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Enabiling Activities for Preparation of Syria's Initial National Communication to UNFCCC

Mitigation of greenhouse gas emissions by Using the Renewable Energy & Energy Efficiency

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Mitigation of greenhouse gas emissions on the Renewable Energy & Energy Efficiency in Syria

(INC-SY_Mitigation_ Oil & Gas Production opportunities-En)

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This report has been approved unanimously by the technical committee, during the Technical Workshop which took place on 28.2.2010, in Samiramis Hotel, Damascus.

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Executive Summary

1. Introduction

Sustainable development is the goal of governments, businesses and communities around the world. The concept encourages us to think globally and act locally, which means beginning at home with an analysis of the lifestyle and purchasing decisions we make as a family.

People in Syria are becoming aware of the need to support local businesses that invest in clean energy and energy efficiency which is an easy way to promote more sustainable business practices everywhere.

If we are able to convince people that Renewable Energy and Energy Efficiency (RE&EE) are viable and cost effective then we could reduce the energy demands of our nation as well as Greenhouse Gas emissions (GHGs).

Buildings have some of the highest energy costs. Fortunately, however, buildings also have some of the greatest opportunity for energy saving.

The **Intergovernmental Panel on Climate Change (IPCC)** Fourth Assessment Report estimates that by 2020 CO_2 emissions from building energy use can be reduced by 29% at no net cost.

2. Background

- ***Syrian Supply Side Efficiency and Energy Conservation and Planning (SSEECP) (UNDP/GEF, SYR/96/G31) [17]***

This Project has been designed to promote energy efficiency on both the supply and demand side and thereby reduce energy consumption, make the economy more efficient, and reduce emissions of greenhouse gases. In support of the overall goal of the demand-side component of the SSEECP project a Demand-side Management (DSM) assessment for Syria was undertaken between 2003 and 2005. The DSM assessment used data collected in the forecast and household surveys together with avoided costs and additional measures costs and saving information, to estimate the cost-effectiveness of over 100 measure and market combinations, grouped into 18 programs. Results of this DSM assessment are adopted in this report. The SSEECP project was completed in 2006.

- ***Syria National Renewable Energy Master Plan (UNDP/DESA, SYR/99/001/08) [13]***

Working with national counterpart agency and with the involvement of different stakeholders, a Master Plan document was prepared which outlines plans and programs for time-bound implementation and corresponding resource outlays with respect to Research, Development and Demonstration projects for technology development, Pilot projects for technology demonstration as well as investment-worthy projects covering different forms of renewable energy. The proposals made in the document were endorsed by the government of Syria. Steps have also been taken by the government to start the implementation of Master Plan proposals. The Master Plan was completed in 2002.

- ***Policy Strategy and Institutional Development to Introduce Photovoltaic Systems into Syrian Arab Republic (UNDP, SYR/97/E01) [35]***

The goal of this study is to provide a guideline to establishing the infrastructure (financial, institutional, legislative and technical) necessary to implement renewable energy systems in general and PV technology in particular as a tool for rural development within the Syrian context and in line with Syria's Master Plan.

A second goal of this study is to ensure that photovoltaic energy systems make an important contribution to Syria's energy needs especially its rural electrification, un-electrified villages, and water pumping applications. This in turn will help in the diversifying the available energy resources.

A third goal of this study is to contribute to a better understanding of the potential impact and of the limitations of PV systems on Sustainable Agriculture and Rural Development (SARD), especially concerning income-generating activities. It is, in fact, of paramount importance to identify the potential contribution of PV to rural development in order to gain further financial and political commitment for PV projects and programs and to design appropriate PV projects. This study was undertaken in 2005.

- ***Codes & Regulations existing in Syria***

Syria has already started the process of developing energy efficiency codes and regulations. However, development, adoption and successful implementation of building energy efficiency codes has not realized yet. A new and differently targeted boost is required to bring the country up to speed on this issue. The relevant existing EE codes and regulations in Syria are the following:

- Code of Thermal Insulation in Building, became in force on November 22, 2007,
- Minimum Efficiency Standards for Electrical Appliances and Equipment in the Residential, Commercial and Service Sectors (No. 18, 2008),
- Energy Conservation Law (No. 3, 2009).

3. Goals of the Report

The goal of this report is to identify potential energy saving measures in the residential sector and to outline the benefits of integrating RE&EE technologies in buildings. Some of these measures are particularly simple to implement in the planning stages of a new building or when replacing existing equipment with new ones; other measures are more appropriate as retrofit options. Some of energy efficiency measures can pay for themselves quickly.

A second goal of this report is to calculate GHG mitigation according to methodology developed by the **IPCC** National Greenhouse Gas Inventories Programme (**IPCC-NGGIP**) laid down in 1996 Guidelines; and estimates the GHG mitigation for the baseline future energy supply scenario (year 2005 as baseline).

4. Energy Consumption in Buildings in Syria

Buildings in the residential, commercial and service sector in Syria have consumed 15.8% of the country total primary energy consumption in 2005 and 28.9% of the country total final energy consumption in 2005.

Energy intensity in 2005 was 135 kWh/m^2/year in residential sector and 163 kWh/m^2.year in commercial sector. For comparison, new low-energy houses in Europe have an annual heat demand of 50-100 kWh/m^2.year.

5. Mitigation Options

The analysis of CO_2 emissions sources suggests that mitigation actions in the residential sector in Syria would contribute to reduce Syria's GHG emissions. Alternatives to the use of fossil fuel resources are the Solar Energy and Energy Efficiency. There are two main approaches to RE&EE in buildings:

- Cut buildings' energy demand by, for example, using equipment that is more energy efficient,
- Produce energy locally from solar energy.

Syria is an ideal site for the use of solar energy. The greatest constraint to the development of solar energy is its initial cost.

Efficiency gains in buildings are likely to provide the greatest energy reductions and in many cases will be the most economical option.

Scenarios in which GHG emissions are reduced or mitigated relative to a baseline case (2005) were analysed for the residential sector for the year 2030.

Building GHG Mitigation Options Considered in this Report

Typical uses for energy in buildings include space heating, hot water preparation, cooking, refrigeration, laundry, and other electrical appliances. With hot climate in summer, air conditioning gains importance. In the building sector which includes also the public and private services sector, lighting is of primary importance.

- ***Solar Water Heating***

The proposed solar water heating systems and fuel saving in 2030 in the residential, commercial and service sectors are presented in Tables (i) and (ii).

Table (i): Fuel Saving in 2030 from Solar Water Heating Systems in the Residential Sector

	Unit	Diesel oil	Electricity	Total
Installing 1,974,026 domestic solar water heaters in 2030	Ktoe	303	76	379
	%	80%	20%	100%

Table (ii): Fuel Saving in 2030 from Solar Water Heating Systems in the Commercial and Service Sectors

	Unit	Diesel oil	Total
Installing 2000 solar water heating systems in 2030	ktoe %	6 100%	6 100%

- ***Photovoltaic (PV) Systems***

PV systems can be of the stand alone type, hybrid type or grid-connected type. The proposed stand alone PV applications up to 2030 are presented in Table (iii).

Table (iii): Proposed PV Applications up to 2030

	Existing Numbers	Proposed numbers	PV system capacity Wp	Total capacity kWp
Electrify communities (houses) located more than 10 km from the grid	8842	2000	500	1000
Electrify health centers located far from the grid	37	6	1500	9
Electrify schools	34	34	1000	34
Drinking water pumping	83	83	2000	166
Irrigation and livestock water pumping	-	1000	6000	6000
Drinking water desalination	30	30	5000	150
Total				7405

The total energy saving from all proposed solar energy applications in 2030 is presented in Table (iv).

Table (iv): Total Energy Savings in 2030 from All Solar Applications

	Unit	Diesel oil	Electricity	Total
Installing 1,974,026 domestic solar water heaters in 2030	Ktoe %	303 80%	76 20%	379 100%
Installing 2000 solar water heating systems in 2030	Ktoe %	6 100%	- -	
PV applications	Ktoe %	1.21 100%	- -	
Total	Ktoe	310.21	76	386.21

- ***Thermal Envelope (Thermal insulation)***

The thermal envelop refers to the shell of the building as a barrier to unwanted heat between the interior of the building and the outside conditions.

The key to success in a venture of this type is setting a goal for a low-energy building before the design begins (utilize system approaches to building design, and consider building form, orientation, thermal insulation and related attributes). Waiting until an architect has designed a building and then trying to include energy efficiency features is not nearly as effective as establishing energy efficiency as a goal at the outset.

Table (v) presents the possible fuel saving in 2030 by installing thermal insulation in building.

Table (v): Fuel Saving in 2030 by Installing Thermal Insulation in Buildings

Scenario	Number of insulated flats in 2030	Diesel oil (10^6 liter)	Electricity (GWh)
Week	200,000	149	587
Medium	600,000	447	1760
High	1,000,000	745	2933

Table (vi) presents the possible energy saving in 2030 by installing thermal insulation in building.

Table (vi): Energy Saving in 2030 by Installing Thermal Insulation in Buildings

Scenario	Units	Diesel oil	Electricity	Total
Week	ktoe	128	147	275
	%	47%	53%	100%
Medium	ktoe	384	440	824
	%	47%	53%	100%
High	ktoe	641	733	1374
	%	47%	53%	100%

- ***Reflective building Roofs***

Increasing the solar reflectance of the building roofs reduces its solar heat gain, lowers its temperatures, and decreases its outflow of thermal infrared radiation into the atmosphere. This process of “negative radiative forcing” effectively counters global warming. Most existing flat roofs are dark and reflect only 10 to 20% of sunlight. Resurfacing conventional dark roofs, with a cool white material that has a long-term solar reflectance of 0.60 or more increases its solar reflectance by at least 40%. Retrofitting 100 m^2 of roof has an effect on radiative forcing equivalent to a one-time offset of 10 tones of CO_2 [40].

Table (vii) presents the possible avoided CO_2 in 2030 by reducing cooling load by installing cool roofs on residential buildings existing in Syria in 2010.

Table (vii): CO_2 Avoided by Reducing Cooling Load by Installing Cool Roofs on Residential Buildings Existing in 2010

Row	Item	Value
1	Estimated residential roof area in 2010	0.3×10^9 m^2
2	Fraction of all buildings that are air conditioned	1%
3	Average air conditioning saving	2.78 kWh/m^2/yr
4	Potential annual saving (Row 1 x Row 2 x Row 3)	8.34 GWh/yr
5	CO_2 emission per kWh electricity generation	0.521 kg CO_2/kWh
6	Annual avoided CO_2 emissions (Row 4 x Row 5)	4.35 kt CO_2/yr

Table (viii) presents the possible avoided CO_2 in 2030 by reducing cooling load by installing cool roofs on residential buildings expected to be constructed in Syria between 2010 & 2030.

Table (viii): CO_2 Avoided in 2030 by Reducing Cooling Load by Installing Cool Roofs on Residential Buildings Expected to be Constructed Between 2010 & 2030

Row	Item	Value
1	Estimated residential roof area in 2030	0.47×10^9 m^2
2	Fraction of all buildings that are air conditioned	2%
3	Average air conditioning saving	2.78 kWh/m^2/yr
4	Potential annual saving (Row 1 x Row 2 x Row 3)	26.1 GWh/yr
5	CO_2 emission per kWh electricity generation	0.521 kg CO_2/kWh
6	Annual avoided CO_2 emissions (Row 4 x Row 5)	13.6 kt CO_2/yr

Table (ix) presents energy saving in 2030 from reducing cooling load by installing cool roofs on residential buildings in Syria.

Table (ix): Energy Saving in 2030 from Reducing Cooling Load by Installing Cool Roofs on Residential Buildings in Syria

<table>
<tr><th>Measures</th><th>Unit</th><th>Electricity</th></tr>
<tr><td rowspan="2">Cooling energy saving by installing a cool roof in 1% of existing building in 2010 (increasing roof’s solar reflectance by 20%)</td><td>GWh/yr</td><td>8.34</td></tr>
<tr><td>ktoe</td><td>2.1</td></tr>
<tr><td rowspan="2">Cooling energy saving by installing a cool roof in 2% of residential buildings expected to be constructed in Syria between 2010 & 2030 (increasing roof’s solar reflectance by 20%)</td><td>GWh/yr</td><td>26.1</td></tr>
<tr><td>ktoe</td><td>6.53</td></tr>
<tr><td rowspan="2">Total</td><td>GWh/yr</td><td>34.44</td></tr>
<tr><td>ktoe</td><td>8.63</td></tr>
</table>

- ***Lighting Systems***

Table (x) presents the proposed measures for improving lighting systems in the residential, commercial, service and industrial sectors and corresponding electric energy saving in 2030. Table (4) in Annex (8) includes these measures.

Table (x): Measures for Improving Lighting Systems in the Residential, Commercial, Service and Industrial Sectors and Corresponding Electric Energy Saving in 2030

No.	Measures	Saving in 2030 (GWh)
1	High-efficiency Lighting in the Religion and Industrial Sectors	477.3
2	CFL and High-efficiency Tube Lamps in Residential Applications	377.1
3	High-efficiency Lighting in Commercial and Government Applications	374.6
4	High-efficiency Street Lighting Measures	249.3
	Total	1478.3

The total electric energy saving in 2030 gained from improving lighting systems measures in the residential, commercial, service and industrial sectors is presented in Table (xi).

Table (xi): Total Electric Energy Saving in 2030 from Improving Lighting Systems in the Residential, Commercial, Service and Industrial Sectors

Measure	Unit	Electricity
Improving Lighting Systems	GWh	1478.3
	ktoe	369.6

- ***Household Appliances, Consumer Electronics and Office Equipment***

Table (xii) presents the proposed measures for improving energy efficiency in electrical appliances in the residential, commercial, and service sectors and corresponding electric energy saving in 2030. Table (5) in Annex (8) includes these measures.

Table (xii): Measures for Improving Energy Efficiency in Electrical Appliances in the Residential, Commercial, and Service Sectors and Corresponding Electric Energy Saving in 2030

No.	**Measures**	**Saving in 2030 (GWh)**
1	High-efficiency Air Conditioners in Residential Applications	197.3
2	High-efficiency Refrigerators in Residential Applications	82.1
3	High-efficiency Air Conditioners in Medium and Large Commercial Applications	76.8
4	High-efficiency Water Heaters and Water Heater Controllers in Residential Applications	75.4
5	High-efficiency motors for Water and Wastewater	71.9

	Pumping	
6	High-efficiency Air Conditioners and Load Control in Small Commercial Applications	58.4
7	High-efficiency Air Conditioners and Load Control in Government Sector Applications	11.2
	Total	**573.1**

The total electric energy saving in 2030 gained from improving energy efficiency measures in the electrical appliances in the residential, commercial, and service sectors is presented in Table (xiii).

Table (xiii): Total Electric Energy Saving in 2030 from Improving Energy Efficiency in the Electrical Appliances in the Residential, Commercial, and Service Sectors

Measure	Unit	Electricity
Improving Energy Efficiency in Electrical Appliances	GWh	**573.1**
	ktoe	**143.3**

The total energy saving in 2030 gained from all energy efficiency measures in the residential, commercial, and service sectors is presented in Table (xiv). Only improving lighting systems measure in industrial sector is included in this Table.

Table (xiv): Total Energy Saving in 2030 from All Energy Efficiency Measures in the Residential, Commercial, and Service Sectors (ktoe)

Measures	Diesel oil	Electricity	Total
1. Thermal insulation (scenario: week)	128	147	**275**
2. Cooling energy saving by installing a cool roof in 1% of existing building in 2010	−	2.1	**2.1**
3. Cooling energy saving by installing a cool roof in 2% of residential buildings constructing in Syria between 2010 & 2030	−	6.53	**6.53**
4. Improving lighting systems	**-**	369.6	**369.6**
5. Improving Energy Efficiency in Electrical Appliances	**-**	143.3	**143.3**
Total	**128**	**668.53**	**796.53**

N.B: Only improving lighting systems measure in industrial sector is included in this Table.

5. Conclusion

Table (xv) presents the total energy saving in 2030 gained from all RE&EE measures in the residential, commercial, and service sectors.

Table (xv): Total Energy Saving in 2030 from All RE&EE Measures in the Residential, Commercial, and Service Sectors

Measures	Units	Diesel oil	Electricity	Total
Solar energy	ktoe	310.21	76	**386.21**
Energy efficiency	ktoe	128	668.53	**796.53**
Total	ktoe	**438.21**	**744.53**	**1182.74**
	Tj	**17529**	**29781**	**47310**

Analysis of the results demonstrates that the development of RE & EE would contribute to reduce the final energy consumption in Syria in 2030 by 2.45%.

Finally, the total CO_2 Emissions Avoided in 2030 (kt CO_2), calculated according to Revised 1996 IPCC Guidelines, are presented in Table (xvi).

Table (xvi): Total CO_2 Emissions Avoided in 2030 (kt CO_2) According to Revised 1996 IPCC Guidelines

MODULE	Energy					
SUBMODULE	CO_2 from fuel combustion					
WORKSHEET	Step by step calculations					
SHEET	Residential					
	Step 1	Step 2		Step 3		
Residential	A[+] **Consum. (ktoe)**	**B[++] CF (TJ/ktoe)**	**C Consum. (TJ)**	**D[+++] CEF (t C/TJ)**	**E Carbon Content (t C)**	**F Carbon Content (Gg C)**
			C=(AxB)		E=(CxD)	F=(Ex10^{-3})
Gas/Diesel Oil	1182.74	40.0	47310	20.2	955,662	955.662

[+] See Table (55), [++]See Table (1), Appendix 20, [+++]See Appendix 21

Cont. Table (xvi)

MODULE	Energy					
SUBMODULE	CO_2 from fuel combustion					
WORKSHEET	Step by step calculations					
SHEET	Residential					
	Step 4			Step 5		Step 6
Residential	**G* Fraction of Carbon Stored**	**H Carbon Stored (Gg C)**	**I Net Carbon Emissions (Gg C)**	**J* Fraction of Carbon Oxidised**	**K Actual Carbon Emissions (Gg C)**	**L Actual CO_2 Emissions (Gg CO_2)**
		H=(FxG)	I=(F-H)		K=(IxJ)	L=(K x [44/12]
Gas/Diesel Oil	0.5	477.831	477.831	0.99	473.05	**1734.5**

[*]See Appendix 21

The total CO_2 Emissions Saving in 2030 from RE&EE measures in the residential, commercial, and service sectors is 1734.5 kt which represents 3% of the total Syria's GHGs emissions in 2005 (58350 kt [8]).

1. Introduction

Syria is in need to critically examine the potential climate change impacts, especially on vulnerable sectors such water and agriculture. In addition, what adaptation strategies Syria should have in place to avoid or reduce climate risks? In terms of mitigation, although Syria does not have GHG reduction commitments, the potential for climate change mitigation projects that have domestic economic benefits as well as global environment benefits (GHG reduction) is still not fully explored. One obvious venue for such projects is through the Clean Development Mechanism (CDM). Other mitigation opportunities include energy efficiency, fuel switching, co-generation, renewable energy (mainly wind and solar), and biogas. Syria can seek financial and technical support from international organization such as GEF, World Bank, UNEP and UNDP to pursue mitigation and adaptation projects that meet national development objectives and priorities.

Renewable Energy and Energy Efficiency have been identified as a priority in the Tenth five-year plan (2006-2010). The Government of Syria has taken a number of measures to promote conservation of energy in the country:

- Establishing National Energy Research Centre (NERC) in 2003 to advise the government on energy policy questions, energy efficiency & renewable energy and fostering Energy conservation awareness,
- Plan to gradually substantially reduce subsidies on energy prices by Y2010,
- Switching all existing thermal power stations from Heavy fuel oil to gas,
- Ratification of the Kyoto Protocol,
- Preparation of a Renewable Energy Master Plan,
- Abolition of import duties on thermal insulation materials, absorbers for flat-plate solar collectors, and evacuated solar collectors,
- Energy conservation legislation,
- Code of Practice for thermal insulation in building,
- Energy Label for residential electric appliances,
- Law to purchase power from independent power producers (IPP),
- Other measures.

2. State of the Art of Renewable Energy

Renewable energy has the following advantages:

- A primary energy of high quality: Many renewable energy sources produce electricity. Hence, 1 kWh of renewable energy replaces 3 kWh of fossil fuel in today's energy systems[1].
- Environmental performance: RES delivers clean, emission-free energy, i.e. reduction of CO_2 emissions, but also reduction of NO_X, SO_X, particulates and ashes.
- RES is emission-free, and avoids environmental insults, which are currently largely treated as external costs in fossil fuel-based energy systems. For coal-fired power stations, the cost of the environmental insults exceeds the cost of electricity. Charging these costs fully to the user would require a tax of 7-10 cents / kWh. The external costs for combusting gas are 2-3 cents / kWh, and for waste-to-heat 18-21 cents / kWh. Renewable energy sources perform much better in this respect (Wind less than 0.1 c / kWh, PV less than 1 c / kWh and biomass less than 0.3 c) (See Table 1 in Annex 1) [1].

- *Photovoltaics*

The cumulative installed Photovoltaics (PV) electricity generation capacity in the world was around 15 GW, with Europe accounting for more than 60% of this (9.5 GW). PV production in the world increased to about 7.3 GW in 2008 (Figure 1 in Annex 1). An 80% rise on the previous year. Europe's production of solar cells rose from 1.1 GW to 1.9 GW, while the installed capacity increased threefold to 4.8 GW, mainly led by Spain, where figures multiplied almost five times from 560MW in 2007 to 2.5–2.7 GW [2].

- *Wind Energy*

Worldwide capacity reaches 121188 MW, out of which 27261 MW were added in 2008. Wind energy continued its growth in 2008 at an increased rate of 29 % (See Figure 2 in Annex 1). All wind turbines installed by the end of 2008 worldwide are generating 260 TWh per annum, equaling more than 1.5 % of the global electricity consumption [3].

For the first time in more than a decade, the USA took over the number one position (25170 MW in 2008) from Germany (23903 MW) in terms of total installations. Spain took the number 3 with 16740 MW (See Figure 3 in Annex 1) [3].

If we are to reach the targets set by the international community and, as of late, for instance, firmly articulated by the EU, there will be 900GW of wind generation by 2020. Nine times the capacity we have today. From 2007 the annual volume of the world market for renewable energies has doubled from €30bn per year to €60bn. It is expected to grow to 400bn € in 2020. This will mean investing over a trillion Euros in the industry worldwide and erecting over 300,000 wind turbines till 2020. To put that into context one wind turbine must be erected every 25 minutes between now and 2020 [4] .

Feed-in tariffs (FITs) were instrumental in developing wind energy in Denmark, Germany and Spain. These incentives provided guaranteed markets and favourable prices that mitigated much of the risk for developers of wind technology and wind farms. Once the wind market is mature, however, feed-in tariffs are not particularly cost-effective. A fixed price per unit of production results in a flat, not downward-sloping, demand curve. Producers face no pressure to cut costs.

The German system of feed-in tariffs for guaranteed prices for wind-generated electricity is also used by a number of other European nations. The subsidy programs, as of mid-2001 in EUR/kWh, are varied between 0.046 and 0.091(See Annex 2) [5].

Table (2) in Annex (1) shows the electricity cost from wind power [6].

- ***Parabolic trough***

Parabolic trough systems use trough-shaped mirror reflectors to concentrate sunlight on to receiver tubes through which a thermal transfer fluid is heated to roughly 400^{o}C which then is used to produce superheated steam. They represent the most mature solar thermal power technology, with 354 MWe of plants connected to the Southern California grid since the 1980s using more than 2 million square meters of parabolic trough collectors. These plants supply 800 million kWh annually at a generation cost of about 14-17 US cents/kWh. Further advances are now being made in the technology, with utility-scale projects planned in Spain, Nevada (USA), Morocco, Algeria, Israel, Egypt, Iran, South Africa and Mexico. Cost of electricity from trough plants is thus expected to fall to 7-8 € cents/kWh in the medium term. Combined with gas-fired combined cycle plants, power generation costs are expected to be 6-7 € cents/kWh in medium term [7].

The existing plants prove that concentrated solar power is commercially feasible, but costs must decrease. Electricity from solar thermal plants currently costs between US$0.13/kWh and US$0.17/kWh, depending on the location of the plant and the amount of sunshine it receives. Conventional power plants generate electricity for between US$0.05 and US$0.15/kWh (excluding any carbon taxes or cap and trade related costs) but in most places it's below US$0.10 (wind power generally costs around US$0.08/kWh) [7].

Sandia labs estimate that the solar thermal costs could fall to around 4.3 c/kWh by 2020 (for parabolic trough) and 3.5 c/kWh by 2020 (for solar towers). Graph (4) in Annex (1) indicates mid-term & long-term projections of levelized cost of electricity generation through CSP [7].

In conclusion, renewable energy is the promise energy for the future and provides an opportunity to significantly reduce the use of fossil fuels and to reap the resulting benefits. The RE applications have evolved significantly to reduce initial costs and thus reduce the costs of producing energy.

The EU adopted a wide-ranging package on climate. The overall 20-20-20 targets have been kept: a 20% cut in emissions of greenhouse gases by 2020, compared with 1990 levels; a 20% increase in the share of renewables in the energy mix; and a 20% cut in energy consumption.

3. Energy Consumption in Syria

3.1 Primary Energy

The total primary energy consumed in 2005 was about 19.6 Mtoe. Table (1) shows the breakdown by sector of the total primary energy consumed in 2005: 35.2% for electricity generation, 9.6% for refining & extraction, 8% for manufacturing industry & construction, 22.7% for transport, 13.3% for household, 2.4% for the service sector and 8.8 % for agricultural sector [8]. Figure (1) shows the breakdown by sector of the total primary energy consumption in 2007 [9].

Table 1. Primary Energy Consumption per Sector in 2005

Year: 2005	**Unit**	
Total Primary Energy Consumption:	**Mtoe**	**%**
Electricity	6.90	35.2
Refining & Extraction	1.88	9.6
Manufacturing Industry & Construction	1.57	8.0
Transportation	4.44	22.7
Household	2.62	13.3
Service	0.47	2.4
Agriculture	1.72	8.8
Total	**19.6**	**100**

Source: [8]

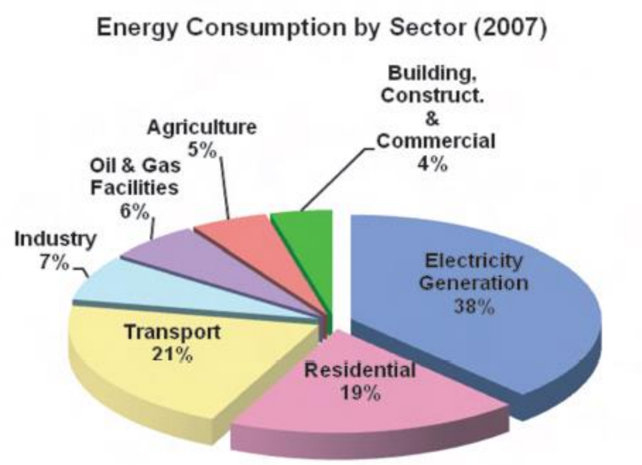

Figure 1. Primary Energy Consumption by Sector in 2007 [9]

3.2 Final energy

The total final energy consumed in 2005 was about 15.25 Mtoe. Table (2) shows the breakdown by sector of the total final energy consumed in 2005: 27% for transport, 23% for household, 19% for industry, 11% for agricultural, 7% for construction, 7% for refining & extraction, and 6% for the service sector [8].

Table (3) shows the breakdown by fuel type of the total primary energy consumption in 2005: 72.1% for oil products, 10.3% for natural gas, 2.6% for traditional fuel, and 15% for electricity [8].

Table 2. Final Energy Consumption per Sector

Year: 2005	Unit	
Total Energy Consumption:	Mtoe	%
Transportation	4.12	27
Household	3.50	23
Industry	2.90	19
Agriculture	1.68	11
Construction	1.07	7
Refining & Extraction	1.07	7
Service	0.91	6
Total	15.25	100

Source: [8]

Table 3: Final Energy Consumption per Fuel

Year: 2005		Unit
Total Final Energy Consumption:	Mtoe	%
Oil Products	10.99	72.1
Natural Gas	1.57	10.3
Traditional fuel	0.40	2.6
Electricity	2.29	15
Total	15.25	100

Source: [8]

3-3: Electric energy

According to the information contained in the Statistical Abstract [10] the electric energy in Syria is consumed for two purposes; lighting and the driving force. The electricity consumption for lighting includes the total lighting power consumption in the residential, commercial, and service sectors as well as the public lighting. The electricity consumption for driving force includes the total power consumption in the industry sector.

The rate of consumption of the residential, commercial and service sectors is semi-fixed at the value of almost 68%, while the industrial sector consumes 32% of the total electricity produced in Syria.

The electric power production in Syria (Table 4) is increased from 30366 GWh in 2003 to 38784 GWh in 2007 at an annual rate of around 8% a year (12.2% in 2005 relative to 2004 and 3.6% in 2007 relative to 2006).

Figure (2) shows the breakdown by sector of the total electric energy consumption in 2007 [9].

It is obvious from Table (4) that, according to data obtained from the Central Bureau of Statistics for the year 2003, the total technical (i.e. inherent) and non-technical energy losses in the electrical energy sector were 10748 GWh including self-consumption and represent 35% of the total generation or 55% of the total consumption in 2003.

In 2007, the total electric energy losses increased to 12154 GWh including self-consumption but represent 31% of the total generation or 47% of the total consumption.

In spite of the decline in losses between 2003 and 2007, it is still very high.

Table 4. Electricity Consumption in Syria (GWh)

Year	2003	2004	2005	2006	2007
Lighting	13070	13922	15109	16594	17685
Consumption ratio	67.5%	67.8%	67.8%	69.2%	68.8%
Industry	6299	6612	7164	7374	7954
Consumption ratio (%)	32.5%	32.2%	32.2%	30.8%	31.2%
Total consumption	19369	20534	22273	23968	25639
Export	249	539	844	986	991
Losses & self consumption	10748	11064	12931	12499	12154
Total	30366	32137	35048	37453	38784
Yearly growth rate (%)	-	5.83%	9.1%	7.1%	3.6%

Source: [10]

The annual percentage of the increased production of electric power is unstable (Table 5) for reasons concerning the status of power plants and the availability of energy sources (hydro, fossil).

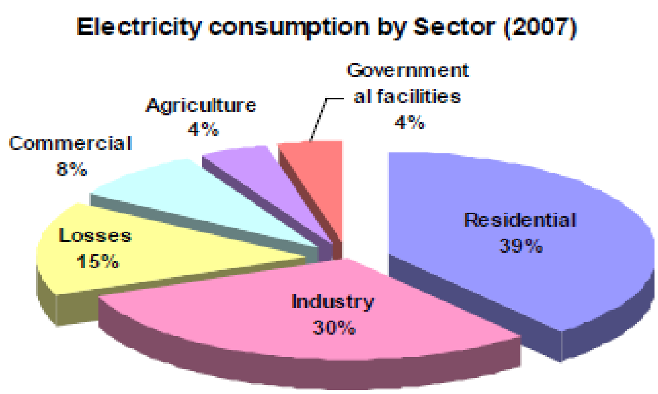

Figure 2: Electricity consumption by Sector in 2007 [9]

Table 5. Electricity Production in Syria (GWh)

year	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
GWh	21159	22819	25217	26712	28012	29533	32077	34935	37504	38644	41023
%	-	7.8	10.5	6	4.8	5.4	8.6	8.9	7.6	3	6.1

Source: Public Establishment for Electrical Generation and Transfer (Statistical reports)

Proportion of the contribution of hydropower in total generation (Table 6) was decreased from 10.7% in 2006 to 7% in 2008. This is due to low generation from hydro sources in addition to the increased generation from fossil sources.

Table 6. Electricity Production in Syria by Energy Source (GWh)

Year	2003	2004	2005	2006	2007	2008
Total (GWh)	29533	32077	34935	37504	38644	41023
Hydro				4001	3526	2872
Thermal				33503	35116	38151

Source: Public Establishment for Electrical Generation and Transfer (Statistical reports)

In conclusion, the household, industry, agriculture and service sectors have consumed 32.5% of the total primary energy consumed in Syria in 2005 (13.3% in the household sector, 8.8% in the agricultural sector, 8% in industry & construction sectors, and 2.4% in the services sector). These sectors have consumed 53% of the total final energy consumed in Syria in 2005 (23% in the household sector, 19% in the industrial sector, and 11% in the agricultural sector).

In 2007 the household sector has consumed 39% of the total electrical energy consumed in Syria, followed by the industrial sector by 30%, commercial sector by 8% and the agricultural sector by 4%.

4. Current Status and Progress Achieved on Renewable Energy in Syria

Many Syrian institutions are active in the field of RE. Each institution still works in isolation from the other, which negatively affects the development of renewable energy applications.

4.1 Projects Implemented in the Field of RE & EE with External Grants

Table (7) presents some of the projects implemented in Syria with grants provided by international bodies and organizations ranging from the mid-nineties.

Table 7. Some of the Projects Implemented in Syria with Grants Provided by International Organizations

Project ID#	Project Title	Starting Year	UNDP Reg. Resources (US$)	Other Resources (US$)		Gross Budget (US$)
				GEF	**Other Sources**	
SYR/96/G31	Supply-Side Efficiency and Energy Conservation and Planning	1996	505,000	4,070,000	37,880,000	42,455,000
SYR/97/E01	Assistance in Decentralized Rural Electrification through Photovoltaics	1997			553,700	553,700
SYR/99/001	Master Plan for Renewable Energy Development in Syria	1999	178,000			178,000

4.2 Studies, Plans and Specifications

- As part of the international drive to reduce greenhouse gas emissions (GHGs), the government of Syria has embarked on a national project to improve energy efficiency leading to a cleaner environment. The Ministry of Electricity in collaboration with UNDP and the GEF program was implementing measures to promote energy efficiency in the areas of industrial production, power generation and private enterprises. By reducing energy consumption in these sectors, GHG emissions should also be reduced.
- The project entailed gathering experience in the field of energy conservation through a variety of training courses and seminars, in addition to collecting concrete data and measurements using the appropriate measuring devices and techniques.
- The Atlas of solar radiation in Syria was completed in 1994, while the Wind Atlas was completed in 1999. The yearly average of solar radiation on a horizontal surface is 5 kWh /m²/ day, equivalent to 1825 kWh /m²/ year. The estimated wind speeds prevailing in the country are 4.5-10 m/s in the southern and central regions.
- The national standards for the solar water heating systems has been issued in 1988, and adopted by the Syrian Order of Engineers in 1993 and renovated in 2009.

- The National Renewable Energy Master Plan has been completed in 2002 [13]. Economic analysis showed that the total resources required to implement the energy development plan is 1.48 billion $ (RE Scenario) and the contribution to primary energy supply in 2011 is 4.31% of the energy demand. There will also be a total of 7225 jobs created for technicians, engineers, managers, teachers and the new institution staff.
- The study on Policy Strategy and Institutional Development to Introduce Photovoltaic Systems into Syrian Arab Republic has been completed in 2005 [35] (Annex 5). The goals of this work is (1) to provide a guideline to establishing the infrastructure (financial, institutional, legislative and technical) necessary to implement renewable energy systems in general and PV technology in particular as a tool for rural development within the Syrian context and in line with Syria's Master Plan, (2) to ensure that photovoltaic energy systems make an important contribution to Syria's energy needs especially its rural electrification, un-electrified villages, and water pumping applications, and (3) to contribute to a better understanding of the potential impact and of the limitations of PV systems on Sustainable Agriculture and Rural Development (SARD), especially concerning income-generating activities.
- Customs exemptions for importing solar absorbent sheets, solar evacuated tubes and thermal insulation materials have been approved in 2005.
- The Ministry of Local Administration decision in November 2009 requiring building permits applicants to submit a study of solar water heating system according to Syrian standard specifications. The applicant for a license must provide a written commitment certified by the notary to install solar water heating system. (Annex 14) [36].

