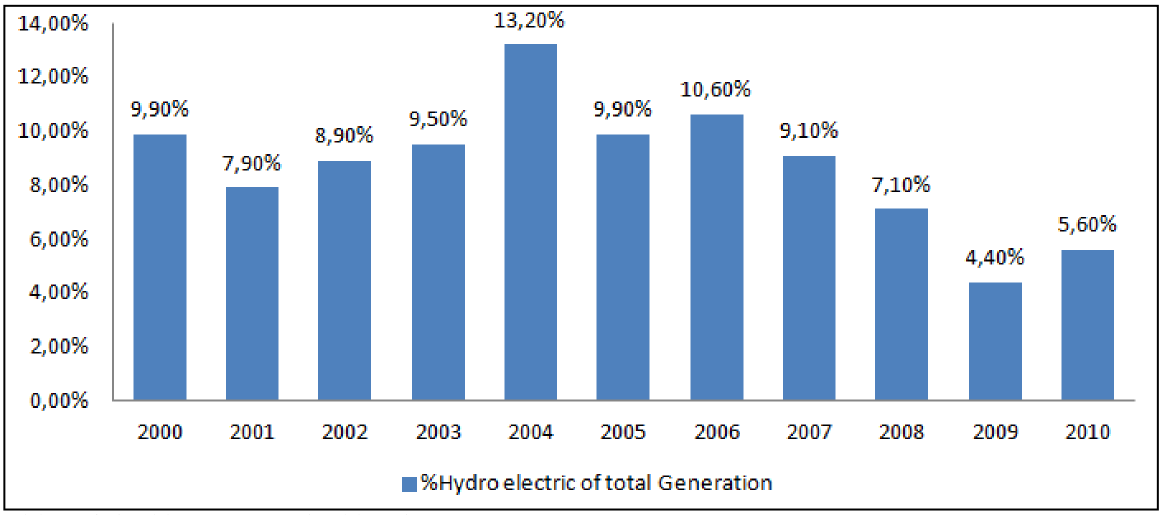
[21]U.S. Department of Energy, December 2006, Report to the Congress on the Interdependency of Energy and Water

Figure 30 - Total Hydro Electrical Energy Generated during 2000-2010



Source: Ministry of Electricity, 2000-2010, Electricity Balances

Figure 31 - The Ratio of hydroelectric production of total electric production during the period 2000-2010



Source: Ministry of Electricity, 2000-2010, Electricity Balances

Table 26 - Water needs for hydropower generation up to 2030

Hydropower generation		2010	2011	2015	2020	2025	2030
Evaporation from surface water of dams	MRS	1940.00	1940.00	1940.00	1795.00	1650.00	1650.00
	MESS	1940.00	1940.00	1940.00	1795.00	1650.00	1650.00
Water needs for hydropower generation	MRS	9356.48	9356.48	9457.31	9275.82	9275.82	9275.82
	MESS	9356.48	9356.48	9457.31	9275.82	9275.82	9275.82

Source: Calculation of the water team of this study

It is clear that there is no difference between the two scenarios in water needs for hydropower generation either for Evaporation or for generation.

2.1.2. Water needs for thermal power stations cooling

There is a relationship between the electricity demand and water supply stations for thermoelectric cooling and fuel reprocessing as well as for periodically washing the concentrators of CSPs. In addition to the water needs for cooling the thermal power plant, there are other uses of water cannot be ignored such as compensation of wet cooling circuit for assistance, compensation of wet cooling circuit for condensers, compensation of heating circuit, compensation of fire fitting, water services within the station, water services for the residential suburb, wash water heaters feedback, drinking water for residential suburb, in addition to irrigation water for the plant area.

The cooling process of the steam condenser circuit in steam power plants and combined cycle power plants in SAR, according to the following models:

- A – Open circuit cooling system: the use of seawater for cooling the steam condenser circuit through the sockets entry and exit of the seawater, as is the case of **Banias steam power plant**,
- B - Closed circuit cooling system: the condensation water is pumped to the cooling tower outside the turbine hall. The cooling towers can be of two types:
  - Dry cooling towers: the cooling process is using the ambiant air and peak coolers, as is the case in Tishreen steam power plants and combined cycle power plants in Gender, Derali, Nasrieh, and Zizon;
  - Wet Cooling towers: condensing water is cooled in cooling tower using ordinary water and formed steam off to the atmosphere, as is the case in **Aleppo steam power plant**.

The field follow-up assessment to water consumption in power plants in SAR showed, a major Lack of attention to recording the amount of consumed water on the one hand and the lack of counters on the socket surface water or pumped from groundwater wells at some power plants on the other hand, despite the scarcity of water in the areas of power plants, which suffer from low levels of groundwater as a result of depletion for different purposes.

Expected demand for water in expansion of thermoelectric power plants in SAR is calculated in this study for the different scenarios: RS, ESS, MRS & MESS, from the intersection of many references[22][23], in addition to estimates of some engineers in power plants in SAR, where the adoption of Water Specific Consumption (WSC) at thermoelectric power plants according to Table 27:

Table 27 - Water Specific Consumption for thermal power plants according to the type of PP

Water amount consumed by ST power plants	2.65	m^3/MWh
Water amount consumed by coal fired ST power plants	2.65	m^3/MWh
Water amount consumed by CSP power plants	2.8	m^3/MWh
Water amount consumed by WF & PV power plants*	0	m^3/MWh
Water amount consumed by GT power plants	0.19	m^3/MWh
Water compensation amount for ST of CC power plants	0.81	m^3/MWh

*Wind farms and photovoltaic power plant do not consume significant quantities of water
Source: Dr M. Kordab, 2011

Thermoelectric generating technologies that use steam to drive a turbine generator require cooling to condense the steam at the turbine exhaust. These plants can receive heat from a variety of sources. Some thermoelectric power plants are built adjacent to surface waters. They withdraw water for cooling and discharge the heated water back to the source.

[22] U.S. Department of Energy, December 2006 Report to the Congress on the Interdependency of Energy and Water
[23] The adverse effects of coal power plants on water resources

There are eleven thermal power plants in SAR distributed in the Syrian territory their thermal installed capacity is 7152 MW as shown in the Table 28. While, the evolution of thermal electrical energy generation by turbine type during the period 2000-2010 is illustrated in Table 29.

Table 28 - Installed Thermal Power Generation Capacity 2010

Station	Total installed capacity (MW)	GT& CC capacity (MW)	Steam turbines capacity (MW)
Der Ali	720	500	220
Tishreen thermal	1036	506	530
Al Nasrieh	504	354	150
Jandar	703	474	229
Zezoon	504	354	150
Banias	985	305	680
Mhardeh	665	35	630
Alzarah	660	-	660
Aleppo	1100	35	1065
Al Taim	105	105	-
Swedieh	170	170	-
Total Thermal	7152	2838	4314

Source: Ministry of Electricity, Electricity Balance-2010

Table 29 – Thermal electric generation by turbine type during the period 2000-2010 (GWh)

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Steam T	12775	14492	14770	15870	16468	18985	21328	22552	23986	22833	21152
Gas T	5721	5642	5775	5775	6410	7323	6992	7303	3761	6969	4163
CC	4219	4479	4968	5085	4952	5182	5190	5263	10404	11581	18493
Total Thermal	22715	24595	25513	26730	27830	31490	33510	35118	38151	41383	43808

Source: Dr M. Kordab, 2011

Water needs for cooling vary from power plant to another according to the cooling system used in the plant, either it is dry or wet system. The availability of enough volume of water is critical to the power plant operation. Additionally, the intake and discharge of large volumes of water by these plants have potential environmental consequences. Table 30 illustrates water consumption in thermoelectric power plants of SAR according to the plant type.

Table 30 - Water consumption by thermoelectric generation during the period 2000-2010(MCM)

	Water consumption by Steam Turbines (MCM)	Water consumption by Gas Turbines (MCM)	Water consumption by Combined Cycle(MCM)	Total Water consump. by Ther. Elec. Gen.
2000	34.49	1.09	3.42	39.00
2001	39.13	1.07	3.63	43.83
2002	39.88	1.10	4.02	45.00
2003	42.85	1.10	4.12	48.07
2004	44.46	1.22	4.01	49.69
2005	51.60	1.40	4.20	57.20
2006	57.89	1.33	4.20	63.42
2007	60.89	1.39	4.26	66.54
2008	64.76	0.72	8.43	73.91
2009	61.65	1.32	9.38	72.35
2010	57.11	0.79	14.98	72.88

Source: Dr M. Kordab, 2011

Table 31 - Forecast of water consumption by thermoelectric generation up to 2030 for RS*

(MCM)	2011	2015	2020	2025	2030
Combined cycle	23.570	35.860	45.283	58.551	80.965
Steam PP	45.408	37.657	27.014	24.046	18.928
Single GT	0.000	0.000	0.000	0.000	0.000
Nuclear PP	0.000	0.000	11.143	29.714	29.714
WF	0	0	0	0	0
CSP	0.000	0.000	0.000	5.600	11.200
PV	0	0	0	0	0
Hydro-electric	0	0	0	0	0
Coal	0.000	0.000	0.000	0.000	14.509
Total	69	74	83	118	155

*RS the Reference Scenario of NERC-GTZ of EE & RE Masterplan, 2010
Source: Dr M. Kordab, 2011

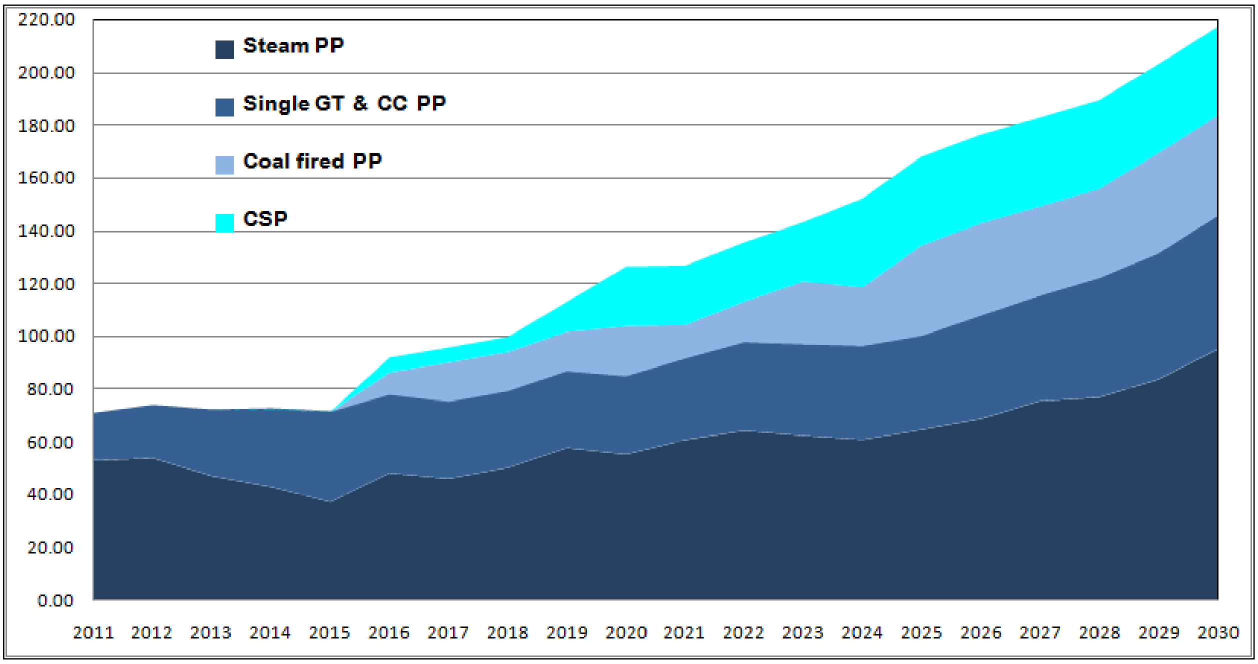
Table 32 and Figure 32 forecast of water consumption by thermoelectric generation up to 2030 for the RS adopted in NERC-GTZ study.

Table 32 - Forecast of water consumption by thermoelectric generation up to 2030 for the MRS

(MCM)	2011	2015	2020	2025	2030
Water consumed by ST PP	52.71	36.94	55.02	64.40	94.81
Water consumed by GT & CC PP	18.09	34.48	29.89	35.80	50.72
Water consumed by coal fired PP	0.00	0.00	19.08	34.36	38.16
Water consumed by CSP	0.00	0.11	22.51	33.71	33.71
Total water amount	70.80	71.54	126.50	168.27	217.40

Source: Dr M. Kordab, 2011

Figure 32 - Forecast of water consumption by thermoelectric generation up to 2030 for the MRS



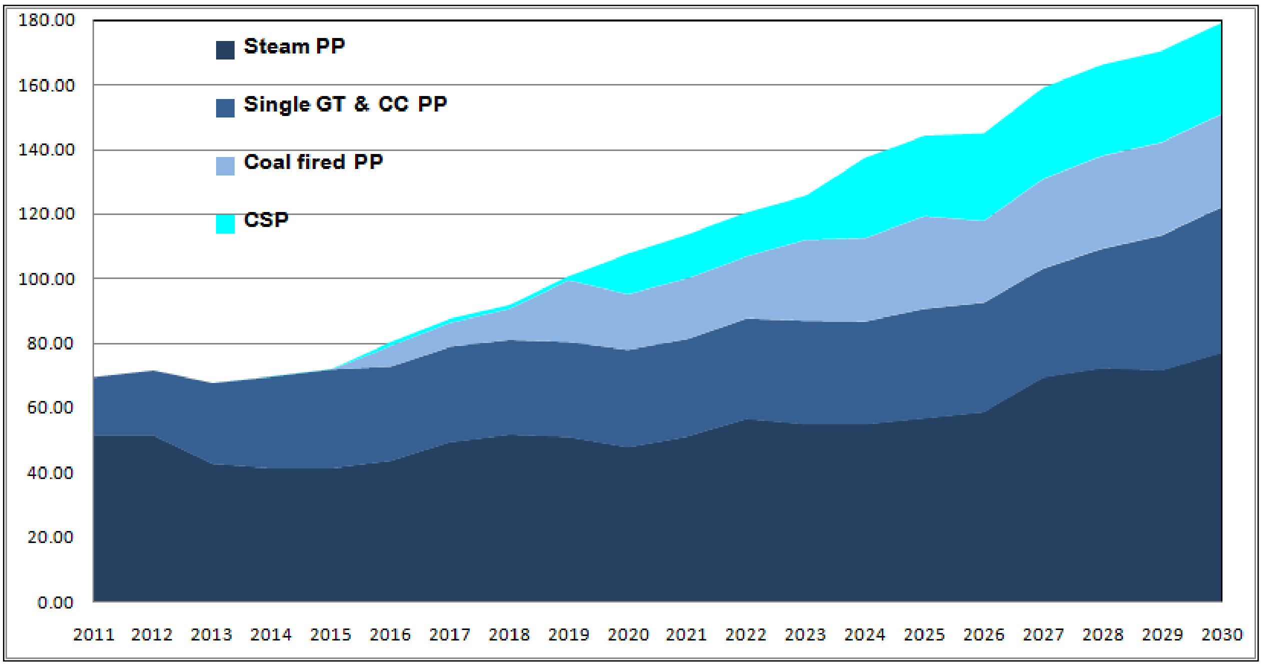
Source: Dr M. Kordab, 2011

Table 33 - Forecast of water consumption by thermoelectric generation up to 2030 for the MESS

(Million cubic meters)	2011	2015	2020	2025	2030
Water consumed by ST PP	51.40	41.18	47.72	56.72	76.95
Water consumed by GT & CC PP	18.09	30.73	30.30	33.98	45.24
Water consumed by coal fired PP	0.00	0.00	17.21	28.62	28.62
Water consumed by CSP	0.00	0.11	12.43	24.75	28.11
Total water amount	69.49	72.02	107.66	144.07	178.92
(Million cubic meters)	2011	2015	2020	2025	2030
Water consumed by ST PP	51.40	41.18	47.72	56.72	76.95
Water consumed by GT & CC PP	18.09	30.73	30.30	33.98	45.24
Water consumed by coal fired PP	0.00	0.00	17.21	28.62	28.62
Water consumed by CSP	0.00	0.11	12.43	24.75	28.11
Total water amount	69.49	72.02	107.66	144.07	178.92

Source: Dr M. Kordab, 2011

Figure 33 - Forecast of water consumption by thermoelectric generation up to 2030 for the MESS



Source: Dr M. Kordab, 2011

2.2. Water needs for the petroleum production and provision sector

Water is used throughout the energy sector, including in resource extraction, production, refining and processing. The energy sector also can impact water quality via waste streams, produced water from oil and gas extraction, and air emissions that may affect downwind watersheds.