4.3 Wind Energy

- Mechanical wind pumps have been successfully demonstrated and operated for many years in the middle of Syria. Unfortunately, the spread of this application now is limited due to the lack of underground water.
- Mechanical wind pumping machines have been manufactured in local workshop in Nabek (an hour's drive north from Damascus) for over forty years. The production rate varies but does not exceed a hundred units a year. About 4000 windpumps were installed in Syria, most of which were abandoned due to lack of underground water. At present, there are some 1000 multi-blades windmills in operation, used mostly for irrigation.
- A 150 kW grid connected wind turbine (NORDEX) was set up in July 1994 in Qunetra in southern Syria. The task of operating, testing and maintenance of this turbine is carried out by Ministry of Electricity personnel. The annual energy output of the turbine is around 300 MWh. This particular turbine was partly funded by UNDP.
- For the purpose of measuring wind speed and direction, twenty wind masts were installed during 2004 and 2005 in the most promising areas in the country.
- Wind generators of 2-3 blades (750 W to 50 kW) have been locally manufactured since 1990 by private company (SAG) located at Adra, near Damascus. These generators

were mainly used for battery charging, defrosting, and pumping water from dams and wells. The total capacity produced by the company till year 2000 was 800 kW.

- A pre-feasibility study for installing 100 MW on the northern shore of the Quattine Lake near Homs city was conducted in 2007[14]. The calculated net energy output at the proposed Wind Farm is 293,300 MWh/y at hub height of 65 m with a capacity factor of 33.3 %. The wind farm avoids the emission amount of CO_2 equivalent to approximately 2.7 million tons over 20 years of life. The value of this quantity at the present time is 29 million Euros or the equivalent of 1.7 billion Syrian pounds over 20 years, or 87 million Syrian pounds per year. As this wind farm fulfils the conditions to be registered as a CDM-activity, the potential benefits of a CDM registration could be generated.
- The Ministry of Electricity announced in November 2009 a Request for Qualification (RFQ) for a Wind Farm project. The purpose of issuing this RFQ is to invite experienced sponsors/developers to submit their qualifications as Independent Power Producer (IPP) to build, own, and operate (on BOO, BOT,.. basis) a 50-100 MW Wind Farm with multiple units installed of identical capacity. The Wind Farm will be located at Al-Sukhna and/or Al Hijana sites [15] (Annex 3).
- A factory for manufacturing and assembling of 2.5 MW wind turbines is currently being set up in the industrial city at Hasia (near Homs city). It is expected to produce the first turbine in September of 2010. This important project is implemented by an investor from the private sector with an agreement with a German firm for the transfer of technology.

4.4 Solar Space Heating

A passive solar building complex for heating 529 flats, implementing Trombe wall and direct gain technique, was completed in the mid-eighties. The complex is situated close to Damascus international airport. Domestic solar water heaters, locally manufactured, have been installed on the roofs of these 529 flats.

Several projects to support small-scale solar space heating in a limited number of houses were carried out.

4.5 Photovoltaics

A Solar village project was implemented in March 1994 in two villages: Abou-Sorra and El-Mucherfeh, which are located 35 km south of Damascus. Funds provide by UNDP were used to buy the equipment necessary for the project. The total power of the installed PV systems is 6.35 kWp.

JICA has proposed a technical cooperation plan for setting up PV systems for four villages in Aleppo region between 1995 and 2000. The works completed include:

a) A centralized PV power plant with a capacity of 35 kWp to supply electricity to 44 houses in the village of Zarzita in the Aleppo region.

b) Individual stand-alone PV systems of various capacities (200 Wp/DC, 300 Wp/DC, and 500 Wp/AC) to supply electricity to 65 houses were installed in the villages of Fedre, Katoura, and Rasem Al-Sheikh Kaleif in Aleppo region.

c) PV station of 5-kWp capacity installed in the village of Rasem Al-Sheikh Kaleif designed for pumping and desalinating water using reverse osmosis technology.

The total power of these PV systems amounts to 66.8 kWp. All these systems incorporate devices necessary for performance evaluation.

Most of the marine beacons have been powered by photovoltaic systems.

The navigation land station for civil aviation at al-Tanf has been powered by 35 kWp photovoltaic system for the benefit of the Directorate General of Civil Aviation.

A Syrian-Ukrainian limited company was founded in 2008 for the assembly and encapsulation of solar cells with a capital of 1024 million SP. The capacity of the production line is 15.9 MWp per year. The respective share of the Syrian Arab Company for Electronic Industries "Syronics" and the Ministry of Electricity is 40% while the share of Ukrainian firm is 20% It is expected to begin production of the PV modules in mid-2010.

4.6 Solar Water Heating

Domestic Solar Water Heating (DSWH) Systems have been produced locally since the early 1980’s in parallel with some systems imported from Jordan. Currently, some solar flat plate collectors are imported from Turkey. But in 2006, the private sector starts to import and marketing of vacuum tube collectors (mainly from China).

The prevalence of DSWH systems is still limited in Syria. The real number of installed DSWH is not accurately known. The cumulative total area of the installed flat-plate solar collectors was estimated at about 87000 square meters in 2005. Currently, the ultimate cost of delivered hot water from a DSWH system has proved to be economically attractive. Unfortunately the initial cost required does not attract enough customers. The governmental and private banks have adopted measures to promote the use of DSWH systems through providing loans of about US$ 1000 for each system.

In 2004 the National Energy Research Centre (NERC) came up with a financial scheme to facilitate granting bank loans to government employees for the purpose of purchasing solar water heating systems. The objective of this initiative “National Pilot Project for Promoting the Solar Energy for Domestic Water Heating Purposes" was to popularize and extend the use of the Domestic Solar Water Heating (DSWH) systems on a national scale, especially in the residential sector. Prototypes of All DSWH systems were experimentally tested at the Higher Institute for Applied Science & Technology (HIAST) before delivery to end users. So far only 625 DSWH systems has been purchased and installed in households. The results were rather disappointing basically because the project targeted low income end-users (government employees) but more importantly because conventional energy remains heavily subsidized by the Government.

The total revenue from the sale of 625 the DSWH Systems installed was 21,560,000 million SL (415,000 US$). The total yearly thermal energy yield was expected to be 1,243,000 kWh/year. The average specific cost was 17.6 SL/kWh (0.34 USD/kWh).

Comparing with heating water by diesel oil, the saving generated from 625 DSWH Systems was 250,000 liters of diesel oil per year. The payback period was 11.9 years (at subsidized price) or 3.2 years (at unsubsidized price). While comparing heating water with electricity, the saving generated from 625 DSWH Systems was 1,243,000 kWh/year. The payback period was 7 years (at subsidized price) or 4.3 years (at unsubsidized price) [16].

The reduction of CO_2 emission based on the production of 1,243,000 kWh/year is 870 tCO_2/year. Assuming a life cycle period of 20 years for DSWH systems, the total reduction over this period will be 17400 tCO_2.

The study in reference [9] predicted that the total cumulative area of solar collectors installed for the purpose of heating water until the end of 2008 is 300000 square meters, 100,000 of them were installed in the years from 2005 to 2008. The study added that efforts are being made to adopt a national strategy for the installation of 100,000 square meters per year. The study also found that the number of manufacturers who obtain licenses for manufacturing solar water heaters is 92, but in fact only 25 of them produce DSWH systems with a capacity ranging from 100 systems a year in small workshops, to 20,000 square meters a year in large workshops.

It follows from this paragraph the following important conclusions:

- The national energy policy is slowly beginning to take shape in Syria.
- Due to the lack of funds and qualified human cadre the Master Plan was not implemented.
- The adoption of a comprehensive and integrated national strategy for RE & EE is the best way to make substantial impact on national energy consumption as well as reduce Greenhouse Gas emissions (GHGs).
- There is a need to focus on wind energy because of its contribution to the largest proportion in the Master Plan, compared with other applications of renewable energy.

5. Current Status and Progress Achieved on Energy Efficiency in Syria

5.1 Energy Audits

A UNDP-supported project on "*Supply-Side Energy Efficiency and Energy Conservation and Planning"* was completed in 2006 [17]. The implementation of the project entailed among other things (Annex 4):

- Conducting over 250 walk-through energy audits in industrial and commercial buildings, hotels and mosques,
- Conducting over 100 detailed energy audits of industrial and large commercial buildings. The potential for energy saving from these detailed audits of industrial and large commercial facilities is 30509 toe or USD 8.4 million per year,
- Preparation of 20 feasibility studies for detailed energy audits has been conducted,
- 10 pilot projects based on feasibility studies have been implemented,

The results of the 100 detailed energy audit studies are summarized in Table (8). A summary of this project and a list of sites where the detailed energy audit studies are carried out are presented in Annex (4).

Table 8. Summary of Energy and Cost Saving Opportunities Identified from 100 Detailed Audits of Industrial and Large Commercial Facilities

Sum of annual saving opportunities		Annual opportunities of thermal energy saving		Annual opportunities of electric energy saving		
Toe	Million $	toe	Million $	GWh	toe	Million $
30509	8.4	28914	5.6	416	1595	2.8

Source: [17]

On the other hand, the energy audits carried out in two hotels, two restaurants and two homes in the old city of Damascus have shown that energy saving opportunities exist and vary from one location to another [18]. Table (9) summarizes the results of these studies. Annex (5) includes more details on these studies.

Table 9. Summary of Energy and Cost Saving Opportunities Identified from Six Energy Audits of Residential and Commercial Facilities in Old City of Damascus

	Est. annual saving (SL)	Est. annual saving (kWh)	Est. annual saving (t CO_2)	Est. Implementation cost (SL)	Payback period (years)
Restaurants					
Casablanca Restaurant	129,869	40,813	14.53	329,000	2.7
Haretna Restaurant	405,723	152,833	65.92	427,150	1.22
Apartments					
Aboud Apartment	24,432	7711	3.9	101,250	4.1
Nahlawi House	10,681	4986	2.56	64,950	5.2
Hotels					
Bait Rumman Hotel	69,505	20,151	10.3	10,650	0.15
Alshahbandar Palace	150,341	44,841	21.82	138,600	0.92

Source: [18]

5.2 Legislations and Regulations

- Establishing National Energy Research Centre (NERC) in 2003 to advise the government on energy policy questions, energy efficiency & renewable energy and fostering energy conservation awareness.
- The "Code of Thermal Insulation in Building ", has been issued by a circular by the Prime Minister, on 22/11/2007, and has been applied from the date of 1/1/2008. This includes the maximum values of the overall heat transfer coefficients (U-value) of the building elements [19].
- The Ministry of Local Administration decision in November 2009 requiring building permits applicants to submit a study for the thermal insulation of the building in according with the "Code of Thermal Insulation in Building ". There are sanctions for non-committed to this decision (Annex 14) [36].
- The “Law of Energy Efficiency Standards for Electrical Appliances in the Residential, Commercial, and Service Sectors" (No. 18), an important by-product of the project “*Supply-Side Energy Efficiency and Energy Conservation and Planning”*, has been issued on14/10/2008. The instructions for this law have been issued on 8/10/2009. Annex (6) shows the proposed energy label for refrigerators.
- The “Energy Conservation Law” (No. 3) has been issued on 22/2/2009. This law aims at [20]:
    - Support to the economic and social development in the Syrian Arab Republic,
    - Maximization of lifespan of fossil fuel reserves available in the Syrian Arab Republic,
    - Minimization of negative environmental impacts resulting from the use of various conventional energy carriers,
    - Contribution to fulfilling the sustainable development requirements

  The law acts to achieve the above objectives as follows:

    - Dissemination and application of the energy conservation concepts, including the rationalization of energy consumption, energy conservation, and energy use efficiency improvement in all areas of lasting impact on the production and consumption of energy.
    - Dissemination of use of various renewable energy applications.
- The Ministry of Electricity is currently amending the Electricity Act to include allowing the private sector to invest in power generation from fossil energy and renewable energy sources. It is expected to see the light of the new law at the beginning of 2010.
- Within the framework of implementing the Tenth Five Year Plan the restructuring of the energy carrier’s tariff in Syria was undertaken during the years 2007 and 2008. The diesel oil tariff was increased on 3 May 2008 from 7 to 25 Syrian pounds per liter and then declined later to 20 Syrian pounds per liter (the official price) or 20.65 Syrian pounds per liter (retail price to the consumer). Also, the price of a liquefied gas bottle

of 12 kg was increased from 145 to 250 Syrian pounds (official rate) and 275 Syrian pounds (retail price to the consumer). The new tariff for electricity has been applied on the first of September in 2007, and was subsequently slightly modified the tariff for consumption above than 1000 kilowatt hours per month in residential sector. Annex (7) includes the new electricity tariff. The current average costs of one kilowatt hour produced from electricity, diesel oil, and liquefied gas (at 100% yield) are presented in Table (10).

Table 10. Average Unit Cost for Electricity, LPG, and Diesel Oil

	Average unit cost (SL/kWh)
Electricity	2.41* (plus taxes and fees)
LPG	1.8**
Diesel oil^{+}	2.08***
Green Diesel, 50 ppm SO_2	2.21^{++}

* For a consumption of 1000 kWh/month (without taxes and fees).
**Assuming a retail price of SL 275 for one bottle gas and100% efficiency.
***Assuming a retail price of SL 20.65 per liter and100% efficiency.
$^{+}$ Diesel oil typically contains 0.7 percent sulfur.
$^{++}$Assuming a retail price of SL 22 per liter and100% efficiency.

5.3 Energy Demand-Side Management (DSM)

Within the framework of the project "*Supply-Side Energy Efficiency and Energy Conservation and Planning*" [17], a detailed report on energy demand management in Syria has been prepared. The main conclusions anticipated (Annex 8) are the following [21]:

- The possibility of saving in 2020 is 4600 GWh and 1.1 million tons of fuel in case of implementing the actions proposed in this report,
- The cumulative energy saving of 77000 GWh and 18 million tons of fuel could be realized by Y2020,
- Considerable saving in peak capacity can be achieved (2500 MW in 2020),
- The Ministry of Electricity could achieve a saving of 310 billion Syrian pounds on the demand side of electricity in 2020 (due to the reduction in fuel consumption, improvement of operation conditions, maintenance and reduction in installed capacity).
- Achieving an annual reduction of CO_2 emissions by 3300 ktons by the year 2020.

The report concluded that the lighting and electric motors can contribute the largest proportion of the estimated saving. The largest saving can be achieved in the residential sector (given that lighting accounts for 20% to 25% of the total consumption of electricity).

5.4 Energy Saving in Public Lighting

The "General Company for Electrical and Communication Works" or "the Syrianet" is undertaking energy saving measures in street lighting through the use of methods and modern technology in the energy-saving devices.

The company has adopted energy-saving devices up to 30-40% and has implemented several projects in this area.

5.5 Importance of Clean Development Mechanism (CDM)

The 1997 Kyoto Protocol commits the 39 participating industrial nations as a whole to a five-percent reduction from 1990 levels in their emissions of gases damaging the climate, such as carbon dioxide, by 2012. It came into force on February 16, 2005. The European Union must thus reduce its average emissions between the years 2008 and 2012 by eight percent compared to the level in 1990. To achieve this goal, the member states are working separately in some areas and together in others. The most important climate protection measure is currently the establishment of the European emissions trading system for companies.

The three flexible mechanisms adopted by Kyoto Protocol are:

1) Emissions Trading (ET), a market-based approach to achieving the environmental protection goals defined by the Kyoto Protocol. This approach allows countries that reduce their greenhouse gas emissions further than required to trade their excess certificates to offset emissions from other sources within or outside the country. Trading can take place at national or international level, or between companies. Emissions trading in Europe began on January 1, 2005, and are regulated by an EU directive. Companies receive a certain amount of certificates, which is reduced from period to period. Companies that have already made significant climate protection efforts or have shown themselves to be particularly innovative can sell their excess certificates, thus receiving an additional source of income.
2) Joint Implementation (JI), the opportunity for countries or companies with projects in other countries which have signed the Kyoto Protocol to acquire Emission Reduction Units (ERUs) that can be offset against their own commitments.
3) Clean Development Mechanism (CDM), the opportunity for countries or companies to acquire Certified Emission Reductions (CERs) that can be used to meet their own commitments by investing in projects in developing and newly industrializing countries (without themselves having to reduce emissions).

The clean development mechanism (CDM) has two objectives:

- To help developing countries to achieve sustainable development and the adoption of environmentally clean projects
- To assist the developed countries to implement their commitments to reduce emissions.

CERs are emissions certificates issued by bodies of the UN Framework Convention on Climate Change and the Kyoto Protocol (Executive Board) for the successful completion of Clean Development Mechanism (CDM) climate protection projects.

The ratification of the Syrian Arab Republic to the Kyoto Protocol on climate change has been issued by the presidential decree No. 73 date 4/9/2005.

CDM involves all the basics characteristics of this mechanism such as contributing to sustainable development; attracting foreign investment; leveraging technological progress; promoting capacity building and institutions' strengthening. Therefore, CDM gives the opportunity to economic growth.

Among the conditions for the implementation of this mechanism in developing countries is identifying a national focal point (Designated National Authority-DNA) for their application (Ministry of State for the Environment in Syria). The responsibility of the DNA is to develop a national strategy includes an initial survey of the sources of emissions and arrangement to the priorities of the proposed project.

In designing a CDM project, the project proponents or participants should consider the three approval criteria that a project has to satisfy:

1) Project not a "baseline" scenario. The baseline is a reference point, a scenario without the CDM project activity. Thus, the proposed project should prove that it can reduce GHG emissions over the baseline using either an approved methodology, or a totally new methodology. There are three acceptable approved baseline methodologies, namely: status quo emissions ("business as usual"); market conditions; and, best available technology. As for new methodology, a project proponent has to explain, among others, how the baseline was established, justify its use, and assess its strengths and weaknesses.
2) Project is "additional". The simplest way to explain "additionality" is to think of a project as eligible for CDM benefits if it can show that by implementing it, there will result a net decrease in GHG emissions relative to a baseline scenario. However, if the project activity is to be undertaken because of a law requiring it, then it is not generally eligible for CDM benefits.
3) Project contributes to "sustainable development". This criteria is a host country prerogative. In order for the DNA to be able to identify the sustainable development impact of a proposed project, the project participants have to propose project level indicators which, when measured, comes up with an overall impact that is positive.

The Center for Environmental Studies carried out a comprehensive study on the sources and amount of emissions in the country. A workshop on CDM was organized in 2004 by the National Energy Research Center (NERC) in cooperation with the Technical University of Athens.

The average selling price of one ton of carbon dioxide in 2005 was 7.5 U.S. dollars, rose to 11 U.S. dollars in 2006, then rose to 17.8 U.S. dollars in 2007, and reached 18.5 U.S. dollars in 2008.

The current price of carbon dioxide is: 10.77 Euros per ton, and it is expected to increase as we approached 2012. Japan and Canada are the most enthusiastic to buy "Certified Emission Reductions".

The annual volumes and values of transactions of carbon dioxide are:

- 947 million tons CO_2e (17000 million U.S. dollars) in 2007,
- 1200 million tons CO_2e (22000 U.S. dollars) in 2007.

The number of projects registered and approved as of April 1, 2008: 979 projects. The total number of projects submitted to take advantage of CDM is 2020 from 49 countries. China and India account for 50% of registered projects.

The world total number of CERs on April 1, 2008 was: 134,993,328 certificates and is predicted to reach 2.7 billion certificates at the end of 2012.

Among the Arab countries, Morocco submitted twenty-five CDM projects, ten projects from Tunisia, and three projects from Egypt. In Syria, two CDM projects have been approved (two landfills in Homs and Aleppo), and there are other projects under study and evaluation.

This mechanism strengthens the economic feasibility of renewable energy projects and it is still a chance to take advantage of CDM in Syria.

The potential of reducing emissions in Syria through the clean development mechanism as proportion of the total amount of emissions in 2008 is presented in Table (11) [29].

Table 11. Potential of Reducing Emissions in Syria through CDM Projects

Emission reduction potential through CDM projects ($MtCO_2e$)	
15%	5%
8.3	2.8

Source: [29]

The CDM project development steps are summarized in table (12).

Table 12. CDM Project Development Steps

CDM Project Development Stages
1. Project Idea Note (PIN)
2. Letter of Intent (LoI)
3. Project Design Document (PDD)
4. Validation
5. Emission Reduction Purchase Agreement (ERPA)
6. Registration
7. Verification

6. The Outlook for Some Important Indicators

6.1 Evolution of the Population until 2030

It is expected that the population of Syria will almost double by Y2030, assuming an annual growth of about 2.4 to 2% (Table 13).

Table 13. Population Estimates & Average Annual Growth Rates

Year	1999	2005	2010	2015	2020	2025	2030
Population (Million)	15.89	18.54	20.87	23.27	25.82	28.50	31.47
Annual Growth Rate (%)	2.6	2.4	2.2	2.1	2.0	2.0	

6.2 Evolution of the Energy Demand until 2030

The expected future development of the final energy demand in Syria by Y2030, broken down by the pattern of consumption is presented in Table (14) [22].

Table 14. Development of the Final Energy Demand in Syria by Y2030

Year	Electricity		Fuel for Heating	Fuel for Vehicles	Non-energy Use*	Total
	(Mtoe)	**MWyr**	**(Mtoe)**	**(Mtoe)**	**(Mtoe)**	**(Mtoe)**
2005	2.050	2722	6.822	4.538	1.036	14.446
2010	2.637	3501	8.673	5.723	1.201	18.235
2015	3.408	4524	11.114	7.337	1.379	23.237
2020	4.427	5878	14.197	9.493	1.597	29.714
2025	5.753	7638	18.010	12.286	1.869	37.918
2030	**7.520**	**9985**	**22.699**	**15.870**	**2.270**	**48.359**

* Asphalt, fertilizer and petrochemical industry. Source [22]

6.3 Exploring the potential of RE&EE in the future

6.3.1 German Aerospace Center (DLR) Study [23]

The DLR study is based on the following scenarios:

- Following up (FU) scenario
- Closing the Gap (CG) scenario
- Low Efficiency gains (LE) scenario
- High Efficiency gains (HE) scenario

Table (15) includes the averages of annual growth of GDP and GDP/capita in Syria between 1990 and 2000.

Table 15. Average Annual Growth Rates of GDP and GDP/Capita in both Scenarios and between 1990 and 2000 (in %)

Growth rate GDP/ capita following up (FU)	Growth rate GDP, following up (FU)	Growth rate GDP/capita closing the gap (CG)	Growth rate GDP, closing the gap (CG)	GDP/capita Growth Rates 1990-2000	GDP Growth rates, 1990-2000
1.2	2.6	4.7	6.1	0.5	3.5

Source: [23]

The DLR paper predicted that the population in Syria will reach to about 35 million in 2050; 10 million of them are representing the rural population (Figure 1 in Annex 12).

The renewable electricity performance indicators which define the representative average renewable electricity yield of a typical facility in Syria are presented in Table (16).

Table 16 . Renewable Electricity Performance Indicators

Hydro	Bio	CSP	Wind	PV
Full load hours per year	Full load hours per year	Direct normal irradiance	Full load hours per year	Global horizontal irradiance
h/y	h/y	kWh/m²/y	h/y	kWh/m²/y
1606	3500	2200	1789	2360

Source: [23]

Table (17) includes the areas required for renewable electricity generation in 2050 for the scenario CG/HE. Photovoltaic surface demand considers only 50 % of the total because many plants will be installed on roofs. Wind power and CSP surface demand is calculated as if exclusively used for power generation. Biomass surface demand is only considered for fuel wood energy [23].

Table 17. Areas Required for Renewable Electricity Generation in 2050 for the Scenario CG/HE.

Hydro	Bio	CSP	Wind	PV	Total	Country	Area used for power generation by RE sources in 2050
km²	km²	km²	km²	km²	km²	km²	%
650	2	699	335	60	1747	185180	0.9%

Source: [23]

The technical and economic renewable electricity supply side potentials in TWh/year in Syria are shown in Table (18).

Table 18. Technical and Economic Renewable Electricity Supply Side Potentials in TWh/year in Syria

Hydro[1]		Bio[2]		CSP[3]		Wind[4]		PV[5]	
Tech.	Econ.	Tech.	Econ.	Tech.	Econ.	Tech.	Econ.	Tech.	Econ.
7.0	4.0	n.a.	4.7	10777	10210	98	12	n.a.	8.5

Source: [23]

[1]: Well documented resource taken from literature.
[2]: From agricultural (bagasse) and municipal waste and renewable solid biomass potentials.
[3]: From DNI and CSP site mapping taking sites with DNI > 2000 kWh/m²/y as economic.
[4]: From wind speed and site mapping taking sites with a yield > 14 GWh/y and from literature (EU).
[5]: No information except for EU. General PV growth rates used for calculation.

The total of the economic potentials are 10,239.2 TWh/year, greater by 250 times the production of electricity in Syria in 2008 (41.023 TWh).

Figure (2 in Annex 12) shows the technical potential of solar thermal electricity in 2050 in a number of Arab countries. The greatest technical potential is located in the Sahara desert in Algeria (170 10^6 GWh/y), more than technical potential in Syria by almost 15 times.

The contribution of fossil fuel and renewable energy sources in electricity generation until 2050 is shown in Figure (3 in Annex 12).

The distribution of the installed power capacity from fossil fuel and renewable energy sources until 2050 is shown in Figure (4 in Annex 12). According to the DLR study, the expected total installed power capacity in Syria will be to about 30000 MW in 2030 and to about 55000 MW in 2050. In addition, the electricity cost of the new plants from all sources will fall to below 8 Euro cents per kWh starting from 2020 (Figure 5 in Annex 12).

The rate of exploitation of renewable energy sources in 2050 in percent of the total economic potential is presented in Table (19).

Table 19. Rate of Exploitation of Renewable Energy Sources in 2050 in percent of the Total Economic Potential

Hydro	Bio	CSP	Wind	PV
81.3%	77.9%	1.1%	50%	n.a.

Source: [23]

The expected power for desalination stations in 2050 will be 41670 GWh/year (Table 20). The CSP capacity potential for solar desalination amounts to 5 GW for Syria. The coastal potentials for CSP plants in Syria seem to be smaller than the expected demand for sea water desalination.

Table 20. Present Seawater Desalination Capacities and Non-Sustainable Use of Water in 2004 and in 2050 as well as Energy Equivalent Required for Desalination in Syria

Multi-Stage-Flash 2004	MED+ VC 2004	Reverse Osmosis 2004	Total Desalination 2004	Non-Sust. Water 2004	Desalination Scenario 2050	Energy for Desalination 2050
Mm^3/y	Mm^3/y	Mm^3/y	Mm^3/y	Mm^3/y	Mm^3/y	TWh/y
0	0	2.2	2.2	8000	12170	41.67

Source: [23]

The biomass electricity potential from agricultural waste (mainly bagasse), wood and municipal waste is summarized in Table (21).

Table 21. Summary of the Biomass Electricity Potential from Agricultural Waste, Wood and Municipal Waste

	Year	Unit	Value
Max Use (Agr. Res.)		%	80
Max Use (Wood)			40
Max Use (Mun.Res.)			80
Max	2050	TWh/y	4.66
Forest		1000 km^2	5
Prod.		t/ha/y	1
Wood		TWh/y	0.25
Mun. Waste	2000	TWh/y	1.49
	2010		2.02
	2020		2.66
	2030		3.30
	2040		3.89
	2050		4.41

Source: [23]

Finally, the DLR paper expects that CO_2 emissions from power plants in 2050 (Figure 6 in Annex 12) will decrease from about 75 Mt/y (without any contribution of renewable energy) to approximately 20 Mt/y (with the proposed contribution of renewable energy), while in 2030 these emissions will be reduced from about 50 Mt/y (without any contribution of renewable energy) to approximately 30 Mt/y (with the proposed contribution of renewable energy). Note that the CO_2 emissions from power plants in 2005 amounted to 21.7 Mt/y [22].

6.3.2 National Paper [22]

According to the scenario of renewable energy this paper proposed the following contribution:

- Increase the share of renewable energy in electricity generation from 1% in 2010 to 10% in 2030. The estimated saving from this share will be about 2.5 million tons of oil equivalent in 2030. Wind power has the largest share and its contribution will increase from 240 MW in 2010 to 5850 MW in 2030, equivalent to 24% of the installed power in 2030 (24000 MW). It is expected that renewable energy sources will produce more than 10000 GWh in 2030.

- Raising the contribution of solar energy gradually to reach 10% from the total thermal applications in 2030.

The CO_2 emissions from power plants in 2030 will decrease from about 61Mt/y (reference scenario, i.e without any contribution of renewable energy) to approximately 54 Mt/y (with the proposed contribution of renewable energy). Note that the greenhouse gas carbon dioxide from power plants in 2005 amounted to 21.7 Mt/y [22].

Finally, it is mentioned in this National Paper that the total installed power of wind farms will reach to 240 MW in 2010. This is not true because there are no contracts signed to implement any wind farm.

6.3.3 Syrian Renewable Energy Master Plan [13]

Table (22) summarizes the results of the economic feasibility and new jobs creation in the Master Plan [13]. The contribution to primary energy supply in 2011 is 350 ktoe which represents 4.31% of the energy demand. The major energy developments during the plan will be in wind energy, bio-energy, solar thermal/PV, and hybrid systems.

Economic analysis of all the renewable energy technology options against the conventional baselines of gas based electricity generation, diesel heaters, gasoline generators and butane lamps revealed that the investment costs of the conventional options would be only 410 million $ as against 1.48 billion $ for the renewable energy master plan. However, the life cycle costs of the conventional options will be 5.6 billion $, in comparison with 3.2 billion $ for the renewable energy options. This shows the economic advantages of pursuing the renewable energy master plan as against the conventional energy developments that are projected to occur.

Table22 . Results of the Economic Feasibility and New Jobs Creation

	Renewable Energy Master Plan	Accelerated Growth Scenario	Focused Growth Scenario
Energy Contribution in 2011	4.31%	6.73%	2.85%
Total Investment Costs	1.48 billion $	2.4 billion $	0.845 billion $
Total Lifecycle Costs	3.2 billion $	5.2 billion $	1.9 billion $
Emission reduction:			
CO_2 (Tonnes/year)	896,000	1400,000	592,000
NO_x (Tonnes/year)	5,900	9,000	4,000
CO (Tonnes/year)	9,100	14,000	6,000
SO_2 (Tonnes/year)	11,200	17,000	7,000
Employment Generation	7,225	11,014	6,301

Source: [13]

Figure (3) illustrates the contribution rates of the various applications of renewable energy proposed in the Master Plan. It appears from this figure that the wind energy has a high-rank by a contribution of 50.23%.

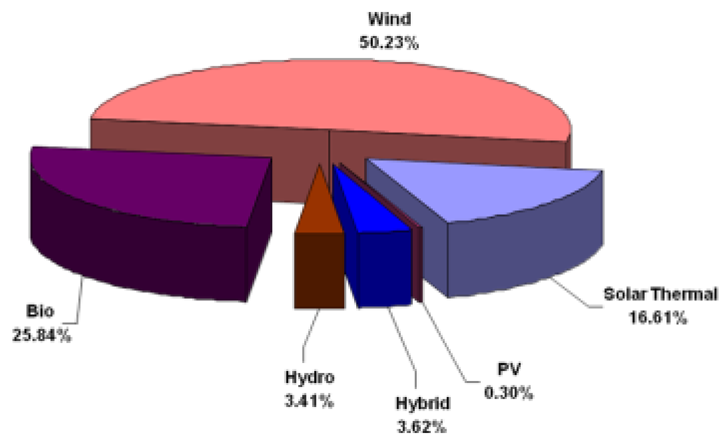

Figure 3: Contribution Rates of Various RE Applications [13]

There will also be a total of 7225 jobs created for technicians, engineers, managers, teachers and the new institution staff. These jobs will be created in the government and private sector and for every job created in the government/public sector 10 jobs will be created in the private sector.

It is estimated that 57% of the master plan costs will be financed by industry, 22% by development assistance agencies and 21% by the government. The government and donor resources finance mostly the non-commercial activities such as accompanying measures and RD&D. Every 1$ contributed by the government leverages almost 4 $ from other sources.

The expected reductions in GHG emissions in 2011 (that are a direct result of displacement of fossil fuel sources with renewable energy) are presented in Table (22).

It follows from this paragraph the following:

1) The Master Plan has not been implemented except the establishment of the National Energy Research Center (NERC) and the execution of some studies proposed in this Master Plan. It was better to hold a seminar to discuss the possibility of implementing the Master Plan. The government cannot implement any plan without the active participation of the private sector and the financial contribution from international donor institutions.
2) The DLR Study [23] has focused only on the electricity generation from renewable energy sources. While the National Paper [22] has proposed a contribution of renewable energy to generate electricity and heat together. The Master Plan has focused on various applications of renewable energy [13].

6.4 Summary of the Results of GHGs Survey and the Future Prospects

Table (23) summarizes the estimated GHGs emissions in Syria in 1990 & 1994 derived from the conference paper presented by Mr. Haitham Nashawati [24].

Table 23. Estimated Emissions of Greenhouse Gases (GHG) in Syria in 1990 & 1994 (Except the Change of Using the Land and Forests)

Potential Sources of Greenhouse Gases	CO_2 kt	CH_4 kt	N_2O kt	NO_x kt	CO kt	NMVOC kt	SO_2 kt
Year 1990							
1. Energy	25300	2.5	1.06	169	259	35	354
2. Industry	2400	1.4	-	-	-	0.035	-
3. Solvents and Chemical use	-	-	-	-	-	9.9	-
4. Agriculture	-	162	14	18	190	-	-
5. Land use change & forestry:		2.2	0.15	0.55	19.4	-	-
Release	(2020)						
Removal	(180)						
Uptake	(2200)						
6. Household waste & sewage water	530	102.8	-	-	-	-	-
Total of Emissions	28230	271	15	188	468	45	354
Year 1994							
7. Energy	31000	2.8	1.27	196	297	40	367
8. Industry	3000	1.4	-	-	-	0.016	-
9. Solvents and Chemical use	-	-	-	-	-	19.8	-
10. Agriculture	-	132.3	14.3	33	333	-	-
11. Land use change & forestry:		2.0	0.14	0.5	17.8	-	-
Release	(2020)						
Removal	(180)						
Uptake	(2200)						
12. Household waste & sewage water	600	116.7	-	-	-	-	-
Total of Emissions	34600	255	16	230	648	60	367

Source [24]

Note: "-"represents not available or not applicable, "kt" represents kilotons. Numbers between brackets are approximate estimation and not an accurate calculation

Figure (4) shows the distribution of GHGs emissions by sector in the years 2000, 2005 and 2010 [27].

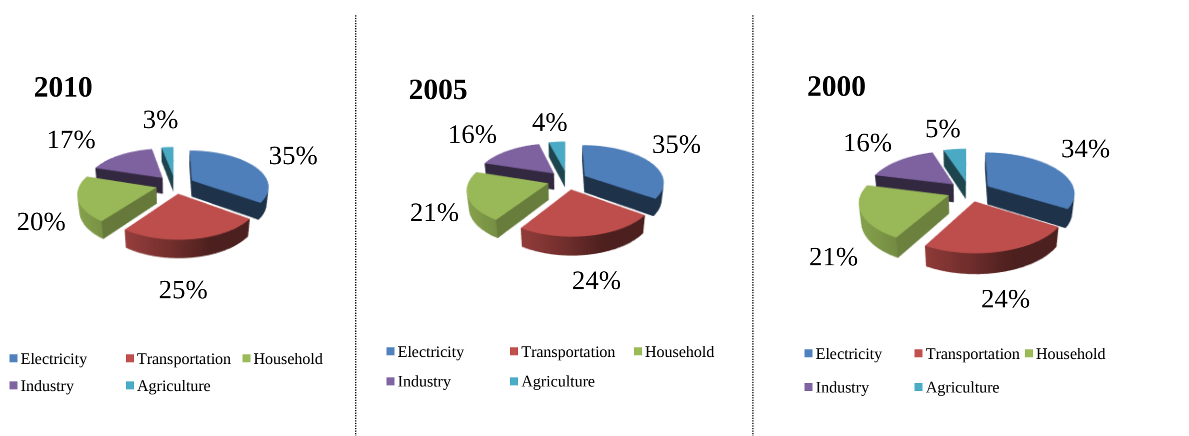

Figure 4: Distribution of GHGs Emissions by Sector in the years 2000, 2005 and 2010
Source [27]

It is obvious from Table (23) that the transport sector is missing.

Table (24) summarizes the estimated GHGs emissions in Syria between 1994 and 2010 derived from the conference paper presented by Mr. Khaled Klaly [25].

As can be seen from the comparison between tables (23) and (24) there is a difference in the total emissions values between Mr. Nashawati's paper [24] (28230 kt in 1990 and 34600 kt in 1994) and Mr. Klaly's paper [25] (25300 kt in 1990 and 30800 kt in 1994). The amount of GHGs emitted by power plants in 2005 was estimated at the 18000 kt in the Mr. Klaly's paper, while it was estimated in the same year by Dr. Hinon [22] at 21700 kt.

Table 24: GHGs Emissions between 1994- 2010

Year	1990		1994		2005		2010	
	kt	**%**	**kt**	**%**	**kt**	**%**	**kt**	**%**
Power Generation Sector	8400	33	10500	34	18000	35	22600	36
Industry Sector	4100	16	4900	16	10000	20	10600	17
Transportation Sector	5300	21	7500	24	8400	16	16100	25
Housing Sector	5600	22	6000	20	12800	25	12400	19
Agriculture Sector	1900	8	1900	6	1900	4	1900	3
Total	25300	100	30800	100	51100	100	63600	100

Source: [25]

The estimated GHGs emissions in the Master Plan [13] were as shown in the Table (25). The values in the Master Plan are **lower** than the values contained in reference [25].

Table 25. Emission Details in Master Plan

Emissions (kt)				
Year	CO_2	NO_x s	CO	SO_2
2005	46342	306	468	576
2010	57949	383	586	721

Source [13]

The estimated GHGs emissions in a paper prepared for the European Union in 2005 [26] were as shown in the Table (26). The values in this paper are **greater** than the values contained in reference [25].

Figure (5) shows the Cost of environmental degradation in the MENA countries as a percentage of GDP [27].

Table 26. Country per Capita GHG Emission Levels

Country	GHG including LULUCF (ktCO2-eq)	GHG excluding LULUCF (ktCO2-eq)	Per capita energy-related CO2 emissions (tCO_2/capita)	Per capita GHG emissions excluding LULUCF (tCO_2-eq/capita)
Syria	71000	71000	3.2	4.4
Jordan	24000	24000	3.2	4.9
Lebanon	19000	18000	3.6	4.2

Source: [26]

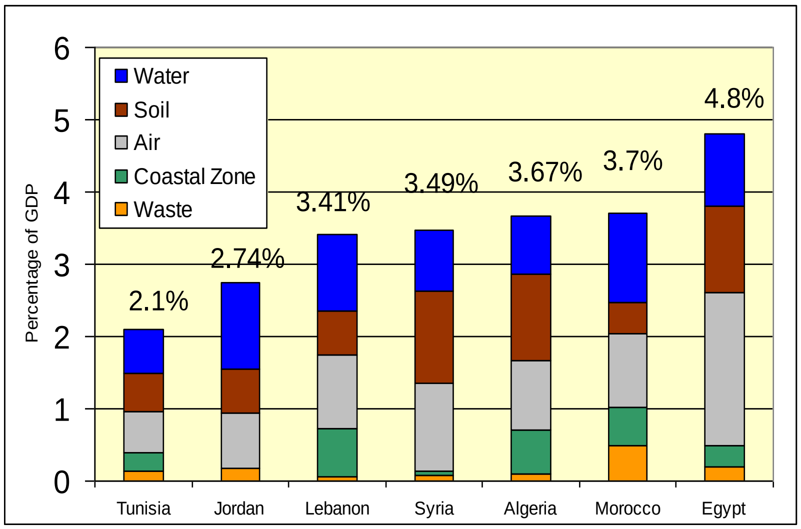

Figure 5: Cost of Environmental Degradation in the MENA Countries Environmental Category: Percentage of GDP [27]

The quantities of fertilizer production and the carbon dioxide emitted by the fertilizer industry are presented in Table (27).

Table 27. CO_2 Emissions from Fertilizer Industry

Year	1990	1994	1996
Fertilizer production (kt)	203	214	184
CO_2 Emission(kt)	763	804	691

1 ton production = 3.8 tons of CO_2e Emissions
(40% higher than the international level).

Source: [25]

It follows from this paragraph that the values of emissions in Syria differ from a reference to another.

This report has to focus on the appropriate measures to reduce GHGs emissions through the development of RE & EE in the residential, commercial and service sectors, in addition to shedding light on the potential of RE & EE in the industrial and agricultural sectors.

The largest contribution of renewable energy can be achieved is in the power generation sector, which is beyond the scope of this report.

7. Residential, Commercial and Service Sectors

The residential, commercial and service sectors have become the major consumer of electricity with a share of 68% (Table 4). Hence, it is essential to reduce energy consumption and improve end-use energy efficiency in these sectors; bearing in mind the fact that these sectors are also the major contributors to peak loads.

There are many reasons for the low efficient use of energy in the residential, commercial and service sectors, including, for example, poorly designed buildings, the use of inappropriate technologies and the incorrect behavior of its residents.

With the increase in energy tariff in the past two years in Syria, energy management in the residential, commercial and service sectors should be practiced in addition to seeking new cheaper alternatives to provide energy.

Energy in households is used for lighting, electric appliances, space & water heating, air conditioning, and other activities. Usually electricity is too expensive for cooking, so gas is used for cooking. People who do not have electricity use kerosene lamps and candles that provide poor illumination and inadequate working hours at night, thus, seriously limiting educational attainment and standing as an obstacle in the way of eradicating illiteracy. Olfactory irritation and respiratory problems also result.

There is a great potential to reduce GHGs emissions in the residential, commercial and service sectors through the use of energy-saving lamps instead of incandescent bulbs, the use of energy-efficient equipment and appliances, the use of thermal insulation and solar water heaters, and improving the efficiency of the traditional oil-stoves.

7.1 Breakdown of the Energy Consumption by Type of Use in the Residential and Service Sectors

7.1.1 Residential Sector

The distribution of the energy consumption in the residential sector for cooking, space and water heating, air conditioning, powering of electrical appliances and other purposes is presented in the Table (28) [11]. Space heating occupies the first place in terms of energy consumption (1441 ktoe), followed by cooking (772 ktoe), water heating (671 ktoe), specific uses (678 ktoe), and finally the consumption of air conditioners (27 ktoe).

Table 28. Breakdown by Type of Use of the Energy Consumption in the Residential Sector in 2005

		Unit	Fossil fuel			Electricity	Solar energy	Traditional fuel	Total or %
			Diesel	Kerosene	LPG				
Total (Urban & rural)		ktoe	1656	1.4	717	968	1.8	245	3589
Cooking	Total	ktoe			672	31		69	772
		%			87%	4%		9%	22%
	Urban	ktoe			349				401
		%			52%				52%
	Rural	ktoe			323				371

		%			48%				48%
Space heating	Total	ktoe	1217		25	46		153	1441
		%	84.5%		1.7%	3.2%		10.6%	40%
	Urban	ktoe							684
		%							47.5%
	Rural	ktoe							757
		%							52.5%
Water heating	Total	ktoe	436		20	188	1.8	25	671
		%	65%		3%	28%	0.3%	3.7%	19%
	Urban	ktoe							476
		%							71%
	Rural	ktoe							195
		%							29%
Air-conditioning	Total	ktoe				26.5			27
		%				100%			0.1%
	Urban	ktoe				23			23
		%				86.7%			87%
	Rural	ktoe				3.5			4
		%				13.3%			13%
Specific uses	Total	ktoe				678			678
		%				100%			18.9%
	Urban	ktoe				420			420
		%				62%			62%
	Rural	ktoe				258			258
		%				38%			38%

Source: Extracted from [11]

7.1.2 Service Sector

The distribution of the energy consumption in the service sector for transport, space heating, air conditioning, thermal uses (space and water heating), and specific electrical uses (lighting and powering electrical appliances) is presented in the Table (29) [11]. Space heating occupies the first place in terms of energy consumption (420 ktoe), followed by specific electrical uses (162 ktoe), thermal uses (155 ktoe), air conditioning (90 ktoe), and finally the consumption of transport (28 ktoe).

The contribution of solar energy in the energy supply in both the residential and service sectors is very low in spite of the great potential available.

Table 29. Breakdown by Type of Use of the Energy Consumption in the in the Service Sector in 2005

	Unit	Fossil fuel			Electricity				Traditional fuel	Total or %
		Transport	Space heating	Thermal use	Air-Condit.	Specific use	Space heating	Thermal use	Thermal use	
Total	ktoe	28	364	80	90	162	56	57	18	855
Trade, Restaurants & Hotels	ktoe	0	29	43	28	56	11	17	18	202
	%		8%	54%	31%	35%	20%	30%	100%	24%
Communications, Storage & Transport	ktoe	28	197	22	20	34	10	3		314
	%	100%	54%	28%	22%	21%	18%	5%		37%
Other Services (Finance..)	ktoe	0	93	10	14	23	7	2		149
	%		26%	12%	16%	14%	12%	4%		17%
Gov. agencies, Worship places & Street lighting	ktoe	0	45	5	28	49	28	35		190
	%		12%	6%	31%	30%	50%	61%		22%

Source: Extracted from [11]

7.2 Breakdown of the Energy Consumption by Type of Fuel in the Residential and Service Sectors

Table (30) shows the distribution of the final energy consumption by fuel type in the residential (rural and urban) and the service sectors in 2005 [11].

7.2.1 Residential Sector

The total number of dwellings in Syria was estimated at 3.479 or 3.5 million dwellings in 2005 [11] (43% in rural areas and 57% in urban areas). Assuming an average occupancy rate of 88% in rural areas and 89% in urban areas, the number of occupied dwellings equal to 3.0914 million dwellings. As the average surface area of the dwelling is about 100 square meters, the total area of the inhabited dwellings is about 310 million square meters.

Table 30. Breakdown by Type of Fuel of the Energy Consumption in the Residential & Service Sectors in 2005

Sector		Unit	Fossil fuel			Electricity	Solar Energy	Traditional fuel	Total
			Diesel oil	Petrol/ Kerosene	LPG				
Resid.	Total (urban & Rural)	ktoe	1656	1.4	717	968	1.8	245	3589
		%	46%	0%	20%	27%	0%	7%	100
	Urban	ktoe	941	0.2	466	645	1.6	9	2063
		%	57%	14%	65%	67%	90%	4%	-
	Rural	ktoe	715	1.2	251	323	0.2	236	1526
		%	43%	86%	35%	33%	10%	96%	-

Service	Total	ktoe	401	11	60	365	0	18	855
	Trade, Restaurants. & Hotels		71			113	-	18	202
	Communications, Storage & Transport		247			68	-	-	315
	Other Services		103			45	-	-	148
	Gov. agencies, Worship places & Street lighting		50			140	-	-	190
Total		ktoe	2057	12.4	777	1333	1.8	263	4444

Source: Extracted from [11]

By dividing the amount of final energy consumption in the residential sector in 2005 (3589 ktoe) by the total area of the inhabited dwellings (310 million square meters) we find the amount of energy consumed per square meter (energy intensity in the residential sector per square meter per year): 11.6 kgoe/m^2.year [11].

7.2.2 Service Sector

The average floor area occupied per capita in the service sector is estimated at about 22 square meters in 2005. By multiplying this area by the number of employees in the service sector (2.785 million) we find the total floor area in the service sector is 61.25 million square meters.

By dividing the amount of final energy consumption in the service sector in 2005 (855 ktoe) by the total floor area of the dwellings (61.25 million square meters) we find the amount of energy consumed per square meter (energy intensity in the service sector per square meter per year): 14 kgoe/m^2.year [11].

In conclusion, the energy intensity 11.6 kgoe/m^2.year or 135 kWh/m^2.year in the residential sector and 14 kgoe/m^2.year or 163 kWh/m^2.year in the service sector are large compared with the current trend in Europe towards an intensity of no more than 70 kWh/m^2.year. This calls for a national energy efficiency policy, to help cutting energy costs in these sectors.

7.3 Evolution of the Number of Residential and Commercial Dwellings

The conventional dwellings (occupied & vacant), rooms, floor areas and number of persons per room (urban & rural) in the years 1970, 1981, 1994, 2004 and 2008 are presented in Table (31). Figure (6) shows the evolution of the number of dwellings in Syria between 1970 and 2008.

Table 31. Conventional Dwellings (Occupied & Vacant), Rooms, Floor Areas and no. of Persons per Room (Urban & Rural) in years: 1970, 1981, 1994, 2004, 2007 and 2008

Year	Urban or Rural	Average floor area per capita (m^2) (2)	No. of persons per room(1)	No. of rooms per dwelling unit	Floor area (1000m^2)	No. of rooms	No. of dwellings
1970	Urban	12.37	2.26	3.11	35334	1261920	405289
	Rural	9.59	3.13	2.07	36305	1210161	584647

	Total	10.83	2.67	2.50	71639	2472081	989936
1981	Urban	14.56	2.03	3.32	75403	2513424	756897
	Rural	12.47	2.56	2.67	69011	2091246	782049
	Total	13.46	2.28	2.99	144414	4604670	1538946
1994	Urban	15.86	1.83	3.42	132097	4534053	1326173
	Rural	12.97	2.30	3.06	103468	3459891	1131730
	Total	14.41	2.04	3.25	235565	7993944	2457903
2004	Urban	17.90	1.50	3.80	192036	7285610	1911901
	Rural	15.30	1.80	3.70	144112	5379200	1456441
	Total	16.70	1.60	3.80	336148	12664810	3368342
2007	Urban	21.63	1.26	3.80	221813	8141822	2144651
	Rural	18.05	1.52	3.68	160958	5879040	1596014
	Total	19.97	1.37	3.75	382771	14020862	3740665
2008	Urban	22.88	1.20	3.80	229810	8385349	2207032
	Rural	17.60	1.57	3.67	169011	6107204	1663504
	Total	20.30	1.36	3.74	398821	14492553	3870536

* (1): For occupied & vacant, (2): For occupied dwellings and their persons
Note: Data housing censuses are accomplished in 1970, 1981, 1994 & 2004.

The number of dwellings (Occupied & Vacant) was increased during the period from 1970 to 1981 from 989,936 to 1,538,946 dwellings at a rate of 50,000 dwelling a year. The resident population in the same period was increased from 6.305 million in 1970 to 9.046 million in 1981. So the rate of increase in this period was a dwelling for every 5 persons.

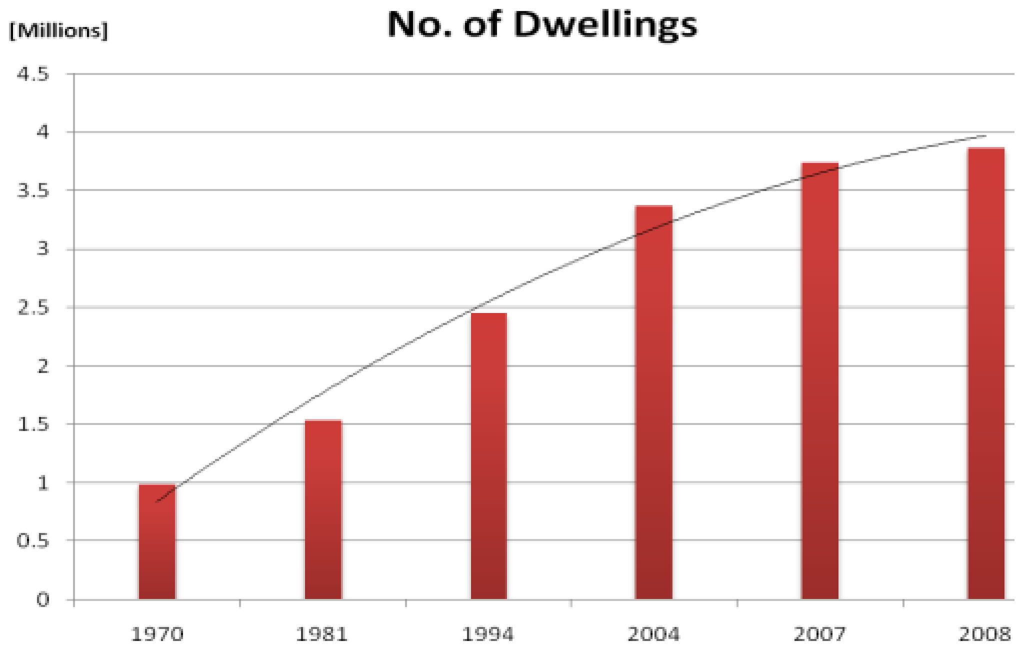

Figure 6. Evolution of the Number of Dwellings in Syria between 1970 and 2008

The number of dwellings in 1994 was 2,457,903 dwellings with a rate of increase of 71,000 dwelling a year between 1981 and 1994. The resident population in the same period was increased from 9.046 million in 1981 to 13.782 million in 1994. So the rate of increase in this period was a dwelling for every 5.15 persons.

The number of dwellings in 2004 was 3,368,342 dwellings with a rate of increase of 91,000 dwelling a year between 1994 and 2004. The resident population in the same period was increased from 13.782 million in 1994 to 17.921 million in 2004. So the rate of increase in this period was a dwelling for every 4.55 persons.

The number of dwellings in 2007 was 3,740,665 dwellings with a rate of increase of 124,000 dwelling a year between 2004 and 2007. The resident population in the same period was increased from 17.921 million in 2004 to 19.405 million in 2007. So the rate of increase in this period was a dwelling for every 4.0 persons.

The number of dwellings in 2008 was 3,870,536 dwellings with a rate of increase of 129,871 dwelling a year between 2007 and 2008. The resident population in the same period was increased from 19.405 million in 2007 to 19.880 million in 2008. So the rate of increase in this period was a dwelling for every 3.7 persons.

It follows from the foregoing that the rate of increase in the number of dwellings during the period between 1970 and 2008 has been improved from a dwelling for every 5 persons to a dwelling for every 3.7 persons. Assuming that a rate of 4 persons per dwelling will last until 2030, the Syrian population is expected to be 31.47 million in 2030. We deduce the expected number of dwellings in 2030: 7867500 (or 7900000) dwellings. On the other hand, assuming that the number of dwellings in Syria at the beginning of 2010 is 4 million dwellings, it means that the number of new dwellings between 2010 and 2030 will be 3.9 million dwellings.

The average floor area per capita has been almost doubled from 10.83 m^2 in 1970 to 20.30 m^2 in 2008.

Table (32) summarizes the annual rates of increase in the number of dwellings in Syria.

Table 32 . Annual Rates of Increase in the Number of Dwellings in Syria

Period	Annual rate of increase (dwellings/year)	Number of persons Per dwelling
1970-1981	50,000	5
1981-1994	71,000	5.15
1994-2004	91,000	4.55
2004-2007	124,000	4.0
2007-2008	129,871	3.7
2010-2030*	195,000	4.0

* Estimated numbers based on statistical data

By dividing the total final energy consumed in the residential sector: 3.5 million tons of oil equivalent in 2005 (Table 2), by the total number of dwellings in Syria in 2005 (3.5 million dwellings [11]) we find the consumption per single dwelling: one ton oil equivalent approx. Assuming that the number of dwellings in Syria will reach 7.9 million dwellings in 2030 and that a dwelling consumes one ton oil equivalent, the final energy consumption in the residential sector will reach 7.9 million tons of oil equivalent in 2030.

7.4 Possible Applications of RE&EE in the Residential Sector

The renewable energy applications suitable for use in the residential sector are: (1) Solar thermal energy for space and water heating, and (2) Photovoltaic energy in rural areas.

The geothermal energy is excluded because it is not available in Syria on a large scale.

Table (33) shows the possible measures for the energy efficiency in the residential sector. Table (34) shows the Compatibility of RE&EE applications in the residential, commercial and service sectors in Syria (low, medium and high).

Table 33. Possible Measures for Energy Efficiency in the Residential Sector

Residential Sector	
1. Building design	√
2. Thermal insulation	√
3. Advanced windows	√
4. Lighting	√
5. Space conditioning	√
6. Water heating	√
7. Refrigeration	√
8. Appliance efficiency	√
9. Improved cook stoves	√

Table 34. Applicable RE/EE Technologies in Residential Sector

Category	Requirements	RE/EE technologies	Compatibility	Competing non-renewable
Urban	Lighting	EE	High	Electricity
	TV	EE	High	Electricity
	Refrigerator	EE	High	Electricity
	Washing machine	EE	medium	Electricity
	Kitchen equipment	EE	Low	Electricity
	Domestic Water Heating	Solar hot water heaters	High	Electricity/ diesel fuel, LPG
Rural	Lighting	EE/PV	High	Kerosene, gas lamp, Auto Battery
	TV	EE/PV	High	Auto Battery
	Refrigerator	hybrid Diesel/PV	High	None
	Washing machine	hybrid Diesel/PV	medium	None
	Kitchen equipment	EE/Biomass	High	Kerosene, diesel, LPG
	Domestic Water Heating	Solar hot water heaters	High	diesel, LPG

7.5 Solar energy applications

7.5.1 Solar Water Heating in the Residential Sector

When SWH systems displace fossil fuels, they reduce ambient air pollutants including oxides of nitrogen, carbon monoxide, and often sulfur dioxide, volatile organic compounds, and particulates as well as CO_2. A recent study supported by the United States Environmental Protection Agency found that SWH was among the most cost-effective ways to reduce CO_2, CO, and NO_x in Mexico City residences and businesses [30].

To assess the possibility of using solar water heaters in the residential sector until the year 2030 the following assumptions and data are adopted:

- The number of dwellings in 2005 in Syria: 3.5 million dwellings,
- The total annual energy consumption for heating water in the residential sector in 2005: 671 ktoe (Table 28),
- The annual consumption per dwelling of final energy for water heating is:

671,000 toe/3,500,000 = 192 kgoe/dwelling/year

= 2233 kWh/dwelling/year (1kgoe=11.63 kWh)

- The number of dwellings in 2030 in Syria is: 7.9 million dwellings,
- Assuming an annual consumption per dwelling of 192 kgoe, the final energy needed to heat the water in these dwellings is:

192 kgoe x 7,900,000 = 1517 ktoe/year

- Given the lack of space for the installation of solar water heaters in all dwellings in 2030, it is assumed that the solar contribution is only **25% in 2030.**

Based on the previous assumptions, Table (35) presents a proposed plan for developing SWH systems in the residential sector up to 2030.

Table 35. Proposed Plan for Developing SWH Systems in the Residential Sector up to 2030

	Unit	Diesel oil	Electricity	Solar Energy	Other fuel	Total (%)
Breakdown of estimated hot water consumption in 2005	ktoe	436	188	1.8	45.2	**671**
	%	65%	28%	**0.3%**	6.7%	**100%**
Breakdown of expected hot water consumption in 2030	ktoe	683	303	379	152	**1517**
	%	45%	20%	**25%**	10%	**100%**

The proposed plan showed in Table (35) assumes that the share of diesel oil and electricity in heating water will decrease from 65% and 28% respectively in 2005 to 45% and 20% respectively in 2030. While the share of other fuel (LPG) will increase from 6.7% in 2005 to 10% in 2030. This increase can be justified by the fact that LPG is sold at the present time at a lower cost than the cost of diesel and electricity.

Assuming that one typical SWH system produces 2233 kWh/year, the projected contribution of solar energy to heat water in the residential sector in 2030 (25%) corresponds to the following number of SWH systems:

$$379 \times 10^6 \text{ kgoe} \times 11.63 \text{ kWh/kgoe} = 4408 \times 10^6 \text{ kWh} = 4408 \text{ GWh}$$

$$4408 \times 10^6 \text{ kWh/ } 2233 \text{ kWh/Solar system} = 1{,}974{,}026 \text{ SWH systems}$$

This means that 25% of the number of occupied dwellings in 2030 (7.9 million dwellings) can be equipped with SWH systems. It may seem to some that the proposed number of solar water heaters (about two million in the year 2030) is exaggerated, but it can be justified as follows:

1) The decision of the Ministry of Local Administration [36] enforces the owners of new residential buildings to install solar water heaters. Assuming that the number of housing units expected to be constructed during the period between 2010 and 2030 is 3.9 million units, the proposed number of solar water heaters remain acceptable and covers almost half the number of new housing between 2010 and 2030. Note that the proposed number of solar water heaters will be distributed between old and new buildings.
2) After the rise in energy prices the demand for solar water heaters is increased over the past two years,
3) The Syrian government Plans to abolish subsidies on energy carriers. So it is natural that solar water heaters will be a cost-effective way to generate hot water in building,
4) Governmental incentives are expected to be issued in the near future for the deployment of solar water heating systems,
5) If we assume that 100,000 solar water heaters can be installed per year (locally produced and / or imported), and if we assume that the capacity of any local company

is to install one solar water heater per day, this means that there must be about 275 companies that manufacture (and / or import) and install solar water heaters. This number is not big at the country level. The estimated number of installers of solar water heaters in Damascus and its countryside is currently more than 50 installers.

The results of the survey applied in the Damascus countryside within the framework of the DSM study (Annex 8) show that 6.5% of households rely on electricity for heating water, while 41% rely on electricity and mostly diesel to heat water. Diesel oil and electricity account for 65% and 28% respectively for the purpose of heating water in 2005 (Table 21). It follows from the foregoing that it is reasonable to estimate that 20% and 80% of housing in Syria will use electricity and diesel oil respectively for heating water in 2030. The low dependency on electricity for heating water is justified by the high cost of electricity. The potential energy saving from SWH Systems in the residential sector in 2030 is presented in Table (36).

Table 36. Potential Energy Saving from SWH Systems in the Residential Sector in 2030

	Unit	Diesel oil	Electricity	Total (%)
Energy saving from 1,974,026 SWH systems in 2030	ktoe %	303 80%	76 20%	**379** **100%**

The most important item in the proposed procedures in the DSM study (Table 3 in Annex 8) is the use of solar water heaters, with an estimated saving of about 978 GWh in 2020. In comparison with the saving proposed in this report (4408 GWh in 2030) we find that the saving in the DSM study is about 65 GWh/yr (over a period of 15 years from the date of completion of the study in 2005 and 2020), while the expected saving in this report is about 220 GWh/yr (over a period of 20 years from 2010 to 2030), which is almost three times greater.

The Syria National Renewable Energy Master Plan (Annex 13) proposed the installation of 300,000 SWH systems with a capacity of 200 liters per system between 2003 and 2011. The achieved saving from these SWH systems is 677 GWh in 2011, or about 85 GWh/yr.

During the preparation of the two reports (DSM and Master Plan) between 2002 and 2006, the energy prices were subsidized by the Government. Therefore it was not possible for the two reporters to propose more saving because the pay-back for the SWH systems was hardly attractive.

After increasing the price of diesel oil from 7 to 20 Syrian pounds, the SWH systems became economically feasible, with a pay-back period of 5.7 years (Annex 5).

7.5.2 Solar Water Heating in the Commercial and Service Sectors

The results of the survey of diesel oil and electricity used for the purpose of heating water in the governmental building in 2005 show that:

- The amount of hot water used: 588,414 cubic meters per year,

- The amount of diesel oil consumption: 13.91 million liters per year (or 11.7 million kg), equivalent to 0.18% of the total consumption of diesel oil in the country in 2004 (6.44 million tons).
- The amount of electricity consumption: 141.3 GWh / y, which is equivalent to 0.69% of the total consumption of electricity in the country in 2004 (20543 GWh)

It is clear from the results of this survey that there is a need to start using solar energy for heating water in the government buildings. Annex (9) contains more details about this survey. Of course, it is impossible to save all the above-mentioned fuel and electricity consumed for heating water due to the lack of appropriate places for installing SWH systems in the governmental buildings.

In the commercial and service sectors, forced circulation SWH systems are required. A limited number of such SWH systems are successfully implemented in some hospitals, hotels and other locations.

It has been suggested in the Master Plan (Annex 13) to install 800 non-domestic SWH systems, with a capacity of 2500 liters per system over a period of 8 years.

Assuming a hospital in Damascus has a load of 2500 liters of hot water per day at a temperature of 60 degrees Celsius. The calculation done by RETScreen software gives the following results:

- An area of flat plate solar collectors: 50 m^2
- Thermal energy yield: 35 MWh / year
- Solar contribution: 76%

The possibility of spreading the use of solar energy for water heating in the commercial and service sectors up to 2030 is large and greater than the number proposed in the Master Plan. Given the difficulty of knowing the number of commercial and service buildings for providing them with SWH systems, the current study assumes that the number can be up to **2000 SWH systems in 2030** with an average capacity of 2500 liters a day per system.

Based on the calculated saving in the software RETScreen the total saving that can be achieved in 2030 from 2000 SWH systems is:

$$2000 \text{ x } 35 \text{ MWh/year} = 70 \text{ GWh/year}$$

It is expected that this number of SWH systems will replace diesel oil water heating systems. So, the results of calculation must be in terms of "liters of diesel oil" and "ton of oil equivalent".

The energy content of the diesel oil at 100% efficiency is:

$$1 \text{ liter} = 35.8 \text{ MJ} \approx 10 \text{ kWh} \approx 0.86 \text{ kgoe (1kgoe=11.63 kWh)}$$

Assuming the efficiency of diesel oil water heating systems of 50%, the energy content of diesel oil become:

$$1 \text{ liter} \approx 5 \text{ kWh} \approx 0.43 \text{ kgoe (1kgoe=11.63 kWh)}$$

The saving from 2000 SWH systems in terms of "liters of diesel oil" is:

$$70 \text{ x } 10^6 \text{ kWh/ 5 (kWh/liter)} = 14\text{x}10^6 \text{ liter}$$

Or in terms of "ton of oil equivalent":

$$14 \times 10^6 \text{ liter} \times 0.43 \text{ (kgoe/liter)} = 6 \text{ ktoe}$$

Or:

$$70 \times 10^6 \text{ kWh} / 11.63 \text{ (kWh/kgoe)} = 6 \text{ ktoe}$$

Table (37) shows the potential saving from 2000 SWH systems in the commercial and service sectors in 2030.

Table 37: Potential Energy Saving from SWH Systems in the Commercial and Service Sectors in 2030

	Unit	Diesel oil	Total (%)
Energy saving from 2000 SWH systems in 2030	ktoe %	6.0 100%	6.0 100%

7.5.3 Solar active Space Heating

There is a possibility for solar space heating, or rather support the traditional space heating. Several successful projects have been implemented to support the underground space heating which did not require temperatures in excess of 50 °C.

It is not expected that this application will be deployed on a large scale due to the lack of vacant space on the roofs of residential buildings. Apart from this, it is impossible to achieve a solar contribution greater than 30%, resulting in a small contribution in reducing GHGs emissions. For these reasons, this application is excluded from the present study.

7.5.4 Photovoltaic Applications

The photovoltaic (PV) applications are very limited in urban areas due to the availability of electricity. In addition, if these applications are implemented in urban areas its contribution in reducing emissions will be very small. For these reasons, the PV applications are excluded from being appropriate in the urban areas.

On the contrary, there are some opportunities for some PV applications in rural or remote areas which are not connected to the electricity grid. The possible PV applications in remote areas are:

- Medical and dental clinics
- Home electrical systems
- Village area illumination
- Drinking water purification
- Refrigeration for medical vaccines storage
- Water pumping for irrigation and drinking
- Village cottage industry
- PV powered ceiling fans

- Portable power for radio, television (long-distance education) and computer power needs
- Other applications

The commercial PV applications are:

- Highway and Billboard lights
- Telecommunication power systems
- Pipelines and oil wells Cathodic Protection
- Boarder and security guards checkpoints
- Beacons, Buoys, and warning signs
- Civil aviation traffic navigational aides
- Emergency telephone call boxes
- Other applications

The results of the statistical survey applied in 2004 on the non-electrified communities are presented in Annex (10). The following is a summary of this survey:

- The number of communities is: 953
- The total number of families is: 14556
- The average number of family members is: 7.2
- The number of individuals living in the communities is: 104,814
- The number of families with seasonal residence is: 3021
- The number of families using LPG for lighting is: 2161
- The number of families using kerosene or diesel oil for lighting is: 5689
- The number of families using diesel generators for lighting is: 992
- The number of families using animal waste-to-energy is: 3716
- The number of families using agricultural residues for energy is: 3410

During 2003 and 2004 another statistical survey was applied on the non-electrified communities located in the provinces of Homs, Hama, and Hasakeh. The survey results are presented in Annex (11). The conclusions of this survey were as follows:

- The amount of fuel (diesel oil, kerosene and LPG) used for lighting was about 2200 tons annually with an average of 436 kg per family,
- The amount of small and medium-sized batteries used for lighting exceeds one million annually with an average of 200 batteries per family,
- Car and large batteries were also used at a rate of 1-2 batteries per family per year,

- The amount of fuel (kerosene and LPG) used for cooking was about 1200 tons annually with an average of 240 kg per family.

Due to the lack of comprehensive and adequate survey of the potentials for wide spread dissemination of PV technology in rural areas of Syria, the potential PV applications presented in Table (38) are extracted from [35] (See Annex 15).

Table 38. Proposed PV Applications

Application	Proposed number of systems	System capacity Wp	Total capacity kWp
Electrification of individual residences in villages located more than 10 km from the electric grid (Table 1 in Annex 15)	480	500	240
Electrification of health centers located far from the electric grid (Table 2 in Annex 15)	6	1500	9
Water pumping (Table 3 in Annex 15)	6	2000	12
Irrigation water pumping (Tables 4 & 5 in Annex 15)	4	6000	24
Total			**285**

Source: [35]

It follows from the foregoing that the potential of PV applications in communities located in remote areas is large. In the light of above-mentioned surveys and studies, Table (39) summarized the proposed PV applications for implementation until 2030.

Table39 . Proposed PV Applications up to 2030

Application	Proposed number of systems	System capacity Wp	Total capacity kWp
Electrification of individual residences	2000	500	1000
Electrification of health centers	37	1500	55
Electrification of schools	34	1000	34
Water pumping	83	2000	166
PV irrigation water pumping	1000	6000	6000
Water desalination	30	5000	150
Total			**7405**

The total capacity of the proposed PV applications to be implemented until the year 2030 is about 7.4 MWp. Based on the conversion factor of PV systems (Table 4 in Annex 13) the calculation of the electrical power that might be produced from the proposed PV applications is as follows:

$$7405 \text{ x } 1.9 \text{ (MWh/y/kWp)} = 14070 \text{ MWh/y} = 14.07 \text{ GWh/y} = 1.21 \text{ ktoe/y}$$

For PV applications, it is normal to obtain this resulting saving which is relatively small compared with the saving calculated from the proposed SWH systems. The proposed share of the PV applications in the Master Plan (Annex 13) was only 0.3% of the total contribution by

RE technologies, while the shares of SWH systems and wind farms were 16.61% and 50.23% respectively.

Finally, Table (40) summarizes the total saving resulting from the proposed actions and possible measures to reduce energy consumption through the implementation of the solar thermal and PV technologies in the residential, commercial and service sectors up to 2030.

Table 40. Sum of Total Energy Saving from Renewable Energy Applications in Residential, Commercial and Service Sectors up to 2030

	Unit	Diesel oil	Electricity	Total (%)
Energy saving gained from SWH systems in residential sector	ktoe	303	76	**379**
	%	80%	20%	**100%**
Energy saving gained from SWH systems in commercial & service sectors	ktoe	6.0		**6.0**
	%	100%		**100%**
Energy saving gained from PV applications	ktoe	1.21		**1.21**
	%	100%		**100%**
Total	**ktoe**	**310.21**	**76**	386.21

7.6 Energy efficiency applications

7.6.1 Building Envelope (thermal insulation)

Given the importance of building heating and cooling to peak residential demand in Syria, and the generally poor thermal performance of buildings in Syria, improvements in building envelopes in a number of sectors of the Syrian economy is a significant opportunity for energy and peak power saving. This opportunity will become even greater as air conditioning (and the summer peak) becomes an increasingly important issue in electricity system planning. The Building envelope improvements apply a package of building envelope improvements in different case/sector combinations. The package of improvements include better wall and ceiling insulation, better windows, better thermal seals, and possibly other relatively low-cost measures. Ultimately, a package of measure particularly developed for application with typical Syrian construction practices can and should be developed. The case/sector combinations to which the measure package is applied as part of a pilot program are:

- New Building Envelope Measures, Residential Buildings
- New Building Envelope Measures, Commercial Buildings
- New Building Envelope Measures, Governmental Buildings
- Building Retrofit Envelope Measures, Residential Buildings
- Building Retrofit Envelope Measures, Commercial Buildings
- Building Retrofit Envelope Measures, Governmental Buildings

It should be noted here that the two green building rating systems LEED and STAR classify buildings according to environmental standards. The models in these two systems were developed to encourage environmental awareness amongst government agencies, architects, engineers, developers, and builders.