Table 34 below shows the connections between the electric power generation and water availability and quality.

Table 34 - Connections between Oil &Gas Extraction, Production Refining and Processing and Water Availability and Quality[24]

Energy Element	Connection to Water Quantity	Connection toWater Quality
Oil &Gas Extraction, Production		
Oil and Gas Exploration	Water for drilling, completion, and fracturing	Impact on shallow groundwater quality
Oil and Gas Production	Large volume of produced, impaired water*	Produced water can impact surface and groundwater
Refining and Processing		
Traditional Oil and Gas Refining	Water needed to refine oil and gas	End user can impact water quality
Energy Transportation and Storage		
Energy Pipelines	Water for hydrostatic testing	Wastewater requires treatment

*Impaired water may be saline or contain contaminants,
Source: Dr M. Kordab, 2011

2.2.1. Water needs in oil & gas production

Water is consumed in oil and natural gas production during drilling oil exploratory wells and during drilling for producing crude oil and natural gas.

The average amount of water consumed in drilling one linear meter by the Syrian Oil Company (SOC) is $6.8m^3/m$. This water consumption rate varies, according to the quality of drilling, if it is for the exploration or for production. In exploratory drilling the rate is around $10m^3$ of water for drilling one linear meter. Often the exploratory drilling accompanied by unexpected problems such as smuggling of drilling fluids due to the lack of knowledge of layers excavated, while in the production drilling the rate is about $3.43m^3$ for one linear meter, this includes installation of the dredger until the end of drilling and the deportation of the dredger, as well as the smuggling of drilling fluid through the penetration of layers, in addition to cooling Engines.

During the period 1961 – 1975 more than 485 wells for exploration had been drilled, during the period 1975 – 1985 about 270 exploratory wells had been drilled and during the period 1986-1995 more than 112 exploratory wells had been drilled and enabled the discovery of 15 oil and gas fields. This period was accompanied by the signing of exploration contracts with 12 foreign companies covered 71 thousand km^2 in addition to the activities of the Syrian Oil Company.

In the period 2003-2007, 14 contracts were signed with foreign companies for oil and natural gas exploration, covering an area of 77 thousand km^2.

Assuming each company has drilled two exploratory wells / year and the Syrian Oil Company has drilled 10 exploratory wells / year, so the total was 62 exploratory wells per year. The average depth of drilling is 3000m. Each exploratory well requires $6.8m^3$ per linear m.

The amount of water needed for drilling the exploration wells = 1.265MCM / year.

Assuming 100 productive wells are drilled/year for a depth ranging between 1750-3700m (average depth is 2500m).

The water needed for a production well is $3.43m^3$ per m.

The amount of water needed for drilling the productive wells = 0.858MCM / year.

As the crude oil production in Syria amounts to 380000 barrels/day and as the average water consumption during oil production is about $0.072m^3$ per barrel of oil.

---

[24] U.S. Department of Energy, December 2006, Report to the Congress on the Interdependency of Energy and Water

The amount of water needed for oil production per year= 9.987 MCM/year.

The water quantity injected to increase the pressure of oil layer is equal 0.34m^3 per barrel of oil. A large part of it consumes for the disposal of water associated with oil and a second part to raise the pressure in the oil layer. The situation is different from company to another. For foreign companies Water injection is an important factor in raising the oil productivity. For example the Euphrates Company injects six barrels of water to produce one barrel of oil, 5 barrels of them are recycled and one barrel of new water from the Euphrates River is needed. If the company produces 100 thousand barrels per day that means 100 thousand barrels of new water per day are needed. After certain time of production from the field, it becomes necessary to raise the pressure by different means either water injection or lifting by N gas.

Assuming that 50% of the produced crude oil needs to be injected, each barrel requires 0.34m^3 water. The amount of water needed for injection to increase the oil layer pressure = 23.579MCM / year.

The total water needed for oil & NG exploration & production=35.689 MCM

2.2.2. Water needs in oil refining

As mentioned above, there are two refineries in Syria. The first is Homs refinery with 5.7 million tons/year capacity. It operates on a mixture of 60% heavy crude oil & 40% light crude oil. The second is Banias refinery with 6 million tons/year capacity. It operates on a mixture of 60% light crude oil and 40% heavy crude oil. Total water consumption in Homs refinery is about 1700m^3 per hour, which equal to 14.892MCM per year. The amount of crude oil refined in the refinery is 5.8 million tons; it means each ton of crude oil needs 2.56m^3 of water to be refined. This includes refining operations, fire fighting system and services.

The amount of water needed to refine 5.8 million tons of crude oil/year in Homs refinery = 14.848MCM/year.

Total water consumption in Banias refinery is about 1200m^3 per hour, which equal to 10.52MCM per year. The amount of oil refined in the refinery, equal to 6 million tons per year, the rate of water consumption is 1.75m^3 per ton oil.

The amount of water needed to refine 6 million tons of crude oil / year in Banias Refinery = 10.500MCM/year.

The difference in consumption between the two refineries that the design of Banias refinery is different and Homs refinery is older.

2.2.3. Water needs in gas treatment plants

Syria started to use natural gas in power generation since 1973 in the Syrian Oil Company in Swedish. NG production has been developed to reach 7 billion m^3 in 2000 and ranged between 8 to 9 billion m^3 per year until 2009. There are many treatment plants for natural gas in Syria some of them are old such as:

- Swedish Gas Treatment Plant which began in 1984, with capacity 660 000m^3/day
- Al Jbiseh Gas Treatment Plant which began in1988, with capacity of 2.98MCM/day
- Al omar Gas Treatment Plant began in 1992, with Capacity of 5MCM/day
- Deir Al-Zour Gas Treatment Plant began in 2001 with capacity 12.95MCM/day

The old treatment plants such as Aljbeseh Gas Treatment Plant is consuming about 100m^3 of water per hour, for cooling circuits, steam boilers, fire fighting system. 75% of them reused and 25% is a new water, that means the water consumption per day is 600m^3, and if the amount of processed gas is about 3 million m^3 per day , the share of 1000m^3 gas is equal to 0.2m^3 of water per 1000m^3 of N gas.

The amount of NG produced in Swedish, Aljbiseh, and Deir al-Zour plants = 21.59MCM/day

The amount of water needed by these **old plants = 1.577MCM of water per year**

The new gas treatment plants such as Alfreklos are more efficient in the consumption of water due to its new design, they consume about 500m³ per day and handle about 6.3 million m³ NG/day, that means the consumption of water = 0.079m³ water per 1000m³ gas/day.

The amount of water needed for treating the gas = 0.182 million m³ of water per year. The total capacity of the natural gas processing plants will become 46 million m³ gas per day. The total amount of water needed in the **new treatment plants = 1.629 million m³ water/year**

2.3. Water needs for other energy supply sectors

In the industrial areas in the Hisia and **Khnaifis (Phosphate production)** there is a need to 1.8m³/sec which equal to **56.7 million m³/year**

The water needs for the refinery to be set up in **Alfreklos** = 0.3m³/sec. = **9.48 million m³ year**

In the severe drought years and low water resources, the first priority of using water is securing the water demand to meet the energy needs, then the needs for drinking and watering livestock, and can customize the amount of the vital minimum necessary in the circumstances to secure the required drinking water by 28 liters/day/per person in winter rise up to 42 liters/day/person in summer.

Table 35 - Water needs for oil, NG exploration & production, oil refining, NG treatment and mineral resources up tp 2030 for MRS & MESS

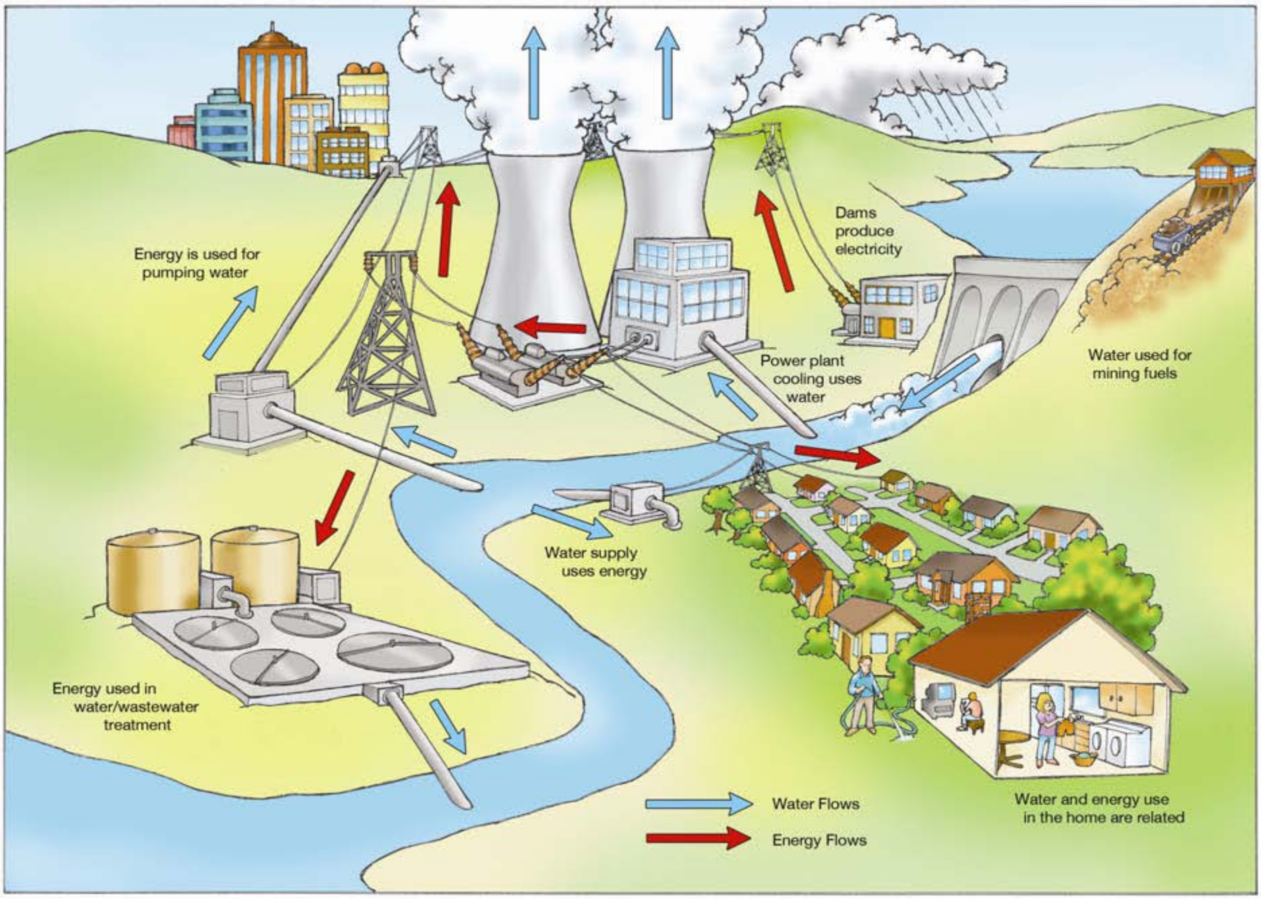
	2010	2011	2015	2020	2025	2030
Oil and NG exploration & production	35.586	35.586	35.586	35.586	35.586	35.586
NG treatment	1.629	1.629	1.629	1.629	1.629	1.629
Refinaries	25.348	25.348	25.348	34.828	34.828	34.828
Miniral resources production	56.700	56.700	56.700	56.700	56.700	56.700

Source: Dr M. Kordab, 2011

IV. Water-energy nexus until 2030

Energy and water are essential, interdependent resources. The availability of adequate water supplies has an impact on the availability of energy and energy production. Generation activities affect the availability and quality of water. In today's economies, energy and water are linked, as illustrated in Figure 34[25].

Figure 34 - Examples of interrelationships between water and energy



Source: Interdependency of Energy and Water, U.S. Department of Energy, December 2006

Each requires the other. These two resources also have increasing demand and growing. Lack of water for hydropower and for thermoelectric power plant cooling can constrain generation and has the potential to increase demand for technologies that reduce the water intensity of the energy sector. At the same time, demand for energy continues to grow. Unfortunately, freshwater withdrawals already exceed precipitation in many areas across the country, significant groundwater pumping or transport of surface water from other locales. Limitations on supply energy and water must begin to be managed together to maintain reliable energy and water supplies.

The interaction of energy and water supplies and infrastructures is becoming clearer. Low water levels from drought and competing uses have limited the ability of power plants to generate power. Additionally, water levels in aquifers have declined significantly, increasing energy requirements for pumping, and, in some cases, leading to ground subsidence issues.

The following paragraphs present the matrix of energy demand including energy needs for water for the two energy scenarios (modified reference scenario MRS) & (modified energy saving scenario MESS) and the

[25] Report to the Congress on the Interdependency of Energy and Water, U.S. Department of Energy, December 2006

matrix of water demand including water needs for energy for the three water scenarios (reference scenario RS), (alternative scenario AS) & (legal scenario LS).

1. Introducing the energy needs for water into the energy demand matrix

Electric energy is needed to supply fresh water to urban sector for domestic use & for services, to supply water to the industrial sector. Energy used in pumping water for irrigation & for pumping irrigation drainage and for watering live stock. Also, energy is used for pumping water from one basin to another as well as for waste water collection & treatment and for waste water re-use. Table 36 shows the electric energy demand for water according to water reference scenario (RS).

Table 36 - Electric Energy Demand Matrix for Water up to 2030 (water RS) (GWh)

Demand sector (GWh)	2009	2015	2020	2025	2030
Urban demand					
Domestic water	1028.50	1139.50	1304.20	1473.10	1551.20
Common services	28.70	31.80	36.40	41.10	43.30
Industry	207.60	229.20	258.10	285.00	314.70
Irrigation	2591.20	3041.50	3270.20	3236.80	3203.40
Irrigation drainage	103.65	121.66	130.81	129.47	128.14
Live stock	14.40	19.30	22.10	24.90	26.20
Water transport*	432.00	479.01	1346.49	1747.36	1780.19
Waste water collection	20.90	32.21	47.12	49.14	46.58
Waste water treatment**	48.24	77.42	120.83	149.21	162.87
Waste water re-use	32.83	47.42	57.56	66.00	69.28
Sea & saline water desalination	2.76	3.17	3.55	3.91	4.22
Total electric energy needs for water	4510.78	5222.19	6597.37	7206.00	7330.08
Total electric energy demand (MRS)	41023.00	63200.00	86300.00	113400.00	148400.00
Total final energy demand (MESS)	41023.00	60100.00	79100.00	99900.00	127500.00
for MRS %	11.00	8.26	7.64	6.35	4.94
for MESS %	11.00	8.69	8.34	7.21	5.75

*42% of drinking water is being transferred for distances more than the scope of the sub-basin, which needs energy for pumping, in average 0.25kWh/m^3 (1.1kWh/m^3 for each lifting stage of 250m). Noting that, Euphrates water is transferred to Aleppo by pumping with average lifting of 110m head, water of Al Sin River is pumped with average lifting of 80m head. After 2020, Euphrates water will be transferred to Palmyra with a rate of 3.0m^3/sec pumped to 450m head, 1.8m^3/sec of them will be pumped to Alfroklos & Hassia with average of 650m head. After 2025 Euphrates water will be transferred to Palmyra with a rate of 6.0m^3/sec, 4.0m^3/sec of them will be pumped to Alfroklos, Hassia, Khnevis and Damascus with average 550meters head. 1250MCM/year of Tigris River will be pumped to 80m head, 30MCM of which with an additional 68m head.

** Actually, 38% of urban wastewater is treated, energy is used for collecting and lifting half of it to 1-3 lifting stages, each stage is 12-15m head and needs an average of 0.13 kWh/m^3 of treated water. Energy is required for treatment, 0.15 kWh / m^3 is needed. In average it is assumed that 1.1kWh/m^3 is needed for pumped re- used water, this accounted to 40% of the total treated water in 2009 and will decline to 25% in 2030.