The lifespan of the residential buildings is estimated between 50 and 75 years. This makes it necessary to make good decisions when constructing buildings (well orientated and thermally isolated) due to the impact of the building construction on future GHGs emissions.

External Thermal Insulation Composite Systems (ETICS) are an opportunity to improve the thermal performance of both new and existing buildings. The system consists of insulating boards that allow for the application of plaster directly without any preparation of the surface being necessary. Many thermal bridges can easily be avoided by insulating the exterior surface of a building's external walls.

Energy saving in buildings depends on climatic conditions. In cold and heating based climates this will mainly depend on heating needs given by the Heating Degree Days, in hot and cooling based climate this will mainly depend on cooling needs given by Cooling Degree Days.

For different climatic conditions, the optimum for part of the building or heating, cooling and ventilation system can be assessed for the optimal size of insulation or energy efficiency that would be the cheapest over a longer term (30 years for example).

Increased insulation will have the same costs independent of the climatic conditions. The saving will on the other hand depends highly on the climate and the amount of heating degree days, but will also be different for the first part and for the following insulation.

Since saving gained from insulation are highly dependent on the climatic conditions, while costs for additional insulation are nearly independent of the climate, this will give a different feasibility of insulation in different climates.

However, the different types of insulation (glazing, heating, cooling or ventilation systems) will interfere to some extent, and improved insulation might reduce the improvement benefits of a boiler and vice-versa. Reductions in total costs can also occur as energy saving will be greatly reduced that a smaller or no heating system will be required.

Additional costs may also appear because of increased thickness of constructions, changed solutions, local price levels and traditions.

An overall solution to this problem would be to estimate the least cost optimum for the overall energy performance of the building, although this is complicated.

Based on the least cost curve method, an indicator can be developed. This indicator can show how far the demands in building code are from the least costs optimum for different parts of the building and the installations. A theoretical graph with this indicator is shown in Figure (7).

If the heating degree days are increased, the thickness of thermal insulation is increased and thus the value of the overall heat transfer coefficient (U-value) is decreased.

Based on the least cost curve shown in Figure (7) the indicator will also show how much of the optimum is achieved. The optimum achievement could be set to 100 %. A value above 100 % would then show that the U-value is over the optimum. Values below 100 would indicate that the level for the building code is stricter than the optimum.

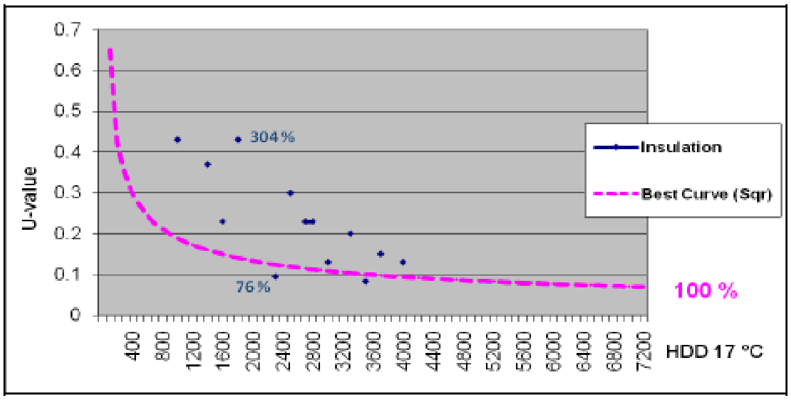

Figure 7: U-Values for Roof Insulation Compared to Life Cost Optimum [37]

There could be good reasons to go beyond the least cost optimum for instance by setting a value for reduced CO_2 (in certificates or by subsidy), or because these requirements could be used to reduce the costs for energy efficient solutions in general or could be a part of a national policy to obtain greenhouse gas emissions. Similarly, improved U-values reduce the need for heating or cooling installations and this might reduce the total costs of the building.

Note that the European Low-Energy-House standard requires an insulation layer in the walls of at least 14cm. This might not be suitable for residential buildings in densely populated Syrian cities.

Table (41) summarizes the maximum values of the U-value for different construction elements in the "Syrian Code of Thermal Insulation in Buildings".

Table 41: Maximum Values for U-Values

Element	Max. U-value	(W/m^2.K)
Roof	U_{roof}	0.5
External wall	U_{ow}	0.8
Window, $A_{win} \leq 0.2\ A_{facade}$	U_{win}	5.2
Window, $A_{win} > 0.2\ A_{facade}$		3.5
Façade	U_{facade}	1.5
Ground floor	U_G	1
Intermediate floor	U_F	1
Floor above crawl space		0.5

A_{facade}: Surface area of the façade,
A_{win}: Surface area of the doors & windows
Source: [19]

U-values in the Syrian code are compared with similar U-values adopted in some neighboring and European countries (See Table 42).

Table 42. Comparison of U-values with some Neighboring and European Countries

Max. U-values (W/m^2.K) in some selected countries				
Country	**Roof Insulation**	**Floor Insulation**	**Wall Insulation**	**Windows**
Syria	0.5	1.0	0.8 (1.5 Façade)	3.5 – 5.2
Dubai	0.44	…	0.57	2.5 – 3.18
Palestinian Terr.	0.9	1.2	1.8 (Façade)	
Jordan	1.0	…	1.8 (Façade)	
Spain	0.1 – 1.39	0.7 – 1.39	1.2 – 1.8	3.4 – 5.2
France	…	1.0 – 1.35	0.4 – 0.6	2.7 – 3.5

The following points are concluded from Table (42):

1. The U-value for the floor in Syrian code (1.0 W/m^2.K) is smaller than the similar value in Palestinian territory (1.2 W/m^2.K) and below the maximum values in French code (1.35 W/m^2.K) and in Spain code (1.39 W/m^2.K). These two values in France and Spain are properly belonged to the southern areas bordering the Mediterranean Sea,
2. The U-value for the roof in Syrian code (0.5 W/m^2.K) is smaller than those in Palestinian territory (0.9 W/m^2.K) and in Jordan (1.0 W/m^2.K) and below the maximum value in Spain code (1.39 W/m^2.K)
3. The U-value for the façade in Syrian code (1.5 W/m^2.K) is smaller than those in Palestinian territory and Jordan (1.8 W/m^2.K) and below the maximum value in Spain code (1.8 W/m^2.K),
4. The U-value for the wall in Syrian code (0.8 W/m^2.K) is much smaller than the minimum value in Spain code (1.2 W/m^2.K),
5. The U-values for the window in Syrian code (3.5-5.2 W/m^2.K) are acceptable and compatible with those in Spain code (3.4-5.2 W/m^2.K).

It is clear from the above-mentioned conclusions that the level for the Syrian building code is stricter than the level in some neighboring countries. In addition, the U-values proposed in the Syrian code are not depending on climatic conditions (internal, mountainous and coastal, for example).

The "Code of Thermal Insulation in Buildings" in Syria should be carefully revised and updated.

Before reviewing the possible EE measures in the residential sector, it is preferable to shed light on the existing large-scale housing projects nominated for the implementation of these measures.

Qudsaya Youth Housing Project in Damascus

Yvonne Hofman published a paper [31] includes a brief step by step guideline to developing a Clean Development Mechanism (CDM) project for the Youth Housing project in the suburb of Damascus (Qudsaya). Table (43) summarized the project as published in the paper (Annex 16). Figure (8) shows a photograph of the pilot project during the construction.

Figure 8: Qudsaya Youth Building Pilot Project in Damascus, Syria

The pilot project consists of five-storey apartment blocks with 16 apartments, a part of the "Youth Residential Complex" consisting of 18 buildings with 12,600 flats in total, situated North West of Damascus in the Qudsaya Suburbs. The total number of apartments to be constructed is 50,000 apartments.

The apartment block has a total floor space of 480 m²; passive building design measures and solar energy are used to improve energy efficiency. The results of this pilot project are as follows:

Table 43. CDM Feasibility Check for the Qudsaya Youth Building Project in Damascus, Syria

Example: Qudsaya Youth Building Project in Syria Damascus

Pilot project: 16 apartments with insulated walls and windows 80sq.m/apartment- start June 2007.

Total project: 50,000 apartments

Table 43.1.: Heat transfer coefficient for walls and windows in baseline and project situation

	Baseline (Traditional system)	Project
Walls	Hollow block walls (2.7 W/m² °C)	Insulated walls (0.53 W/m² °C)
Windows	Aluminum windows with single glass (8.35 W/m² °C)	U-PVC windows with double glass (2.4 W/m² °C)

Result: decrease in heating and air-conditioning energy use.

CDM feasibility check:

- Syria has ratified the Kyoto Protocol and thus the project can be developed as CDM
- The project reduces CO_2 emissions, as shown in the table below
- The project will most likely be additional to business as usual as:
  - The investment of the insulation measures is much higher than without the measures

- Syrian law and regulation has not set any building standards,

- The annual carbon revenue is estimated to be Euro 1.470.000 per year, compared to which transaction cost is only a fraction.
- The total energy saving exceeds 60 GWh and thus and new methodology needs to be developed.

Table 43.2. Energy and Emission Reductions per Apartment

Energy consumption	Baseline	Project	Saving	Emission reduction per apartment (tCO_2 eq./yr)
Diesel (litre/yr)	1800	540	1260	3.2
Electricity (kWh/yr)	3240	1380	1860	1
Total				**4.2**

Energy saving for 50,000 apartments: 63 million liter diesel and 93 GWh electricity

Emission reduction for 50,000 apartments: 210,000 tone CO_2.

Annual Carbon income based on price of 7 Euro/t CO_2: Euro 1,470,000 per year.

Source: [31]

- Heat transfer coefficient of the walls before the thermal insulation: 2.7 W/m² °C
- Heat transfer coefficient of the walls after the thermal insulation: 0.53 W/m² °C
- Heat transfer coefficient of windows (aluminum with single glass): 8.35 W/ m² °C
- Heat transfer coefficient of the energy-efficient windows (U-PVC double glass): 2.4 W/m² °C
- Annual saving in diesel oil consumption per apartment: 1260 litre /yr
- Annual saving in electricity consumption per apartment: 1860 kWh /yr
- Annual saving in diesel oil consumption for 50,000 apartments: 63,106 litre /yr
- Annual saving in electricity consumption of 50,000 apartments: 93 GWh/yr
- Emission reduction per apartment: 4.2 tCO2 eq. /yr
- Emission reduction for 50,000 apartments: 210 ktCO2 eq. /yr
- Annual Carbon income based on price of 7 Euro/t CO_2: Euro 1,470,000
- -Compared to a conventional building, the total primary energy consumption of the pilot project is reduced by over 63%
- Increase in the investment cost: 35%

The Project was evaluated as non-economic because of the high cost of thermal insulation and poor knowledge of know-how in selecting and applying appropriate technologies to improve the energy efficiency.

With a view to the adoption of a viable solution for replication, it was proposed to adopt the most cost efficient measures to reduce the payback period to 10 years.

In the above-mentioned paper, the following conversion factors are considered: 2.54 $kgCO_2$ eq/liter for diesel oil, and 0.538 $kgCO_2$ eq / kWh for electricity.

The information contained in the Yvonne Hofman paper [31] is similar to the information contained in the study "Energy Efficiency in the Construction Sector in the Mediterranean, Market Analysis and Capacity Assessment-Syria" [39]. The potential for energy efficiency in the "Qudsaya Youth Housing Project" [39] is shown in Table (44).

The source of the information in the two references [31] and [39] is "Mahjoub House ", a local private company makes U-PVC windows and doors. The total saving shown in Table (43) is calculated for 50,000 apartments while the total savings shown in Table (44) are calculated for 11,000 apartments.

It follows from the foregoing the following remarks:

- The detailed information on EE measures in this pilot project (materials used and the thickness of thermal insulation, etc.) is not yet known,
- The U-value adopted for the single glass aluminum window (8.35 $W/m^2.°C$) seems to be high,
- Some U-values adopted are sticker than those recommended in the "Syrian Code of Thermal Insulation". For example, The U-value for the insulated wall (0.53 $W / m^2 °C$) is much lower than the recommended value in the Syrian code (0.8 $W/m^2.°C$) and the U-value for the U-PVC window (2.4 $W/m^2.°C$) is much lower than the recommended value in the Syrian code (3.5-5.2 $W / m^2 ° C$),
- The pilot project suffers from the surplus of thermal heat energy produced by the flat-plate solar collectors in summer. A seasonal storage was adopted (installation of a thermally insulated storage tank with capacity of 50 cubic meters),
- So, it was not surprising that this pilot project was not economically viable,
- Even if in case of the adoption of the Syrian code values, the project will remain economically unviable,
- For these reasons the pilot project is not suitable for replication.

Table 44. Potential for Energy Efficiency in the Residential Sector

Potential for Energy Efficiency in the Residential Sector					
Space heating	Conventional building process		New System based on energy-efficient technologies		Potential savings
	lit/day	lit/year	lit/day	lit/year	lit/year
Fuel oil consumption/ apartment	15	1800	4.5	540	1260
Fuel oil consumed in heating 11000 apts.	165,000	19,800,000	49,500	5,940,000	13,860,000
Ventilating & Air conditioning	Conventional Building Process		Process based on energy-efficient building technologies		Potential savings
	KWh/day	KWh /year	KWh/day	KWh /year	KWh /year
	27	3240	11.5	1380	1860
Total energy consumed in heating 11000 apts.	**297,000**	**35640000**	**126500**	**15,180,000**	**20,460,000**

Notes:
No. of days requiring heating and/or ventilating & air- conditioning: 120 days/year
Hours per day: 10 hrs.
Conventional insulation: Walls built using concrete blocs + aluminum frame windows (single glazing).
Energy-efficient insulation: Cavity Wall Insulation including U-PVC windows (double glazing)
Source: Mhd. Khaled Mahjoub, Company Chairman, Mahjoub House , Source: [39]

New-Sham Housing Complex in Damascus

The "Cooperative Housing Association for Vocational Syndicates in Damascus" is the unique district heating company that distributes heat via a low-pressure hot water system in "New-Sham Housing Complex" in Damascus.

This association requested tenders prices for supplying a study to provide the following buildings with solar water heating systems:

- Tower buildings (T1) consisting of 50 apartments and 12 floors. The total number of buildings is 42 building and the total number of apartments is 2100 apartment,
- Multi storey buildings (A1) consisting of 8 apartments and 4 floors, and the total number of buildings is 91 building,
- Multi storey buildings (C4) consisting of 16 apartments and 4 floors and the total number of buildings is 80 building,
- Multi storey buildings (E1) consisting of 24 apartments and 4 floors and the total number of buildings is 24 building.

The total number of apartments is 4800 apartments having a total area of 699,500 square meters, with an average of 145 square meters per apartment.

All apartments consume about nine million liters of diesel oil annually for space heating and water heating with an average of 1875 liters diesel oil per apartment. These apartments consume about three million liters of diesel oil per year for water heating in the summer, with an average of 625 liters of diesel oil per apartment.

The efficiency of the existing old boilers is estimated at 40% and the control system is failed.

It is planned to insulate all the building. Few buildings have been externally insulated with a view to achieve an economic solution. It is also planned to develop a CDM project for the solar water heating systems and EE measures.

- ***A proposal of possible saving gained from thermal insulation in buildings***

To achieve the purpose of this report, it should find a solution helping the assessment of the potential EE measures in the residential sector. The objective is to achieve the economic feasibility of the thermal insulation through adopting the appropriate U-values.

The current study proposes the adoption of the U-values shown in Table (45). The detailed calculations of the overall heat transfer coefficients of the construction elements of a typical apartment before and after thermal insulation are presented in Annex (17).

Table 45. Summary of the Results of U-Values Calculations (Annex 17)

Element	$(W/m^2.K)$ U-Value	
	Before insulation	**After insulation**
Roof (insulation thickness=2 cm)	1.84	0.96 ≈ 1.0
Wall (insulation thickness=3 cm)	2.92	0.915≈ 1.0
Façade (insulation thickness=3 cm)	3.38	1.77 ≈ 1.8
Al window, single glass	5.2	5.2
Floor	2.03	2.03

The following results are deduced from the table (45):

- Percentage of improving the thermal insulation of the roof is:

$$U_{Roof} – U_{Roof,I} \ / U_{Roof} = 1.84\text{-}0.96/1.84 = 47.8 \%$$

- Percentage of improving the thermal insulation of the external wall is:

$$U_{Wall} – U_{Wall,I} \ / U_{Wall} = 2.92\text{-}0.915/2.92 = 68.7 \%$$

- Percentage of improving the thermal insulation of the façade is:

$$U_{Facad} – U_{Facadl,I} \ / U_{Facad} = 3.38\text{-}1.77/3.38 = 47.6 \%$$

The overall performance of the entire building envelope ($U_{Overall}$-value) can be calculated by the following equations, which take into account the heat U-value for each element of the building:

- Before insulation, including the heat loss through the floor:

$$U_{Overall} = U_{Ceiling} + U_{Wall} + U_{Floor} + 0.2 \text{ x } U_{Window}$$

$$U_{Overall} = 1.84 + 2.92 + 2.03 + 0.2 * 5.2 = \mathbf{7.83\ W/m^2.K}$$

- Before insulation, excluding the heat loss through the floor:

$$U_{Overall} = U_{Ceiling} + U_{Wall} + 0.2 \text{ x } U_{Window}$$

$$U_{Overall} = 1.84 + 2.92 + 0.2 * 5.2 = \mathbf{5.80\ W/m^2.K}$$

- After insulation, including the heat loss through the floor:

$$U_{Overall,I} = U_{Ceiling,I} + U_{Wall,I} + U_{Floor,I} + 0.2 \text{ x } U_{Window,i}$$

$$U_{Overall,I} = 1.0 + 1.0 + 2.03 + 0.2 * 5.2 = \mathbf{5.07\ W/m^2.K}$$

- After insulation, excluding the heat loss through the floor:

$$U_{Overall,I} = U_{Ceiling,I} + U_{Wall,I} + 0.2 \text{ x } U_{Window,i}$$

$$U_{Overall,I} = 1.0 + 1.0 + 0.2 * 5.2 = \mathbf{3.04\ W/m^2.K}$$

The relative difference of the ($U_{Overall}$-value) before and after insulation, including the heat loss through the floor:

$$U_{Overall} - U_{Overall,i} / U_{Overall} = 7.83 – 5.07 / 7.83 = \mathbf{35\%}$$

The relative difference of the ($U_{Overall}$-value) before and after insulation, excluding the heat loss through the floor:

$$U_{Overall} - U_{Overall,i} / U_{Overall} = 5.80 – 3.04 / 5.80 = \mathbf{47.6\%}$$

According to the U-values adopted in the “Syrian Code of Thermal Insulation” the ($U_{Overall}$-value), including the heat loss through the floor is:

$$U_{Overall,I} = U_{Ceiling,I} + U_{Wall,I} + U_{Floor,I} + 0.2 \text{ x } U_{Window,i}$$

$$U_{Overall,I} = 0.5 + 0.8 + 1.0 + 0.2 \text{ x } 5.2 = \mathbf{3.34\ W/m^2.K}$$

And the ($U_{Overall}$-value), excluding the heat loss through the floor is:

$$U_{Overall,I} = U_{Ceiling,I} + U_{Wall,I} + 0.2 \text{ x } U_{Window,i}$$

$$U_{Overall,I} = 0.5 + 0.8 + 0.2 \text{ x } 5.2 = \mathbf{2.34\ W/m^2.K}$$

According to the U-values adopted in the “Syrian Code of Thermal Insulation” the relative difference of the ($U_{Overall}$-value) before and after insulation, including the heat loss through the floor is:

$$U_{Overall} - U_{Overall,i} / U_{Overall} = 7.83 – 3.34 / 7.83 = \mathbf{57\%}$$

And the relative difference of the ($U_{Overall}$-value) before and after insulation, excluding the heat loss through the floor is:

$$U_{Overall} - U_{Overall,i} / U_{Overall} = 5.80 – 2.34 / 5.80 = \mathbf{59.7\%}$$

According to the literature in this area, a reduction of 70-75% on energy consumption can be achieved in the residential buildings.

The economic feasibility study of thermal insulation for a typical apartment having an area of 120 square meters is presented in Annex (17). Table (46) summarizes the results of this study.

Table 46: Results of the Feasibility Study for Insulating a Typical Flat with 120 m^2

	Unit	Value
External walls (100m^2 for walls & 20 m^2 for windows)		
Thermal losses in non-insulated walls (including windows)	W	7436
Thermal losses in insulated walls (including windows)	W	3894
Thermal energy saving resulted from insulating the walls	W	3542
	kcal/h	3046
	liter mazout/hr	0.354
Annual saving in diesel oil for space heating	liter mazout/yr	450
	SL/yr	9225
Annual saving in electricity for air-conditioning	kWh/yr	1771
	SL/yr	4268
Roof (120 m^2)		
Thermal loss in non-insulated roof	W	4858
Thermal loss in insulated roof	W	2534
Thermal energy saving resulted from insulating the roof	W	2324
	kcal/h	1999
	liter mazout/hr	0.232
Annual saving in diesel oil for space heating	liter mazout/yr	295
	SL/yr	6048
Annual saving in electricity for air-conditioning	kWh/yr	1162
	SL/yr	2800
The flat		
Sum of thermal losses in non-insulated walls & roof	W	12294
Sum of thermal losses in insulated walls & roof	W	6428
Sum of the thermal energy saving resulted from insulating the roof & walls	W	5866
	kcal/hr	5045
	liter mazout/hr	0.587
Sum of the annual saving in diesel oil for space heating	liter mazout/yr	745
	SL/yr	15273
Sum of the annual saving in electricity for air-conditioning	kWh/yr	2933
	SL/yr	7068
Sum of the total annual saving in diesel oil & electricity	SL/yr	22341
Initial cost for the thermal insulation	SL	33000
Payback period	years	1.5

The economic feasibility study shows that the thermal insulation is a cost effective measure with a payback period less than 2 years.

Without taking into account the heat loss from the floor, which was not calculated in the feasibility study, the total saving percentage is:

(Total heat loss before insulation - Total heat loss after insulation) / (Total heat loss before insulation)

That is:

12294-6428/12294= 5866/12294 = **47.7%**

This is the same percentage as calculated by using the ($U_{Overall}$-value) equation. This means that saving can be estimated using the concept of the "overall coefficient of heat transfer".

Table (47) compares the results of the feasibility study with the results included in Table (44).

Table 47. Comparison between Studies in Annex (17) & in Table (44)

	Unit	Results from study in Annex (17)	Results from study in Table (44)
Sum of the annual saving in diesel oil for space heating	liter/yr	745	1260
	liter/m^2.yr	6.2	15.75
Sum of the annual saving in electricity for air-conditioning	kWh/yr	2933	1860
	kWh/ m^2.yr	24.44	23.25

The annual saving in electricity per square area are the same in both studies, while the annual saving in the diesel oil per square area is more than doubled in the Qudsaya project due to the use of lower U-values.

The results of the feasibility study in the Annex (17) are more convincing than the findings in the Qudsaya project. Therefore, the assessment of the potential of EE measures in the residential sector will be based on the results of the above-mentioned feasibility study.

- *A proposal for the potential of the thermal insulation in the residential buildings up to 2030*

Before proposing the potential for thermal insulation in the residential buildings we must first shed light on the current status of buildings, as well as on the “Syrian Code of Thermal Insulation”:

1) Most of the existing and new residential buildings are "commercial" that is, they are constructed with the lowest possible cost,
2) The enforcement of the “Syrian Code of Thermal Insulation”, has been faced many difficulties,
3) The “Syrian Code of Thermal Insulation” does not encourage contractors and construction companies to adopt it due to the increased cost resulting from the implementation of thermal insulation,
4) It is possible that the “Syrian Code of Thermal Insulation” can be applied but with less requirements of the U-values,
5) The enforcement of the “Syrian Code of Thermal Insulation” needs more time, more workshops to explain it and further awareness campaigns.
6) The “Syrian Code of Thermal Insulation” should be carefully revised and updated,
7) The Syrian government does not provide at present any facilities and incentives to encourage the thermal insulation of the residential buildings,
8) The expertise to undertaking the thermal insulation is not available widely in the country (particularly with regard to avoiding thermal bridges). It should be noted here that the cost of errors resulting from the thermal insulation is estimated at 10 billion

Euros a year in Germany, which is considered the most progressive European countries in the field of thermal insulation of residential buildings,

9) Despite the intensified government efforts to prevent the unlicensed construction, unfortunately this phenomenon will continue,

10) The results of the thermal insulation in the pilot project in Qudsaya do not encourage the replication of this pilot project on the entire project (50,000 apartments).

To assess the potential for the use of thermal insulation, it is recommended to focus on the new residential buildings for the following two reasons:

1) The implementation of the thermal insulation in new buildings is much easier in comparison with old buildings,

2) The “Syrian Code of Thermal Insulation” addressed only the new buildings.

Assuming the number of dwellings expected to be constructed during the period between 2010 and 2030 is 3.9 million dwellings, with an average annual rate of 195,000 dwellings a year, and on the basis of the foregoing about the current status of the buildings, the number of dwellings proposed to be thermally insulated during the next twenty years depends on the following:

1) Possible decline in annual demand for housing in the future than the figure estimated above in the case the population growth rate declined from 2.2% per year,

2) The increase of the level of income will reflect on the quality of housing, so more insulated houses will be demanded,

3) Energy prices in Syria are closely linked to the extent of the thermal insulation in residential buildings. If energy prices are relatively low to medium, this will help not to disseminate the thermal insulation on a large scale. It is true that the government had restructured the energy tariff over the past two years, but the subsidy shifted from "fuel subsidies" to "diesel oil coupons" and then to direct financial support of ten thousand Syrian pounds per family,

4) The extent of the thermal insulation in residential buildings is closely linked to the availability of the insulation materials at low cost. It is well known that the expanded polystyrene is relatively cheap and manufactured locally, but the extruded polystyrene, which has lower thermal conductivity (Tables 1 and 2 in Annex 18), has slightly higher price and is not manufactured now in Syria. Extruded polystyrene is environmentally friendly because it can be manufactured from used materials. The extruded polystyrene imported from Saudi Arabia was used in the pilot project in Qudsaya,

5) The extent of thermal insulation in residential buildings is closely linked to the increasing of public awareness.

It follows from the foregoing that it is logically to propose a modest number of new dwellings to be thermally insulated. Therefore the present study suggests for instance three scenarios (See Table 48). The surface area of each dwelling is assumed to be 120 m^2.

Table 48. Proposed Number of Dwellings to be Insulated in 2030 (120 m^2 for Each Dwelling)

Scenario	Number of insulated dwellings per year	Total number of insulated dwellings in 2030
Low	10,000	200,000
Medium	30,000	600,000
High	50,000	1,000,000

- *Calculation of the possible saving from the proposed insulated dwellings up to 2030*

Based on the following results of the study in Annex (17) on a dwelling of 120 m^2:

-Total annual saving in diesel oil for the purpose of space heating is 745 liter/yr

-Total annual saving in electricity for the purpose of air conditioning is 2933kWh/yr

The calculated savings in diesel oil (for space heating) and electricity (for air conditioning) from the proposed insulated dwellings up to 2030 are presented in Table (49). Table (50) shows same savings but in term of kilo tones oil equivalent.

Table 49. Potential Savings in Fuel & Electricity from the Proposed Insulated Dwellings in 2030

Scenario	Total number of insulated dwellings in 2030	Saving in diesel oil (10^6 liter)	Saving in electricity (GWh)
Low	200,000	149	587
Medium	600,000	447	1760
High	1,000,000	745	2933

The total saving in 2030 in term of GWh is equal to 2077 GWh, or approximately 100 GWh per year (over the period between 2010 and 2030).

It should be noted that the DSM study (Annex 8) addressed this subject in the paragraph "Improved Building Envelope Measures for Residential, Commercial, and Government Buildings", and reached to the possibility of saving about 700 GWh in 2020, with an average of approximately 50 GWh per year (over the period between 2005 and 2020).

Table 50: Potential of Total Saving from the Proposed Insulated Dwellings in 2030

Scenario	Unit	Diesel oil	Electricity*	Total (%)
Low	ktoe	128	147	**275**
	%	47%	53%	**100%**
Medium	ktoe	384	440	**824**
	%	47%	53%	**100%**
High	ktoe	641	733	**1374**
	%	47%	53%	**100%**

* 1ktoe = 4 GWh, η≈34% (Power plants)

Finally, the low scenario is adopted because it is the closest scenario to the DSM study, and the most realistic scenario.

7.6.2 Reflective Surfaces of Solar Radiation (Cool roofs) [40]

Some Syrian residents in the last floors spray the roofs with cheap lime (calcium) at the beginning of every summer to reduce the absorbed solar heat, which helps to cool relatively the last floors.

Increasing the solar reflectance of the urban surface reduces its solar heat gain, lowers its temperatures, and decreases its outflow of thermal infrared radiation into the atmosphere. This process of “negative radiative forcing” can help counter the effects of global warming.

Most existing flat roofs are dark and reflect only 10 to 20% of sunlight. Resurfacing conventional dark roofs with a cool white material that has a long-term solar reflectance of 0.60 or more increases its solar reflectance by at least 0.40. Retrofitting 100 m^2 of roof has an effect on radiative forcing equivalent to a one-time offset of 10 tonnes of CO_2. Given that CO_2 is currently traded in Europe at $20/tonne, the value of this change could be worth up to $200.

The solar reflectance of pavement can be raised on average by about 0.15, the equivalent of a reduction of 4 tonnes of CO_2 per 100 m^2.

In addition, cool roofs reduce cooling-energy use in air conditioned buildings and increase comfort in unconditioned buildings. Cool roofs and cool pavements mitigate summer urban heat islands (See Figure 9), improving outdoor air quality and comfort.

The permanently retrofitting of urban roofs and pavements in the tropical and temperate regions of the world with solar-reflective materials would have an effect on global radiative forcing equivalent to a one-time offset of 44 Gt of emitted CO_2, worth $880 billion at $20/tonne [40].

Building energy-efficiency standards typically specify both mandatory and prescriptive requirements. Mandatory requirements, such as practices for the proper installation of insulation, must be implemented in all buildings subject to the standard. A prescriptive requirement typically specifies the characteristics or performance of a single component of the building (e.g., the thermal resistance of duct insulation) or of a group of components (e.g., the thermal transmittance of a roof assembly).

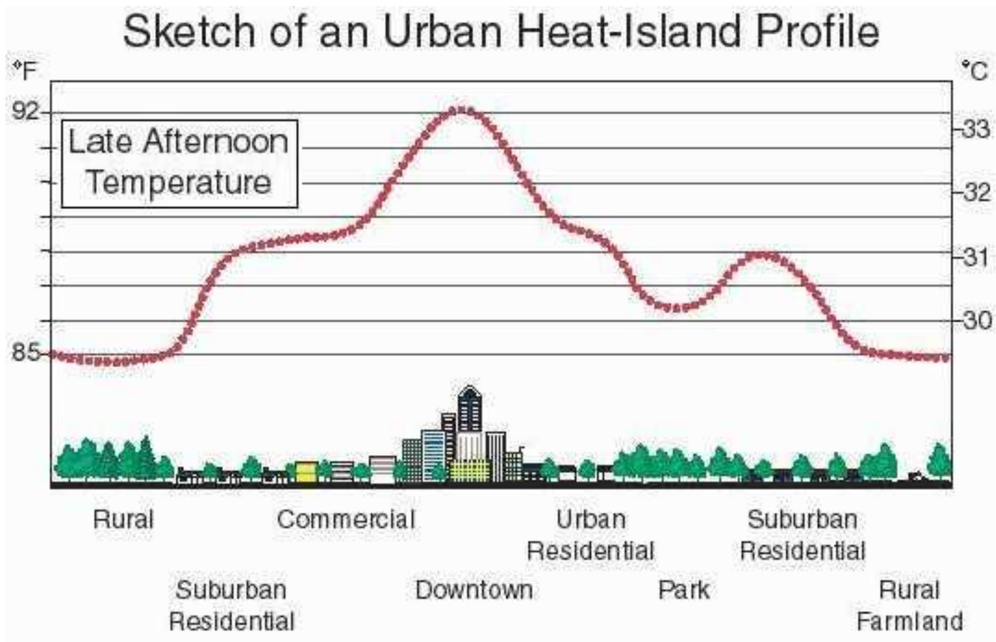

Figure 9: Urban Heat Island Profile

The following is a list of cool roof standards in the U.S:

1) **ASHRAE Standard 90.1-2007** prescribes cool materials for low-sloped roofs on nonresidential buildings in some U.S. climates.
2) **ASHRAE Standards 90.1-2004 and 90.1-2001** offer credits for cool materials for low sloped roofs on nonresidential buildings in some U.S. climates.
3) **ASHRAE Standard 90.2-2004** offers credits for cool materials for all roofs on residential buildings in some U.S. climate zones.
4) **LEED Green Building Rating System.** The Leadership in Energy and Environmental Design (LEED) Green Building Rating System assigns one rating point for the use of a cool roof in its Sustainable Sites Credit.

The current study proposes to use solar reflective materials when roofs are built or resurfaced.

Table (51) shows the total possible saving in 2030 resulting from resurfacing conventional dark roofs in all existing roofs in Syria in 2010 with a cool white material that increases its solar reflectance by 0.20. This converting process is estimated to be progressively implemented during the period between 2010 and 2030.

Reference [40] includes calculation of the annual cooling energy saving (kWh) by installing a cool roof (increasing roof's solar reflectance by 0.20) for a typical 100 m^2 house in many cities in the world including Damascus.

Table 51: CO_2 Offset Equivalence of Increasing the Albedo of Roof Surfaces in All Syrian Urban Areas

Row	Item	Value
1	Area of Syria	186 x10^9 m^2
2	Roof area in 2007	282,771,000 m^2
3	Estimated roof area in 2010	0.3 x10^9 m^2
4	Emitted CO_2 offset for increasing roof albedo by 20%	-50 kg CO_2/m^2 of roof
5	Potential emitted CO_2 equivalent reduction of cool roofs [Row 3 x Row 4] [one-time only, not annual]	15 Mt CO_2
6	Time to resurfaces all roofs	20 years
7	Annual CO_2 equivalent emission reduction for cool roofs [Row 5/ Row 6]	0.75 Mt CO_2/yr
8	Potential emitted CO_2 equivalent reduction of cool roofs in 2030	15 Mt CO_2
9	Current Syrian yearly CO_2 equivalent emissions (in 2010)	63 Mt CO_2

The calculated saving for the meteorological station of the Damascus International Airport with cooling degree-days of CDD18 = 1074 °C-days is 278 kWh/yr per 100 m^2, or 2.78 kWh/m^2/yr [40].

Assuming a saving of 2.78 kWh/m^2/yr, Table (52) shows the total annual saving in 2030 resulting from reducing cooling load by converting 1% of the entire surface of existing buildings in Syria in 2010 to cool roofs. This converting process is estimated to be progressively implemented during the period between 2010 and 2030.

Table 52. CO_2 Avoided by Reducing Cooling Load by Installing Cool Roofs on Residential Buildings Existing in 2010

Row	Item	Value
1	Estimated residential roof area in 2010	0.3 x10^9 m^2
2	Fraction of all buildings that are air conditioned	1%
3	Average air conditioning saving	2.78 kWh/m^2/yr
4	Potential annual saving (Row 1 x Row 2 x Row 3)	8.34 GWh/yr
5	CO_2 emission per kWh electricity generation	0.521 kg CO_2/kWh*
6	Annual avoided CO_2 emissions (Row 4 x Row 5)	4.35 kt CO_2/yr

* Source: RETScreen Software

Assuming the number of dwellings expected to be constructed during the period between 2010 and 2030 is 3.9 million units, the total area of these dwellings is 0.47x109 m^2 (average area of 120 m^2 per dwelling).

Assuming a saving of 2.78 kWh/m^2/yr, Table (53) shows the total annual saving in 2030 resulting from reducing cooling load by converting 2% of the entire surface of the residential buildings, expected to be constructed between 2010 and 2030, to cool roofs. This converting process is estimated to be progressively implemented during the period between 2010 and 2030.

Table 53: CO_2 Avoided in 2030 by Reducing Cooling Load by Installing Cool Roofs on Residential Buildings Expected to be Constructed Between 2010 & 2030

Row	Item	Value
1	Estimated residential roof area in 2030	0.47×10^9 m^2
2	Fraction all buildings that are air conditioned	2%
3	Average air conditioning saving	2.78 $kWh/m^2/yr$
4	Potential annual saving (Row 1 x Row 2 x Row 3)	26.1 GWh/yr
5	CO_2 emission per kWh electricity generation	0.521 kg CO_2/kWh*
6	Annual avoided CO_2 emissions (Row 4 x Row 5)	13.6 kt CO_2/yr

* Source: RETScreen Software

Finally, assuming a saving of 2.78 $kWh/m^2/yr$, Table (54) shows the total annual saving in 2030 resulting from reducing cooling load by converting 1% of the entire surface of existing buildings in Syria in 2010 and 2% of the entire surface of the residential buildings, expected to be constructed between 2010 and 2030, to cool roofs. This converting process is estimated to be progressively implemented during the period between 2010 and 2030.

Table 54: Potential Saving in 2030 by Reducing Cooling Load by Installing Cool Roofs on Residential Buildings

Measures	Unit	Electricity*
Potential saving in cooling load from transferring 1% of the roofs on residential buildings existing in 2010 to cool roofs	GWh/yr	**8.34**
	ktoe	**2.1**
Potential saving in cooling load from transferring 2% of the roofs on residential buildings expected to be constructed between 2010 & 2030 to cool roofs	GWh/yr	**26.1**
	ktoe	**6.53**
Total	GWh/yr	**34.44**
	ktoe	8.63

* 1ktoe = 4 GWh, $\eta \approx 34\%$ (Power plants)

7.6.3 Lighting

The ways to improve the energy efficiency in lighting are:

- ***Replacement of incandescent light bulbs with Compact Fluorescent Light bulbs (CFLs)***

Standard, incandescent light bulbs are common in Syria. These bulbs are extremely inefficient - most of the electricity they use produces heat, not light. The incandescent lamp yields only 5%. They are not only inefficient, but also they provide only 750 to 1,000 hours of light (at most). When used in fixtures burning for 12 to 20 hours a day, they must be replaced every two to three months. And, all of the heat they produce adds to the air conditioning load of the building.

Compact Fluorescent Light bulbs (CFLs) deliver the same amount of light as incandescent bulbs, but use one-third the energy. They also last for 8,000 to 10,000 hours. Their longer life reduces the replacement schedule for long-burning fixtures to once a year (See Figure 10).

CFLs emit a quarter of the heat of incandescent bulbs. It is not recommended to use CFLs in the ceilings of more than 4.5 meters, in the cold outdoor, and in the areas that need spotlighting.

Figure 10: Various Sizes and Configurations of CFLs

- ***Replacement of the lighting fixture***

There is a need for increased reflectivity from the reflective portions of the lighting fixture. In addition, there is a further requirement to obtain better control over the direction of the light emitted from the lighting fixture. Therefore there is a need for a new and improved lighting fixture which is more efficient and one which emits more light rays at high angles. The higher the reflectivity of the fitting, the higher the light emission, and the greater the efficiency.

- ***Replacement the magnetic ballast with electronic magnetic***

Magnetic ballasts have the disadvantage that a large amount of energy is lost in the ballast itself, as much as 20% of the energy consumption of the light source. For a 58 W fluorescent tube, this means that about 13 W is lost in the ballast. Electronic ballasts on the other hand have losses of only 1 or 2%. Magnetic ballasts still tend to be used widely in Syria that are more than 10 or 15 years old.

- ***Use of LEDs***

LEDs (Light Emitting Diodes) are solid light bulbs which are extremely energy-efficient. Until recently, LEDs were limited to single-bulb use in applications such as instrument panels, electronics, pen lights and, more recently, strings of indoor and outdoor.

Manufacturers have expanded the application of LEDs by "clustering" the small bulbs. The first clustered bulbs were used for battery powered items such as flashlights and headlamps. Today, LED bulbs are made using as many as 180 bulbs per cluster, and encased in diffuser lenses which spread the light in wider beams. Now available with standard bases which fit common household light fixtures, LEDs are the next generation in home lighting.

- ***Smart Switching***

The fastest saving can be achieved with “smart switching” of the lighting. Lighting is frequently switched on unnecessarily when e.g. there is sufficient daylight or there is nobody in the room. With hand operated systems especially, lights tend to be left burning needlessly. The advice is therefore to make the greatest possible use of automatic light regulating equipment. Examples include:

- Daylight sensors
- Presence sensors (Occupancy sensors)
- Timers
- Daylight dimming controls

To choose the qualified CFL with the right amount of light, find a qualified CFL that is labeled as equivalent to the incandescent bulb you are replacing. Light bulb manufacturers include this information right on the product packaging to make it easy for consumers to choose the equivalent bulb. Common terms include "Soft White 60" or "60 Watt Replacement."

You should also check the lumen rating to find the right CFL. The higher the lumen rating, the greater the light output. Table (55) will help you to determine what CFL wattage is best to replace your incandescent light bulb.

Table 55. Light Output Equivalency

Incandescent bulbs (W)	Minimum light output (Lumens)	Common CFL bulbs (W)
40	450	9-13
60	800	13-15
75	1100	18-25
100	1600	23-30
150	2600	30-52

When choosing bulbs be careful of the uncertainties in CFL power ratings. Table (56) shows the difference between the rated power and the actual power measured by the reporter for some bulbs available in local market [18].

After replacing the incandescent light bulbs with CFLs in Omayyad mosque, the electricity consumption dropped from 310 MWh to 104 MWh over 10 thousand hours.

Figure (11) shows potential of CO_2 saving from different types of lamps. New lighting technology is shown in Figure (12).

Table 56. Uncertainties of CFL Power Ratings & Their Costs

CFL bulb	Rated power (W)	Measured power (W)	Price SL
PL type (China)	21	14	175
PL type (China)	36	34	250
PL type (China)	55	38	325
Osta, MR16 with reflector (China)	9	5	50
OSRAM, 100 W replacement, (China)	20	17	125
OSRAM, 120 W replacement, (China)	23	20	150
OSRAM, Spiral 100 W replacement (China)	18	18	150
OSRAM, Spiral 120 W replacement (China)	23	23	160
OSRAM, Spiral 75W replacement (China)	13	12	150

Source:[18]

Area of lighting	Energy saving	CO2 savings per lamp per year
Road lighting	HPL → 57% → CosmoPolis	109 kg CO_2
Shop Lighting	Halo → 80% → CDM	115 kg CO_2
Office & Industrial Lighting	TL8 → 61% → TL5	77 kg CO_2
Home Lighting	GLS → 85% → CFLi	34 kg CO_2
LEDs	GLS → 82% → LED	34 kg CO_2

Incandescent Watt = (4-5) x fluorescent Watt = 12 LED x Watt

Figure 11: Energy Saving Lamps [38]

Royal Philips Electronics has called for joint action between the lighting industry, NGOs, energy suppliers and governments to replace the incandescent light bulb by the many alternative energy-saving light bulbs available on the market today. A successful switch-over would make a significant contribution to the issue of climate change and help reach Kyoto commitments.

Lighting in Syria consumes 20% to 25% of the total electricity consumption in buildings [21]. The most commonly used lamps are the fluorescent lamps (120 cm length). Despite the widespread of energy-saving lamps incandescent lamps are still used in Syria. The use of chandeliers in ceilings is a bad habit in Syria because of its large consumption of electricity.

Old Technology	New technology
	
• Old fluorescent lamps • Passive Analogue drivers	• High efficiency TL5 fluorescent lamps • Active electronic drivers • Lighting control systems

Figure 12: New Lighting Technology (1kWh energy = 0.42 kg CO_2) [38]

The results of DSM study [21] relating to the potential saving in lighting in the residential and industrial sectors are shown in Table (57). See Tables (3) and (4) in Annex (8).

Table 57. Proposed Measures for DSM (Lighting)

Measures	Saving in 2020 (GWh)
High-efficiency lighting for religion & industrial buildings	477.3
High-efficiency tube & CFL lamps in Households	377.1
High-efficiency lighting for commercial & governmental buildings	374.6
High-efficiency street lighting	249.3
Total	1478.3

Source: [21]

The present study proposes the adoption of the measures proposed in the DSM study for the following reasons:

1) These procedures have not been implemented to date,
2) Surveys were based on good and reliable data,
3) A logical analysis of these measures,
4) Difficult to propose other new measures due to limited time allocated for the current study.

For these reasons, the current study suggests to maintain the same saving proposed in the DSM study until 2030 instead of 2020.

Table (58) summarizes the potential saving from EE measures in lighting systems in the residential, commercial, and service sectors in 2030.

Table 58. Potential Saving from Energy Efficiency Measures in Lighting Systems in the Residential, Commercial, and Service Sectors in 2030

Measure	Unit	Electricity*
Increasing energy efficiency in lighting systems in The Residential, Commercial, and Service Sectors	GWh	**1478.3**
	ktoe	**369.6**

* 1ktoe = 4 GWh, η≈34% (Power plants)

7.6.4 Electrical appliances

A statistical survey has revealed that 31% of electricity consumption in Syrian households is used to power refrigerators. It is estimated that 2.62 million home refrigerators currently in use and consume about 2056 GWh/yr. By enforcing Labels for refrigerators or decreasing the refrigerator consumption from 785 to 600 kWh/yr, it is possible to save 485 GWh/yr or 130000 tonnes heavy fuel/yr and around 400 ktonnes CO_2.

About 40% of houses in Damascus city are equipped with air conditioning while about 28% of houses in Damascus countryside are equipped with air conditioning [21].

The candidate electrical appliances for EE measures in the residential, commercial and service sectors include are:

- Residential refrigerators and air conditioners,
- Air-conditioners in commercial and governmental establishments,
- Electric water heaters,
- Motors for pumping drinking water.

Other electrical appliances are not considered for their low contribution in emissions mitigation.

The results of DSM study [21] relating to the potential saving in electrical appliances in the residential, commercial and service sectors are shown in Table (59). See Table (5) in Annex (8).

The present study proposes the adoption of the measures proposed in the DSM study for the following reasons:

- These procedures have not been implemented to date,
- Surveys were based on good and reliable data,
- A logical analysis of these measures,
- Difficult to propose other new measures due to limited time allocated for the current study.

Table 59: Proposed Measures for DSM (Electrical Appliances)

Measures	Saving in 2020 (GWh)
High-efficiency AC in households	197.3
High-efficiency refrigerators in households	82.1
High-efficiency AC and load control for medium & large commercial customers	76.8
High-efficiency water heaters & water heaters control in households	75.4
High-efficiency motors for pumping applications	71.9
High-efficiency AC and load control for small commercial customers	58.4
High-efficiency AC and load control for governmental buildings	11.2
Total	573.1

Source: [21]

For these reasons, the current study suggests to maintain the same saving proposed in the DSM study until 2030 instead of 2020.

Table (60) summarizes the potential saving from EE measures in electrical appliances in the residential, commercial, and service sectors in 2030.

Table 60. Potential Saving from Energy Efficiency Measures in Electrical Appliances in the Residential, Commercial, and Service Sectors in 2030

Measure	Unit	Electricity*
Increasing energy efficiency in electrical appliances in The Residential, Commercial, and Service Sectors	GWh	**573.1**
	ktoe	**143.3**

* 1ktoe = 4 GWh, η≈34% (Power plants)

7.6.5 Traditional Stoves

Diesel oil is used in Syria for the purpose of space heating in both central heating boilers and traditional stoves. The traditional stoves are locally manufactured and widespread used because of their low cost comparing with central heating systems. About 70 to 80% of houses use these stoves for heating one room or more.

Because of poor design of these stoves, they emit gases resulting from incomplete combustion and cause pollution of the environment. The ways to improve the energy efficiency in boilers are:

- Increase the overall efficiency, thereby reducing the consumption,
- Improve the combustion process, thereby reducing greenhouse gas emissions to the atmosphere,
- Use of new technology for Burners "Porous medium burner" (See Figure 13).

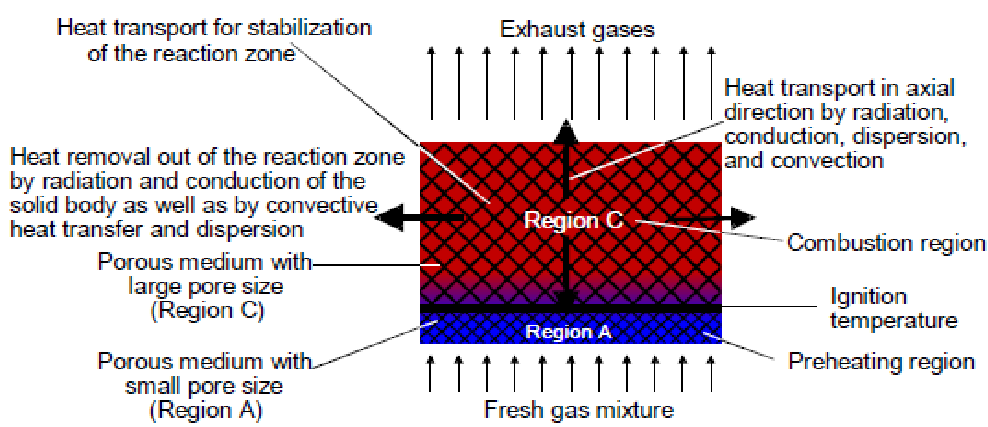

Figure 13: Schematic Setup of a Porous Burner

Combustion in porous media offers remarkable advantages compared with techniques involving free flame burners. Porous media burners are characterized by higher burning rates, increased flame stability, and lower combustion zone temperatures, which lead to a reduction in NO_X formation. In addition, they show very low CO emissions and are of very small size. Therefore such burners have become increasingly more popular during the past few years. Often this type of burner is applied in small to medium scale appliances, mostly for domestic use (See Figure 14).

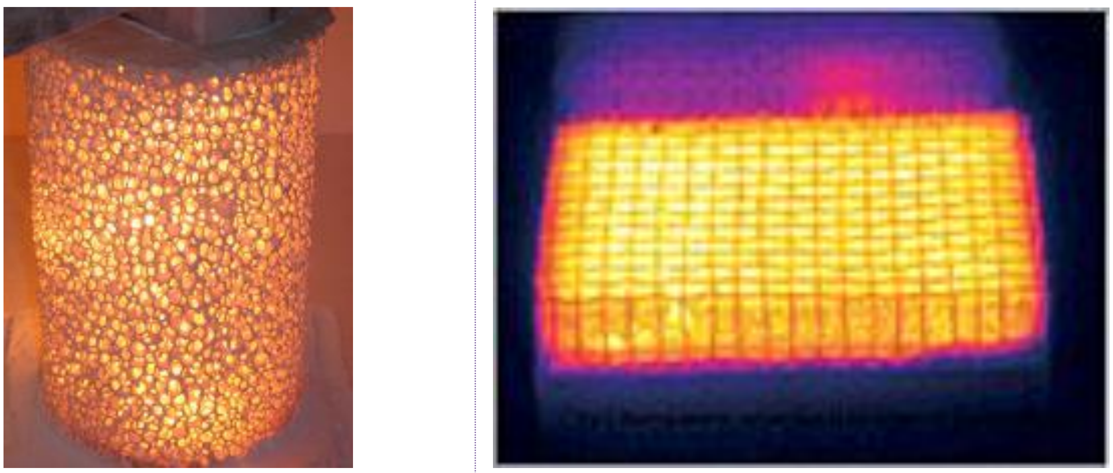

Figure 14: Ceramic Burned at 1200 °C

Compared with traditional combustion, this new technology leads to the following features resulting from the intensive heat transfer within the porous body and the stability of combustion [41]:

- Wide, infinitely variable dynamic power range of 1:20 compared to conventional state-of-the-art burners which show a power range of only 1:3,
- High power density, i.e. burner and heat exchanger are about 10 times smaller in volume than conventional burner heat exchanger units for comparable thermal loads,
- Very low emissions (C_{CO} < 7 mg/(kWh) and C_{NOx} < 25 mg/(kWh)) over the complete dynamic power range,

Stable Combustion.

This technology is expected to be deployed in many applications, including space heating in residential buildings. Considering that this technology is still in the development stage, it is expected that commercial burners will be developed in the near future. The prospects for use this technology in traditional stoves in Syria is very large.

Due to the lack of this technology on a commercial level, it is difficult to study the possibility of using it in the traditional stoves or to estimate the potential saving resulting from the EE measures in these stoves.

Finally, the total potential saving from EE measures in the residential, commercial and service sectors in 2030 is shown in table (61).

Table 61. Total Potential Saving from the Energy Efficiency Measures in the Residential, Commercial, and Service Sectors in 2030 (ktoe)

Measure	Diesel oil	Electricity	Total
Thermal insulation (low scenario)	128	147	**275**
Reducing cooling load from transferring 1% of the roofs on residential buildings existing in 2010 to cool roofs	-	2.1	**2.1**
Reducing cooling load from transferring 2% of the roofs on residential buildings expected to be constructed between 2010 & 2030 to cool roofs	-	6.53	**6.53**
Increasing energy efficiency in lighting systems	-	369.6	**369.6**
Increasing energy efficiency in electrical appliances	-	143.3	**143.3**
Total	**128**	**668.53**	**796.53**

7.7 Total potential saving resulting from the proposed RE&EE measures in the residential, commercial and service sectors in 2030

Table (62) shows the total potential saving resulting from the proposed RE&EE measures in the residential, commercial and service sectors in 2030.

Table 62. Total Potential Saving from the RE&EE Measures in the Residential, Commercial, and Service Sectors in 2030 (ktoe)

Measure	Unit	Diesel oil	Electricity	Total
Renewable energy measures	ktoe	310.21	76	**386.21**
Energy efficiency measures	ktoe	128	668.53	**796.53**
Total	ktoe	**438.21**	**744.53**	**1182.74**
	Tj*	**17529**	**29781**	**47310**

*1ktoe = 40.0 Tj (Appendix 20)

Conclusion:

The total saving in 2030 is: 1183 ktoe, which represents 6.0% of the primary energy consumed in Syria in 2005 (19.6 Mtoe), or 7.75% of the final energy consumed in Syria in 2005 (15.25 Mtoe). Also, the total saving represents 2.45% of the final energy consumed in Syria in 2030 48.359 Mtoe).

7.8 Calculation of Avoided CO2 Emissions

The saving proposed in 2030 will be reflected on a reduction in the consumption of diesel oil and electricity. Electricity in Syria is produced from hydro, fuel oil and gas, and most of the thermal power plants are switched from fuel oil to gas. The saving in electricity will impact on the saving in fuel oil. Given that the energy content of fuel oil and diesel oil are the same (0.0402 Gj /kg for fuel oil and 0.04 Gj /kg for diesel oil - See Table 1 in Annex 20), the total potential saving in 2030 will reflect the saving in diesel fuel only. Table (63) summarizes the calculation of avoided carbon dioxide emissions in 2030 (according to Revised 1996 IPCC, Annex 21).

Table 63: CO_2 Emissions Avoided in 2030 (kt CO_2) According to Revised 1996 IPCC Guidelines

MODULE	Energy					
SUBMODULE	CO_2 from fuel combustion					
WORKSHEET	Step by step calculations					
SHEET	Residential					
	Step 1	Step 2		Step 3		
Residential	A[+] Consum. (ktoe)	**B[++] Conv.Factor (TJ/ktoe)**	**C Consum. (TJ)**	**D[+++] Carbon Emission Factor (t C/TJ)**	**E Carbon Content (t C)**	**F Carbon Content (Gg C)**
			C=(AxB)		E=(CxD)	F=(Ex10^{-3})
Gas/Diesel Oil	1182.74	40.0	47310	20.2	955,662	955.662

[+] See Table (55), [++]See Table (1), Appendix 20, [+++]See Appendix 21.

Cont. Table (63)

MODULE	Energy					
SUBMODULE	CO_2 from fuel combustion					
WORKSHEET	Step by step calculations					
SHEET	Residential					
	Step 4			Step 5		Step 6
Residential	**G* Fraction of Carbon Stored**	**H Carbon Stored (Gg C)**	**I Net Carbon Emissions (Gg C)**	**J* Fraction of Carbon Oxidised**	**K Actual Carbon Emissions (Gg C)**	**L Actual CO_2 Emissions (Gg CO_2)**
		H=(FxG)	I=(F-H)		K=(IxJ)	L=(K x [44/12]
Gas/Diesel Oil	0.5	477.831	477.831	0.99	473.05	**1734.5**

[*]See Appendix 21

Conclusion:

The avoided CO2 emission in 2030 is: 1734.5 kilotons, and represent 3% of emissions in 2005 (58350 kt [8]).

7.9 Potential for developing CDM projects

Table (64) shows the CDM project potential for various project categories.

Table 64. CDM Project Potential for Various Project Categories

Project categories	Description	Estimated potential in Syria
Energy efficiency in service sector (i.e. tourism)	Energy system Upgrading	• Significant potential. • Options: use of energy efficient lighting /cooling/ heating systems, building design, etc.
Energy efficiency in households	Energy system Upgrading (lighting, heating, cooling and building design)	• Significant potential due to urbanization. • Options: use of energy efficient lighting /cooling /heating systems, building insulation, etc.
Solar (thermal and PV)	RES	• Modest usage of solar energy. • Solar energy (either thermal or PV) has one of the largest RES potentials in Syria. • Small-scale (off-grid) decentralized solar has significant rural as well as urban potential. • Implementation currently depending on economy technology.

The nominated projects to be implemented within the framework of the CDM are:

- **Qudsaya Youth Housing Project in Damascus** (Energy efficiency measures and use of solar water heating)
- **New-Sham Housing Complex in Damascus** (Energy efficiency measures and use of solar water heating)
- **Fund to support solar water heater project**, launched by the Ministry of Electricity in 2008.

The interested parties have to study the possibility to benefit from the clean development mechanism for the implementation of these projects before the year 2012.

8. Industrial Sector

8.1 Breakdown of energy consumption in the industrial sector

Primary energy consumption in the industry and construction sector increased from 1.50 Mtoe in 1994 to 1.94 Mtoe in 1999, then fell to 1.57 Mtoe in 2005[8]. There are no sufficient data on the distribution of energy consumption in sub-sectors as industries of engineering, textile, chemical, food, pharmaceutical, cement, ceramics and others.

The electricity needed to run the industrial motors is estimated at 70% of the total electricity consumption in the industrial sector [21]. Therefore, it should focus on improving the motors performance.

Replacement of motors with premium efficiency motors instead of standard motors when existing motors fail, and replacement of motors with premium efficiency motors instead of rewinding existing motors when existing motors fail are the most appropriate EE measures in this field. This procedure needs a well-trained team to conduct energy audits and to suggest saving opportunities.

Table (65) shows the possible measures for reducing GHG emissions in the industrial sector.

Table 65. Possible Measures for Energy Efficiency in the Industrial Sector

Industrial sector	
1. Lighting	√
2. Refrigeration	√
3. Industrial processes	√
4. Cogeneration	√
5. Waste heat recovery	√
6. Water heating or Preheating	√
7. Efficient drives	√
8. Renovation and restructuring of high energy- consumption in industry (cement industry)	√
9. Management practices	√
10. Fuel switching, including the use of waste materials	√
11. Carbon dioxide capture and storage (CCS), including oxy-fuel combustion	√

In addition to measures mentioned in Table (58) it is recommended to study the possibility of providing the industrial cities in Adra, Hasia, Sheikh Najjar, and Deir ezzor with natural gas or with waste gas. This procedure needs to study the requirement of these industrial cities of gas and estimate the cost to transport gas to industrial cities.

8.2 Improvement of the energy efficiency of industrial motors

The results of DSM study [21] relating to the potential saving in industrial motors are shown in Table (66). See Table (3) in Annex (8).

Table 66. Proposed Measures for DSM (Lighting)

Measures	Saving in 2020 (GWh)
High-efficiency motors in industry sector (small capacities)	432.0
Motor system improvements for air compressors, fans and pumps	322.6
High-efficiency motors in industry sector (high capacities)	81.5
TOU Meters	2.1
Total	838.2

Source: [21]

The present study proposes the adoption of the measures proposed in the DSM study for the following reasons:

- These procedures have not been implemented to date,
- Surveys were based on good and reliable data,
- A logical analysis of these measures,
- Difficult to propose other new measures due to limited time allocated for the current study.

For these reasons, the current study suggests to maintain the same saving proposed in the DSM study until 2030 instead of 2020.

Table (67) summarizes the potential saving from EE measures in industrial motors in 2030.

Table 67. Potential Saving from Energy Efficiency Measures in Electrical Motors in the Industrial Sector in 2030

Measure	Unit	Electricity*
Increasing energy efficiency in electrical motors in The Industrial Sector	GWh	**838.2**
	ktoe	**209.55**

* 1ktoe = 4 GWh, η≈34% (Power plants)

8.3 Potential for Developing CDM projects

Table (68) shows the CDM project potential for various project categories.

Table 68: CDM Project Potential for Various Project Categories

Project categories	Description	Estimated potential in Syria
Fuel switch in industry	Oil to NG	• Significant potential for fuel switch in industry. • Fuel switch in industry sector generally lags behind power sector due to time required for grid development.
Energy efficiency in industry	Process upgrading and co-generation	1. Significant potential for EE in industry, which could be, implemented parallel with implementation of fuel switch to NG in industry. • More specific analysis is required.
Wind	RES	• Significant potential. • Syria does not have practical experience with wind power implementation.
Solar (thermal and PV)	RES	• Modest usage of solar energy. • Solar energy (either thermal or PV) has one of the largest RES potentials in Syria.
GHG abatement	N_2O, CH_4 (methane capture LFs, waste water treatment, etc.), and CO_2 Carbon Capture and Storage(CCS)	• Significant GHG abatement potential, especially with respect to N_2O (cement / fertilizers) and CH_4 (landfills/waste water) emission abatement. • High LFG (Landfill Fuel Gas) potentials. • Significant CO_2 abatement in form of Carbon Capture and Storage (i.e. underground CO_2 storage) possible in medium to long term. • Short- to medium term some niche opportunities for CO_2-Enhanced Oil Recovery might exist (more analysis required), other storage options in empty gas fields or aquifers might also be considered in the long-term.

The Japanese company Shimizu Construction Co. Ltd., has been studying the following CDM projects in Syria:

- Banias Refinery Flaring Reduction and Gas Utilization (5th March 2008): Project Idea Note (PIN) Report. The total number of crediting years is 10 years. The annual average over the crediting period of estimated reductions is 10,000 tCO_2e. See Annex (19),
- CDM Project Study for Energy Utilization of Ammonia Plant Tail Gas in Homs, Syria: Fiscal 2008 CDM/JI Feasibility Study Provisional Report. The total number of crediting years is 10 years. The annual average over the crediting period of estimated reductions is 85,250 tCO_2e, or 850,250 tCO2 over 10 years. See Annex (19),
- Reduction of greenhouse gas nitrous oxide (N_2O) in nitric acid plant in the General Company for Fertilizers in Homs. The annual average over the crediting period of estimated reductions is 1,166,920 tons of carbon equivalents over 7 years.

These CDM projects Contribute to the transfer of clean technologies certified by the United Nations, and improve the environmental situation in the industrial sector. In terms of economic benefits, any of these projects do not need local investments for their implementation, but provide an economic return equal to half the value of the reduced amounts of carbon in the international carbon market after the recovery of the Japanese company of the value of investments during the three years [28].

Table (69) shows the potential saving from the CDM projects actually at validation phase.

Table 69. Potential Saving from CDM Projects Actually at Validation Phase

	Banias Refinery Flaring Reduction and Gas Utilization	Energy Utilization of Ammonia Plant Tail Gas	Nitric acid plant	Total
No. of projects	1	1	1	3
Emission Reductions (tCO_2e)	10,000	85,025	166,700	261,725
Emission Reductions kCERs/y	10.0	85.025	166.7	261.725

8.4 Trade and manufacturing of cooling and air conditioning equipment

A survey on Hydrochlorofluorocarbon (HCFCs) in three countries: Malaysia, Sir lanka and Syria was carried out in 2005 through UNDP appointed international experts [32]. Tables (70), (71) and (72) summarize the results of this survey.

Table 70. HCFCs Consumption in Syria (Cooling & AC Sector)

HCFC-22 (%)	HCFC-141b (%)	Other HCFCs (%)	Total (metric tonnes)
72	27	1	757

Source: [32]

Table 71: Unconstrained Demand Forecasts for HCFCs in Syria

2005 Consumption (metric tonnes)	Growth Rate (%)	Unconstrained 2015 Consumption (metric tonnes)	Growth Factor (2015/2005)
757	10	1965	2.596

Source: [32]

Table 72. Impacts of Current and Unconstrained Consumption of HCFCs between 2005 and 2015 on Ozone Depletion as well as Global Warming

Increase in Ozone Depletion (ODP tonnes)	Increase in Global Warming (tones/tonne CO2)
65.39	1,972,410

Source: [32]

9. Agriculture Sector

9.1 Breakdown of energy consumption in the agricultural sector

Primary energy consumption in the agricultural sector increased from 0.69 Mtoe in 1994 to 1.72 Mtoe in 2005[8].

Energy consumption in the agricultural sector is concentrated mainly in the agricultural machinery (tractors and harvesters etc.) and irrigation pumps. The estimated consumption of diesel oil in the agricultural sector is about one million tons annually. Table (73) shows the breakdown of energy consumption by fuel type in the agricultural sector in 2005[12].

The total energy consumption in the agricultural sector is estimated at 1.525 Mtoe in 2005 in reference [12], while it is estimated at 1.68 Mtoe in 2005 in reference [8]. The small difference of 0.155 Mtoe represents 9%.

Table 73. Breakdown of Energy Consumption by Fuel Type in the Agriculture Sector

	Diesel oil	Coke	Organic & vegetarian fuel	Electricity	Total
	kt	**kt**	**Kt**	**MWh**	
Tractors and harvesters	1022				
Heating greenhouses	186		43		
Heating Poultries	30	100			
Cooling & AC				3311	
Fishing	4				
Assistance services	10				
Irrigation	145			5039	
Drinking water				990	
Total consumption	**1397**	**100**	**43**	**9340**	
Total consumption (Mtoe)*	**1.439**	**0.068**	**0.0173**	**0.0008**	**1.525**

***** 1GJ=0.0239 toe, 1 MWh= 0.086 toe (electricity)
43.1 GJ/ton (diesel oil), 28.5 GJ/ton (coke), 16.8 GJ/ton (Organic & vegetarian fuel)
Source [12]

Table (74) shows the possible measures for reducing GHG emissions in the agricultural sector.

Table 74. Possible Measures for Reducing GHGs Emissions in Agriculture Sector

Agriculture sector	
Water use-related operations	
1. Efficient irrigation pumping	√
2. Efficient water use	√
Agriculture	
3. N_2O Rational use of fertilizers to reduce N_2O emissions	√
4. Absorption increase of soil water	√
5. Reduction of agricultural residue burning	√
Livestock-related operations	
6. Improvement of cattle feed	√

7. Reduction of CH_4 emissions from enteric fermentation	√
8. Manure management and management of livestock population	√
Waste Management	
9. Reduction of disposal of organic materials in landfills	√
10. Recovery of methane to generate electricity	√
11. Solid waste and/or sewage management, composting, and incineration	√
Land use change and forestry	
12. Enhancement of GHG sinks by preserving and increasing the density of existing forest cover	√
13. Planting high productivity forests	√
Others	
14. Switch to environmentally friendly agricultural practices	√
15. Development of markets for environmentally sensitive agricultural products	√
16. Revision and strengthening of legislation and promotion of education, training and public awareness on waste issues	√
17. Legal framework for long-term management of forests	√
18. Forest inventories	√
19. Investing in alternative sustainable economic activities for rural populations	√
20. Promoting programmes of conservation, regeneration, reforestation, and afforestation	√

Table (75) shows the applicable renewable energy technologies in the agricultural sector.

Table 75. Applicable Renewable Energy Technologies in Agriculture Sector

Category	Requirements	RE/EE technologies	Compatibility	Competing non-renewable
Agriculture	Water pumping for drink water	PV (for pumping heads not more than 50 m), Or: Hybrid Diesel/PV	High	Diesel engines
	Water pumping for crop			
	Irrigation			
	Water pumping for animals			
	Water desalination	PV		None

9.2 Energy efficiency measures for pumping and irrigation motors

The estimation of the number of irrigation pumps is about 121000 pumps that represents more than 70% of the total well and surface water pumps used in the agricultural sector.

The results of DSM study [21] relating to the potential saving in pumping motors in the agricultural sector are shown in Table (76). See Table (3) in Annex (8).

Table 76. Proposed Measures for DSM in Agriculture Sector

Measures	Saving in 2020 (GWh)
High-efficiency motors and load control for agriculture and irrigation pumping	**16.8**

Source: [21]

The present study proposes the adoption of the measures proposed in the DSM study for the following reasons:

- These procedures have not been implemented to date,
- Surveys were based on good and reliable data,
- A logical analysis of these measures,
- Difficult to propose other new measures due to limited time allocated for the current study.

For these reasons, the current study suggests to maintain the same saving proposed in the DSM study until 2030 instead of 2020.

Table (77) summarizes the potential saving from EE measures in pumping motors in 2030.

Table 77. Potential Saving from Energy Efficiency Measures in Motors for Agriculture and Irrigation Pumping in the Industrial Sector in 2030

Measure	**Unit**	**Electricity***
Increasing energy efficiency in motors and load control for agriculture and irrigation pumping	GWh	**16.8**
	ktoe	**4.2**

* 1ktoe = 4 GWh, η≈34% (Power plants)

9.3 Potential for developing CDM projects

Table (78) shows the CDM project potential for various project categories.

Table 78. CDM Project Potential for Various Project Categories

Project categories	**Description**	**Estimated potential in Syria**
Solar (thermal and PV)	RES	• Modest usage of solar energy. • Solar energy (either thermal or PV) has one of the largest RES potentials in Syria.
Reforestation / biomass/agriculture	RES	• The strict water supply situation is main determinant for a forestation / reforestation or biomass production. • Potential for energy crops with low irrigation requirements and that are suitable for arid regions (i.e. to prevent desertification).
GHG abatement	N_2O, CH_4 (methane capture LFs, waste water	• High LFG (Landfill Fuel Gas) potentials. • Significant CO_2 abatement in form of Carbon

	treatment, etc.), and CO_2 Carbon Capture and Storage(CCS)	Capture and Storage (i.e. underground CO_2 storage) possible in medium to long term.

The Japanese company Shimizu Construction Co. Ltd., has been studying the following CDM projects in Syria:

Registered projects:

- Dir Baalbeh Landfill Gas Capture Project in Homs. The total number of crediting years is 14 years. The annual average over the crediting period of estimated reductions is 76,414 tCO_2e.
- Tal Dman Landfill Gas Capture Project in Aleppo. The total number of crediting years is 14 years. The annual average over the crediting period of estimated reductions is 73,205 tCO_2e.

Project at validation:

Damascus Landfill Gas Capture and Utilization (5th March 2008). The total number of crediting years is 21 years. The annual average over the crediting period of estimated reductions is 200,000 tCO_2e.

Table (79) shows the potential saving from CDM projects in the agricultural sector.