Source: Dr M. Kordab, 2011

It is clear that the total electric energy demand for water use was 11% of total electric energy generated in 2009, will be 8.26% for MRS & 8.69 for MESS in 2015, and will arrive to 4.94% for MRS & to 5.75% for MESS in 2030.

Table 37 shows urban waste water treated, collected and reused by pumping up to 2030.

Table 37 - Urban waste water treated, collected and reused by pumping up to 2030

		2009	2015	2020	2025	2030
Urban Waste water(BCM)	RS	0.85	0.94	1.07	1.21	1.28
Ratio of treated waste water%		38	55	75	82	85
Ratio of collected treated waste water by pumping%		50	48	45	38	33
Ratio of re-used treated waste water by pumping%		40	36	28	26	25
Urban Waste water(BCM)	AS	0.85	0.92	1.04	1.15	1.18
Ratio of treated waste water%		38	55	75	82	85
Ratio of collected treated waste water by pumping%		50	48	45	38	33
Ratio of re-used treated waste water by pumping%		40	36	28	26	25
Urban Waste water(BCM)	LS	0.85	0.9	1.01	1.11	1.12
Ratio of treated waste water%		38	55	75	82	85
Ratio of collected treated waste water by pumping%		50	48	45	38	33
Ratio of re-used treated waste water by pumping%		40	36	28	26	25

Source: Dr M. Kordab, 2011

Table 38 shows gasoil demand for water according to water RS. It shows that gasoil represented 1.24% of final energy demand in 2009 and decreases to 0.65% for MRS & to 0.74% in 2025.

Table 38 - Matrix of Gasoil (Diesel) Demand for water needs up to 2030 (water RS)

Demand sector (Ktoe)	2011	2015	2020	2025	2030
Agriculture & Irrigation (Ktoe)	223.71	260.16	275.99	269.93	263.93
Life stock (Ktoe)	1.24	1.38	1.58	1.78	1.88
Total gasoil neded for water (Ktoe)	224.95	261.54	277.57	271.71	265.81
Total final energy demand (MRS)	18159.92	22184.55	26759.08	33098.39	41014.58
Total final energy demand (MESS)	18159.92	20019.17	25112.01	30202.87	35973.23
Total energy for water in MRS %	1.24	1.18	1.04	0.82	0.65
Total energy for water in MESS %	1.24	1.31	1.11	0.90	0.74

Source: Dr M. Kordab, 2011

Table 39 shows the electric energy demand for water according to water alternative scenario (AS). In the other hand, gasoil (diesel) is needed for pumping underground water for irrigation & for life stock watering. Table 40 shows the gasoil demand for water according to water alternative scenario (AS).

The total electric energy demand for water use was 11% of total electric energy generated in 2009, would be 7.68% for MRS & 8.08 for MESS in 2015, and will arrive to 4.23% for MRS & to 4.92% in 2030.

Table 39 - Electric Energy Demand Matrix for Water up to 2030 (water AS) (GWh)

Demand sector(GWh)	2009	2015	2020	2025	2030
Urban demand					
Domestic water	1028.50	1088.80	1182.80	1294.50	1305.80
Common services	28.70	31.80	36.40	41.10	43.30
Industry	207.60	224.60	262.90	291.00	325.70
Irrigation	2591.20	2754.90	2638.70	2578.00	2488.90
Irrigation drainage	103.65	110.20	105.55	103.12	99.56
Life stock	14.40	19.30	22.10	24.90	26.20
Water transport	432.00	469.43	1330.05	1716.40	1728.03
Waste water collection	20.90	31.56	45.71	46.68	42.86
Waste water treatment	48.24	75.87	117.20	141.75	149.84
Waste water re-use	32.83	46.47	55.83	62.70	63.73
Sea & saline water desalination	2.76	3.17	3.55	3.91	4.22
Total energy for water	4510.78	4856.10	5800.80	6304.07	6278.14
Total final energy demand(MRS)	41023.00	63200.00	86300.00	113400.00	148400.00
Total final energy demand (MESS)	41023.00	60100.00	79100.00	99900.00	127500.00
Total energy for water in MRS %	11.00	7.68	6.72	5.56	4.23
Total energy for water in MESS %	11.00	8.08	7.33	6.31	4.92

Source: Dr M. Kordab, 2011

Table 40 - Matrix of Gasoil (Diesel) Demand for water needs up to 2030 (water AS)

Demand sector (Ktoe)	2009	2015	2020	2025	2030
Agriculture& Irrigation (Ktoe)	223.71	235.68	222.69	214.07	205.07
Life stock (Ktoe)	1.24	1.38	1.58	1.78	1.88
Total gasoil needed for water(Ktoe)	224.95	237.06	224.27	215.85	206.95
Total final energy demand (MRS)	18159.92	22184.55	26759.08	33098.39	41014.58
Total final energy demand (MESS)	18159.92	20019.17	25112.01	30202.87	35973.23
Total energy for water in MRS %	1.24	1.07	0.84	0.65	0.50
Total energy for water in MESS %	1.24	1.18	0.89	0.71	0.58

Source: Dr M. Kordab, 2011

Gasoil represented 1.24% of final energy demand in 2009 and decreases to 0.50% for MRS & to 0.58% in 2030. Oil needed for pumping ground water for irrigation and life stock will decrease up to 2030 by shifting to PV water pumping systems.

Table 41 shows the electric energy demand for water according to water legal scenario (LS).

Table 41 - Electric Energy Demand Matrix for Water up to 2030 (water LS) (GWh)

Demand sector(GWh)	2009	2015	2020	2025	2030
Urban demand Domestic water Common services	 1028.50 28.70	 1023.20 31.80	 1135.10 36.40	 1229.20 41.10	 1240.50 43.30
Industry	207.60	226.50	259.10	277.80	287.80
Irrigation	2591.20	2574.50	2335.00	2257.80	2159.60
Irrigation drainage	103.65	102.98	93.40	90.31	86.38
Life stock	14.40	19.30	22.10	24.90	26.20
Water transport	432.00	460.04	1314.09	1692.87	1698.03
Waste water collection	20.90	30.93	44.34	44.82	40.71
Waste water treatment	48.24	74.35	113.69	136.08	142.35
Waste water re-use	32.83	45.54	54.16	60.20	60.55
Sea & saline water desalination	2.76	3.17	3.55	3.91	4.22
Total electric energy for water	4510.78	4592.32	5410.93	5858.99	5789.65
Total final energy demand (MRS)	41023.00	63200.00	86300.00	113400.00	148400.00
Total final energy demand (MESS)	41023.00	60100.00	79100.00	99900.00	127500.00
Total energy for water in MRS %	11.00	7.27	6.27	5.17	3.90
Total energy for water in MESS %	11.00	7.64	6.84	5.86	4.54

Source: Dr M. Kordab, 2011

In the other hand gasoil (diesel) is needed for pumping underground water for irrigation & for life stock watering. Table 42 shows the gasoil demand for water according to water legal scenario (LS).

Table 42 - Matrix of Gasoil (Diesel) Demand for water needs up to 2030 (water LS)

Demand sector (Ktoe)	2009	2015	2020	2025	2030
Agriculture & Irrigation (Ktoe)	223.71	161.94	116.25	105.5	103.13
Life stock (Ktoe)	1.24	1.38	1.58	1.78	1.88
Total gasoil needed for water(Ktoe)	224.95	163.32	117.83	107.28	105.01
Total final energy demand (MRS)	18159.92	22184.55	26759.08	33098.39	41014.58
Total final energy demand (MESS)	18159.92	20019.17	25112.01	30202.87	35973.23
Total energy for water in MRS %	1.24	0.74	0.44	0.32	0.26
Total energy for water in MESS %	1.24	0.82	0.47	0.36	0.29

Source: Dr M. Kordab, 2011

Gasoil represented 1.24% of final energy demand in 2009 and decreases to 0.26% for MRS & to 0.29% for MESS in 2030 as other renewable technology systems will be used for water pumping up to 2030.

Gasoil is needed in the three scenarios for agriculture & irrigation and for life stock. The total gasoil needed for water in 2030 is 265.81ktoe for RS, 206.95ktoe for AS and 105.01ktoe for LS. As the total final energy demand for the energy MRS is the same for the three water scenarios equal 41014.58ktoe as well as for MESS for the three water scenarios equal 35973.23ktoe that gives the percentage of energy for water in MESS more than the percentage of energy for water in MRS.

2. Introducing the water needs for energy into the water demand matrix

Water is used for power generation either directly by hydro-power generation plants or indirectly for thermoelectric cooling and many other services in the thermal power plants. for fuel reprocessing as well as for periodically washing concentrators of CSPs. Water is also needed throughout the energy sector, in oil & NG extraction & production either during drilling exploratory wells or during drilling for producing crude oil and natural gas as well as during oil refining and processing. Table 43 shows the matrix of estimated water demand for energy sector during 2011-2030 for the modified reference scenario (MRS), while Table 44 shows the matrix for the modified energy saving scenario (MESS).

Table 43 - Water Demand Matrix for Energy up to 2030 (MCM)

Demand sector(MCM)	MRS				
	2011	2015	2020	2025	2030
Hydro-power generation					
Ev. From surface water of dams	1940.00	1940.00	1795.00	1650.00	1650.00
Water needs for hydro-power generation	9356.48	9457.31	9275.82	9275.82	9275.82
Oil and NG sector					
Oil and NG exploration and production	35.586	35.586	35.586	35.586	35.586
NG treatment	1.629	1.629	1.629	1.629	1.629
Oil Refineries	25.348	25.348	34.828	34.828	34.828
Mineral resources production	56.700	56.700	56.700	56.700	56.700
Thermo-electric generation sector					
ST PP	52.710	36.940	55.020	64.400	94.810
CC PP and GT PP	18.090	34.480	29.890	35.800	50.720
Coal fired PP	0.000	0.000	19.080	34.360	38.160
CSP	0.000	0.110	22.510	33.710	33.710
Net total water needs for energy	190.063	190.793	255.243	297.013	346.143
Total national water needs RS	17908.00	19093.56	20859.64	21125.50	21291.54
Total water needs for energy % of national water needs (RS)	1.06	1.00	1.22	1.41	1.63
Total national water needs AS	17908.00	18003.00	18234.55	18167.62	17925.16
Total water needs for energy % of national water needs (AS)	1.06	1.06	1.40	1.63	1.93
Total national water needs LS	17908.00	16386.81	14677.25	14401.87	14070.81
Total water needs for energy % of national water needs (LS)	1.06	1.16	1.74	2.06	2.46

Source: Dr M. Kordab, 2011

Table 43 shows the total water needs for energy, in the energy MRS, is 190.793MCM in 2015, 255.243MCM in 2020 and 346.143MCM in 2030. That equal:

- 1%, 1.22% & 1.63% of the total national water needs in the RS in the years 2015, 2020 & 2030 respectively,
- 1.06%, 1.4% & 1.93% of the total national water needs in the AS in the years 2015, 2020 & 2030 respectively,
- 1.16%, 1.74% & 2.46% of the total national water needs in the LS in the years 2015, 2020 & 2030 respectively.

The percentage of the total water needs for energy is the biggest in the LS because the total national water needs in the LS is the lowest.

Table 44 - Water Demand Matrix for Energy up to 2030 (MCM)

Demand sector (MCM)	MESS				
	2011	2015	2020	2025	2030
Hydro-power generation					
Ev. Tr. from surface water of dams	1940.00	1940.00	1795.00	1650.00	1650.00
Water needs for hydro-power generation	9356.48	9457.31	9275.82	9275.82	9275.82
oil and NG sector					
Oil and NG exploration and production	35.586	35.586	35.586	35.586	35.586
NG treatment	1.629	1.629	1.629	1.629	1.629
Refineries	25.348	25.348	34.828	34.828	34.828
Mineral resources production	56.700	56.700	56.700	56.700	56.700
Thermo-electric generation sector					
ST PP	51.400	41.180	47.720	56.720	76.950
CC PP and GT PP	18.090	30.730	30.300	33.980	45.240
Coal fired PP	0.000	0.000	17.210	28.620	28.620
CSP	0.000	0.110	12.430	24.750	28.110
Net total water needs for energy	188.753	191.283	236.403	272.813	307.663
Total national water needs RS	17908.00	19093.56	20859.64	21125.50	21291.54
Total water needs for energy % of national water needs (RS)	1.05	1.00	1.13	1.29	1.45
Total national water needs AS	17908.00	18003.00	18234.55	18167.62	17925.16
Total water needs for energy % of national water needs (AS)	1.05	1.06	1.30	1.50	1.72
Total national water needs LS	17908.00	16386.81	14677.25	14401.87	14070.81
Total water needs for energy % of national water needs (LS)	1.05	1.17	1.61	1.89	2.19

Source: Dr M. Kordab, 2011

Table 44 shows the total water needs for energy, in the energy MESS, is 191.283MCM in 2015, 236.403MCM in 2020 and 307.663MCM in 2030. That equal:

- 1%, 1.13% & 1.45% of the total national water needs in the RS in the years 2015, 2020 & 2030 respectively,
- 1.06%, 1.3% & 1.72% of the total national water needs in the AS in the years 2015, 2020 & 2030 respectively,
- 1.17%, 1.61% & 2.19% of the total national water needs in the LS in the years 2015, 2020 & 2030 respectively.

The percentage of the total water needs for energy is the biggest in the LS because the total national water needs in the LS is the lowest.

3. The need for an integrated planning approach for both energy and water

In SAR, where most of its territory is in the semi arid zone, water is a limited and valuable natural resource. Until today, the General Establishment for Electricity Generation and Transmission (GEEGT) do not adequately integrate water into electric resource planning.

However it is very important to:

1) Integrate the value of water into electric resource planning and to outline important policy changes that would improve integration.
2) Develop a range of values for use in electric planning as the value of water varies from one location to another, according to the type of use and scarcity of the resource.

As SAR population continue to grow and climate change reduces available supplies, the scarcity and value of water will undoubtedly increase.

When developing and evaluating electric resource plans, GEEGT & the concerned water Utility should consider the cost of committing water to power generation over the life time of the power plant.

In SAR, water is essential for sustaining agriculture, municipalities, industrial operations, and many forms of electricity generation. Yet water has historically been underpriced and undervalued due in large part to the externalities associated with its supply, use, and reallocation. To efficiently allocate water, managers should evaluate the full value of water, including use values, non-use values, and any externalities. As water scarcity increases, recognizing the long-term value of water will be increasingly important.

SAR has seen the fastest population growth in MENA region. In addition, it is projected that climate change will increase average temperatures and Evapotranspiration rates. Historically, drought conditions and a growing population have increased the value of water.

Accordingly, we would expect the value of water in the SAR to continue rising in the future. Importantly, energy efficiency and water-efficient renewable energy sources like wind and solar photovoltaic can provide both direct and indirect long-term water savings. By reducing the demand for electricity generation, energy efficiency measures can reduce water use at existing power plants and delay the need to develop new plants. Even certain energy efficiency measures, like ultra-low flow showerheads, save water directly. Concerned utilities' resource plans should reflect the benefits or costs of energy choices—whether renewable, energy efficiency, or conventional sources of energy—on water.

To better integrate water into electric resource-planning processes, it is important to assess the cost and value of water for thermoelectric generation and the value of water for alternative uses[26].

Water use at thermoelectric power plants competes directly with the water demands of cities, agriculture, and environmental needs. Recently, utilities and developers have proposed building new thermoelectric power plants in rural locations, distant from municipalities.

Many of these rural plants will draw on water supplies that would other- wise sustain agriculture or environmental needs, and in many cases, the municipal value of water is not directly relevant.

As utilities consider the retirement of older, water-intensive plants, they should consider the economic benefit the water could provide. Water used by electric utilities has value because:

1) it costs money to obtain, deliver, and treat water used to condense steam in thermoelectric power plants;
2) water may have value in alternative uses;

---

[26] Stacy Tellinghuisen, Water for Power Generation: What's the Value? Natural Resources Journal [Vol. 50]

3) water in specific locations may be scarce, resulting in an economic rent on water.

Electric utilities should examine all three aspects of value when assessing additions of new power plants and considering continued operation of existing power plants.

The value of water for alternative uses will vary, depending on the location and competing demands.

At a minimum, GEEGT should report water consumption for existing facilities, and projected water consumption for different proposed future PP as part of their integrated resource plans. Finally, in considering new water intensive power plants, utilities should assess both the value of water today and the potential value of water in the future.

V. Water-energy-climate change nexus until 2030

1. Climate change in Syria (evolution of temperatures, precipitation predicted extremes in the case of A2 and B2 or B1 scenario as possible)

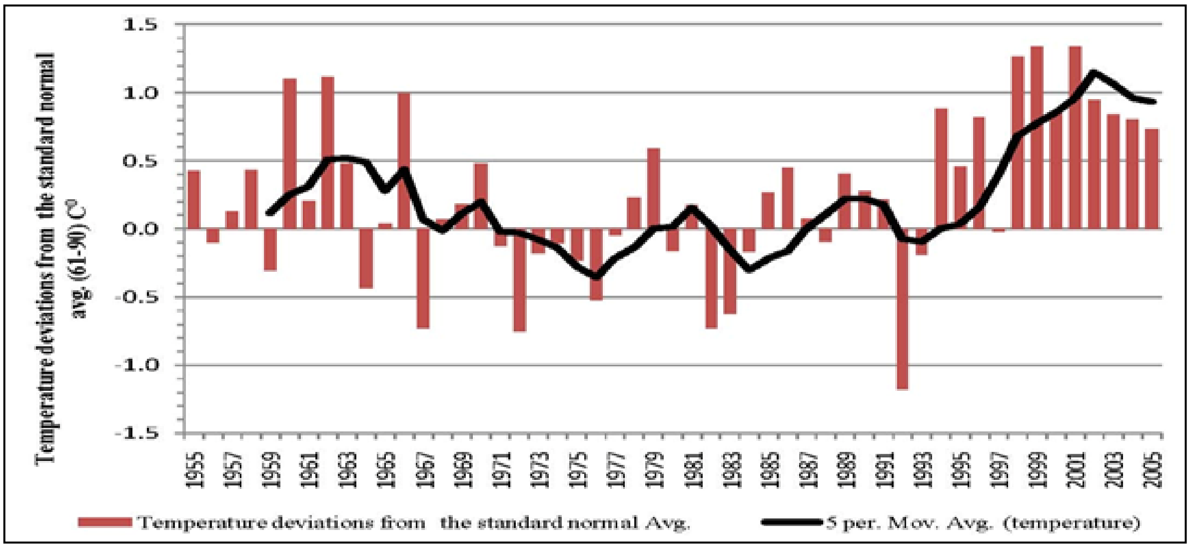
During the reference period, Syria's climate was characterized by the Mediterranean climate; humid to semi-humid in the western and mountainous parts, dry to semi-dry in the inland plains in the eastern and southeastern parts with average annual rainfall starting from 1400mm/year in the coastal region to less than 100mm/year in the Badia. Rain falls in end-Autumn, Winter and Spring. Hot dry climate is dominant over the long summer in which mean temperature reaches 30°C. Table 45 shows the climatic elements (temperature T°C, relative humidity H% and wind speed V m/sec) in different areas of Syria.

Table 45 - Climatic elements (temperature, relative humidity & wind velocity of Syria's areas)

Geographic area	Climate elements							
	Temperature (° C)				Humidity, H (%)			Wind Speed m/sec
	annual Mean	Maximum Aug.	Minimum Average	Minimum	annual Mean	Maximum Aug.	Minimum an.-	3.6
Coastal Plain	18.1	29.9	15.4	8.0	67.0	73.0	60.0	3.8
Coastal mountains	15.2	27.4	11.6	4.0	60.0	65.0	76.0	2.9
Western Inland Area	17.4	37.7	11.0			49.0	75.0	4.0
Mountainous Western Inland	12.8	30.2	5.8					2.9
Northeastern Region	18.6	40.4	11.7			29.0	72.0	3.3
Arid Lands and the Steppe (Al-Badiah)	19.9	39.7	13.0			31.0	71.0	3.6

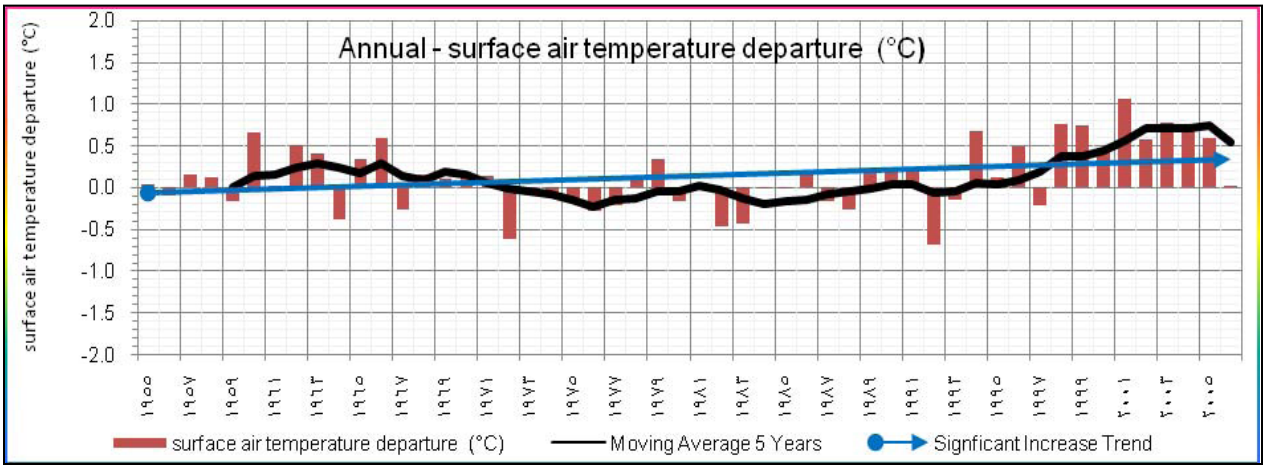
Source: Dr M. Kordab, 2011

Figure 35 - Mean Annual Temperature Deviations from the Standard Average for Stations Representative of Syria's Climate Zones during the Years 1955–2005



Source: Initial National Communication of the SYRIAN ARAB REPUBLIC, April 2010

Figure 36 - Annual Surface air temperature deviation in Syria over the period 1955-2005

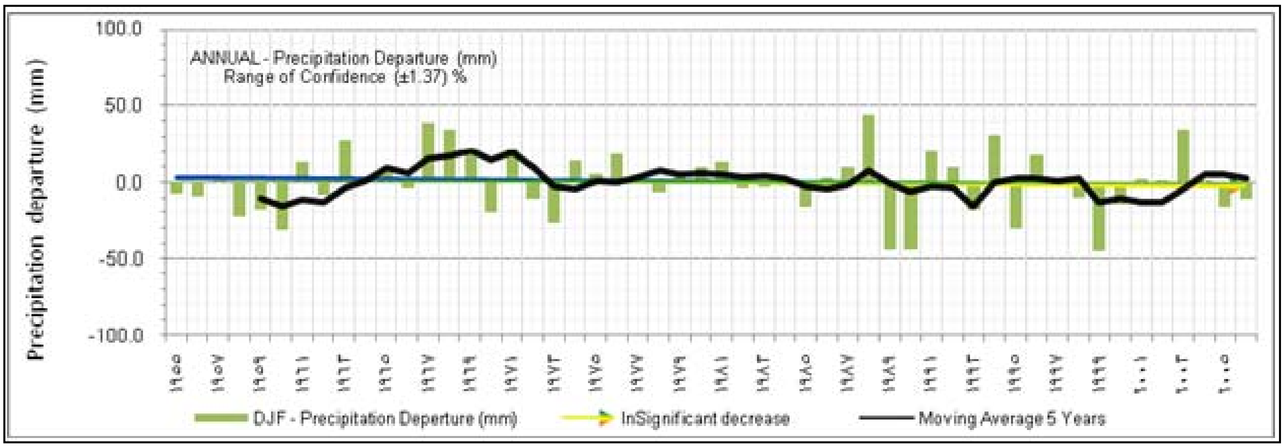


Source: Initial National Communication of the SYRIAN ARAB REPUBLIC, April 2010

Minimum temperature reduced to below zero in some years, and it may reach -21.8°C in the inland mountains. Average wind velocity was twice the above figure in some years (in case of storms 17-23m/sec for several days a year).

Figure 35 shows the average annual deviation of temperatures versus the reference average annual rate over a 50-year period[27]. Figure 35 reveals that the increase in mean annual temperature rates until the mid-first decade of the current century (compared with the mid-decade of early reference chain) is approximate 0.55-0.60°C (for a movable average on a 9-year interval). Figure 36 confirms that the changes in atmosphere temperature at land surface were not more than 0.40°C for the same period. Table 71 in study annexes shows the climates statistics of some different stations in Syria, where a general trend of decreasing rainfall at the country level during the period until 2005 on average 12-15mm/year as shown in Figure 37.

Figure 37 - Annual Precipitation Deviation (mm) in Syria over the period 1955-2005



Source: Initial National Communication of the SYRIAN ARAB REPUBLIC,April 2010

Two scenarios A2 and B2 of climatic changes published in 2010 assume a severe effect on rainfall and temperature until 2030. It is noted, according to different probabilities, that the northeastern region (Hassakeh, Deir Ezzor and Raqqa provinces) and the Syrian Badia are the most susceptible areas (Table 46).

[27] Initial National Communication of the SYRIAN ARAB REPUBLIC, April 2010

Table 46 - Climate change effect on temperature & rainfall according to A2 & B2 Scenarios

Indicator	Scenarios	Winter	Spring	Summer	Autumn	Annual
T, ᴼC	A2	0.57:0.67	0.43:0.77	0.80:1.23	0.77:1.17	0.60:0.97
	B2	0.67:0.87	0.57:0.80	0.77:1.67	0.80:1.20	0.77:1.17
P, mm/year	A2	2,0:-8.0	2,0:-5.3	2.7:-2.7	-2.7:-10.5	-2.0:-27.0
	B2	2.7:-4.0	2.7:-6.7	5.3:-5.3	-2.7:-12.7	-5.7:-30.0

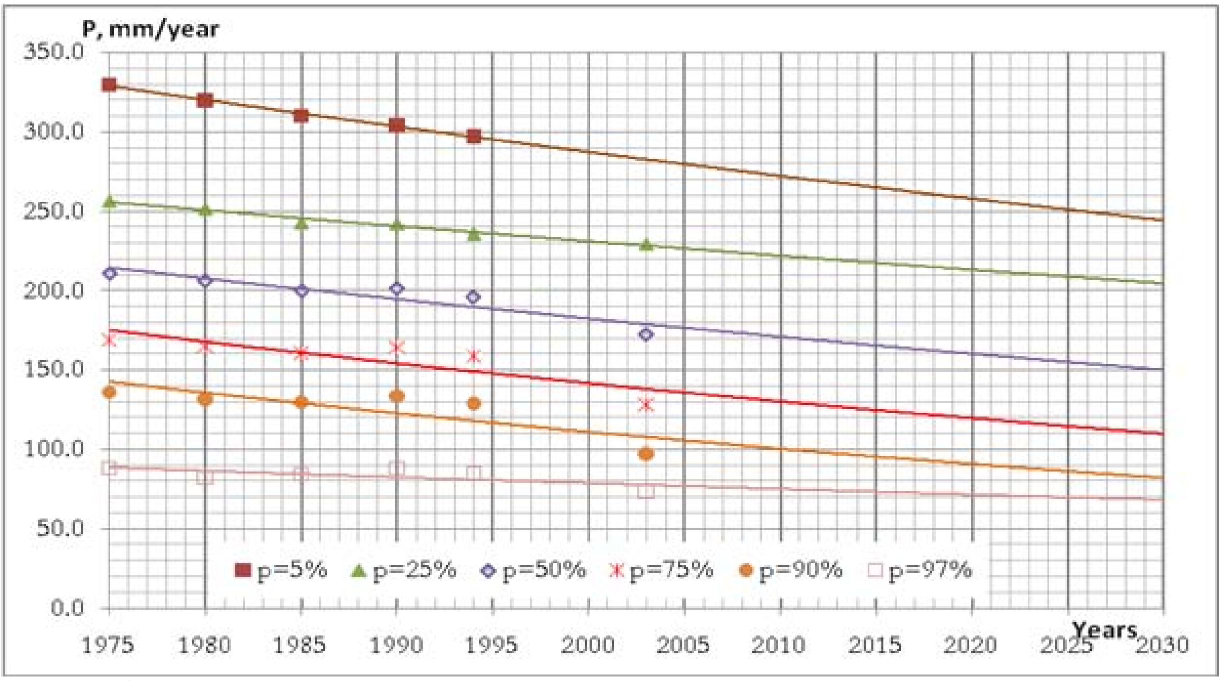
Source: Initial National Communication of the SYRIAN ARAB REPUBLIC, April 2010

In this table there are two values for each season either for temperature or for rainfall, the first value expresses the changes made in the criterion in the southern region of Syria, while the second value expresses the predicted change in the northeastern region. The Badia region has a severe change similar to that of the eastern region. As a result, noticeable changes in the velocity and directions of local and dominant winds are expected.

Severe impacts of drought caused by the above changes are also noticed due to the effect of degradation: both available water resources and soil on agriculture and all other productive sectors. The dust storms occurred in the second half of the first decade of the current century underline the expected impact in more than half Syrian areas until 2030.

Figure 38 illustrates the rainfall changes in the Lower Euphrates and Aleppo plains owing to long-term modeling of the climatic data of meteorological stations available Syrian water basin from 1958 to 2009, along with the projection of these changes until 2030 for different probabilities of rainfall supply.

Figure 38 - Rainfall changes in the Lower Euphrates and Aleppo plains[28]



Source: Dr M. Kordab, 2011

The study shows the curve of rainfall drop, on an average year, at 29.5% until 2030. For dry years that adopt the ligal scenario for water use planning in irrigated agriculture, the rainfall drop is at 37.1% for the same period[2], and this drop appears in other water basins in different forms.

---

[28] Daoud, Majar & Uzon, Feb. 2011, The Impact of Climate Change in Euphrates water Basin on Irrigation Water Demand Management , HIWM, Homs

2. Climate change impacts on WRs, demand and deficit

2.1. Climate change impacts on WRs

Rainfall changes affect, in the same degree, surface & groundwater inland WRs. The data of national studies and the Initial National Communication of the Syrian Arab Republic underline that the national internal WRs until 2030 will decline at 15-20% for surface WRs and at 28-30% for groundwater supply (the least figure for A2 scenario and the highest figure for B2 scenario).

The reports issued by Turkish scientific institutions working in the field of climate changes underline a 5-degree temperature increase in the source areas of the Euphrates and Tigris rivers, resulting in a reduction in rainfall by 100mm/year. Thus, the Euphrates water supply decreased from 27.048BCM/year to 16.329BCM/year (Onol and Semazzi, 2006). Due to the expected rising temperature in the northeastern region (adjacent to the sources of the Euphrates river) up to 0.97°C and rainfall drop at a rate of 30.0mm/year until 2030 for B2 scenario, the WRs change was considered to have a linear relation with rainfall or increasing temperature, that is:

- The projected average Euphrates supplies in A2 scenario will reach 24.969BCM/year in 2030. Once these supplies are distributed among the riparian countries with the same currently in force portions, the Syria's share from the Euphrates water, considering the climate changes, will be nearly 6.104BCM/year (versus 6.623BCM/year in 2010).
- In B2 scenario, the above supplies will reach 23.831BCM/year in 2030. Once these supplies are distributed among the riparian countries with the same currently in force portions, the Syria's share from the Euphrates water, considering the climate changes, will be nearly 5.826BCM/year.

The various scenarios assume that the Syrian WRs from internal water sources will be close to the supplies of a dry year in 2030 with exploitation potential of about 1.25BCM/year from the Tigris river. Taking the results of climatic studies into account, the internal WRs is expected to be close to 80.8% of a reference dry-year supply and amounts reaching 5.528BCM/year, allowing for country WRs of about 12.882BCM/year in A2 versus 76.6% internal WRs from a refernce dry-year supply in B2 and amounts reaching 5.252BCM/year, allowing for country WRs nearly 12.329BCM/year only. Table 47 shows water demand & WRs without climate change effects for different water's scenarios.