Table 79. Potential Saving from CDM Projects (Registered & at Validation Phase)

	Dir Baalbeh Landfill (registered)	Tal Dman Landfill (at validation)	Damascus Landfill	Total
No. of projects	1	1	1	3
Emission Reductions (tCO_2e)	76,414	73,205	200,000	349,619
Emission Reductions kCERs/y	76.414	73.205	200.0	349.619

10. Economic and Environmental Impacts of Proposed Measures

Water Heating Costs

It is necessary to shed light on the cost of heating water from different energy sources before achieving the economic feasibility of SWH systems. Suppose that a family needs about 200 liters of hot water per day at a temperature of 45 °C. Heating this amount of water can be done by electricity, diesel oil, LPG, or solar energy. The thermal energy needed for heating 200 liters at temperature difference 25 °C (45 °C for hot water- 20 °C for cold water) is:

200 x 25 °C x 4.186/3600 x 365 days/year = 2122 kWh/year

The cost for producing this amount of thermal energy depends on the energy source:

Electricity:

Assuming 90% the efficiency of an electric tank heater, the electric energy needed is:

2122 (kWh/year)/0.9 = 2358 kWh/year

Assuming the consumption of the family is not more than 1000 kWh/ month, the average tariff per kWh is 2.41 SL (See Table 10) plus 23% fees. The cost of the electricity consumed for heating 200 liters of water per day is:

2358 (kWh/year) x 2.41(SL/kWh) +23%= 6990 SL/year

Or:

6990 (SL/year)/2122 (kWh/year) = **3.3 SL/kWh**

Diesel oil:

Assuming 55% the efficiency of a boiler, the thermal energy needed is:

2122 (kWh/year)/0.55 = 3858 kWh/year

The average cost of diesel oil is 2.08 SL kWh (See Table 10), and the cost of diesel oil consumed for heating 200 liters of water per day is:

3858 (kWh/year) x 2.08 (SL/kWh) = 8024 SL/year

Or:

8024 (SL/year)/2122 (kWh/year) = **3.78 SL/kWh**

LPG

Assuming 80% the efficiency of a gas heater, the thermal energy needed is:

2122 (kWh/year)/0.80 = 2653 kWh/year

The average cost of diesel oil is 1.8 SL kWh (See Table 10), and the cost of LPG consumed for heating 200 liters of water per day is:

2653 (kWh/year) x 1.8 (SL/kWh) = 4775 SL/year

Or:

4775 (SL/year)/2122 (kWh/year) = **2.25 SL/kWh**

Solar energy

Assuming the price of the SWH system is 45,000 SL and its life time of 20 years, we find by simple calculation that the annual cost of the SWH system is:

45000/20 years = 2250 SL/year

Or:

2250 (SL/year) /2122 (kWh/year) = **1.06 SL/kWh**

The following points are concluded:

- The cheapest way to heat water in Syria is by LPG in comparison with diesel oil and electricity,
- The cost of heating water with electricity is cheaper than diesel oil due to the low efficiency of boiler (or the traditional diesel oil heater). This result is not in favor of the Ministry of Electricity,
- Heating water by diesel oil, LPG and electricity at same cost requires that diesel oil tariff must decrease to 18 SL per liter and raise the price of gas bottle to 400 SL,
- Currently, SWH system is cheaper than the alternatives. But this application needs incentives to overcome the high initial cost.

11. Obstacles and Barriers Facing the Implementation of Reducing GHGs Emissions in the Sectors Considered

The following is a summary of the obstacles and barriers facing the implementation of reducing GHGs emissions in the residential, commercial and service Sectors:

Solar Water Heating (SWH):

- Lack of incentives,
- Lack of financing mechanism for low income people,
- Normalized testing of SWH systems are not mandatory,
- SWH systems standards are not mandatory,
- Lack of sufficient surface areas at building roofs for installing SWH systems,
- Lack of enforcement of SWH systems in governmental buildings.

High Efficiency Lighting:

- Absence of incentives program,
- Lack of normalized testing on lighting devices,

Thermal Insulation of Buildings:

- Absence of incentives program,
- Lack of normalized testing on insulation materials,
- Lack of incentives and mechanism of financing,
- Weak enforcement of the "Code of Thermal Insulation".

Residential Electric Appliances:

- Weak enforcement of the "Law of Energy Efficiency Standards for Electrical Appliances in the Residential, Commercial, and Service Sectors",
- Uncontrollable second hand electric appliances market (e.g. refrigerators),
- Lack of normalized testing on electric appliances,
- Lack of suitable financing mechanisms.

Energy Tariff:

Despite the restructuring of energy tariff in Syria, it is still not encouraging for the deployment of RE&EE use on a large scale.

Other Energy Efficiency Technologies:

- Lack of “Building Energy Efficiency Code”. The exiting code of thermal insulation is a first step towards the preparation of the building code,
- Barriers attributable to cultural or socio-economic factors. There is a lack of knowledge of the building residents of the importance of developing RE&EE in buildings,
- Most energy-saving products, tools and equipment are sold at high prices,
- Lack of expertise of engineers, designers and contractors on the basic technical measures that lead to improving the energy efficiency in buildings,
- Technological barriers. Most of the RE& EE technologies need to be transferred from developed countries,
- Lack of “National Energy Efficiency Program”,
- Lack of integrated resource planning,
- Insufficient (human) resources,
- Lack of accredited labs,
- Lack of harmonization with neighboring countries,
- Lack of competitive drives.

The solutions and recommendations to overcome these obstacles and barriers are as follows:

1) Develop a data base on energy to provide accurate data to policy makers and to customers,
2) Develop “Building Energy Efficiency Code”,
3) Develop “National Energy Efficiency Program”
4) Provide tax break incentives on RE&EE imported equipment,
5) Develop appropriate financial incentives for RE&EE implementation,
6) Improve the educational programs relevant to RE&EE in universities: focus on R&D, provide training programs ,
7) Improve the know how transfer in RE&EE fields,
8) Develop public awareness campaign (media, exhibition, and fairs),
9) Establish helpdesks and information offices in the “Order of Engineering” and “ Chambers of Commerce” to provide guidelines,
10) Review of the energy tariff periodically, to take into account the promotion of RE&EE,
11) Inform and persuade decision-makers at different levels of the importance of the subject,
12) Design, implementation, monitoring and evaluation of pilot projects in the field of RE&EE to consider the possibility of replication.

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Annex 1: State of the Art of the Renewable Energy Technology

Table (1): External costs in fossil fuel-based energy systems & RE

	External costs (US$ cents / kWh)
Coal-fired power station	7-10
Combusting gas	2-3
Waste-to-heat	18-21
Wind	< 0.1
PV	< 1.0
Biomass	< 0.3

Source: [1]

Table (2): Electricity Cost from Wind Power

Wind Energy cost breakdown	2000 full load hours [EUR/kWh]	2500 full load hours [EUR/kWh]
Investment (12 year annuity at 4%)	0.04 to 0.05	0.03 to 0.04
Operation and maintenance including major overhauls	0.012	0.012
Other operational expenses	0.008	0.008
Total	**0.060 to 0.070**	**0.050 to 0.060**

Source:[6]

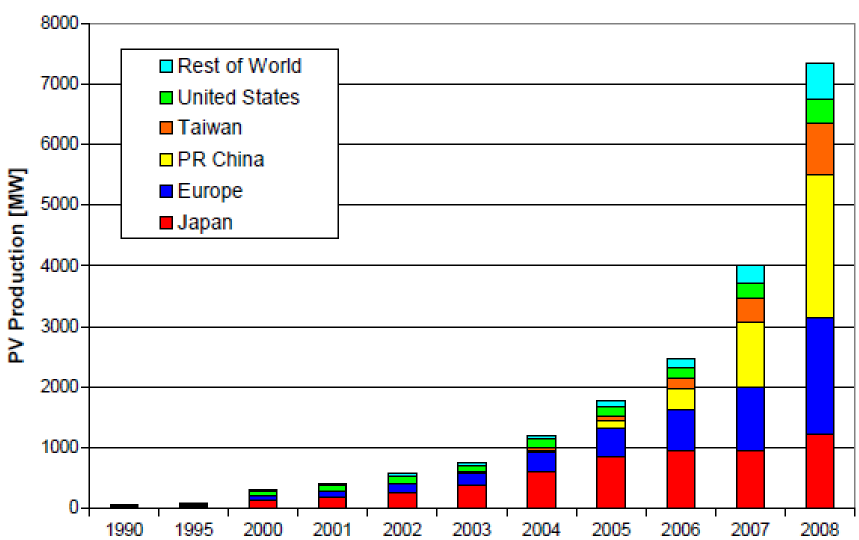

Figure (1): World photovoltaic cell/module production from 1990 to 2008 [2]

Figure (2): Growth rate in relation to the installed capacity of the previous year [3]

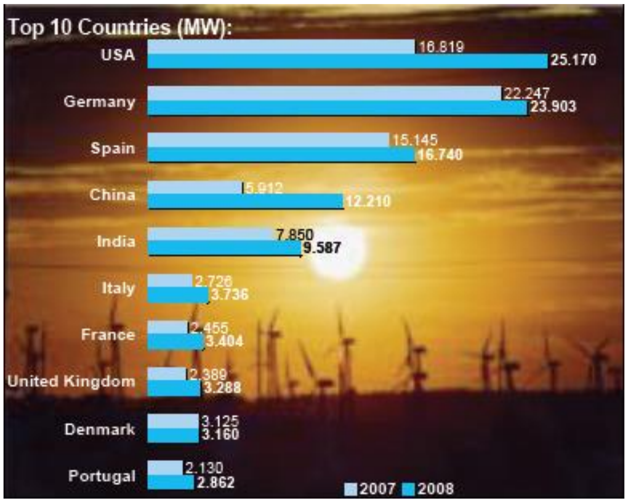

Figure (3): Leading wind markets 2008[3]

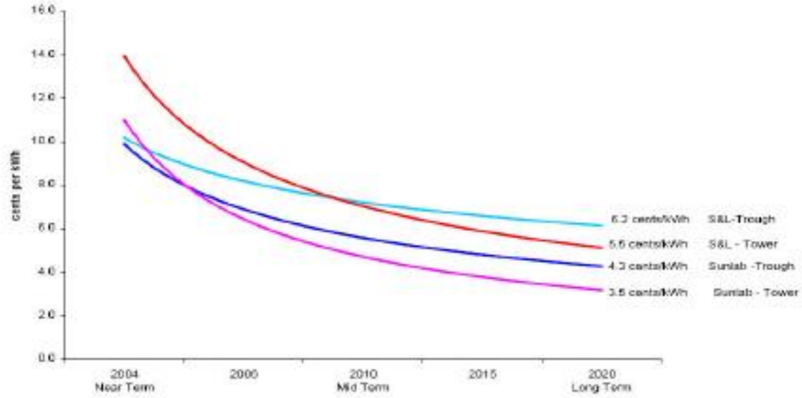

Figure (4): Mid-term & long-term projections of levelized cost of electricity generation through CSP (Trough and Tower) [7]

Annex 2

Feed-in Tariffs in some European countries

Country	Feed-in Tariffs (FIT) (EUR/kWh)
Austria	0.05–0.09 depending on region
Denmark	Moving from FIT of 0.057 to TGC (Tradable Green Certificate) market rate
France	0.073–0.087
Germany	0.062–0.091
Greece	0.06 mainland, 0.07 islands, additional loan subsidy
Ireland	Auction with price cap of 0.048 for projects greater than 3 MW
Italy	0.1045 for first eight years, 0.0531 thereafter
Netherlands	Development of TGC market, current price 0.077
Portugal	0.06, additional loan subsidies
Spain	0.0626 or added 0.028 onto market price
Sweden	0.046, additional investment grants, moving to TGC
U.K	TGC with current value of 0.047

Source:[5]

Annex 3

Request for Qualification (RFQ) For Developers/Sponsors of a 50-100 MW Wind Park Independent Power Producer (IPP) Project through International Competitive Bidding (ICB) November 2009

ضمن إطار سعي وزارة الكهرباء في إعادة التوازن إلى ميزان العرض والطلب على الطاقة الكهربائية، وتحقيق وفورات في استهلاك مصادر الطاقة الأولية، وتخفيض إنبعاثات غازات الدفيئة المنبعثة من حرق الوقود، فإن الوزارة تنهج إلى دعم أبحاث الطاقات المتجددة بشكل عام والسعي لدمجها في منظومة التوليد الكهربائية (وبشكل خاص طاقة الرياح و الطاقة الكهروشمسية).

ومن هذا المنطلق تقوم المؤسسة العامة لتوليد ونقل الطاقة الكهربائية وبالتعاون مع المركز الوطني لبحوث الطاقة بدراسة مشاريع الطاقات المتجددة الممكن والجدي تنفيذها وربطها بالمنظومة الكهربائية.

وقد بينت الدراسات والأبحاث والقياسات التي تمت لحينه أن طاقة الرياح في القطر هي من الطاقات المتجددة الواعدة، سواء من حيث الكمون أو من حيث سرعات الرياح السائدة في كثير من مناطق القطر. ويبين أطلس الرياح . في سورية ، كما تبين دراسات الجدوى الأولية المعدة لبعض المناطق المرشحة جدوى إقامة محطات توليد بطاقة الرياح.

والمؤسسة العامة لتوليد ونقل الطاقة الكهربائية تزمع الإعلان عن رغبتها في مشاركة القطاع الخاص لبناء واستثمار محطة توليد كهربائية (من مزارع الرياح) باستطاعة تتراوح بين 50 – 100 ميغاواط، علماً أن هذا المشروع النموذجي في المشاركة سيكون وفق نظام **BOO** ولمدة **20–25** عام، وذلك في منطقة السخنة (محافظة حمص) أو الهيجانة (محافظة ريف دمشق).

وسوف تقوم المؤسسة في غضون الفترة القريبة القادمة بدعوة المطورين والمستثمرين المهتمين بالمشروع للتقدم بملفات مؤهلاتهم وخبراتهم في هذا المجال.

Source:[15]

Annex 4

Supply-Side Efficiency and Energy Conservation and Planning

Project Title:	**Syria: Supply-Side Efficiency and Energy Conservation and Planning**
GEF Focal Area:	Climate Change
GEF Eligibility:	Under financial mechanism of Convention. Convention ratified 4 January 1996.
Total Project Costs:	$ 29.855 million
GEF Financing:	$ 4.070 million
Government counterpart financing of GEF component:	£S 36 million (in-kind) $ 25.1 million (investment for the rehabilitation of Banias power plant)
Co-financing	$ 0.685 million (UNDP)
Associated Project:	UNDP Energy Programme
GEF Operational Focal Point:	Ministry of Planning
GEF Implementing Agency:	UNDP
Executing Agency:	Government of Syria
Local Counterpart Agencies:	Ministry of Electricity Public Establishment of Electricity for Generation and Transmission (PEEGT) Public Establishment for Distribution and Exploitation of Electrical Energy (PEDEEE)
Estimated Approval Date:	January 1997
Project Duration:	Three years
GEF Preparation Costs:	$ 540,000 (PRIF)

List of feasibility studies for detailed energy audits:

- General Company for Mosiaf Shoes
- Basel Hospital
- Al Kadam Batteries Factory
- Bceda Water Station (BWS)
- Cotton Gin of Al-Hasakeh
- Syrian Arab Dairy Products Company (Power Factor)
- Syrian Arab Dairy Products Company (Steam System)
- International Hospital in Dara'a
- Hasakeh Poultry Establishment
- Helalia Water Station
- Higher Institute for Applied Science & Technology
- Almouasah Hospital

- National Hospital In Salamia
- General Company for Cleaning Product (SAR)
- Homs Sugar
- Abo Zraik Water Station
- Sydnaya Poultry Establishment
- Harasta Yeast Factory
- General Company of Glass
- Doma Hospital

Annex 5

Energy Audits: Summary of Energy and Cost Saving Opportunities Identified

1. Casablanca Restaurant

Recommendations	Fuel type involved	Estimated annual saving (SL)	Estimated annual saving (kWh)	Estimated annual saving (t CO_2)	Estimated implementation cost (SL)	Simple payback period (years)
1. Installing under-floor heating system.	Diesel	33,750	13,500	3.6	192,000	5.7
1. Oil-fired oven: replacing the burner nozzle with a new smaller size.	Diesel	30,000	12,000	3.2	2000	0.1
2. Installing solar water heating systems.	Diesel	21,000	4200	1.12	120,000	5.7
3. Replacing 21 incandescent bulbs with compact fluorescent lights.	Electricity	7158	1763	1.23	15,000	2.1
4. General energy saving measures (5% of total energy consumption).	Diesel/ Electricity	37,961	9350	6.5	-	immediate
Totals /Averages		129,869	40,813	14.53	329,000	2.7

Source:[18]

2. Haretna Restaurant

Recommendations	Fuel type involved	Estimated annual saving (SL)	Estimated annual saving (kWh)	Estimated annual saving (t CO_2)	Estimated implementation cost (SL)	Simple payback period (years)
1. Replacing 5 old refrigerators with new, more efficient units.	Electricity	34,290	7,520	5.3	115,000	3.4
2. Installing solar water heating systems.	Diesel	52,500	10,500	2.8	300,000	5.7
3. Replacing 4 incandescent bulbs with compact fluorescent lights.	Electricity	8714	1911	1.34	600	0.07
4. Replacing 77 conventional magnetic ballasts with electronic ballasts.	Electricity	20,140	4417	3.1	11,550	0.6
5. Energy saving measures on cooking.	LPG	100,375	54,800	13.81	-	immediate
	Electricity	10,226	2243	1.57	-	immediate
6. Energy saving measures on space & water	Diesel	69,450	27,780	7.4	-	immediate

heating.						
7. General energy saving measures (5% of total energy consumption).	Diesel/ Electricity	110,028	43,662	30.6	-	immediate
Totals /Averages		405,723	152,833	65.92	427,150	1.22

Source:[18]

3. Aboud Apartment

Recommendations	Fuel Type Involved	Estimated annual saving (SL)	Estimated annual saving (kWh)	Estimated annual saving (t CO_2)	Estimated implementation cost (SL)	Simple payback period (years)
1. Installing solar water heating system.	Diesel	10500	2100	0.56	60000	5.7
2. Insulating the roof with 3 cm of expanded polystyrene.	Diesel	4300	1372	0.37	30000	7
3. Replacing incandescent bulbs with compact fluorescent lights.	Electricity	3123	1329	0.93	3150	1
4. Replacing conventional magnetic ballasts with electronic ballasts.	Electricity	376	160	0.11	2100	5.6
5. General energy saving measures (10% of total energy consumption)	Diesel/ Electricity	6133	2750	1.93	6000	1
Totals / Averages		24,432	7711	3.9	101,250	4.1

Source:[18]

4. Nahlawi House

Recommendations	Fuel type involved	Estimated annual saving (SL)	Estimated annual saving (kWh)	Estimated annual saving (t CO_2)	Estimated implementation cost (SL)	Simple payback period (years)
1. Installing solar water heating system.	LPG	4620	2100	0.54	60,000	13
2. Replacing incandescent bulbs with compact fluorescent lights.	Electricity	1256	598	0.42	3150	2.5
3. Replacing conventional	Electricity	342	163	0.11	1800	5.3

magnetic ballasts with electronic ballasts.						
4. General energy saving measures (10% of total energy consumption)	Diesel/ Electricity	4463	2125	1.49	-	Immediate
Totals / Averages		10,681	4986	2.56	64,950	5.2

Source:[18]

5. Bait Rumman Hotel

Recommendations	Fuel type involved	Estimated annual saving (SL)	Estimated annual saving (kWh)	Estimated annual saving (t CO_2)	Estimated implementation cost (SL)	Simple payback period (years)
• Replacing 71 incandescent bulbs with compact fluorescent lights.	Electricity	26,730	5111	3.58	10,650	0.4
• Energy saving measures on space & water heating.	Diesel	21,813	8725	2.3	-	immediate
• General energy saving measures (5% of total energy consumption).	Diesel/ Electricity	20,962	6315	4.42	-	immediate
Totals /Averages		69,505	20,151	10.3	10,650	0.15

Source:[18]

6. Alshahbandar Palace *hotel & café*

	Fuel type involved	Estimated annual saving (SL)	Estimated annual saving (kWh)	Estimated annual saving (t CO_2)	Estimated implementation cost (SL)	Simple payback period (years)
1. Replacing 124 incandescent bulbs with compact fluorescent lights.	Electricity	28,336	6107	4.3	18,600	0.7
2. Installing two solar water heating systems.	Diesel	21,000	4200	1.12	120,000	5.7
3. Energy saving measures on space & water heating.	Diesel	44,425	17,770	4.7	-	immediate
4. General energy saving measures (5% of total energy consumption).	Diesel/ Electricity	56,580	16,764	11.7	-	immediate
Totals /Averages		150,341	44,841	21.82	138,600	0.92

Source:[18]

Annex 6

Energy Label for Refrigerators

Annex 7

Electric Energy Tariff in Syria (SL/kWh)

		Peak 17h00-22h00	**Diurnal 07h00-17h00**	**Nocturnal 22h00-07h00**	**Average**
High Voltage	230 kV	3.00	2.00	1.50	2.0
	66 kV	3.76	2.50	1.80	2.5
	20 kV	4.50	2.80	1.85	2.80
Industrial	20/0.4 kV	5.00	3.36	2.45	3.36
Agriculture		2.54	1.80	1.40	1.80
Commercial 20/0.4 kV	1-400 kWh/month	2.50			
	401-1000 kWh/month	3.50			
	> 1000 kWh/month	4.00			
Residential 0.4 kV	1-50 kWh/month	0.25			
	51-100 kWh/month	0.35			
	101-200 kWh/month	0.50			
	201-300 kWh/month	0.75			
	301-400 kWh/month	2.00			
	401-500 kWh/month	3.00			
	501-1000 kWh/month	3.50			
	> 1000 kWh/month	7.00			
	Average tariff (subsidised category) (1-300 kWh): 0.52 SL/kWh Average tariff (301-400 kWh): 0.89 SL/kWh Average tariff (401-500 kWh): 1.31 SL/kWh Average tariff (1-1000 kWh): 2.41 SL/kWh				
Religious Buildings	Free of Charge				

Annex 8

DSM Study

Table (1): Summary Appliance Ownership and Usage Results, Rural Damascus Samples

Distribution of household appliances in Greater Damascus				
App1iance	**Penetration (%)**	**Saturation (%)**	**Estimated average annual consumption (kWh/household)**	**Fraction (%) of estimated average annual consumption (kWh/household)**
Electric oven	21.60	21.91	135	3.11
Microwave oven	7.41	7. 41	42	0.96
Electric element in Gas oven	7.4 I	8.64	44	1.01
Manual washing machine	44.44	44.44	234	5.39
Automatic washing machine	52.47	52.47	435	10.05
Space heater	8.64	10. 19	46	1.06
Iron	80.86	84.88	369	8.53
Hair drier	22.22	22.84	107	2.48
Refrigerator	95.99	103.70	744	17.17
Freezer	3.27	13.58	68	1.57
Dishwasher	0.62	0.62	NA	NA
Electric water heater	6.48	6.48	103	2.38
Dual- fuel water heater	41.05	4 I .36	468	10.80
Vacuum cleaner	53.40	53.40	316	7.29
Black and White TV	4.32	5.25	8	0. 18
Colour TV	94.75	103.70	203	4 69
Satellite receiver	55.88	55.86	2 I	0.50
Computer and Monitor	12.96	2.96	24	0.57
Water pump	23.15	23.15	52	1.20
Ceiling fan	66.05	1 15.74	144	3.33
Table or floor fan	42.59	53.40	42	0.97
Air conditioner	27.47	37.96	724	6.73
Humidifier	1.23	I .23	2	0.04
Total	. . .	. . .	4330	I 00

Source: [39]

Table (2): Summary Appliance Ownership and Usage Results, Damascus Samples

Distribution of household appliances in Damascus				
Appliance	**Penetration**	**Saturation**	**Estimated average annual consumption (kWh per household)**	**Fraction (%)**
Electric oven	26.64%	27.41%	170	2.78%
Micro wave oven	27.41%	27.41%	361	5.91%
Electric Element in Gas oven	14.29%	16.22%	121	1.97%
Manual Washing Machine	18.53%	1853%	123	2.00%
Automatic Washing Machine	80.69%	80.69%	596	9.74%
Space Heater	21.62%	25.48%	188	3.07%
Iron	76.83%	82.63%	449	7.34%
Hair Dryer	43.63%	46.72%	465	7.60%
Refrigerator	96.53%	109.27%	783	12.81%
Freezer	40.93%	46.33%	232	3.79%
Dishwasher	2.32%	2.32%	ND	ND
Electric Water Heater	19.31%	19.31%	353	5.77%
Dual-fuel Water Heater	23.94%	25.10%	342	5.59%
Vacuum Cleaner	69.88%	70.27%	178	2.92%
Black and White TV	2.70%	5.02%	9	0.15%
ColorTV	89.58%	109.27%	243	3.98%
Satellite Receiver	66.80%	66.80%	29	0.48%
Computer + Monitor	33.20%	3320%	61	1.00%
Water Pump	6.95%	6.95%	14	0.23%
Ceiling Fan	43.63%	73.36%	64	1.05%
Table or Floor Fan	46.33%	66.80%	71	1.17%
Air Conditioner	40.93%	66.02%	1256	20.54%
Humidifier	1.54%	1.54%	6115	0.10%

Source: [39]

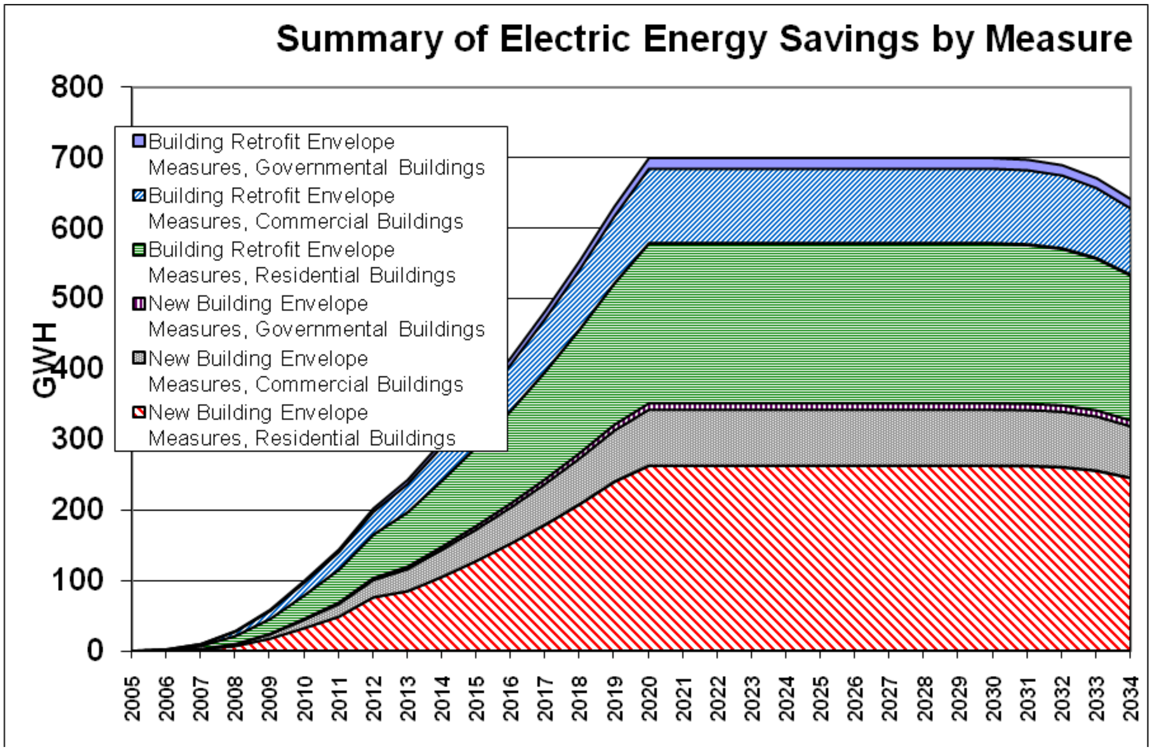

Figure (1): Improved Building Envelope Measures for Residential, Commercial, and Government Buildings [21]

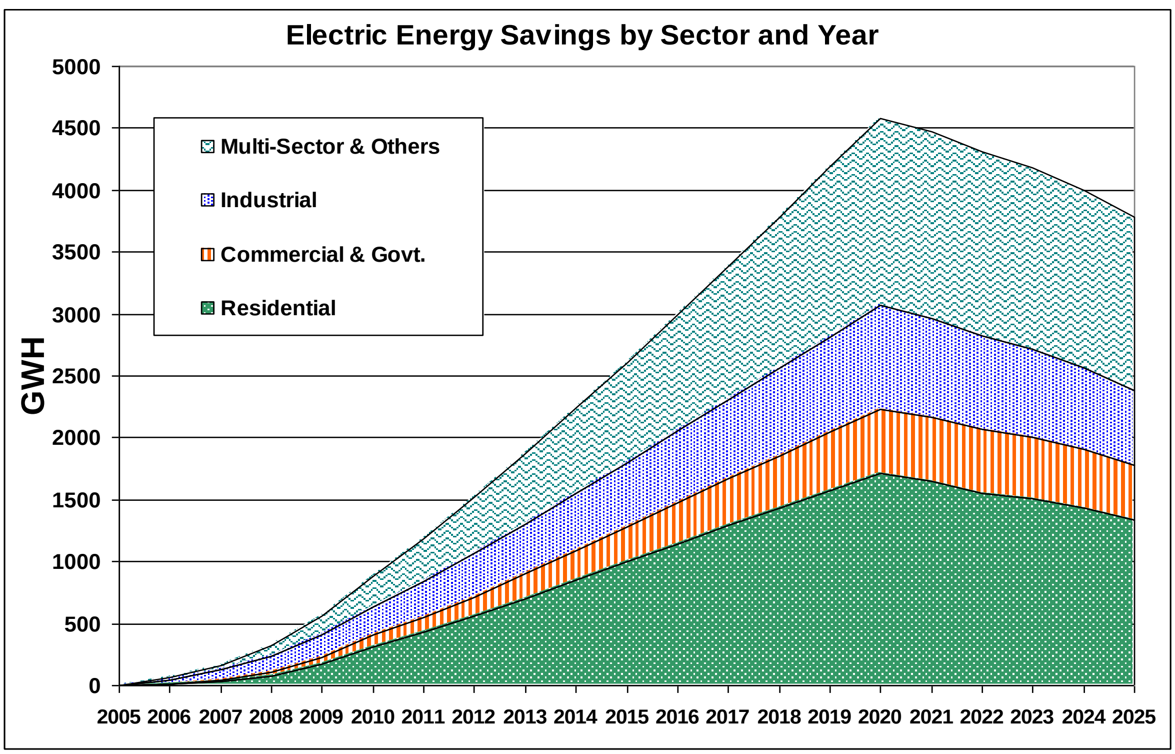

Figure (2): Electric Energy Savings by Sector and Year [21]

Table (3): Proposed DSM Measures

	Measures	Potential Savings in 2020 (GWh)
1	Solar water heating systems	977.5
2	Building envelope program in residential, commercial & governmental buildings	699.2
3	High-efficiency lighting for religion & industrial buildings	477.3
4	High-efficiency motors in industry sector (small capacities)	432.0
5	High-efficiency tube & CFL lamps in Households	377.1
6	High-efficiency lighting for commercial & governmental buildings	374.6
7	Motor system improvements for air compressors, fans and pumps	322.6
8	High-efficiency street lighting	249.3
9	High-efficiency AC in households	197.3
10	High-efficiency refrigerators in households	82.1
11	High-efficiency motors in industry sector (high capacities)	81.5
12	High-efficiency AC and load control for medium & large commercial customers	76.8
13	High-efficiency water heaters & water heaters control in households	75.4
14	High-efficiency motors for pumping applications	71.9
15	High-efficiency AC and load control for small commercial customers	58.4
16	High-efficiency motors and load control for agriculture and irrigation pumping	16.8
17	High-efficiency AC and load control for governmental buildings	11.2
18	TOU Meters	2.1
	Total	**4583**

Source: [21]

Table (4): Measures for Improving Lighting Systems

No.	**Measure**	**Details**
1	**High-efficiency Lighting in the Religion and Industrial Sectors**	CFLs replacing Incandescent Lamps for Religion Sector Customers
		Higher-efficiency Fluorescent Lamps for Religion Sector Customers
		Advanced Lighting Measures for Religion Sector Customers
		CFLs replacing Incandescent Lamps for Industrial Sector Customers
		Higher-efficiency Fluorescent Lamps for Industrial Sector Customers
		Advanced Lighting Measures for Industrial Sector Customers
2	**CFL and High-efficiency Tube**	CFL Replacing Incandescent lamps in Households with » 200 kWh Monthly Consumption

	Lamps in Residential Applications	CFL Replacing Incandescent lamps in Households with over 200 kWh Monthly Consumption
		CFL Replacing Chandelier Incandescent lamps in HH with » 200 kWh Monthly Consumption
		CFL Replacing Chandelier Incandescent lamps in HH with over 200 kWh Monthly Consumption
		High-efficiency Tube Lamps in Households with » 200 kWh Monthly Consumption
		High-efficiency Tube Lamps in Households with over 200 kWh Monthly Consumption
3	**High-efficiency Lighting in Commercial and Government Applications**	CFLs replacing Incandescent lamps for Commercial Customers
		Higher-efficiency Fluorescent Lamps for Commercial Customers
		Advanced Lighting Measures for Commercial Customers
		CFLs replacing Incandescent Lamps for Government Sector Customers
		Higher-efficiency Fluorescent Lamps for Government Sector Customers
		Advanced Lighting Measures for Government Sector Customers
4	**High-efficiency Street Lighting Measures**	Higher-efficiency High-Pressure Sodium Street Lighting Bulbs and Fixtures
		Higher-efficiency Mercury Street Lighting Bulbs and Fixtures
		Higher-efficiency Fluorescent Street Lighting Bulbs and Fixtures
		CFL Bulbs and Fixtures Replacing Incandescent Street Lighting
		LED Traffic Lights Replacing Incandescent Traffic Lights

Table (5): Measures for Improving Energy Efficiency in Electrical Appliances

No.	**Measure**	**Details**
1	High-efficiency Air Conditioners in Residential Applications	Higher-efficiency Room AC in Households with »300 kWh Monthly Consumption
		Higher-efficiency Room AC in Households with over 300 kWh Monthly Consumption
		Highest-efficiency Room AC in Households with » 300 kWh Monthly Consumption
		Highest-efficiency Room AC in Households with over 300 kWh Monthly Consumption
		Air Conditioners Controlled by Utility
		Evaporative Coolers
2	High-efficiency Refrigerators in Residential Applications	Improved Refrigerators in Households with » 50 kWh Monthly Consumption
		Improved Refrigerators in Households with 51 - 100 kWh Monthly Consumption
		Improved Refrigerators in Households with 101 - 200 kWh Monthly Consumption
		Improved Refrigerators in Households with 201 - 300 kWh Monthly Consumption
		Improved Refrigerators in Households with over 300 kWh Monthly Consumption
3	High-efficiency Air	Higher-efficiency Split-type AC for Medium Commercial

	Conditioners in Medium and Large Commercial Applications	Customers
		Highest-efficiency Split-type AC for Medium Commercial Customers
		Higher-efficiency package AC units for Large Commercial Customers
		Higher-efficiency chillers for Very Large Commercial Customers
		Medium Commercial AC Load Control
		Evaporative Coolers for Medium and Large Commercial Customers
4	High-efficiency Water Heaters and Water Heater Controllers in Residential Applications	Higher-efficiency All-Electric WH in Households with » 300 kWh Monthly Consumption
		Higher- efficiency All-Electric WH in Households with over 300 kWh Monthly Consumption
		Added High- efficiency WH in dual-fuel Households with » 300 kWh Monthly Consumption
		Added High- efficiency WH in dual-fuel Households with over 300 kWh Monthly Consumption
		Water Heater Control by Utility--All Electric Households
		Water Heater Control by Utility--Dual-fuel Households
5	High-efficiency motors for Water and Wastewater Pumping	Higher-efficiency Motors for Pumping Applications-- < 50 kW capacity
		Higher-efficiency Motors for Pumping Applications--Motors 50 - 100 kW capacity
		Higher-efficiency Motors for Pumping Applications--Motors over 100 kW capacity
		Higher-efficiency Pump Motors vs. Rewound, < 50 kW capacity
		Higher-efficiency Pump Motors vs. Rewound, 50 - 100 kW capacity
		Higher-efficiency Pump Motors vs. Rewound, over 100 kW capacity
6	High-efficiency Air Conditioners and Load Control in Small Commercial Applications	Higher-efficiency Room and Split AC for Small Commercial Customers
		Highest-efficiency Room and Split AC for Small Commercial Customers
		Small Commercial AC Load Control
		Evaporative Coolers for Small Commercial Customers
7	High-efficiency Air Conditioners and Load Control in Government Sector Applications	Higher-efficiency Split-type AC for Smaller Government Buildings
		Highest-efficiency Split-type AC for Smaller Government Buildings
		Higher-efficiency package AC units for Larger Government Buildings
		AC Load Control for Smaller Government Buildings

Annex 9

Statistical Survey of Diesel fuel and electricity used for water heating in governmental utilities

Mohafaza	No. of samples	Quantity of hot water	Diesel oil used for heating water		Electricity used for heating water		Total
-	-	m^3/y	10^3 Liter/y	Toe/y	MWh/y	Toe/y	Toe/y
Damascus	59	421350	9228.3	7888	141091	35272.7	43161
Rural Damascus	25	17532	835.5	714	22.8	5.71	720
Tartous	6	0	51.4	44	0	0.00	44
Latakia	4	78	261.4	223	1.6	0.39	224
Hama	6	1170	56.5	48	0.7	0.17	48
Idleb	9	0	1017.1	869	0	0.00	869
Aleppo	21	47104	845.1	722	125	31.35	754
Raqqa	6	0	563	481	0	0.00	481
Deir-ezzor	11	3915	126.2	108	23.7	5.93	114
Souwidaa	24	97265	929.3	794	2.2	0.54	795
Total	**171**	**588,414**	**13,913.8**	**11,891**	**141,267**	**35,317**	**47,210**

Annex 10

Statistical Survey of Non Electrified Communities in Syria in 2004

المحافظة	متوسط عدد أفراد الأسرة	عدد التجمعات	عدد الأسر في التجمع	عدد الأفراد القاطنين في التجمع	عدد الأسر ذات الإقامة الموسمية	عدد الأسر التي تستخدم الوقود الآتي للإنارة			عدد الأسر التي تستخدم المخلفات الآتية كطاقة	
						الغاز	الكاز أو المازوت	مجموعات الديزل	الحيوانية	الزراعية
1- محافظة درعا	4.6	14	238	1091	103	84	162	50	79	93
2- محافظة القنيطرة	6.4	1	5	32	0	3	0	2	0	0
3- محافظة السويداء	6.1	12	200	1223	27	153	15	79	94	100
4- محافظة دمشق	لم تدرس لأن التجمعات الموجودة هي توسعات و امتدادات لمناطق مخالفات و غيرها									
5- محافظة ريف دمشق	6.3	59	1761	8442	696	553	547	295	0	103
6- محافظة حمص	12.8	87	958	12268	10					
7- محافظة حماه	7.9	136	1689	13315	218					
8- محافظة طرطوس	5.1	7	45	230	11	37	6	1	0	0
9- محافظة اللاذقية	5.1	34	404	2060	186	232	284	29	0	379
10- محافظة ادلب	5.7	50	1042	5931	404	187	229	473	0	63
11- محافظة حلب	6.8	25	534	3646	11	485	24	13	0	0
12- محافظة الرقة	7.2	69	867	6231	159	14	821	21	399	804
13- محافظة دير الزور	7.4	130	3747	27818	1042	413	3601	29	3144	1868
14- محافظة الحسكة	7.3	329	3066	22527	154					
المجمـوع العـام	**7.2**	**953**	**14556**	**104814**	**3021**	**2161**	**5689**	**992**	**3716**	**3410**

Annex 11

Statistical Survey of Non Electrified Communities in Homs, Hamah and Al-hassakeh

During 2003-2004 the Ministry of Electricity in cooperation with central bureau of statistics and UNDP office in Damascus implemented a survey about energy consumption in the non electrified communities in three Governorates, Homs, Hama and Al-hassakeh as an essential approach in order to launch overall survey in all Syrian remote areas.