Table 47 - Water demand & WRs for different water scenarios without CC up to 2030

(BCM)	Reference Scenario			Alternative Scenario			Legal Scenario		
Sector	2009	2020	2030	2009	2020	2030	2009	2020	2030
Domestic demand	1.21	1.53	1.82	1.21	1.49	1.68	1.21	1.44	1.59
Irrigation demand	16.18	18.68	18.80	16.18	16.12	15.52	16.18	12.64	11.84
Industrial demand	0.52	0.65	0.79	0.52	0.63	0.72	0.52	0.59	0.63
urban demand	1.73	2.18	2.61	1.73	2.11	2.40	1.73	2.03	2.23
Total demand	17.91	20.86	21.29	17.91	18.23	17.93	17.91	14.68	14.07
Fresh WR's	14.90	14.69	13.42	14.90	14.69	13.42	14.90	13.42	13.42
re-use water*	4.89	5.74	5.98	4.89	4.27	3.50	4.89	2.91	2.30
Total WR's	19.79	20.43	19.40	19.79	18.95	16.92	19.79	16.33	15.72
EV	1.94	1.80	1.65	1.94	1.80	1.65	1.94	1.65	1.65
Fresh water deficit	-4.95	-7.97	-9.52	-4.95	-5.34	-6.16	-4.95	-2.91	-2.30
Total water deficit	-0.06	-2.23	-3.54	-0.06	-1.08	-2.65	-0.06	0.00	0.00

*Note: It is assumed that domestic waste share =70% - *Irrigation drainage share=25% in RS, 15% in AS & 10% in LS
Source: Dr M. Kordab, 2011

2.2. Climate change impacts on water demand

Water demand for biotic needs (human, animal and plant) increases as temperature rate increases compared to mean temperature at country level. This can't be done without conducting in-depth studies to identify water demand change in irrigation agriculture sector due to the decreased period of crop growth and harvest. Therefore, water demand change, in irrigation & agriculture sector, water life stock and drinking water and domestic use sector, will increase at 5.3% for A2 in 2030. So the total water demand will be equal to 21.395BCM in 2020 and 22.378BCM/year in 2030 according to the reference scenario (RS), 18.701BCM/year in 2020 and then to 18.837BCM/year in 2030 according to the alternative scenario (AS), and 15.051BCM/year in 2020 and up to 15.094BCM/year in 2030 according to the legal scenario (LS). However, this demand will increase at 6.4% in B2 with total water demand equal to 21.507BCM/year in 2020 and 22.604BCM/year in 2030 according to the (RS), 19.380BCM/year in 2020 to reach 19.026BCM/year in 2030 according to the (AS) and 15.128BCM/year in 2020 to drop to 14.931BCM/year in 2030 according to the (LS).

Table 48 shows water demand & WRs for different water scenarios with CC A2 scenarion up to 2030, while Table 49 shows water demand & WRs with CC B2 scenario up to 2030.

Table 48 - Water demand & WRs for different water scenarios with CC A2 scenario up to 2030

(BCM)	Reference Scenario			Alternative Scenario			Legal Scenario		
Sector	2009	2020	2030	2009	2020	2030	2009	2020	2030
Domestic demand	1.21	1.57	1.92	1.21	1.53	1.77	1.21	1.48	1.68
Irrigation demand	16.18	19.18	19.80	16.18	16.55	16.35	16.18	12.98	12.47
Industrial demand	0.52	0.65	0.79	0.52	0.63	0.72	0.52	0.59	0.63
urban demand	1.73	2.18	2.71	1.73	2.11	2.49	1.73	2.07	2.31
Total demand	17.91	21.40	22.50	17.91	18.70	18.84	17.91	15.05	14.78
Fresh WR's	14.90	13.76	12.88	14.90	13.76	12.88	14.90	13.15	12.88
re-use water*	4.89	5.90	6.29	4.89	4.38	3.69	4.89	2.98	2.42
Total WR's	19.79	19.66	19.18	19.79	18.14	16.57	19.79	16.14	15.30
EV	1.94	1.80	1.72	1.94	1.80	1.72	1.94	1.69	1.69
Fresh water deficit	-4.95	-9.43	-11.34	-4.95	-6.74	-7.68	-4.95	-3.59	-3.59
Total water deficit	-0.06	-3.53	-5.05	-0.06	-2.36	-3.99	-0.06	-0.60	-1.16

*Note: It is assumed that domestic waste share =70% - *Irrigation drainage share=25% in RS, 15% in AS & 10% in LS
Source: Dr M. Kordab, 2011

Table 49 - Water demand & WRs for the different water scenarios with CC B2 scenario up to 2030

(BCM)	Reference Scenario			Alternative Scenario			Legal Scenario		
Sector	2009	2020	2030	2009	2020	2030	2009	2020	2030
Domestic demand	1.21	1.58	1.94	1.21	1.54	1.79	1.21	1.49	1.70
Irrigation demand	16.18	19.28	20.00	16.18	16.64	16.52	16.18	13.05	12.60
Industrial demand	0.52	0.65	0.79	0.52	0.63	0.72	0.52	0.59	0.63
urban demand	1.73	2.23	2.73	1.73	2.16	2.51	1.73	2.08	2.33
Total demand	17.91	21.51	22.73	17.91	18.80	19.03	17.91	15.13	14.93
Fresh WR's	14.90	13.69	12.33	14.90	12.92	12.33	14.90	12.87	12.33
re-use water*	4.89	5.93	6.36	4.89	4.40	3.73	4.89	3.00	2.45
Total WR's	19.79	19.61	18.69	19.79	17.32	16.06	19.79	15.87	14.78
EV	1.94	1.84	1.74	1.94	1.89	1.74	1.94	1.69	1.74
Fresh water deficit	11.17	-9.66	-12.14	-4.95	-7.77	-8.43	-4.95	-3.95	-4.34
Total water deficit	-0.06	-3.74	-5.78	-0.06	-3.37	-4.71	-0.06	-0.95	-1.89

*Note: It is assumed that domestic waste share =70% - *Irrigation drainage share=25% in RS, 15% in AS & 10% in LS
Source: Dr M. Kordab, 2011

2.3. Water deficit based on climate change impacts

The following table shows fresh water deficit & total water deficit with out CC impacts for different water scenarios:

Table 50 - Fresh water deficit & total water deficit with out CC impacts for different water scenarios

(BCM)	Reference Scenario			Alternative Scenario			Legal Scenario		
	2009	2020	2030	2009	2020	2030	2009	2020	2030
Fresh water deficit	-4.95	-7.97	-9.52	-4.95	-5.34	-6.16	-4.95	-2.91	-2.30
Total water deficit	-0.06	-2.23	-3.54	-0.06	-1.08	-2.65	-0.06	0.00	0.00

Source: Dr M. Kordab, 2011

And the following table shows fresh water deficit & total water deficit with CC impacts according to IP CC A2 scenario for different water scenarios.

Table 51 - Fresh water deficit & total water deficit with CC impacts according to IP CC A2 scenario for different water scenarios

(BCM)	Reference Scenario			Alternative Scenario			Legal Scenario		
	2009	2020	2030	2009	2020	2030	2009	2020	2030
Fresh water deficit	-4.95	-9.43	-11.34	-4.95	-6.74	-7.68	-4.95	-3.59	-3.59
Total water deficit	-0.06	-3.53	-5.05	-0.06	-2.36	-3.99	-0.06	-0.60	-1.16

Source: Dr M. Kordab, 2011

While the following table shows fresh water deficit & total water deficit with IP CC impacts according to IP CC B2 scenario, for different water scenarios.

Table 52 - Fresh water deficit & total water deficit with IP CC impacts according to IP CC B2 scenario, for different water scenarios

(BCM)	Reference Scenario			Alternative Scenario			Legal Scenario		
	2009	2020	2030	2009	2020	2030	2009	2020	2030
Fresh water deficit	11.17	-9.66	-12.14	-4.95	-7.77	-8.43	-4.95	-3.95	-4.34
Total water deficit	16.06	-3.74	-5.78	-0.06	-3.37	-4.71	-0.06	-0.95	-1.89

Source: Dr M. Kordab, 2011

It is clear from these tables that for water RS in 2020, fresh water deficit will be, 7.97MCM without CC impacts, will increase to 9.43MCM with IP CC A2 scenario and to 9.66MCM with IP CC B2 scenario, while the total water deficit will be 2.23MCM without CC impacts, will increase to 3.53MCM with IP CC A2 scenario and to 3.74MCM with IPCC B2 scenario, for AS in 2020, fresh water deficit will be, 5.34MCM without CC impacts, will increase to 6.74MCM with IP CC A2 scenario and to 7.77MCM with IP CC B2 scenario while the total water deficit will be 1.08MCM without CC impacts, will increase to 2.36MCM with IP CC A2 scenario and to 3.37MCM with IPCC B2 scenario and for LS in 2020, fresh water deficit will be, 2.91MCM without CC impacts, will increase to 3.59MCM with IP CC A2 scenario and to 3.95MCM with IP CC B2 scenario while the total water deficit will be 1.16MCM with IP CC A2 scenario and 0.95MCM with IPCC B2 scenario. In 2030 for water RS, fresh water deficit will be 9.52MCM without CC impacts, will increase to 11.34MCM with IP CC A2 scenario and to 12.14MCM with IP CC B2 scenario, while the total water deficit 2.65MCM without CC impacts, will increase to 3.99MCM with IP CC A2 scenario and to 4.71MCM with IP CC B2 scenario , in 2030 for AS, fresh water deficit will be, 6.16MCM without CC impacts, will increase to7.68MCM with IP CC A2 scenario and to 8.43MCM with IP CC B2 scenario, while the total water deficit will be 2.65MCM without CC impacts, will increase to 3.99MCM with IP CC A2 scenario and to 4.71MCM with IPCC B2 scenario and in 2030 for LS, fresh water deficit will be, 2.30MCM without CC impacts, will increase to 3.59MCM with IP CC A2 scenario and 4.34MCM with IP CC B2 scenario while the total water deficit will be 1.16MCM with IP CC A2 scenario and 1.89MCM with IPCC B2 scenario.

2.4. Additional energy required to cover water deficit

While is dealing with the problem of water shortage, SAR will face two possibilities: the first possibility is to secure water sources to cover the deficit of the total water through desalination of sea water, reducing demand on water resources in the low-priority sectors (especially irrigated agriculture). That requires additional energy use (including capital investment for infrastructure) to create a new energy system for desalination and water transfers between basins (with more than 1600m head in some cases), while the second possibility requires a complete restructuring to change the production style in the agriculture sector towards the transition from plant production to livestock production in order to achieve national food security.

3. Climate change impacts on energy resources, demand and deficit

3.1. Climate change impacts on energy demand

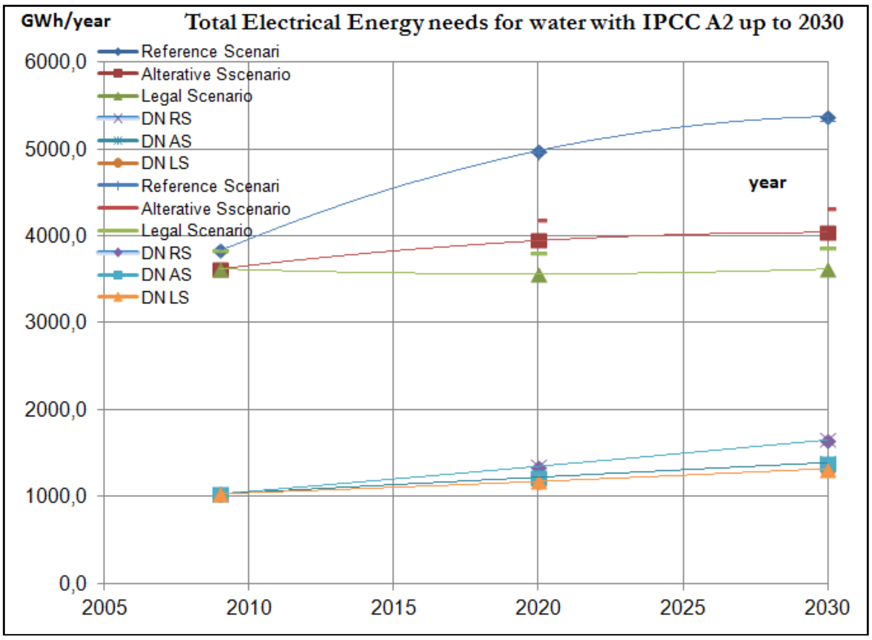
The Syrian power generation sector relies mainly upon fossil fuel with an average share above 80% during the last two decades[29]. Due to the comprehensive nature of the impact of climate change on different socioeconomic activities, it is most likely that all consumption sectors could be affected. This includes the housing, transport, agriculture and industrial sectors. Electricity generation, water and agriculture seem to be the most sensitive sectors to climate change. The housing sector will suffer the most under the new conditions, whereas the most sensitive segments of society would be low-income households.

The ever-increasing scarcity of water will affect power production, as the amount of water required for the cooling process becomes limited. Nevertheless, in many cases, electricity is needed for water pumping, water transportation and water distribution. Moreover a rise in the price of electricity could limit water availability for various consuming sectors.

Demand for energy sources for water supply in various economic sectors in SAR is increasing due to the effects of climate change for all scenarios of water supply (RS, AS & LS) in the two climate change scenarios IPCC A2 & IPCC B2. Figure 39 & Figure 40 illustrate electrical energy needs and diesel oil needs for water supply in IPCC A2 scenario.

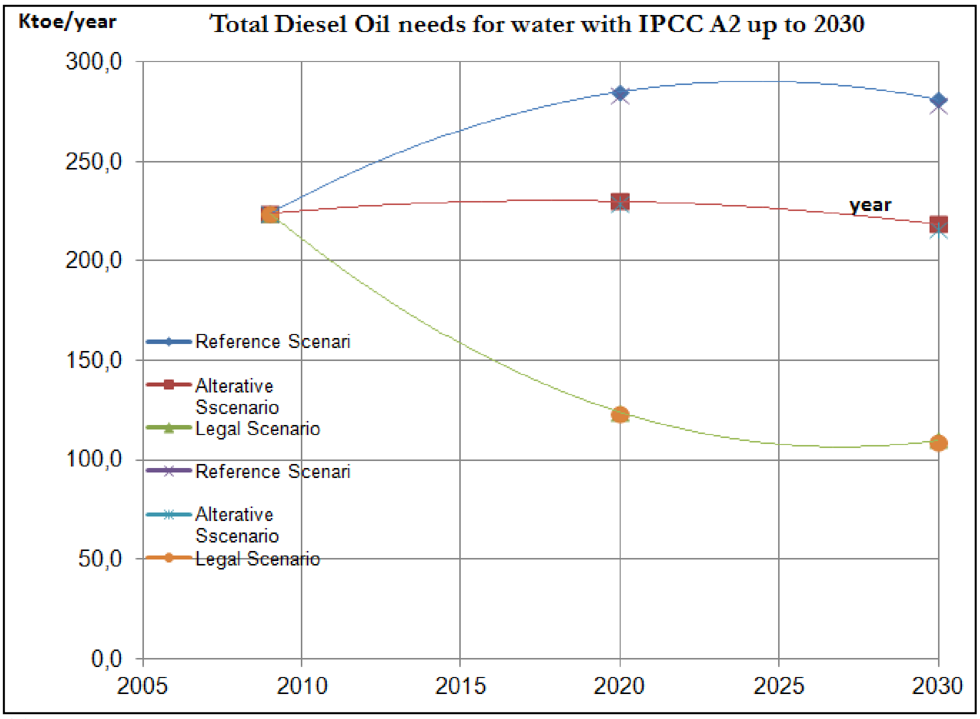
[29] (Initial National Communication for the SAR –April-2010)

Figure 39 - Electrical Energy Needs for Water Supply with IPCC A2 up to 2030



Source: Dr M. Kordab, 2011

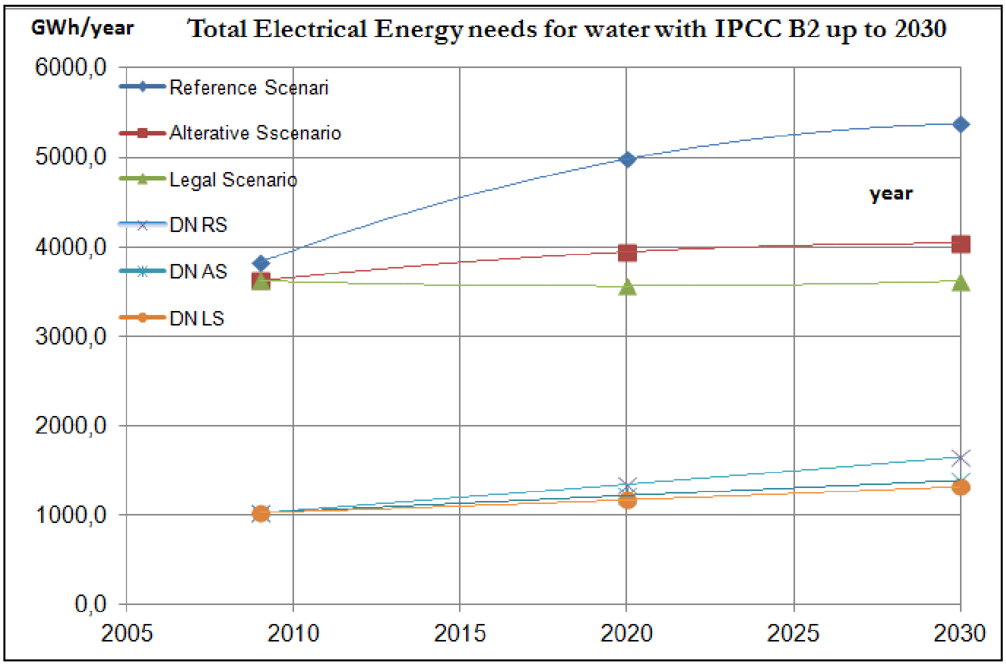
Figure 40 - Diesel Oil Needs for Water Supply with IPCC A2 up to 2030



Source: Dr M. Kordab, 2011

Where electrical energy demand for water supply in the RS will increase by 39.0% compared with the reference year, and this increase by 12.9% in the AS, and not more than 1.1% in the LS. The Diesel fuel demand will increase in the RS by 24.2% even and will arrive to the peak demand in 2025, diesel oil demand will decrease in AS by 3.5% despite the arrival at its peak in 2020, while in the legal scenario, the demand will decrease rapidly to settle at 48.5% compared with the year 2009, while Figure 41 & Figure 42 illustrate electrical energy needs and diesel oil needs for water supply in IPCC B2 scenario.

Figure 41 - Electrical Energy Needs for Water Supply with IPCC B2 up to 2030



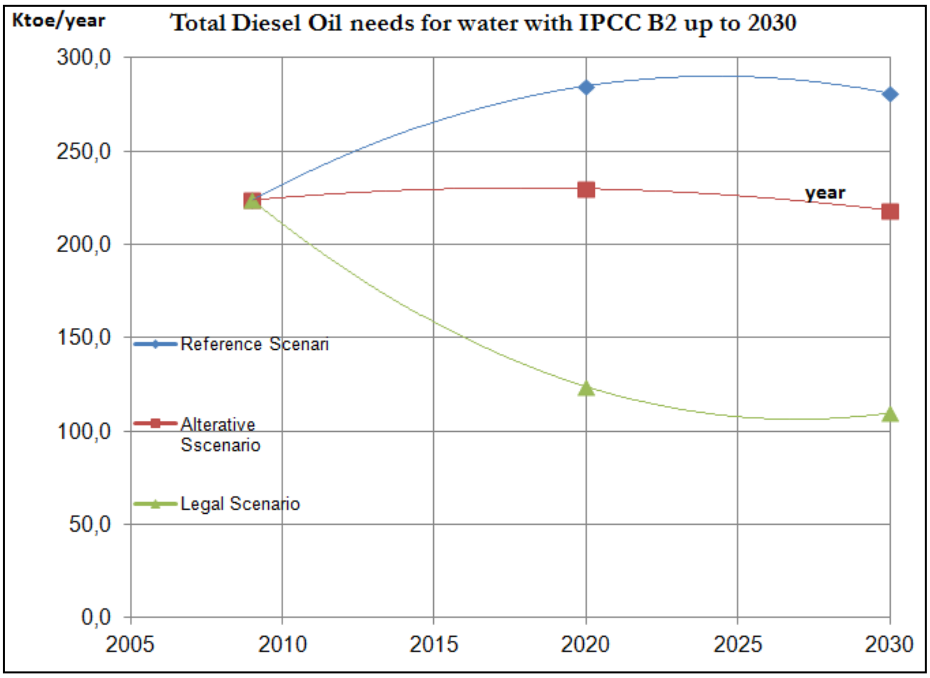
Source: Dr M. Kordab, 2011

Energy demand for water supply, in this scenario, to avoid the effects of climate change will increase, where electrical energy demand for water supply in the R S will increase by 40.4% compared with the reference year 2009, by 14.0% in the AS, and beyond 2.1% in the LS. The demand for diesel fuel will increase by 25.5% in the RS, note that the peak demand remaining in the year 2025, by 2.5% in the AS despite the arrival to the peak before 2020, while decreasing rapidly to settle 49.1% when compared with the year 2009 in the LS.

To deal with expected future climate change, various development trends are applicable. However the feasibility of the assumed development trends should be evaluated while bearing in mind energy indicators for sustainable development. The social (easy access to and affordability of energy services), economic, environmental and institutional implications should be adequately studied. This means that a future energy supply strategy should assure adequate, reliable and efficient energy services to all segments of society at affordable cost, compatible with local conditions and in an environmentally safe manner.

According to these requirements, the Syrian energy sector possesses great potential to deal with expected climate change. The coping capacity of this sector will depend on conservation measures and efficiency improvement (shifting to modern alternatives) with the aim of reducing the dependency on fossil fuels. Its share amounts presently to more than 95% of total primary energy in SAR. The coping capacity of the energy sub-sectors can be classified as follows:

Figure 42 - Diesel oil needs for water supply with IPCC B2 up to 2030



Source: Dr M. Kordab, 2011

- **The power sector**

  The potential of this main sub-sector depends on:

  – Efficiency improvements, for instance shifting to combined cycle power plants,

  – Shifting from fuel oil to natural gas,

  – Reducing illegal consumption in electricity distribution,

  – Increasing the share of renewable energy power plants.

- **The transport sector**

  Improvements could be made by:

  – Shifting to modern form of public transportation like Passenger Trains, Metro,

  – Shifting to trains for transporting freight,

  – Replacing old cars by new ones, more efficient alternatives, including modern hybrid cars.

- **Industries**

  – Improving the efficiency of industrial processes, mainly in the application of heat,

  – Rehabilitating and modernizing energy consuming industries like cement, iron, glass, and fertilizers production.

- **Agriculture**

  – Improvements could be made in water pumping by using RE technology applications,

  – Adopting innovative ways for water demand management,

  – New machines for agriculture,

  – Reducing the share of water intensive agricultures like cotton cultivation (due to both, high energy and water requirements).

- **Housing**
  - Conservation measures in all residential backgrounds (changes in behavior),
  - Development of alternative heating devices,
  - Increasing the share of solar energy for water and residential heating,
  - Increased insulation in buildings,
  - Improving the efficiency of air conditioners and refrigerators.

The coping capacity to climate change of the energy sector is reflected by its ability to undergo required restructuration, technological change and improvements. The choice of clean technologies (renewable energy and through the use of improved devices in other sub-sectors) should be a clear one. The ability to restructure the energy sector, presently apparently obsolete, is a realistic and promising option, even if the burdens are of a financial and structural nature.

However, the increased share of renewable energy (coming mainly from wind and solar) requires significantly higher installed capacity – due to the low availability factor of renewable energy-.The results of evaluations show that replacing one capacity unit of fossil fired by renewable sources of energy results in a factor of about 2. To alleviate the impact of climate change on the energy sector, various policies and adaptation measures can be assessed. The feasibility of imposed policies and measures should be evaluated on the basis of cost and time efficiency: the lower the cost and faster the impact (i.e. reducing GHG emissions and alleviating their impact), the more favorable the measure.

Thus following measures can be considered for SAR:

- Encouraging renewable sources of energy;
- Energy conservation measures: both behavior (related to energy consumption) and technical;
- Encouraging the introduction of clean technologies in all energy conversion processes;
- Introducing mitigation (reduction) techniques (for instance the capture CO_2 and its storage);
- Removing subsidies on fuel will reduce total consumption, due to the reduction of individual consumption and technologically-triggered improvements;
- Imposing limits on CO_2 emissions (taxes and fines).

VI. Economic perspectives

1. Estimated required investments to supply energy and water needs until 2030 without CC impacts

1.1. Estimated required investments in the energy sector for baseline and alternative scenarios

In order to estimate the required investment and operational costs of expansion power generation plants in the SAR up to 2030 the following basic & fundamental assumption shown in Table 53 are adopted for the calculation.

Table 53 - Fundamental data to calculate Initial & operational cost and purchase prices of electricity from private sector during the period 2011-2030

Purchase Price of KWh produced from private sector WF	6 2.85	Cent US/KWh SP/KWh
Purchase Price of KWh produced from private sector PV	15 7.125	Cent US/KWh SP/KWh
Purchase Price of KWh produced from private sector CSP	8 3.80	Cent US/KWh SP/KWh
Purchase Price of KWh produced from hydro-power sector	0.3 0.63	S P/KWh Cent US/KWh
Purchase Price of KWh produced from Ministry of Oil	5.89 12.4	S P/KWh Cent US/KWh
Purchase Price of KWh produced from private sector Coal PP	5 2.375	Cent US/KWh SP/KWh
Purchase Price of Kwh imported from neighboring countries	6 2.85	Cent US/KWh SP/KWh
Cost of energy conversion from Private Sector	2 0.95	Cent US/KWh SP/KWh
Average Price of Heavy Fuel Oil	400 19000	$US/Ton SP/Ton
Average Price of Compressed NG	37.5 17.8125	Cent $US/m3 SP/m3
Initial Cost of new Steam Power Plants	1000 47500	$US/KW SP/KW
Initial Cost of new Combined Cycle Power Plants	1200 57000	$US/KW SP/KW
Euro exchange rate	68	S P
$US exchange rate	47.5	S P
Initial Cost of CSP Power Plants	3500 166250	$US/KW SP/KW
Initial Cost of Storage Hydro-power Plants	1500 71250	$US/KW SP/KW
Initial Cost of first Wind Farm Power Plants	1800 85500	$US/KW SP/KW
Initial Cost of future Wind Farm Power Plants	950 45125	$US/KW SP/KW
Ratio of Custom cost to Initial cost	15	%
Ratio of operational cost CSP to Initial cost	5	%
Ratio of operational cost of Storage Hydro- power to Initial cost	6	%
Ratio of operational cost of Wind Farms to Initial cost	1	%
Discount rate	9	%

Source: Dr M. Kordab, 2011

Estimation of required investment will cover the two scenarios adopted by the study of EE & RE Master plan in SAR executed by (GTZ- NERC, 2010) where two nuclear power plants should be installed at 2020 & 2025 and the two other modified scenarios adopted by the energy team of this study where the two nuclear power plants are neglected (taking in consideration the catastrophe of Fukushima power plant of Japan, 2011) using instead, more RE & coal fired Power Plants.

Actually this study didn't take into consideration nuclear PPs for the following reasons:

1) Political situation in the Middle East.
2) High cost of installed Capacity of nuclear PP.
3) Difficulties in preparing & purchasing nuclear fuel.
4) Needs for high qualification (skills) of working personal.
5) Expectations of earth quake in the Middle East in the future.
6) Some developed countries are planning to close their nuclear PPs (Japan by 2012, Germany by 2020, and France by 2040).

The following Table 54 summarizes capital cost (investment cost) of expansion power generation plants for the Reference Scenario RS & Energy Saving Scenario ESS adopted in the study of EE & RE Master plan prepared by (GTZ- NERC , 2010).

Table 54 - Forecast of Capital Cost for Expansion of Power Generation Plants up to 2030 for the RS & ESS* (Million U.S. dollar)

Million $US	Capital cost	2010-2015	2016-2020	2021-2025	2026-2030	Total
Référence Scenario (RS)	Total	2097	8325	8411	8504	27336
	Of it Renewable	172	172	172	86	429
Energy saving Scenario (ESS)	Total	2477	2477	2477	10214	35245
	Of it Renewable	1024	1024	1024	3787	11739

RS & ESS: Reference Scenario & Energy Saving Scenario of GTZ- NERC Study on EE & RE Master plan in SAR. Euro Exchange Rate= 68 Syrian Pound, US $ Exchange Rate= 47.5 Syrian Pound
Source: Dr M. Kordab, 2011

It becomes clear from this table, the total investment needed for the RS amounted to 27.336 billion $US distributed at four five years period, while the total investment needed for the ESS amounted to 35.245 billion $US which means the enhanced use of renewable energy sources implies significant additional investments amounted to more than 8 billion $US. For the total twenty year time period under consideration. The investment required for renewable energy increases from 429 million $US in the RS (where a minimal use of RE PPs) to 11.739 billion $US in the ESS.

Please note that the Scenarios (of GTZ- NERC Study on EE & RE Master plan in SAR) illustrate a high cost of renewables. The reason could be:

1) High assumptions of input data (prices of installed renewable power).
2) Backup capacities needed for Wind Farms & Photovoltaic's PPs, in order to cover peak load.

The following Table 55 summarizes the analysis of capital and operational costs including fuel cost for the expansion of power generation plants capacity for the Modified Reference Scenario (MRS) and Modified Energy Saving Scenario (MESS) adapted in this study.

Table 55 - Forecast of capital & operational costs for expansion of power generation plants up to 2030 for the M RS & MESS ($US)

Million $US	Modified RS costs			Modified ES S costs		
	Capital cost	Operation & fuel	Total	Capital cost	Operation & fuel	Total
2011-2016	6506	25382	31888	5512	24638	30151
2016-2020	10372	28433	38805	6194	27271	33465
2021-2025	11444	34247	45691	9983	30028	40011
2030 - 2026	17183	43785	60968	12731	37001	49732
Total	45506	131846	177352	34421	118939	153359
NPV	17532	54416	71948	13250	50555	63806

Source: Dr M. Kordab, 2011

Details of this analysis are illustrated in Annexes (Table 72, Table 73 & Table 74).

It becomes clear from this table the total capital cost needed for the MRS amounted to 45.506 billion $US distributed, as illustrated in Annex (Table 72), 12.890 billion $US of which for HFO & NG fired PPs, 4.065 billion $US of which for CSP PPs, 0.752 billion $US for PV Systems, 1.725 billion $US for pumping storage PPs, 2.455 billion $US for wind farms PPs and the cost of purchased electricity from private sector 23,619 Billion $US (included coal fired, PV, WF and CSP PPs).

While the total capital cost needed for the MESS amounted to 34.421 billion $US only distributed, as illustrated in Annex (Table 75) 10.475 billion $US of which for HFO & NG fired PPs, 0.845 billion $US of which for CSP PPs, 0.752 billion $US of which for PV Systems, 1.725 billion $US for pumping storage PP, 1.909 billion $US for wind farms PPs and the cost of purchased electricity from private sector 18.714 billion $US (included coal fired, PV, WF and CSP PPs).

The total operational & fuel cost in the MRS is amounted to 131.846 billion $US distributed as illustrated in Annex (Table 74), 127.511 billion $US of which for operational & fuel cost of HFO & NG fired PPs (new & existing steam & CC PPs), 2.751 $US operational cost of CSP PPs, 1.346 billion $US for operational cost of pumping storage hydro power plant and relatively small (0.239 346 billion $US) operational cost for WF & PV systems.

The total operational & fuel cost in the MESS is amounted to 118,939 billion $US distributed as illustrated in Annex (Table 74), 116.821 billion $US of which for operational & fuel cost of HFO & NG fired PPs (new & existing steam & CC PPs), 0.577 billion $US operational cost of CSP PPs, 1.346 billion $US for operational cost of pumping storage hydro power plant and relatively small (0.195 billion $US) operational cost for WF & PV systems.

1.2. Estimated required investments in the water sector for reference and alternative scenarios

In addition to the water needs for cooling the thermal power plant, there are other uses of water cannot be ignored such as compensation of wet cooling circuit for assistance, compensation of wet cooling circuit for condensers, compensation of heating circuit, compensation of fire fitting, water services within the station, water services for the residential suburb, wash water heaters feedback, drinking water for residential suburb, in addition to irrigation water for the plant area. But as the cooling part is the most important and costly, cost analysis will be concentrated on it.

1.3. The Cost of power generation plants' Cooling Systems[30]

Water availability and cost can influence the type of resource in which an electric utility invests, and most utilities incorporate the cost of water into their decisions about cooling technologies for thermoelectric power plants. Thermoelectric power plants require water to generate steam, which must then be condensed and cooled. Most thermoelectric power plants rely on wet recirculating cooling systems to cool and condense the steam. Dry- and hybrid-cooling systems reduce the total consumptive use of water and the costs associated with pumping, treating, and discharging water, but they incur greater capital costs and often generate less electricity during the hottest periods, when electricity demand is highest.