Results analysis

Since it was discovered, Electricity has been considered a key factor for development in all fields of life, and in Syria this is no exception where the electric system has to be expanded in order to meet the increasing demand. International research shows that it is not economically feasible to connect remote area to the main grid, especially in the case of scattered small villages.

The development of renewable energy especially solar, wind, and biomass energy, gives an economic solution to electrify remote areas. In Syria renewable energy has been used in different fields, such as wind mill in the past Al-Qalamon region), and in the form of hydroelectric and biomass residues in the present. No doubt that renewable energy, basically of wind, solar and biomass energy, could essentially contribute to the national energy balance; and the Master Plan of renewable energy in Syria which has been prepared and published by the Ministry of Electricity financed by UNDP, has enhanced our understanding of the current situation and future possibility for the renewable energy in the S.A.R .

As a continuation of the Master plan and for the purpose of rural area developing, a survey was executed in cooperation with the Central Bureau of Statistics and financed by UNDP. The survey shows the energy use in remote non electrified area in three Governorates, Homs, Hama, and Al-Hassakeh, which forms is an essential basis by which the approach will be developed in order to launch overall survey in the whole country, and hereunder a brief summary of survey’s result is presented.

General Data about Communities

The results show some unoccupied communities though they are mentioned in the administration division and in the schedules of the electricity distribution company as non electrified communities. The number of the unoccupied communities is 14 while the total number of communities is 510 in the three Governorates.

28% of studied communities are less than 1000 meters far from the nearest electrified communities, so they are candidates for detailed study to connect them to the main grid, while 72% of these communities are more than 1000 meters far away, and this means trying to find other sources of energy than the main grid.

Usually these communities obtain drinking water by one of two ways, either from nearby water wells; wells not far more than 1 km counted 196 well, or by tankers from distant sources. Total number of wells is 245, 64 of them owned by the state and the rest by residents of communities, noting that depth of water in 83 wells was no more than

100 meters, which gives a good possibility to use pumps operated by PV cells.

Total number of families in the studied communities is 5036 families. 210 families live seasonally in the communities. The population in the communities was 43181 persons;

Average size of family is 8.6 person per family.

Total number of houses is 5759 including tents. 1781 houses are built by bricks and cement, the rest are build by stone, wood and mud. Occupied houses are 4752 and 98.76% of which are heated.

Energy Resources and Uses within Communities:

The results shows considerable quantities of consumed oil products is for purpose of lighting, cooking, water and space heating; which indicates inefficient use of these sources. The number of small and medium size batteries used annually is 1031203, analyzing these data will help the feasibility studies for energy substitution studies. As well as people of communities used 4770 of chemical batteries (car batteries) to operate TVs.

Total annual amount of consumed DO by these communities is 5719 000 liters , 1135 liters per family per year, knowing that average amount for rural family in electrified communities according to previous survey is 771 liters per family per year. 60.87% of the total amount is used for space heating, 23.38% is used for lighting, 0.45% is used for water heating and 15.3% is used to operate cars or tractors. Average price of DO is (7.5) S.P per liter.

Total annual amount of consumed LPG 134030 Bottles, 1608 tons, and the average is

26.6 bottles per family per year, - knowing that the average in the previous survey for electrified rural area was 17.9 Bottles per family per year - 18.32% of total amount used for lighting, 81.62% is used for cooking and water heating, 0.06% is used for space heating. The cost of LPG bottle is 175 S.P.

Total amount of kerosene consumed annually within the communities is 601000 liters, the average is 119.6 liter per family per year , knowing that the average in the previous mentioned survey was 40 liter per family per year in the electrified communities, 55.88% of total amount is used for lighting, 44.4% is used for cooking and water heating, 0.08% is used for space heating. The cost of kerosene is 21 S.P per liter.

Total annual amount of animal residue is 2011 tons, 2.84% of the total amount is used for space heating, and 97.16% is used for cooking and water heating. Knowing that a lot of animal residue is not collected and left in the ground, there is a possibility to use this amount of residues to produce biogas as an alternative for LPG.

Total annual amount of agricultural residues is 8641 tons, including 3544 tons of purchased wood which cost between 1000 and 3000 S.P. per ton, 8.74% is used for space heating and the rest for cooking and water heating. When asking people how they get rid off the crops residue, 50.98% answered they use it to feed animals,

18.96% answered they just leave it on the ground or burn it, so this indicate that there is a possibility to obtain biogas from these residues.

Facilities Available in the Communities

The results show that there are about 34 schools within the communities and 3 veterinary clinic located in Homs desert, besides 6 small commercial shops. The annual number of small and medium size batteries was 929 batteries, and the annual amount of consumed light oil was 44600 liters, 83.74% used for space heating, and the rest for lighting. Total annual amount of consumed LPG was 134000 Bottles , 1608 tons, 34.39% used for lighting, 57,47% for cooking and water heating, the rest for space heating. While total annual amount of kerosene consumed was 605 000 liters, 73.68% for lighting, the rest for cooking and water heating, there was no notice for any use of biomass residue within the facilities.

Conclusion:

Total amount of fossil fuel (Diesel Oil, kerosene and LPG) consumed is about 6800 tons, the average is 1358 Kg. per family, and this costs every family about 15000 SP based on local prices and 450 $ according to the international prices. The total number of consumed small and medium batteries was more than one million batteries, this means that the average is 200 batteries for each family, as well as every family uses at least one liquid battery, and this increases the lighting cost with about 2000 SP. So it is very feasible to find alternative source of energy for those poor families who spend a big portion of their income to get poor lighting.

Total annual amount of kerosene and LPG which is used for cooking is about 2110 tons, average of 419 kg per family. This means that encouraging the use of solar cooker will help to improve the living conditions of these families.

Annex 12

Concentrating Solar Power for the Mediterranean Region Final Report by German Aerospace Center (DLR) Institute of Technical Thermodynamics Section Systems Analysis and Technology Assessment Study commissioned by Federal Ministry for the Environment, Nature Conservation and Nuclear Safety Germany

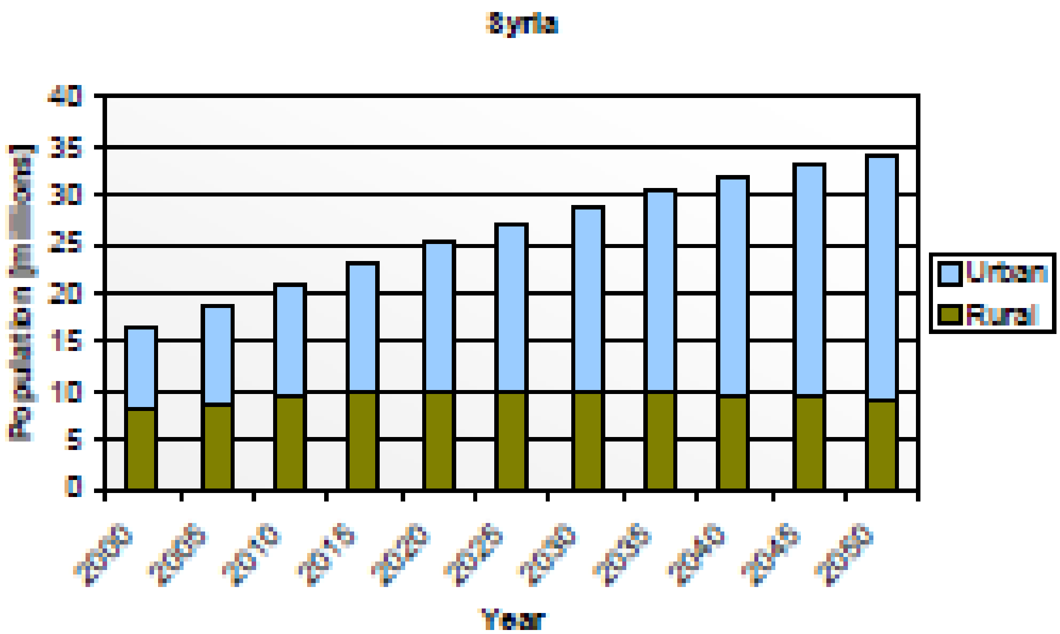

Figure (1): Development of rural and urban population in Syria until 2050 [23]

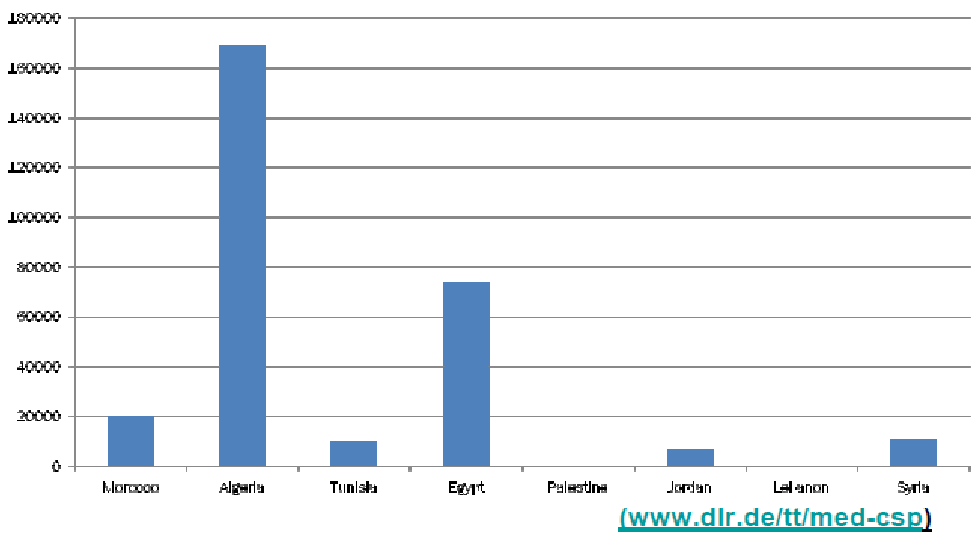

Figure (2): Technical Potential of Solar Thermal Electricity (TWh/yr) [33]

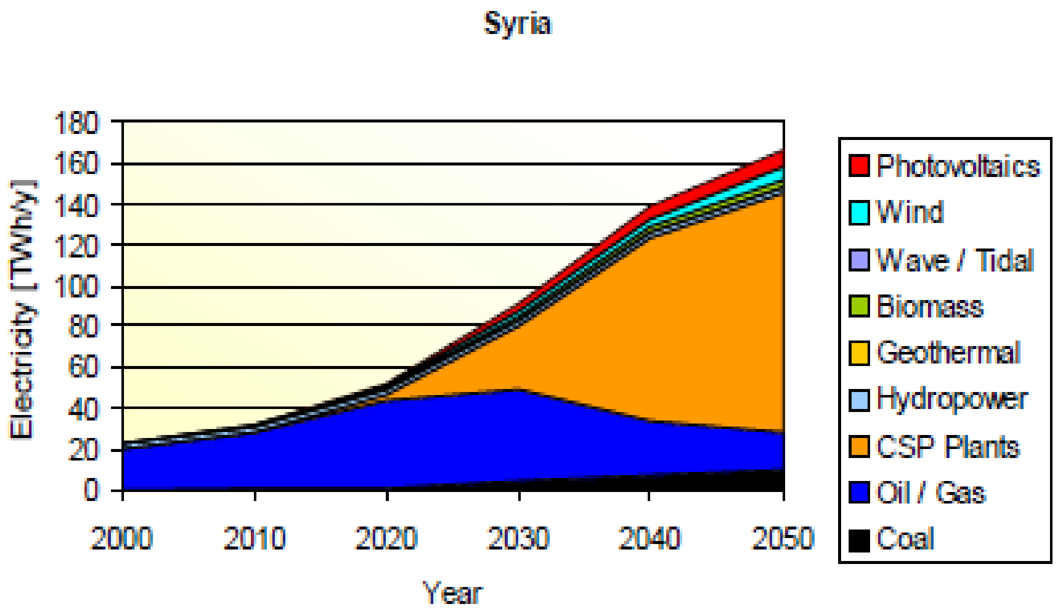

Figure (3): Scenario CG/HE for Syria [23]

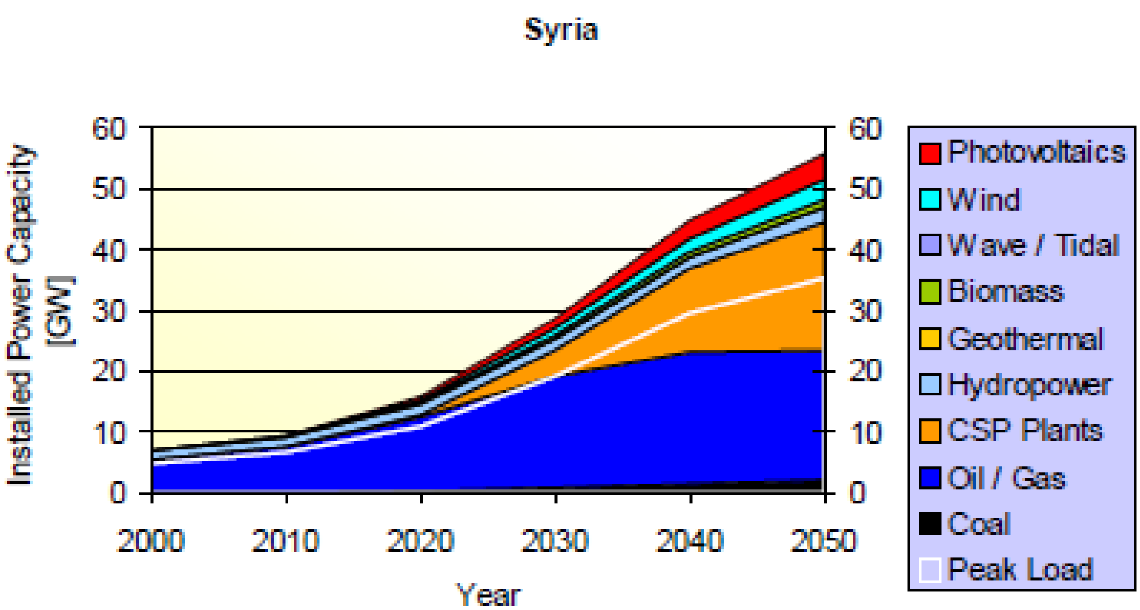

Figure (4): Scenario CG/HE for Syria [23]

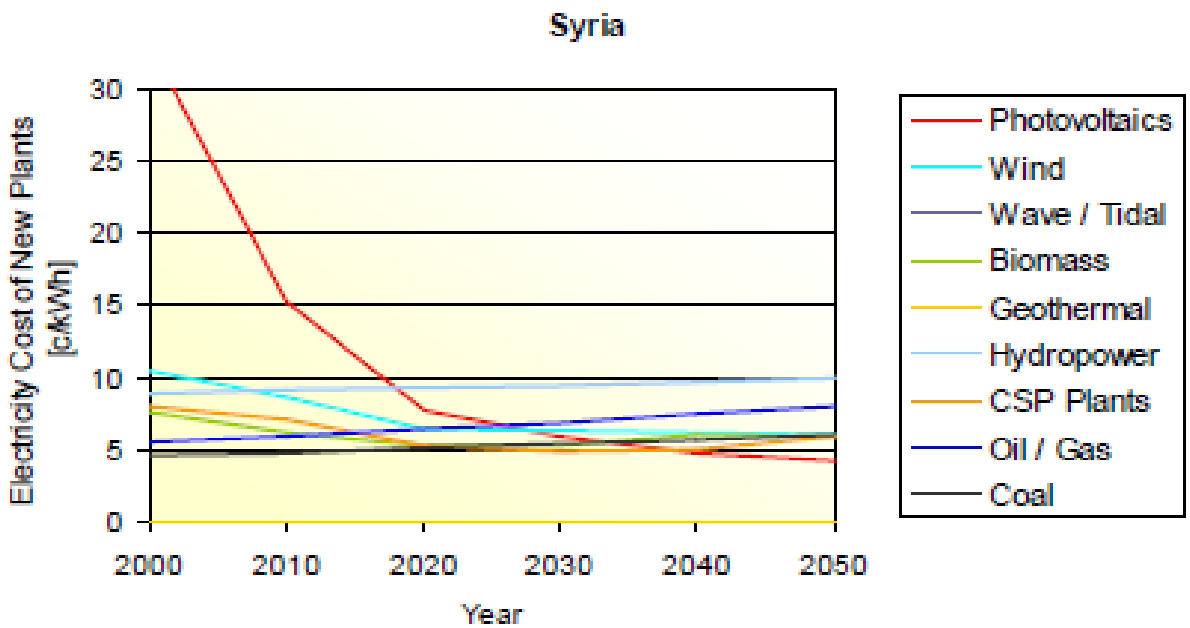

Figure (5): Scenario CG/HE for Syria [23]

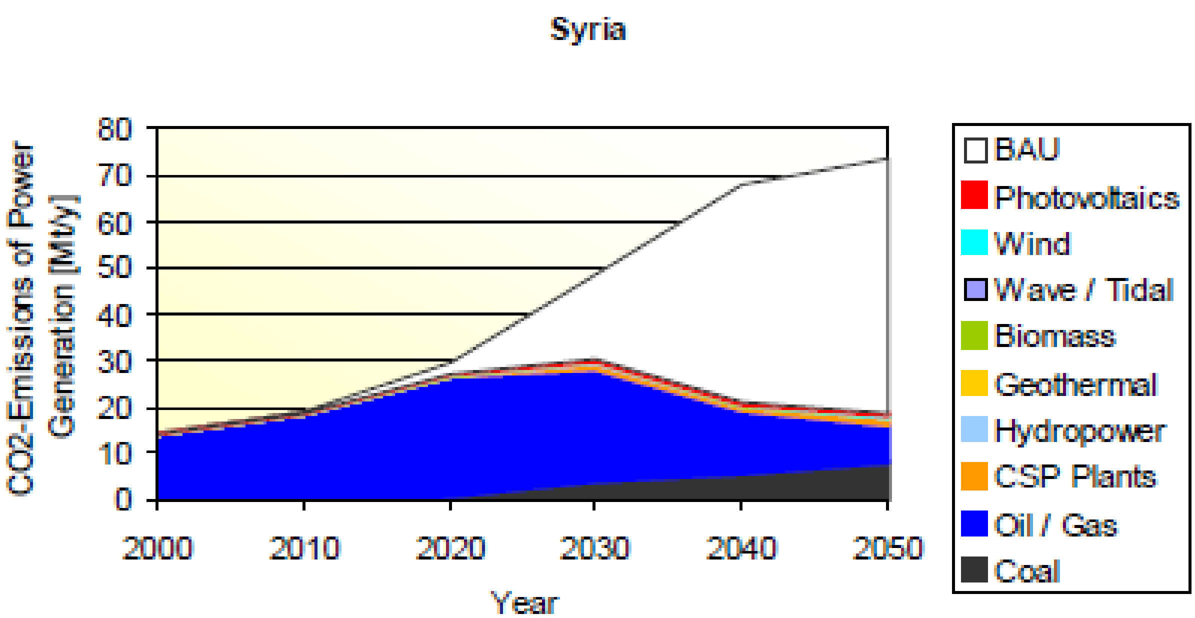

Figure (6): Scenario CG/HE for Syria [23]

Annex 13

Syrian Renewable Energy Master Plan [13]

أولاً : مقدمة

قررت الحكومة السورية إعداد خطة طموحة لاستثمار مصادرها المتاحة في سوريا، ولتنفيذ ذلك حصلت على معونة مالية من الأمم المتحدة لإعداد مخطط عام لاستثمار الطاقة المتجددة في سوريا . أعد هذا المخطط مجموعة من الخبراء الدوليين من مكتب الدراسات الدولي (IT Power) بالتعاون مع فريق من الخبراء المحليين . يتألف تقرير هذا المخطط العام من خمسة أجزاء رئيسية، وعدد صفحاته 300. يستعرض هذا الملحق بإيجاز الملامح الأساسية لهذا المخطط .

ثانياً : أهداف المخطط العام Objectives

إن أهداف المخطط العام هي:

- زيادة مشاركة مصادر الطاقة المتجددة في الميزان الطاقي الوطني.
- تقليص الاعتماد على مصادر الطاقة التقليدية في بعض القطاعات ما أمكن.
- المساهمة في تنوع مصادر الطاقة .
- نقل تقانة تطبيقات الطاقة المتجددة إلى سوريا .
- خلق فرص عمل حقيقية جديدة .
- المساهمة في التنمية المستديمة ذات الأثر الإيجابي للبيئة .

ثالثاً :عناصر المخطط العام Plan Elements

يتألف المخطط العام المقترح تنفيذه بين عامي 2002 و 2011 من خطتين رئيستين هما:

خطة تطوير الطاقة Energy Development Plan

وتحوي مجموعة من النشاطات المقترحة لتطوير استثمار الطاقة المتجددة لأغراض توليد الحرارة والكهرباء لتغطية جزء من احتياجات القطر من الطاقة.

تشمل هذه الخطة التطبيقات التالية : الطاقة الشمسية الحرارية والطاقة الكهرضوئية (الفوتوفولطائية PV) وطاقة الرياح وطاقة الكتلة الحيوية والطاقة المائية ونظم الطاقة الهجينة (طاقة شمسية – مولد ديزل ، طاقة رياح – طاقة شمسية) . يلخص الجدول (1) تكاليف خطة تطوير الطاقة المتجددة. يتوقع في نهاية عام 2011 أن تبلغ مشاركة تطبيقات الطاقة المتجددة 350 كيلو طن مكافئ نفط ، أي بنسبة مشاركة قدرها % 4.31 من الطلب الإجمالي على الطاقة في سوريا في هذا العام. يوضح الشكل (1) نسب مشاركة مختلف تطبيقات الطاقة المتجددة. إن البرامج الرئيسة لهذه الخطة هي :

برنامج البحث والتطوير والاستعراض Research, Development and Demonstration

يتألف هذا البرنامج من عشرين مشروعاً ، وتقدر تكاليفه ب 11 مليون دولار أمريكي . تحظى تطبيقات الطاقة الشمسية الحرارية والكهرضوئية بنسبة % 67 من التمويل الإجمالي لهذا البرنامج.

الجدول (1): تكاليف خطة تطوير الطاقة المتجددة

	RD&D	Pilot Projects	Bankable projects
Resources Required	11 million $	90 million $	1.35 billion $
Components	20	12	21
Period	2002-2011	2003-2011	2003 onwards
Major technologies	Solar and Hybrids	Bioenergy and Wind	Wind, Bioenergy and Solar
Energy Contribution (ktoe)	1	21	328

برنامج المشروعات الرائدة Pilot Projects

يهدف هذا البرنامج إلى الإنتقال من المشروعات الاستعراضية الناجحة إلى التصنيع الجزئي والتسويق لمثل هذه المشروعات. يتألف هذا البرنامج من 12 مشروعاً، وتقدر تكاليفه بـ 90 مليون دولار أمريكي . تحظى تطبيقات طاقة الكتلة الحيوية بنسبة % 81 وطاقة الرياح بنسبة % 15 من التمويل الإجمالي لهذا البرنامج.

برنامج المشروعات التجارية Bankable Projects

يتألف هذا البرنامج من 21 مشروعاً تجارياً قابلاً للتمويل من قبل المصارف أو الهيئات الدولية، وتقدر تكاليفه بـ 1.35 مليار دولار أمريكي، ويشمل التطبيقات الناضجة والناجحة على نطاق التسويق التجاري (توليد الكهرباء من طاقة الرياح وطاقة الكتلة الحيوية وتسخين المياه بالطاقة الشمسية) .

خطة الإجراءات المرافقة Accompanying Measures Plan

تحوي مجموعة من النشاطات التي يمكن أن تلعب دوراً هاماً في تسهيل تطبيق خطة تطوير الطاقة المتجددة. تشمل هذه الخطة عدد من الدراسات وبرامج التدريب وتأهيل الأطر البشرية والتطوير المؤسسي وزيادة الوعي العام . يبلغ التمويل المقترح لهذه الخطة 32.8 مليون دولار أمريكي. يدون الجدول (2) ملخصاً عن هذه الخطة.

الجدول (2) : ملخص عن خطة الإجراءات المرافقة

	Studies	Training/ Promotion	Institutional Development
Resources Required	1.3 million $	2.7 million $	28.8 million $
Activities	27	9	9
Period	2002-2007	2003-2011	2002-2011
Activities	Technology, social, institutional, policy and	Training, media campaign, trade	Creation of Apex body, financial institutions,

	capacity building studies	fairs	upgrading quality assurance, education system

الدراسات Studies

يبلغ عددها 27 وتتنوع مواضيعها لتشمل السياسات والتطوير المؤسسي والمالي وتأهيل الأطر البشرية ونظم الطاقة الشمسية الحرارية والطاقة الكهرضوئية ونظم الطاقة الهجينة والطاقة الحرارية الجوفية. تقدر تكاليف هذه الدراسات بـ 1.3 مليون دولار أمريكي، ويشرف على تنفيذها خبراء محليون ودوليون.

التدريب والترويج Training and Promotion

يشمل برنامج التدريب والترويج 9 أنواع من النشاطات بحيث تتضمن التدريب وحضور المؤتمرات الدولية والإعلانات وحملات الدعاية وتنظيم المعارض التجارية الخاصة. تقدر تكاليف هذا البرنامج بـ 2.7 مليون دولار أمريكي .

التطوير المؤسسي Institutional Development

يعتبر التطوير المؤسسي العنصر الأساسي والفعال للإجراءات المرافقة، ويتألف من 9 أنشطة، وتقدر تكاليفه بـ 28.8 مليون دولار أمريكي. يتضمن برنامج التطوير المؤسسي إحداث أربع مؤسسات هي:

المركز الرئيسي Apex Body

وهو مركز يدير وينسق نشاطات الطاقة المتجددة في سوريا ، ويُقترح أن يكون تابعاً للجنة العليا للطاقة ، ويرأس مجلس إدارته وزير الكهرباء . يقترح إحداثه في عام 2002، وتقدر تكاليف إحداثه وتشغيله بـ 7 ملايين دولار أمريكي .

المؤسسة المالية للطاقة المتجددة Renewable Energy Finance Corporation

وهي مؤسسة إدارية تشرف على تشغيل صندوق الطاقة المتجددة (Interim Renewable Energy Fund) المقترح إلحاقه بالمؤسسة المالية في عام 2008 بعد أن يزداد حجم عمليات القروض المصرفية. تُقدر تكاليف إحداث وتشغيل هذه المؤسسات المالية بـ 5 ملايين دولار أمريكي.

جمعية المستهلك Consumer Association

وتضم مستخدمي ومصنعي أجهزة الطاقة المتجددة، وتهدف إلى إقناع المستهلك بهذه الأجهزة. يتوقع لهذه الجمعية أن تعيل نفسها بنفسها في عام 2007، وتحتاج إلى نصف مليون دولار أمريكي للوصول إلى هذه المرحلة.

الجمعية السورية لمصنعي أجهزة الطاقة المتجددة Syrian Renewable Industries Association

يُقترح تأسيسها لتشكيل جماعة ضغط صناعية بحيث تكون المؤسسة الرئيسة لرعاية ودعم صناعة أجهزة الطاقة المتجددة. يُتوقع لهذه الجمعية أن تعيل نفسها بنفسها في عام 2005، وتحتاج إلى 192000 ألف دولار أمريكي لتأسيسها وإقلاعها.

إضافة إلى هذه المؤسسات الأربعة، يُقترح تحديث المؤسسات الثلاثة التالية بغية إدراج الطاقة المتجددة في أعمالها:

نظام ضمان الجودة Quality Assurance System

يتألف من الهيئة العامة للمواصفات والمقاييس السورية والمخبر الوطني للمعايير والمعايرة التابع لمركز الدراسات والبحوث العلمية. يُقترح إحداث فرع في الهيئة العامة للمواصفات والمقاييس السورية يُعنى بأنظمة الطاقة المتجددة ، كما يُقترح تطوير وتحديث أجهزة الاختبار في مركز الدراسات والبحوث العلمية. تُقدر تكاليف تطوير نظام ضمان الجودة ب 9 ملايين دولار أمريكي.

– نظام التعليم العالي Higher Education System

إن تطوير نظام التعليم العالي في سوريا ضروري لاستيعاب تأهيل حوالي 6500 مهندس وفني وإداري يتطلبهم المخطط العام لاستثمار الطاقة المتجددة في سوريا. تُقدر تكاليف تطوير نظام التعليم العالي ب 3.9 مليون دولار أمريكي.

– نظام الرصد المناخي الطاقي Energy Meteorological Framework

ينبغي تطوير إمكانات الهيئة العامة للأرصاد الجوية من خلال تزويدها بأجهزة القياس ومعالجة المعطيات. تُقدر تكاليف تطوير نظام الرصد المناخي ب 3 ملايين دولار أمريكي.

<u>رابعاً : التكاليف والفوائد Costs and Benefits</u>

تبلغ التكاليف الإجمالية لتنفيذ المخطط العام 1.48 مليار دولار أمريكي، منها % 98 لتنفيذ خطة تطوير الطاقة المتجددة والباقي لتنفيذ خطة الإجراءات المرافقة. تحظى طاقة الرياح بأعلى نسبة إذ تتطلب % 44 من هذه التكاليف، تليها طاقة الكتلة الحيوية بنسبة % 22، ثم الطاقة الشمسية بنسبة % 18، ثم نظم الطاقة الهجينة بنسبة % 13 وأخيراً الطاقة الكهرمائية بنسبة % 3.

يتطلب التطوير المؤسسي حوالي %88 من تكاليف تنفيذ الإجراءات المرافقة .

استناداً إلى معايير مختلفة، قُدّرت مشاركة القطاع الخاص بنسبة %57 من التكاليف الإجمالية للمخطط العام ، وقُدّرت مشاركة الجهات الدولية المانحة بنسبة %22 ومشاركة الحكومة السورية بنسبة % 21. وهذا يعني أن كل دولار أمريكي واحد مستثمر من قبل الحكومة السورية يقابله 3.8 دولار أمريكي مستثمر من قبل القطاع الخاص والجهات الدولية المانحة.

يساعد المخطط العام على خلق 7225 فرصة عمل لمهندسين وفنيين وإداريين ومدرسين. إن كل فرصة عمل تخلقها الحكومة يقابلها 10 فرص عمل يخلقها القطاع الخاص.

يؤدي تنفيذ المخطط العام إلى خفض الكميات التالية في عام 2011 : 896000 طن/السنة من CO_2 و11200 طن/السنة من SO_2 و5900 طن/السنة من NO_x و9100 طن/السنة من CO. إن التكاليف الاجتماعية السنوية التي يمكن تجنبها من هذه الإنبعاثات تكافئ 120 مليون دولار أمريكي.

تُبين نتائج الدراسة الاقتصادية أن تكاليف الاستثمار المكافئة للطاقة التقليدية تبلغ 410 ملايين دولار أمريكي مقارنة مع 1.48 مليار دولار أمريكي للطاقة المتجددة. لكن تكاليف التشغيل للطاقة التقليدية تُقدر ب 5.6 مليار دولار أمريكي مقارنة مع 3.2 مليار دولار أمريكي للطاقة المتجددة.

<u>خامساً: السيناريوات البديلة Alternative Growth Scenario</u>

أُقترح سيناريوين بديلين للمخطط العام هما :

سيناريو النمو السريع Accelerated Growth Scenario

ويتطلب دعم مالي أكبر من الحكومة السورية والجهات الدولية المانحة والقطاع الخاص. تبلغ تكاليف هذا السيناريو 2.4 مليار دولار أمريكي، بحيث تصل نسبة مشاركة الطاقة المتجددة إلى % 6.73 من الطلب الإجمالي على الطاقة في عام 2011 .

سيناريو النمو المركز Focused Growth Scenario

ويمكن تنفيذه في حال ضعف الموارد المالية بحيث يتم التركيز على التقانات ذات الأولوية العالية كنظم تسخين المياه بالطاقة الشمسية والعنفات الريحية والأنظمة الكهرضوئية والطاقة الكهرمائية. تُقدّر تكاليف هذا السيناريو بـ 845 مليون دولار أمريكي بحيث تصل نسبة مشاركة الطاقة المتجددة إلى % 2.85 من الطلب الإجمالي على الطاقة في عام 2011. يدون الجدول (3) المقارنة بين هذين السيناريوين مع المخطط العام.

سادساً : الاستنتاجات والمقترحات Conclusions & Recommendations

انطلاقاً من الأهمية البالغة لتقانات الطاقة المتجددة، وانسجاماً مع الاهتمام العالمي لها، ولما تحققه من مزايا اقتصادية وبيئية، تبرز أهمية المخطط العام لاستثمار الطاقة المتجددة في سوريا من خلال الاستنتاجات التالية :

إعداد استراتيجية واضحة،

اقتراح حصر الأنشطة المبعثرة في مجال الطاقة المتجددة في هيكل مؤسسي واحد،

التركيز على تشجيع الاستثمار لتنفيذ مشروعات الطاقة المتجددة،

التركيز على دور الجهات الدولية المانحة في تقديم الدعم المالي للبرنامج المقترح،

اقتراح المشاركة المتعددة في تمويل برنامج المخطط العام وذلك من قبل القطاع الخاص والمؤسسات الدولية المانحة والحكومة السورية. إن مشاركة الحكومة السورية بنسبة % 21 من الكلفة الإجمالية للمخطط العام تقابل ما مقداره 311 مليون دولار أمريكي، أي بمعدل 31.1 مليون دولار أمريكي في كل سنة من السنوات العشرة المقترحة لتنفيذ المخطط العام، وهذه الكلفة السنوية تشكل نسبة % 0.37 من ميزانية سوريا لعام 2003 .