The full cost of water use includes capital cost, O & M cost, and opportunity cost (the value that would otherwise be obtained from applying that water to its best alternative use). When making water-supply decisions, utilities do not typically take into account the opportunity cost associated with those decisions.

The Electric Power Research Institute (EPRI) of USA[31] analyzed the cost of dry- vs. wet-cooling systems in two types of thermoelectric power plants: a 500MW combined-cycle natural gas plant and a 325MW coal plant. The report, published in 2004, assessed the capital cost of the different cooling systems, along with the annual costs of operating and maintaining the cooling system and the cost of capacity shortfalls for dry-cooling systems. Table 56 summarizes EPRI's analysis of the costs of cooling systems for a combined-cycle gas plant.

Table 56 - Cost analysis of wet- and dry-cooling systems for thermoelectric power plants in hot and arid areas (case of southwestern states of USA)

Plant	water provided by a water utility		water purchased from willing sellers	
1. Cooling System	Wet	Dry	Wet	Dry
2. Capital Cost of Cooling Equipment ($)	7,629,421	30,414,637	7,629,421	30,414,637
3. Cost of Water Rights ($/m^3)	0	0	1.2	1.2
4. Annualized Capital Cost ($/yr)*	610,354	2,433,171	945,476	2,433,171
5. Annual O&M Costs** (excluding water) ($/yr)	1,493,501	2,704,540	583,501	2,704,540
6. Annual Cost of Water ($/yr)	910,000	-	0	0
7. Total Annual Costs ($/yr)	2,103,855	5,137,711	1,528,977	5,137,711
8. Volume of Water Consumed (million m^3/yr)	3.445	-	3.445	-
9. Added Value of Water ($/m^3/yr)	0.88	-	1.05	-

*Capital costs are annualized using a 7 percent discount rate and 30-year period.
** O & M costs include maintenance costs, fan power costs (for both wet and dry systems), and lost revenues from lost capacity during hot periods (for dry-cooled systems), along with system maintenance costs
Source: Dr M. Kordab, 2011

Using EPRI's data and assumptions, an implicit value of water is derived for power generation from the power-plant owner's perspective, the added value of that water is 0.88 $US/m^3/year if the water is provided by a water utility.

Dry-cooling systems have similar economic impacts on coal, solar thermal, and other thermoelectric power plants. For example, the capital cost of installing dry-cooling technology in solar thermal plants is typically three to five times as expensive as wet-cooling systems.

It should be noted that the power plant type and the technology adopted are playing an important role in estimating the water consumption of the plant as well as the fuel type and specifications to be used (heavy fuel oil or NG)

Table 57 shows a practical example of a power generation plant with 250MW capacity expected to be installed at Al Nasiriyah site (about 60 km northeast of Damascus), in partnership with the private sector.

[30] Stacy Tellinghuisen *Water for Power Generation: What's the Value?, *Natural Resources Journal* [Vol. 50], p 683-720
[31] Epri, comparison of alternate cooling technologies for U.S. power plants: economic, environmental, and other tradeoffs (2004).

The table includes a comparison between selected technologies to be used at this plant: (CCGT), Low Speed Internal Combustion Engines (LSDE), or Average Speed Internal Combustion Engines (MSDE), as well as the additional equipment for fuel treatment according to the technology and the type of fuel used, which include:

- Flue Gas Desulphurization "FGD"
- Selective Catalytic Reduction "SCR"
- Electrostatic Precipitators "ESP"

Table 57 - A comparison between CCGT & Low or Medium Speed Internal Combustion Engines including water consumption

Statement		CCGT	L.S.D.E – 1%HFO & NG		L.S.D.E – 4%HFO & NG		M.S.D.E 1%HFO		M.S.D.E-4%HFO	
fuel		NG	NG	1% HFO	NG	4% HFO	NG	1%HFO	NG	4%HFO
FGD incorporated		No	No	No	Yes	Yes	No	No	Yes	Yes
SCR incorporated		yes	yes	yes	Yes	Yes	yes	Yes	Yes	Yes
ESP incorporated		No	No	No	Yes	Yes	No	No	Yes	Yes
water consumption										
plant make-up	m^3/hr	15-20	1.5-2	1.5-2	1.5-2	1.5-2	1.5-2	1.5-2	1.5-2	1.5-2
domestic water	m^3/hr	5	5	5	5	5	5	5	5	5
SCR	m^3/hr	4-5	4_5	4-5	4-5	4-5	4-5	4-5	4-5	4-5
FGD	m^3/hr	0	0	0	80-100	80-100	0	0	80-100	80-100
Total	m^3/hr	20-25	10.5-12	10	90.5-112	90.5-112	10.5-12	10.5-12	90.5-100	90.5-100

Source: www.syriaipppproject.org

The final budgets of General Establishment for Electricity Generation in SAR do not reflect the economic cost of water used, and is limited to financial cost, which include drilling and maintenance of groundwater wells and water network at the power plant site in addition to the cost of drinking water purchased from the Water Utility.

Please kindly note, that the above mentioned paragraph is based on good reference. Local examples could not reflect good results, because of lack of data.

It is possible to calculate the investment needed for water in power plants expansions for the different scenarios (RS, MRS & MESS) used in this study.

Table 58 - Available, planned and needed power capacity for MRS & MESS up to 2030

		2011	2015	2020	2025	2030
Existing capacity without retirements		7019	6813	6218	5790	5170
Planned thermal capacity up to 2015		150	3610	4110	4110	4110
Planned wind farms (WF) up to 2015		-	350	350	350	350
Planned Photovoltaic's (PV) up to 2015		3	38	38	38	38
Deficit or needed capacities to be added	MRS	1763	1055	4499	8323	13105
	MESS	1674	492	3217	6066	9823

Source: Dr M. Kordab, 2011

Table 59 - Estimated investment needed for expansion of power generation plants up to 2030 for RS (Million $US)

(Million $US)	2010-2015	2016-2020	2021-2025	2026-2030	Total
Combined cycle	210.10	258.49	327.98	430.86	1227.43
Steam PP	289.17	223.10	187.46	103.41	803.15
Single GT	0.00	0.00	0.00	0.00	0.00
WF	0.00	0.00	0.00	0.00	0.00
CSP	0.00	0.00	6.81	54.48	61.29
PV	0.00	0.00	0.00	0.00	0.00
Hydro-electric	0.00	0.00	0.00	0.00	0.00
coal	0.00	0.00	0.00	88.22	88.22
Total	499.27	495.14	612.59	857.64	2464.64

Source: Dr M. Kordab, 2011

Table 60 - Estimated investment needs for expansion of power generation plants up to 2030 for MRS (Million $US)

(Million USD$)	2011-2015	2016-2020	2021-2025	2026-2030	Total
ST PP	282.88	311.46	378.97	484.76	1458.07
Single GT&CC PP	155.59	180.31	208.43	271.85	816.19
Coal fired PP	0.00	87.74	132.26	217.92	437.92
CSP	0.27	61.97	164.12	204.98	431.34
Total	438.75	641.48	883.78	1179.51	3143.52

Source: Dr M. Kordab, 2011

Table 61 - Estimated investment needs for expansion of power generation plants up to 2030 for MRS (Million $US)

(Million USD$)	2011-2015	2016-2020	2021-2025	2026-2030	Total
ST PP	276.83	295.49	333.06	424.00	1329.38
Single GT&CC PP	149.28	180.27	194.41	233.88	757.83
Coal fired PP	0.00	72.49	142.29	168.51	383.29
CSP	0.27	21.11	109.64	169.57	300.59
Total	426.39	569.36	779.39	995.95	2771.09

Source: Dr M. Kordab, 2011

VII. References

Carey King, Ian Duncan, Michael Webber (2008). *Water Demand Projections for Power Generation in Texas*. Prepared for Texas Water Development Board, August 31, 2008.

Daoud M. & W. Alhazim (2009). *Prospects for the use of various technologies conserved of water resources to irrigate crops in SAR.* Scientific Agricultural Research Conference VII, 3-4 August 2009, Duma, Damascus, SAR.

Daoud, Majar & Uzon (2011). *The Impact of Climate Change in Euphrates water Basin on Irrigation Water Demand Management.* HIWM, Homs.

EPRI (2004). *Comparison of Alternate Cooling Technologies for U.S. Power Plants: Economic, Environmental and other Trade-offs.*

Katana M. H. (2008). *The needs of the agricultural Sector of energy and the impact of changes of energy price on the sector.* Directorate of Statistics & Planning, Ministry of Agriculture and Agrarian Reform, Damascus.

National Committee for Energy Studies (2010). *Energy Demand Analysis in Syria for the period 2005-2030.* National Energy Congress, Damascus, Syrian Arab Republic.

OAPEC (2001-2009). *OAPEC Statistical Reports.* Kuwait, OAPEC.

Soumi G. & M. Daoud (2001). *Formulation and implementation project of population policy: population trends & water resource.* State Planning Commission, National Population Conference, November 2001.

Soumi G., M. Abo Omar & M. Daoud. *Status & development trends of future demand onwater resources (1970-2015). Report to the Council of Ministers.* Directorate of Irrigation & Water Use, Damascus.

Syrian Council of Ministers (2010). *National Committee for Energy Studies, National Energy Congress, Damascus, Syrian Arab Republic; March 2010.*

Syrian Ministry of Agriculture (1985-2009). *Statistical Agriculture Reports.*

Syrian Ministry of Electricity (2000-2010). *Electricity Balances.*

Syrian Ministry of Electricity (2003-2009). *Technical Statistical Reports.* Damascus.

Syrian Ministry of Electricity - National Energy Research Centre (NERC), GTZ (2010). *Master plan For Energy Efficiency and Renewable Energies (MEERE).*

Syrian Ministry of Electricity, UNDP (2001). *RE Master plan, Potential and Plans of Renewable Energy Resources and Applications in Syria.* Damascus.

Syrian Ministry of Irrigation (2005). *Syrian Water Legislation n°31.* Damascus.

Syrian Ministry of Oil & Mineral Resources (2010). *Strategic plan for NG production 2010-2025.* Saidnaya WS.

Syrian Ministry of Oil and Mineral Resources (2010). *Strategic Plan for oil & gas sector in Syria.*

Syrian Ministry of Oil and Mineral Resources (2010). *Strategic Plan for oil & gas sector in Damascus.*

Syrian National Energy Research Center (2001). *RE Master plan in Syria.* Damascus.

Syrian State Ministry for Environment Affaires, UNDP (2010). *Syrian Initial National Communication.*

Tellinghuisen, Stacy (2010). Water for Power Generation: What's the Value? *Natural Resources Journal,* vol. 50, issue 3.

U.S. Department of Energy (2006). *Report to the Congress on the Interdependency of Energy and Water, USA, December 2006.*

Елистратов В. В. (2008). Использование возобновляемой энергии (уч. Пособие). Санкт-Петербург, Изд-во Политехн. Ун-та, стр. 17-23.

Елистратов В. В. и др. (2007). Гидроэлектростанции малой мощности (учПособие). Санкт-Петербург, Изд-во Политехн. Ун-та, стр. 28-34.

VIII. Study Annexes

Table 62 - Water resources scenarios up to year 2030: demand, fresh & total water deficit (MCM)

Scenario	Data		Year				
			2009	2015	2020	2025	2030
Reference Scenario	Fresh water resources		14896	15950	14685	13420	13420
	EV		1940	1940	1795	1650	1650
	Demand	Domestic	1209	1340.57	1534.33	1733.03	1824.91
		Industrial	519	573.02	645.31	712.48	786.63
		Agriculture & Irrigation	16180	17180	18680	18680	18680
	Water re-use /waste + drainage		4891.3	5233.396	5744.031	5883.119	5947.437
	Fresh water deficit		-4952	-5083.58	-7969.64	-9355.5	-9521.54
	Total water resources deficit		-60.7	149.81	-2225.61	-3472.38	-3574.1
Alternative Scenario	Fresh water resources		14896	15950	14685	13420	13420
	ET		1940	1940	1795	1650	1650
	Demand	Domestic	1209	1313.75	1488.3	1646.38	1678.92
		Industrial	519	561.56	625.95	676.85	723.7
		Agriculture & Irrigation	16180	16127.69	16120.29	15844.39	15522.55
	Water re-use /waste+drenage		4891.3	4548.358	4265.869	4004.454	3503.624
	Fresh water deficit		-4952	-3993	-5344.55	-6397.62	-6155.16
	Total water resources deficit		-60.7	555.36	-1078.68	-2393.17	-2651.54
Legal Scenario	Fresh water resources		14896	13420	13420	13420	13420
	ET		1940	1650	1650	1650	1650
	Demand	Domestic	1209	1287.48	1443.65	1580.52	1594.97
		Industrial	519	539.32	588.96	617.29	632.51
		Agriculture & Irrigation	16180	14560.01	12644.64	12204.06	11843.33
	Water re-use /waste+drenage		4891.3	3813.237	2907.252	2631.872	2300.813
	Fresh water deficit		-4952	-4616.81	-2907.25	-2631.87	-2300.81
	Total water resources deficit		-60.7	-803.57	0	0	0

Source: Dr M. Kordab, 2011

Table 63 - Water Supply for different use & for different scenarios (year 2009 & year 2030) (%)

Year				Water demand	Scenario
2030		2009			
%	MCM	%	MCM		
8.41	1940.00	6.68	1210.00	Domestic supply	RS
3.43	790.00	2.87	520.00	Industrial supply	
86.72	20000.00	89.27	16180.00	Irrigation & agriculture	
1.16	267.47	0.99	180.00	Live stock	
0.02	5.08	0.02	3.10	Transport	
0.27	61.4	0.17	30.7	Other needs	
100.00	23063.95	100.00	18123.80	Total	
9.24	1790.00			Domestic supply	AS
3.72	720.00			Industrial supply	
85.31	16520.00			Irrigation & agriculture	
1.38	267.47			Live stock	
0.03	5.08			Transport	
0.32	61.40			Other needs	
100.00	19363.95			Total	
11.14	1700.00			Domestic supply	LS
4.13	630.00			Industrial supply	
82.55	12600.00			Irrigation & agriculture	
1.75	267.47			Live stock	
0.03	5.08			Transport	
0.40	61.40			Other needs	
100.00	15263.95			Total	

Source: Dr M. Kordab, 2011

Table 64 - Distribution of water for irrigation according to different scenarios

Scenario	Irr. Water Resource	Years				
		2009	2015	2020	2025	2030
Reference Scenario	Governmental	5560.0	6588.5	7163.7	7163.7	7163.7
	Underground	7988.7	7471.3	8123.6	8123.6	8123.6
	Surface	2631.3	3118.0	3390.3	3390.3	3390.3
	Total	16180.0	17177.7	18677.5	18677.5	18677.5
Alternative Scenario	Governmental	5560.0	6184.9	6182.1	6076.3	5952.8
	Underground	7988.7	7013.6	7010.4	6890.4	6750.5
	Surface	2631.3	2927.0	2925.7	2875.6	2817.2
	Total	16180.0	16125.6	16118.2	15842.3	15520.6
Legal Scenario	Governmental	5560.0	6096.1	6360.6	6417.1	6172.2
	Underground	7988.7	5578.9	3273.9	2750.0	2750.0
	Surface	2631.3	2885.0	3010.2	3037.0	2921.1
	Total	16180.0	14560.0	12644.6	12204.1	11843.3

Source: Dr M. Kordab, 2011

Table 65 - Energy intensity for water supply, kWh/m³

Scenario		2009	2015	2020	2025	2030
RS	energy Intensity for domestic water supply	0.850	0.850	0.850	0.850	0.850
AS		0.850	0.829	0.795	0.786	0.778
LS		0.850	0.795	0.786	0.778	0.778
RS	energy Intensity for industrial water supply	0.400	0.400	0.400	0.400	0.400
AS		0.400	0.400	0.420	0.430	0.450
LS		0.400	0.420	0.440	0.450	0.455

Source: Dr M. Kordab, 2011

Table 66 - Energy demand for water supply according to different scenarios

Energy demand for water supply according to different scenarios							
Year					Elec. (GWh)		Scenario
2030	2025	2020	2015	2009	Oil (ktoe)		
1551.2	1473.1	1304.2	1139.5	1028.5	domestic water use		RS.
314.7	285.0	258.1	229.2	207.6	industry		
3203.4	3236.8	3270.2	3041.5	2591.2	Elec.	irrigation & agriculture	
223.7	223.7	223.7	223.7	223.7	Oil		
5069.3	4994.9	4832.5	4410.2	3827.3	Elec.	Total	
223.7	223.7	223.7	223.7	223.7	Oil		
1305.8	1294.5	1182.8	1088.8	1028.5	domestic water use		AS.
325.7	291.0	262.9	224.6	207.6	industry		
2488.9	2567.0	2638.7	2754.9	2591.2	Elec.	irrigation & agriculture	
223.7	223.7	223.7	223.7	223.7	Oil		
4120.4	4152.5	4084.4	4068.3	3827.3	Elec.	Total	
223.7	223.7	223.7	223.7	223.7	Oil		
1240.5	1229.2	1135.1	1023.2	1028.5	domestic water use		LS
287.8	277.8	259.1	226.5	207.6	industry		
2159.6	2257.8	2316.4	2483.4	2591.2	Elec.	irrigation & agriculture	
223.7	223.7	223.7	223.7	223.7	Oil		
3687.9	3764.8	3710.6	3733.2	3827.3	Elec.	Total	
223.7	223.7	223.7	223.7	223.7	Oil		

Source: Dr M. Kordab, 2011

Table 67 - Primary Energy demand in SAR during 2000-2009 (Mtoe)

Years	2000	2001	2002	2003	2004
Oil products	11.61	12.01	11.73	12.48	13.73
Natural gas	3.83	4.01	4.88	5.00	4.67
Hydro power	0.60	0.53	0.55	0.62	0.88
Wood fuel	0.6	0.6	0.6	0.6	0.6
Total energy demand	16.64	17.15	17.76	18.70	19.88
Annual growth%		3.06	3.55	5.29	6.32
years	2005	2006	2007	2008	2009
Oil products	16.00	16.8	18.18	17.76	15.20
Natural gas	4.53	4.57	4.45	4.75	6.37
Hydro power	0.76	0.89	0.88	0.72	0.48
Wood fuel	0.6	0.6	0.6	0.6	0.6
Total energy demand	21.89	22.89	24.11	23.83	22.66
Annual growth%	7.2	4.57	5.34	-1.16	-4.92

Source: Syrian Energy Balances 2000-2009

Table 68 - Distribution of electricity produced according to the generation type during the period 2000 - 2008 (GWh)

	2000	2001	2002	2003	2004	2005	2006	2007	2008
Total Electricity production	25218	26714	28014	29534	32077	34935	37505	38645	41023
Total Hydropower	2503	2119	2501	2804	4247	3445	3994	3526	2872
Thermal Electricity production	22715	24595	25513	26730	27830	31490	33511	35119	38151
Steam Turbines production	12775	14492	14770	15870	16468	18985	21329	22552	23986
Gas Turbines production	5721	5624	5775	5775	6410	7323	6992	7304	3761
Combined cycle Turbines Production	4219	4479	4968	5085	4952	5182	5190	5263	10404
1- Thermal Production by Fuel oil	11708	12889	10724	11200	13765	17846	19557	22176	23693
2-Thermal Production by Natural Gas	11007	11706	14788	15530	14065	13644	13954	12943	14460

Source: Ministry of Electricity, Electricity Statistical Reports, 2000-2009

Table 69 - Nominal Installed Capacity (MW)

	2000	2001	2002	2003	2004	2005	2006	2007	2008
Nominal installed capacity	7302	7407	7313	7313	7313	7159	7159	7459	7959
Steam Turbines	3701	3701	3701	3701	3701	3547	3547	3547	3547
Gas Turbines (Diesel)	394	394	90	90	90	90	90	90	90
Gas Turbines(NG)	1292	1292	1292	1292	1292	1292	1292	617	1117
Combined cycle	702	702	702	702	702	702	702	1677	1677
Installed hydropower	1213	1318	1528	1528	1528	1528	1528	1528	1528
Growth rate of installed capacity%		1%	-1.3%	0.0%	0.0%	-2.1%	0.0%	4.2%	6.7%

Source: Syrian Ministry of Electricity, Electricity Statistical Reports

Table 70 - Available Installed Capacity (MW)

	2000	2001	2002	2003	2004	2005	2006	2007	2008
Available Installed Thermal Capacity	5882	6395	6605	6605	6520	6008	5950	6250	6479
Steam Turbines	3050	3355	3355	3355	3270	2995	3035	3035	3035
Gas Turbines (Diesel)	90	3035	3035	3035	3035	0	0	0	0
Gas Turbines(NG)	1140	1140	1140	1140	1140	1172	1124	464	944
Combined cycle	640	640	640	640	640	640	640	1600	1600
Available Installed Hydro power	962	1170	1380	1380	1380	1201	1151	1151	900

Source: Dr M. Kordab, 2011

Table 71 - Climate Statistics from some stations of Climate areas in Syria

Area	Station Name	Latituds (N)	Longitude (E)	Altitude (m)	Yearly			
					Maximum temperature (°C)	Minimum temperature (°C)	Mean temperature (°C)	Rain (mm)
Coastal Region	Lattakia	35°36'	35°46'	9	23	16	19.5	799.2
	Safita	34° 49'	36°08'	370	22.2	14.5	18.3	1,130.5
	Tartous	34° 52'	35°53'	5	23.3	15.0	19.1	879.0
Western Inland Syria	Tell Abyad	36° 42'	38°57'	348	24.8	9.0	16.9	296.7
	Jerablus	36° 49'	38°00'	351	24.6	10.2	17.4	324.7
	Aleppo	36° 11'	37°14'	385	23.8	11.0	17.4	330.4
	Almeselmiah	36° 20'	37°14'	415	23.4	9.5	16.4	332.5
	Idlib	35° 56'	36°37'	451	22.3	12.6	17.4	505.4
	Hama	35° 07'	36°24'	305	24.7	10.8	17.7	352.4
	Salamiya	35° 01'	37°02'	448	24	9.3	16.7	307.6
	Homs	34° 46'	36°43'	483	22.8	10.7	16.8	435.7
	Damascus, I. A	33° 26'	36°32'	610	25.0	7.9	16.5	143.7
	Mezzeh	33° 29'	36°13'	730	24.3	10.3	17.3	204.5
	Kharabo	33° 30'	36°27'	620	24.7	6.7	15.7	164.0
	Dera'a	32° 36'	36°07'	543	24.0	10.4	17.2	266.0
South Inland Syria	An-Nabk	34° 01'	36°44'	1,329	19.2	6.5	12.9	119.6
	Suweida	32° 44'	36°34'	1,015	21.7	9.9	15.8	353.6
Euphrates and Steppe	Palmyra	34° 33'	38°18'	400	25.6	12.2	18.9	136.0
	Deir ez-Zor	35° 17'	40°11'	215	26.6	13.1	19.9	156.3
	Abou Kemal	34° 26'	40°55'	175	27.5	12.8	20.2	135.0
	Raqqa	35° 54'	38°59'	246	25.5	11.6	18.5	211.2
	At-Tanf	32° 29'	38°40'	712	24.8	9.9	17.3	106.6
Northeastern Syria	Qamishli	37° 02'	41°12'	449	25.1	12.4	18.8	437.0
	Hassake	36° 34'	40°43'	307	25.7	10.7	18.2	288.8

Source: Dr M. Kordab, 2011

Table 72 - Detailed Initial Cost Required for Expansion of Generation Power Plants during 2011-2030 for the MRS (Million $US)

Million US$	2011 - 2015	2016 - 2020	2021 - 2025	2026 - 2030	Total
Planned projects during 2011-2015	4608	841	554	554	6557
Public sector expansion projects:	4439	288	0	0	4727
Thermal PP	3977	288	0	0	4265
CSP (10 MW)	40	0	0	0	40
WF	270	0	0	0	270
PV	152	0	0	0	152
Cost of purchased electricity from private sector	169	554	554	554	1830
From Alnasrieh PP	127	344	344	344	1158
From WF	42	210	210	210	672
Expansion projects during 2016-2030	1898	9531	10891	16630	38949
Public sector expansion projects:	1898	5996	2868	6399	17160
CSP	1208	2818	0	0	4025
Pumping storage hydro-pp	690	1035	0	0	1725
WF	0	874	219	1093	2185
PV	0	200	200	200	600
New steam power plants	0	759	690	966	2415
New CC power plants	0	311	1760	4140	6210
Cost of purchased electricity from private sector	0	3535	8023	10231	21789
CSP with water desalination	0	440	2200	2200	4840
2nd CSP	0	0	480	1200	1680
WF	0	1295	1943	2231	5469
PV	0	0	600	600	1200
Coal fired Power plant No./1/	0	1800	2000	2000	5800
Coal fired Power plant No./2/	0	0	800	2000	2800
Grand Total	6506	10372	11444	17183	45506

Source: Dr M. Kordab, 2011

Table 73 - Detailed Operational & Fuel cost required for Expansion Power Plants during 2011-2030 for the MRS (Million $US)

Million US$	2011-2015	2016-2020	2021 - 2025	2026 - 2030	Total
Planned projects during 2011-2015	25382	26784	25417	24222	101805
Public sector expansion projects:	25382	26784	25417	24222	101805
Thermal PP	25368	26756	25389	24195	101709
CSP (10 MW)	4	10	10	10	34
WF	8	14	14	14	49
PV	2	4	4	4	13
Cost of purchased electricity from private sector	0	0	0	0	0
From Alnasrieh PP	0	0	0	0	0
From WF	0	0	0	0	0
Expansion projects during 2016-2030	0	1649	8830	19562	30041
Public sector expansion projects:	0	1649	8830	19562	30041
CSP	0	704	1006	1006	2717
Pumping storage hydro-pp	0	311	518	518	1346
WF	0	0	55	98	153
PV	0	3	8	13	24
New steam power plants	0	448	3360	6944	10752
New CC power plants	0	183	3883	10983	15050
Cost of purchased electricity from private sector	0	0	0	0	0
CSP with water desalination	0	0	0	0	0
2nd CSP	0	0	0	0	0
WF	0	0	0	0	0
PV	0	0	0	0	0
Coal fired Power plant No./1/	0	0	0	0	0
Coal fired Power plant No./2/	0	0	0	0	0
Grand Total	25382	28433	34247	43785	131846

Source: Dr M. Kordab, 2011

Table 74 - Detailed Initial, Operational & Fuel Cost Required for Expansion Power Plants During 2011-2030 for the MRS (Million $US)

Million US$	2011 - 2015	2016 - 2020	2021 - 2025	2026 - 2030	Total
Planned projects during 2011-2015	29990	27625	25971	24776	108362
Public sector expansion projects:	29821	27071	25417	24222	106532
Thermal PP	29345	27044	25389	24195	105973
CSP (10 MW)	44	10	10	10	74
WF	278	14	14	14	319
PV	154	4	4	4	165
Cost of purchased electricity from private sector	169	554	554	554	1830
From Alnasrieh PP	127	344	344	344	1158
From WF	42	210	210	210	672
Expansion projects during 2016-2030	1898	11180	19720	36192	68990
Public sector expansion projects:	1898	7645	11698	25961	47201
CSP	1208	3522	1006	1006	6742
Pumping storage hydro-pp	690	1346	518	518	3071
WF	0	874	273	1191	2338
PV	0	203	208	213	624
New steam power plants	0	1207	4050	7910	13167
New CC power plants	0	494	5643	15123	21260
Cost of purchased electricity from private sector	0	3535	8023	10231	21789
CSP with water desalination	0	440	2200	2200	4840
2nd CSP	0	0	480	1200	1680
WF	0	1295	1943	2231	5469
PV	0	0	600	600	1200
Coal fired Power plant No./1/	0	1800	2000	2000	5800
Coal fired Power plant No./2/	0	0	800	2000	2800
Grand Total	31888	38805	45691	60968	177352

Source: Dr M. Kordab, 2011

Table 75 - Detailed Initial Cost required for Expansion Generation Power Plants during 2011-2030 for the MRS (Million $US)

Million US$	2011 - 2015	2016 - 2020	2021 - 2025	2026 - 2030	Total
Planned projects during 2011-2015	4581	841	554	554	6529
Public sector expansion projects:	4439	288	0	0	4727
Thermal PP	3977	288	0	0	4265
CSP (10 MW)	40	0	0	0	40
WF	270	0	0	0	270
PV	152	0	0	0	152
Cost of purchased electricity from private sector	141	554	554	554	1802
From Alnasrieh PP	99	344	344	344	1130
From WF	42	210	210	210	672
Expansion projects during 2016-2030	932	5353	9430	12177	27891
Public sector expansion projects:	932	2696	2862	4490	10979
CSP	242	403	161	0	805
Pumping storage hydro-pp	690	1035	0	0	1725
WF	0	437	983	219	1639
PV	0	200	200	200	600
New steam power plants	0	311	794	966	2070
New CC power plants	0	311	725	3105	4140
Cost of purchased electricity from private sector	0	2657	6568	7688	16912
CSP with water desalination	0	440	2200	2200	4840
2nd CSP	0	0	480	1200	1680
WF	0	441	508	508	1456
PV	0	576	780	780	2136
Coal fired Power plant No./1/	0	1200	2000	2000	5200
Coal fired Power plant No./2/	0	0	600	1000	1600
Grand Total	5512	6194	9983	12731	34421

Source: Dr M. Kordab, 2011

Table 76 - Detailed Operational & Fuel Cost required for Expansion Power Plants during 2011-2030 for the MRS (Million $US)

Million US$	2011-2015	2016-2020	2021-2025	2026-2030	Total
Planned projects during 2011-2015	24638	26634	25091	24212	100575
Public sector expansion projects:	24638	26634	25091	24212	100575
Thermal PP	24624	26606	25064	24184	100479
CSP (10 MW)	4	10	10	10	34
WF	8	14	14	14	49
PV	2	4	4	4	13
Cost of purchased electricity from private sector	0	0	0	0	0
From Alnasrieh PP	0	0	0	0	0
From WF	0	0	0	0	0
Expansion projects during 2016-2030	0	638	4937	12790	18364
Public sector expansion projects:	0	638	4937	12790	18364
CSP	0	141	201	201	543
Pumping storage hydro-pp	0	311	518	518	1346
WF	0	0	27	82	109
PV	0	3	8	13	24
New steam power plants	0	0	2016	5376	7392
New CC power plants	0	183	2167	6600	8950
Cost of purchased electricity from private sector	0	0	0	0	0
CSP with water desalination	0	0	0	0	0
2nd CSP	0	0	0	0	0
WF	0	0	0	0	0
PV	0	0	0	0	0
Coal fired Power plant No./1/	0	0	0	0	0
Coal fired Power plant No./2/	0	0	0	0	0
Grand Total	24638	27271	30028	37001	118939

Source: Dr M. Kordab, 2011

Table 77 - Detailed Initial, Operational & Fuel Cost required for Expansion Power Plants during 2011-2030 for the MRS (Million $US)

Million US$	2011 - 2015	2016 - 2020	2021 - 2025	2026 - 2030	Total
Planned projects during 2011-2015	29219	27475	25645	24766	107104
Public sector expansion projects:	29078	26921	25091	24212	105302
Thermal PP	28601	26894	25064	24184	104743
CSP (10 MW)	44	10	10	10	74
WF	278	14	14	14	319
PV	154	4	4	4	165
Cost of purchased electricity from private sector	141	554	554	554	1802
From Alnasrieh PP	99	344	344	344	1130
From WF	42	210	210	210	672
Expansion projects during 2016-2030	932	5990	14366	24967	46255
Public sector expansion projects:	932	3333	7799	17279	29343
CSP	242	543	362	201	1348
Pumping storage hydro-pp	690	1346	518	518	3071
WF	0	437	1011	300	1748
PV	0	203	208	213	624
New steam power plants	0	311	2810	6342	9462
New CC power plants	0	494	2891	9705	13090
Cost of purchased electricity from private sector	0	2657	6568	7688	16912
CSP with water desalination	0	440	2200	2200	4840
2nd CSP	0	0	480	1200	1680
WF	0	441	508	508	1456
PV	0	576	780	780	2136
Coal fired Power plant No./1/	0	1200	2000	2000	5200
Coal fired Power plant No./2/	0	0	600	1000	1600
Grand Total	30151	33465	40011	49732	153359

Source: Dr M. Kordab, 2011

IX. Table of illustrations