Table (3): Conversion factors

Description	Unit	Factor	Unit
PV	1kWp =	1.9	MWh/a
Hot Water	1lpd =	0.008	MWh/a
Space Heating & Cooling	1sqm =	0.19	MWh/a
Dryer	1sqm =	0.55	MWh/a
Industrial Process heat	1sqm =	0.20	MWh/a
Wind	1kW =	2.5	MWh/a
Hydro	1kW =	2.76	MWh/a
Biogas	1cum =	5.30	MWh/a
Briquetting (Wood) & Gasification	1 kW=	4.38	MWh/a

Table (4): Emissions

Name of the gas	Volume of the emission (kt)
CO_2	2.573
NO_x	0.017
CO	0.026
SO_2	0.032

Table (5): Cost of Emissions (Source IRP report Stockholm Energy Institute)

Cost of Emissions ($ / 1000 tonnes)	
CO_2	32000
SO_2	2194000
CO	636000
No_x	10473000

Table (6): Details of the Economic Analysis

	Capacity per system		Total No of Systems	RE master plan Investment	BASELINE Investment	RE master Plan Life Cycle Cost	BASELINE Life Cycle Cost
Solar Thermal							
Solar Thermal Space Heating Systems	**25**	**Sqm**	**1600**	**$6,194,444**	**$1,920,000**	**$11,604,860**	**$13,132,986**
Solar Thermal Space Cooling Systems	**25**	**Sqm**	**1600**	**$6,190,972**	**$1,920,000**	**$11,598,355**	**$13,132,986**
Solar Thermal Domestic Hot Water Systems	**200**	**Lpd**	**300000**	**$135,222,222**	**$30,000,000**	**$253,329,404**	**$868,602,908**
Solar Thermal Hot Water Supply for Non Domestic Applications	**2500**	**Lpd**	**800**	**$4,305,556**	**$1,040,000**	**$8,066,158**	**$30,111,567**
Solar Dryers for Small Scale Agricultural Applications	**200**	**Sqm**	**100**	**$2,133,333**	**$1,500,000**	**$3,996,651**	**$6,010,145**
Industrial Process Heat	**1000**	**Sqm**	**750**	**$62,500,000**	**$37,500,000**	**$142,089,392**	**$175,253,635**
TOTAL				16,546,527	73,880,000	430,684,820	1,106,244,228
Photovoltaic							
PV Village Electrification	**0.6**	**kWp**	**6000**	**$17,040,000**	**$4,756,438**	**$33,747,689**	**$59,155,968**
Solar Home Systems for Bedouins	**80**	**Wp**	**5000**	**$1,894,667**	**$115,000**	**$3,752,384**	**$4,212,444**
PV Powered Pumping Systems for Urban Water Supply	**100**	**Wp**	**100**	**$32,500**	**$25,000**	**$60,886**	**$178,236**
PV Health and Education Systems	**500**	**Wp**	**500**	**$1,179,167**	**$500,000**	**$2,680,753**	**$2,250,715**
PV Pumping Systems	**3**	**kWp**	**500**	**$5,240,000**	**$1,500,000**	**$9,816,775**	**$15,152,145**
	Capacity per system		Total No of Systems	REMP Investment	BASELINE Investment	REMP Life Cycle Cost	BASELINE Life Cycle Cost
PV Professional applications	**5**	**kWp**	**100**	**$2,308,333**	**$500,000**	**$4,324,502**	**$5,050,715**
TOTAL				7,694,666	7,396,438	54,382,988	86,000,223
Hybrid Configurations							
PV-Diesel Hybrid Systems	**3**	**kWp**	**50**	**$355,000**	**$99,092**	**$704,760**	**$931,532**
PV-Wind Hybrid Systems (Stand alone)	**2 & 3**	**kWp/ kW**	**30**	**$199,556**	**$39,312**	**$453,676**	**$521,086**
PV-Wind Desalination System	**100 & 500**	**kWp/ kW**	**1**	**$1,400,000**	**$125,265**	**$3,182,802**	**$1,901,808**
Integrated Solar Combined Cycle Plant	**150**	**MW**	**1**	**$180,000,000**	**$12,375,000**	**$409,217,449**	**$187,880,100**
TOTAL				181,954,555	12,638,670	413,558,686	191,234,525
Hydro							
Micro Hydro Schemes	**25**	**MW**	**2**	**$36,944,444**	**$15,770,548**	**$91,379,507**	**$209,039,090**
TOTAL				36,944,444	15,770,547	91,379,507	209,039,090
Bio-Energy							

Briquetting and Gasification	**30**	**kW**	**10**	**$175,000**	**$128,571**	**$327,850**	**$1,133,824**
Urban Solid Waste Projects	**25**	**MW**	**4**	**$61,666,667**	**$9,722,222**	**$115,528,200**	**$403,408,350**
Biogas Systems (Small scale)	**60**	**Cum**	**2300**	**$240,557,143**	**$71,565,558**	**$450,667,033**	**$631,110,194**
Biogas Systems (Large scale)	**1000**	**Cum**	**35**	**$60,814,286**	**$18,150,685**	**$113,931,324**	**$160,064,180**
TOTAL				363,213,095	99,567,036	680,454,407	1,195,716,547
	Capacity per system		Total No of Systems	REMP Investment	BASELINE Investment	REMP Life Cycle Cost	BASELINE Life Cycle Cost
Wind							
Wind Farms (Grid tied)	**1**	**MW**	**700**	**$533,750,000**	**$174,000,000**	**$1,320,193,407**	**$2,474,041,667**
Water Pumping Wind Mills	**12.56**	**Sqm**	**200**	**$4,172,711**	**$102,857**	**$10,320,910**	**$1,462,488**
Wind Electric (Stand alone)	**100**	**kW**	**1000**	**$75,875,000**	**$24,857,143**	**$187,671,522**	**$353,434,524**
Defrosting Wind Machines	**7**	**kW**	**300**	**$830,083**	**$1,404,000**	**$2,053,153**	**$19,962,957**
TOTAL				614,627,794	200,364,000	1,520,238,991	2,848,901,635
Total cost of Accompanying measures				$32,828,520			
RD & Demo Cost				$11,000,000			
GRAND TOTAL				1,483,409,604	409,616,693	3,190,699,401	5,637,136,251

Annex 14

Decision to Enforce SWH Systems and Thermal Insulation in Buildings

إلزام طالبي ترخيص البناء بـ "الطاقة الشمسية"

دمشق– جريدة البعث:

أصدرت وزارة الإدارة المحلية قراراً قضى بإلزام طالبي الترخيص بالبناء في مدن مراكز المحافظات ومجالس المدن والبلديات تقديم الآتي، إضافة إلى الوثائق والدراسات والمخططات الواجب تقديمها للترخيص، دراسة ميكانيكية خاصة بالطاقة الشمسية لتسخين المياه واعتماد النظام المركزي ذي الدارة المغلقة وحسب المواصفات القياسية السورية لأنظمة التسخين الشمسي:

آ– دراسة ميكانيكية وفقاً لمبادئ وأسس ومواد كود العزل الحراري المعتمد.

ب– تعهد خطي موثق لدى الكاتب بالعدل بتنفيذ وتركيب لواقط الطاقة الشمسية حسب وضع كل بناء (شبكة عادية– شبكة مركزية).

ولفتت المادة الثانية من القرار إلى عدم منح إجازة السكن المنصوص عنها في الفقرة /د/ من المادة /9/ من القانون رقم/14/ لعام 1974 أو الموافقة على الإفراز في حال عدم التنفيذ.

وبينت المادة الثالثة من هذا القرار أن تعمل مجالس الوحدات الإدارية ولجان الأحياء بالتنسيق مع اللجان الإدارية المنتخبة وفق أحكام القانون /55/ لعام 2002 وقانون التعاون السكني رقم /17/ لعام 2007 للاستفادة من استخدام الطاقة الشمسية للأبنية القائمة قبل تاريخ صدور هذا القرار.

Annex 15

POLICY STRATEGY AND INSTITUTIONAL DEVELOPMENT TO INTRODUCE PHOTOVOLTAIC SYSTEMS INTO SYRIAN ARAB REPUBLIC

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April 2005

Summary

Due to the lack of comprehensive and adequate survey of the potentials for wide spread dissemination of PV technology in rural areas of Syria, the following are sites suggested for Phase-I of a deployment strategy.

I- Village electrification: The following Table-1 is extracted from a 2004 statistical survey of non-electrified communities in Syria. The survey was conducted by the Ministry of Electricity. Shown in the Table are four Syrian Governorates with 102 non-electrified villages located more than 10 Km from the electric grid. The PV suggested systems power requirement is ~ 500 Wp per house (family).

Table-1, Non-electrified villages

Governorate	Communities located more than 10 km from the grid	Average size of community (family)
Hama	26	11.4
Homs	37	11.7
Dier-alzzor	30	27
Hassakeh	9	9.4

II- Health centers electrification: There are already 13 health centers, and 24 health centers will be constructed in the near future, all are far from the grid and can be electrified by PV systems with capacity of (1000-1500 Wp).

Table-2, Non-electrified Health Centers

Proposed health care centers for PV electrification		
Governorate	**Existing**	**Planned**
Damascus	1	-
Aleppo	10	4
Homs	-	3
Hamma	1	-
Dier-alzzor	1	-
Raqa	-	17

III- Drinking water pumping: In the table below there are examples of drinking water pumping stations in Aleppo that may be powered by PV systems (information provided by Aleppo water Authority).

Table-3, Drinking Water Wells Sites

Wells for drinking water in Aleppo Governorate					
N.	**Name of well**	**Region**	**Well Depth, m**	**Static level , m**	**Dynamic level , m**
1	Arada	Samaan	400	120	150
2	Kantarah	Albab	283	142	178
3	Althahraa	Izaz	350	270	338
4	Mayasah	Izaz	425	102	128
5	Sheek akeel	Samaan	300	175	219
6	Om aletham	Menbej	175-100	75	94

IV- Irrigation and livestock water pumping: PV systems may also be used for pumping water from rivers to irrigate neighboring lands, and for drip irrigation, besides traditional pumping from wells. The sites provided in Table-4 and Table-5 represent very good and strong examples of agricultural pumping needs with PV systems to replace the used diesel generators.

Table-4, Irrigation Wells at Dier-alzzor Governorate

Dier-alzzor Governorate							
N	**Name of well**	**Region**	**Well Depth (m)**	**Pump Depth (m)**	**Water volume (m^3/day)**	**Diesel pump (hp)**	**Est. PV system kW**
1	Alrathemee	Albokamal	600	120	25	40	4
2	Sawab kadwm	Albokama	263	202	72	10	19.5
3	Sawab jaded	Albokamal	270	220	270	40	79.5
4	Sawab jaded	Albokama	270	220	108	30	32
5	Maizeliah	Albokama	169	130	171	20	30
6	Kedr almaa	Badeyat alsham	150	30	160	20	6.5
7	Abo hayaya	Badeyat alsham	150	24	30	15	1
8	Azman	Alshoola	400	140	13	15	2.5
9	Kabajeb	Kabajeb	300	100	275	25	37
10	Wahet alshola 2	Alshoola	105	20	25	15	1
11	Albeda	Jazeera	150	43	140	20	8
12	Jarwan	Jazeera	150	40	150	20	8
13	Abo kashab	Jazeera	125	30	117	15	5
14	Rweshed	Jazeera	105	18	10	15	0.5
15	Abo kabra	Jazeera	110	45	60	20	4

16	Jwef alsader	Jazeera	200	113	90	15	14
17	Jleb alhokoma 1	Jazeera	100	60	80	20	6.5
18	Faydat ebn almweneh	Badeyat almayadeen	200	66	150	20	13.25
19	Makaz alshola	Alshoola	100	30	150	15	6
20	Jwef aldafeena	Albeshree	240	40	150	10	8
21	Alaakorah	Badeyat alsham	150	40	60	15	3.25

Table-5, Irrigation Wells at Raqa Governorate

Raqa Governorate							
N	**Name**	**Region**	**Pump Depth (m)**	**Well Depth (m)**	**Diesel pump (hp)**	**Water volume (m^3/day)**	**Est. PV system (kW)**
1	Alamaalah	S Rasafa 35km	132	300	15	165	29
2	Almeksar	S Rasafa 20km	140	300	20	200	37.5
3	Alakar	SW Rasafa 15km	180	300	20	220	53
4	Aladad	W Rasafa10km	75	165	15	153	15.5
5	Mherah	S Raqa25km	150	300	20	140	28
6	Abotabat	S Raqa45km	114	300	20	153	23.5
7	Aljeere	S Raqa65km	135	250	15	35	6.5
8	Hayelalreman	SE Raqa40km	130	300	15	130	22.5
9	Twalalaba	NE Raqa60km	192	500	35	90	23
10	Rjomakdan	S Raqa50km	125	304	20	135	22.5

V- Brackish water desalination: By 2025, nearly 50% of the world's population will live in water-stressed areas, according the World Meteorological Organization, and conservation and reuse alone will not solve global water scarcity. Desalination removes saline from brackish or sea water and creates fresh water for drinking, irrigation, and industrial use. PV systems may be used to power RO water desalination units. The total number of saline wells in Syria is around 30 villages.

PV Systems Selection

The following is our recommendation of what Phase-I applications could consist of:

I. Select 10 villages from each of the four governorates listed in the table provided above. On the average each village has 12 families (house). Hence, the number of PV systems installed will be 480 with a total PV power requirement of 240 kWp.

II. Select 6 health centers representing the Governorates listed in the table provided above. This represents a total PV power requirement of 9 kWp.

III. Select 6 drinking water pumping sites from the list in the table provided above. These systems require a total of 12 kWp of PV power (based on an average of 2 kWp per system).

IV. Similarly, select 4 irrigation and livestock water pumping sites from the locations provided above. Assuming an average of 6 kWp per system, the total PV power requirement is 24 kWp.

Based on the above site selection and suitable PV systems, the PV power requirement for Phase-I is 285 kWp. This number could be increased or decreased based on availability of funds, workable financing schemes, and ability to set up the infrastructure needed for the implementation plan.

Creative financing plans must be available to encourage the end users to participate in the implementation program. Various successful financing and loan programs are provided in this report.

Annex 16:

Qudsaya Youth Building Project in Damascus- Syria

(www.med-enec.com)

Pilot Project Syria

Five story apartment blocks with 30 apartments, part of the New Youth Residential Complex consisting of 18 buildings with 12,600 flats in total, situated North West of Damascus in the Kudsia Suburbs.

The apartment block has a total floor space of 480 m²; passive building design measures and solar energy are used to improve energy efficiency.

Partners

General Company for Engineering Studies and Consulting (GCEC)

tech-studies-co@mail.sy

General Institute for Housing (GIH)

jhe@net.sy

National Energy Research Centre (NERC)

nerc@mail.sy

Summary

In 1998, GCEC did a research called "Towards Better Climatic Responses in Architecture and Urban Design" examining the comfort in houses of Old Damascus and comparing it to ordinary "modern" houses.

The results persuaded the team to promote the advantages of the old traditional ways of building in Old Damascus and to rediscover design measures already implemented in the past.

The overall energy concept is based on passive building design measures combined with new energy efficient technologies and the use of renewable energies.

Profitability

Compared to a conventional building, the total primary energy consumption of the pilot project is reduced by over 60%.

Due to the 35% higher investment costs, however, the project is economically not feasible.

Only concentrating on the most cost efficient measures brings the payback time down to around 10 years.

Main technical features of the Pilot Project

The role of passive solar design has been maximized to limit as much as possible the use of active solar systems.

- Basic measures with high / moderate cost efficiency
- enhanced insulation of the building envelope and the roof
- double glazing
- PVC shutters for the windows
- shading of the windows and the building by surrounding trees
- glazed stairwells to enhance natural cross ventilation due to solar chimney effect
- solar water heating
- energy efficient lighting
- Additional demonstration measures
- solar assisted floor heating (25% solar thermal, 75% fuel)

Main results of the Pilot Project

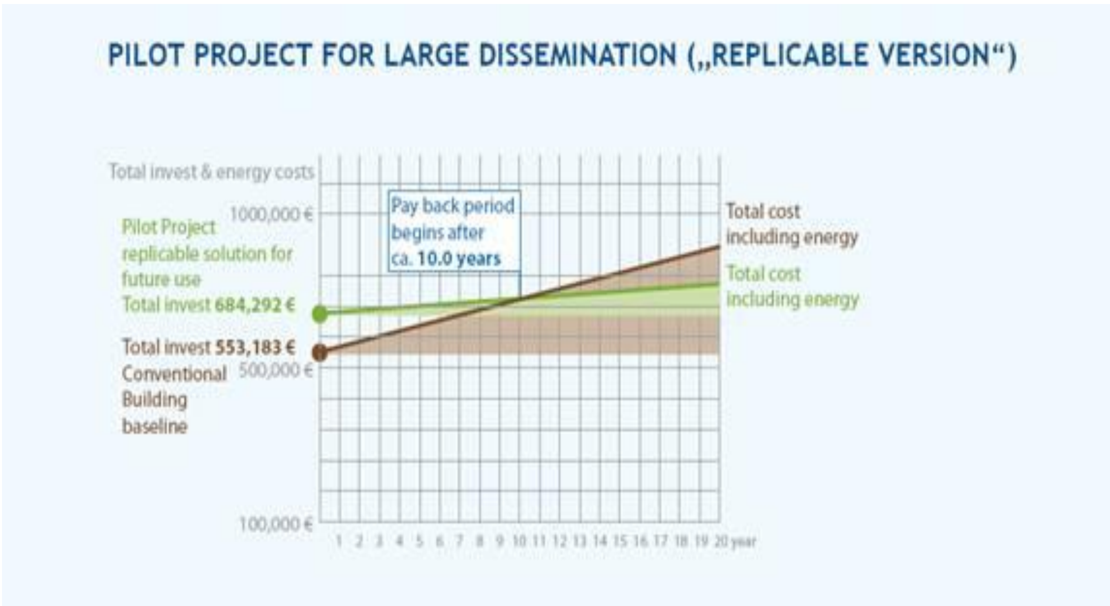
The pilot project reduces the energy consumption by 63%, compared to a conventional building, due to passive measures and the use of solar thermal energy for space and water heating.

The incremental costs for the pilot project are rather high with nearly 35%, the pay-back for the realized measures is hardly attractive.

Major reasons are unavailability of cheap insulation products on the national market lack of know-how for identifying and applying appropriate energy saving technologies and products low cost-efficiency of solar space heating subsidized energy-prices.

The replicable solution has been based on learning and scale effects in a large building program and on skipping the more expensive measures. This brings the pay-back period down to 10 years.

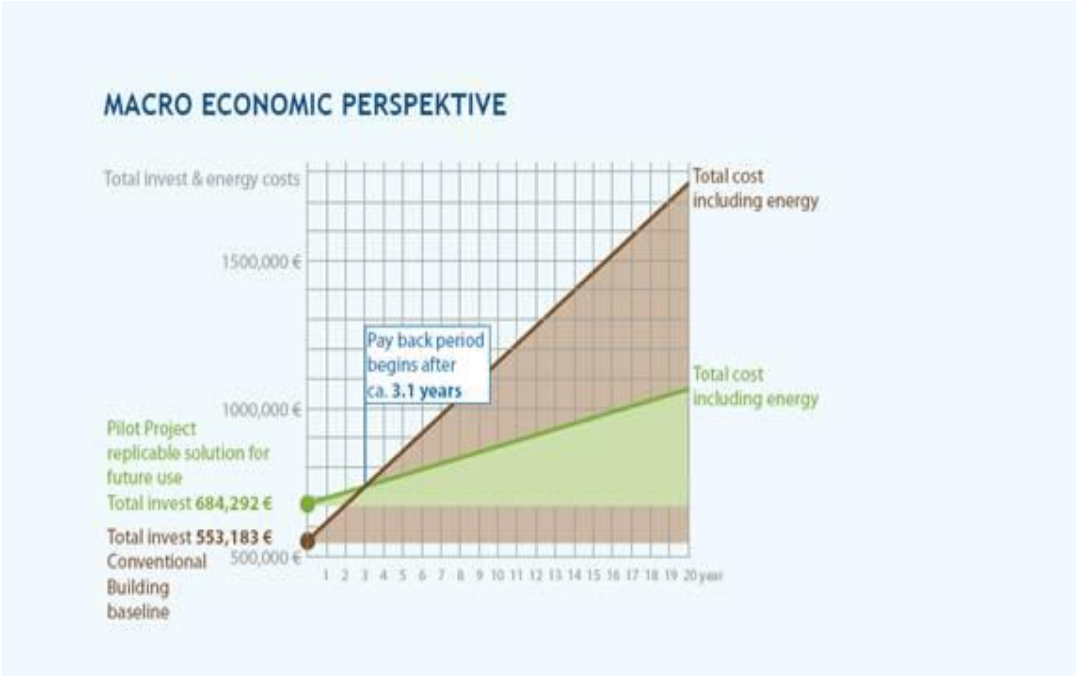
Graph 1:



When realizing this "replicable solution", significant additional benefits for the country in form of reduced energy subsidies arise.

Considering these benefits, the State may have an interest in subsidizing this type of building, increasing thus the pay-back (Graph 2).

Graph 2:



MACRO ECONOMIC PERSPEKTIVE
Total invest & energy costs
1500,000 €
1000,000 €
500,000 €
Total cost including energy
Pay back period begins after ca. 3.1 years
Total cost including energy
Pilot Project replicable solution for future use
Total invest 684,292 €
Total invest 553,183 €
Conventional Building baseline
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 year

Annex 17

Calculation of U-values of Construction Elements and Feasibility Study of Thermally Insulating Typical Flat of 120 m²

Table (1): Exterior Film Coefficients

Air film	Resistance (m^2.K/W)
Outside, adjacent to walls and roofs	R_o = 0.04
Inside, adjacent to roofs	R_i = 0.17
Inside, adjacent to walls	R_i = 0.13

1. Intermediate floor

Table (2): Default properties of common intermediate floor material

Element	Thickness (cm)	Density (kg/m^3)	Thermal conductivity (W/m.K)
Internal plaster	1.5	1800	1.0
Reinforced concrete	15	2300	1.75
Sand	5	1520	0.33
Build-up flooring	5	-	1.6

$$R_{Sol} = R_i + R_{Plaster} + R_{Concret} + R_{Sand} + R_{Tile} + R_o$$

$$R_{Sol} = 0.17 + 0.015/1 + 0.15/1.75 + 0.05/0.33 + 0.05/1.6 + 0.04$$

$$R_{Sol} = 0.4935 \ [m^2.K/W]$$

$$U_{Sol} = 1/R_{roof} = 1/0.4935 = 2.03 \ [W/m^2.K]$$

2. Roof

Table (3): Default Properties of Common Roof Material (before insulation)

Element	Thickness (cm)	Density (kg/m^3)	Thermal conductivity (W/m.K)
Internal plaster	1.5	1800	1.0
Reinforced hollow concrete (hourdi)	15	2300	1.75
Concrete	5	1800	1.0
Sand	5	1520	0.33
Build-up roofing	5	-	1.6

$$R_{Roof} = R_i + R_{Plaster} + R_{Concret} + R_{Beton} + R_{Sand} + R_{Tile} + R_o$$

$$R_{Roof} = 0.17 + 0.015/1 + 0.15/1.75 + 0.05/1 + 0.05/0.33 + 0.05/1.6 + 0.04$$

$$R_{Roof} = 0.5435 \ [m^2.K/W]$$

$$U_{Roof} = 1/R_{Roof} = 1/0.5435 = 1.84 \ [W/m^2.K]$$

Table (4): Default property of common roof insulation

Added Element	Thickness (cm)	Density (kg/m^3)	Thermal conductivity (W/m.K)
Expanded polystyrene	2.0	15	0.04

$$R_{Roof,i}= R_{Roof} + 0.02/0.04= 0.5435+0.5= 1.0435\ [m^2.K/W]$$
$$U_{Roof,i} = 1/R_{Roof,i} =1/1.0435 = 0.96\ [W/m^2.K]$$

3. Wall

Table (5): Default properties of common wall material (before insulation)

Element	Thickness (cm)	Density (kg/m^3)	Thermal conductivity (W/m.K)
Internal plaster	1.5	1800	1.0
Solid concrete block	20	2000	1.4
External plaster	1.5	1800	1.0

$$R_{Wall} = R_i + R_{Plaster.i} + R_{Bloc} + R_{Plaster,o} + R_o$$
$$R_{Wall} = 0.13 + 0.015/1 + 0.20/1.4 + 0.015/1 + 0.04$$
$$R_{Wall} = 0.343\ [m^2.K/W]$$
$$U_{Wall} = 1/R_{Wall} = 1/0.343= 2.92\ [W/m^2.K]$$

Table (6): Default property of common wall insulation

Added Element	Thickness (cm)	Density (kg/m^3)	Thermal conductivity (W/m.K)
Expanded polystyrene	3.0	15	0.04

$$R_{Wall,i}= R_{Wall} + 0.03/0.04= 0.343+0.75= 1.093\ [m^2.K/W]$$
$$U_{Wall,i} = 1/R_{Wall,i} =1/1.093 = 0.915\ [W/m^2.K]$$

4. Façade before insulation

Assuming that the windows account for 20% of the area of the outer wall and consisting of Al frame with single glass:

Table (7): Default property of common window

Element	U-value ($W/m^2.K$)
Single glass, Al frame	5.2

$$U_{Facad}= U_{Wall} \times 0.8+U_W \times 0.2$$
$$U_{Facad}= 2.92 \times 0.8+5.2 \times 0.2 = 3.38\ [W/m^2.K]$$

5. Façade after insulation

Assuming maintaining the Al window:

$$U_{Facad,i}= U_{Wall,i} \times 0.8 + U_W \times 0.2$$
$$U_{Facad,i}= 0.915 \times 0.8 + 5.2 \times 0.2 = 1.77\ [W/m^2.K]$$

Feasibility Study of Thermally Insulating Typical Flat of 120 m2

Assuming a typical apartment located on the top floor in Damascus city has an area of 120 m^2 and is open on three directions. The area of the outer walls is 100 m^2 and the area of windows is 20 m^2.

- Thermal loss of the façade, before insulation:

$$Q_{wall} = A\ [m^2] \times U_{wall}\ [W/m^2.K] * \Delta T\ [K]$$

$$Q_{wall} = 100\ [m^2] \times 3.38\ [W/m^2.K] * 22\ [K] = 7436W$$

- Thermal loss of the façade, after insulation:

$$Q_{wall,i} = A\ [m^2] \times U_{wall,i}\ [W/m^2.K] * \Delta T\ [K]$$

$$Q_{wall,i} = 100\ [m^2] \times 1.77\ [W/m^2.K] * 22\ [K] = 3894W$$

- Energy Saving gained from insulation the façade:

$$Q_{wall} - Q_{wall,i} = 7436 - 3894 = 3542\ W = 3046\ kcal/h = 0.354\ liter\ mazout/h$$

The total annual heating degree days (DD 18 ° C) in Damascus city are 1500 ° C-days, but the total for the heating period: from November to April are 1271 ° C-days [Atlas solar radiation]. The total annual cooling degree days are more than 1000 ° C-days in Damascus. But as fans are commonly used instead of air conditioners, it is assumed that the number of operation hours of air conditioning in the summer is 500 hours:

- Annual saving gained in diesel oil for the purpose of space heating:

0.354 liter mazout/h x 1271 hr = 450 liter mazout/yr

- Value of annual saving gained in diesel oil for the purpose of space heating:

450 liter mazout x 20.5 SL/liter = 9225 SL/yr

- Annual saving gained in electricity for the purpose of air conditioning:

3542 W x 500 hr = 1771 kWh/yr

- Value of annual saving gained in electricity for the purpose of air conditioning:

1771 kWh x 2.41 SL/kWh (Table 5-4) = 4268 SL/yr

- Thermal loss of the roof, before insulation:

$$Q_{Roof} = A\ [m^2] \times U_{Roof}\ [W/m^2.K] * \Delta T\ [K]$$

$$Q_{Roof} = 120\ [m^2] \times 1.84\ [W/m^2.K] * 22\ [K] = 4858\ W$$

- Thermal loss of the roof, after insulation:

$$Q_{Roof,i} = A\ [m^2] \times U_{Roof,i}\ [W/m^2.K] * \Delta T\ [K]$$

$$Q_{Roof,i} = 120\ [m^2] \times 0.96\ [W/m^2.K] * 22\ [K] = 2534\ W$$

- Energy Saving gained from insulation the roof:

$$Q_{Roof} - Q_{Roof,i} = 4858 - 2534 = 2324\ W = 1999\ kcal/h = 0.232\ liter\ mazout/h$$

- Annual saving gained in diesel oil for the purpose of space heating:

0.232 liter mazout/h x 1271 hr = 295 liter mazout/yr

- Value of annual saving gained in diesel oil for the purpose of space heating:

295 liter mazout x 20.5 SL/liter = 6048 SL/yr

- Annual saving gained in electricity for the purpose of air conditioning:

2324 W x 500 hr = 1162 kWh/yr

- Value of annual saving gained in electricity for the purpose of air conditioning:

1162 kWh x 2.41 SL/kWh (Table 5-4) = 2800 SL/yr

- Sum of the energy savings gained from the insulation of façade and roof:

3542 W + 2324 W = 5866 W = 5045 kcal/h = 0.587 liter mazout/h

- Sum of the annual savings gained in diesel oil for the purpose of space heating:

450 liter mazout + 295 liter mazout = 745 liter mazout/yr

- Sum of the annual values of the saving gained in diesel oil for the purpose of space heating:

9225 SL/yr + 6048 SL/yr = 15273 SL/yr

- Sum of the annual savings gained in electricity for the purpose of air conditioning:

1771 kWh + 1162 kWh = 2933 kWh/yr

- Sum of the annual values of the saving gained in electricity for the purpose of air conditioning:

4268 SL/yr + 2800 SL/yr = 7068 SL/yr

- Sum of the annual values of savings gained in diesel oil and electricity for the purpose of space heating and air conditioning:

15273 + 7068 = 22341 SL/yr

Assuming the price per square meter of expanded polystyrene insulation of 150 Syrian pounds including transport and installation expenses, about 220 square meters of insulation is required (100 square meters to insulate the external walls and 120 square meters to insulate the roof), and the total cost of the insulation is:

$$150 \text{ SL/m}^2 \times 220 \text{ m}^2 = 33000 \text{ SL}$$

Without taking into account the saving resulting from the reduction in the capacity of equipment (for new apartments) the payback period is:

33000 SL/ 22341 SL/yr = 1.5 years

Annex 18

Comparison of Thermal Insulation Materials

Insulation material properties \Properties	Thermal conductivity (W/mK)	Density (kg/m^3)	At the request of resistance to the thickness (mm)	At the request of the resistance to density (kg/m^3)	Compared with the XPS plate thickness of the plate in multiples	Compared with the XPS weight increase in multiples XPS
XPS	**0.028**	**40-50**	**25**	**1.13**	**/**	**/**
Cement perlite	**0.16**	**400**	**143**	**57.13**	**5.72**	**50.58**
Asphalt perlite	**0.12**	**400**	**107**	**42086**	**4.28**	**37.93**
Aerated Concrete	**0.19**	**500**	**170**	**84.84**	**6.8**	**75.08**
Cement stone vermiculite expansion	**0.14**	**350**	**125**	**43.75**	**58**	**38.73**
Cement polystyrene board	**0.09**	**300**	**80**	**24**	**3.2**	**21.34**
Polyethylene foam	**0.042**	**20-30**	**38**	**0.94**	**1.52**	**0.83**
Rigid polystyrene foam	**0.023**	**60**	**21**	**1.23**	**0.84**	**1.09**

Perlite	**PU**	**EPS** البوليسترين الممدد	**XPS** البوليسترين المبثوق	
0.077	**0.02** **≥ 0.06**	**0.041** **≥ 0.06**	**0.03** **≤ 0.04**	**الناقلية الحرارية (W/m.K)** **في البداية** – **بعد ثلاث سنوات** –
AE	**165** **110**	**80** **60**	**350** **350**	**مقاومة الانضغاط (kPa)** **في الحالة الجافة** – **في الحالة الرطبة** –
	-	**≥ 65**	**≥ 300**	**مقاومة الشد (kPa/m^2)**
220	**25-30**	**25-28**	**32-≥39**	**الكتلة الحجمية (الكثافة) (kg/m^3)**
110-130	**≤ 6.0** **≥40**	**≤ 8.0** **≥40**	**≤ 0.76** **≤ 1.0**	الامتصاصية للماء (% v/v) في البداية – بعد ثلاث سنوات –
	21	**38**	**25**	**السمك (mm)**
	جيد	**جيد**	**جيد**	**استقرارية الحجم**

القابلية للاحتراق	**B2**	**B1**	-	
الاستخدام المباشر	سهل	سهل	سهل	
المادة الأولية	100% مواد معاد تصنيعها	100% مواد جديدة	100% مواد جديدة	
الكلفة	منخفضة	متوسطة	عالية	
إجراءات التصنيع	سهلة	سهلة	معقدة	

Annex 19

Reports of CDM

Name of Project: Energy Utilization of Ammonia Plant Tail Gas

Location: Homs, Syria

Title of Feasibility Study (FS)	**CDM Project Study for Energy Utilization of Ammonia Plant Tail Gas in Syria**
FY	FY 2008
Main Implementing Entity	Shimizu Corporation
FS Partner(s)	Ohsumi Co., Ltd.; and Climate Experts PLC.
Location of Project Activity	Syria (Homs City)
Summary of FS Report	PDF (273KB)
Description of Project Activity	The project is to be implemented in an ammonia manufacturing plant located within a general chemical fertilizer company (GFC) in Homs, the third largest city in Syria. It is a CDM project that aims to utilize purge gases (exhaust gas: CH_4 = 12%, H_2 = 60%, plus nitrogen, ammonia and argon, etc., but not including harmful substances) as an alternative fuel in the plant boiler, which currently uses natural gas as fuel.
Targeted GHG	CO_2, and CH_4
Category of Project Activity	Others (Waste Gas Utilisation)
CDM/JI	CDM
Duration of Project Activity/ Crediting Period	2010-2020 / 2011-2020
Baseline Scenario (including Methodology to be applied)	The physical project boundary in the proposed new methodology is "The area of GFC where purge gas is recovered and used as boiler fuel". In the project, it is planned to recover purge gas in the ammonia plant and to install a new multi-fuel fired boiler next to the two existing natural gas fired boilers. Therefore, the project boundary is limited to this area. It is expected that the baseline scenario will be maintenance of the status quo.
Demonstration of Additionality	The baseline scenario will basically be demonstrated through grasping how things have actually been within GFC from the past to present and presenting reasons and evidence to support this. Regarding existence of barriers, evidence will be collected and a chronological table will be compiled with a view to tracking the decision making by the GFC. Concerning actual proof, a number

	of baseline scenarios different from maintenance of the status quo will be presented and the most likely one (in the case where the CDM project is not implemented) will be selected as the baseline scenario. In this case, the project will be divided into two major components, and the separate scenarios (combinations) will be examined within these. This can demonstrate that maintenance of the status quo is the baseline scenario and that the project is additional.
Estimation of GHG Emission Reductions	85,250tCO2 on average per year. 850,250tCO2 over 10 years
Monitoring Plan (including Methodology to be applied)	Through monitoring the amount of methane included in the purge gas used in the project activities and the heating value obtained through combusting this methane gas in the boilers, the greenhouse gas emissions reductions comprising destroyed methane and substituted fuel will be calculated.
Environmental Impact Analysis	The project will have a beneficial impact on the environment because it will effectively utilize methane gas that is currently discharged into the atmosphere and also will reduce the quantity of fuel consumption. Moreover, examination is being given to simultaneously introducing equipment for recovering ammonia contained in the purge gas, and this will also have a beneficial environmental impact.
Issues and Tasks for Project Materialisation	Although it will be necessary to prepare a new methodology and obtain approval from the United Nations for this, it is expected to secure CERs from 2011 and, providing that the price of CERs is 10US$/tCO2 or more, the project should be economically viable. Shimizu Corporation intends to work for the fast realization of the project including the necessary fundraising while monitoring political and economic trends in Syria.
Co-benefits Effects	The project site of GFC is one of the sources of atmospheric pollution in Homs City. Moreover, the purge gas targeted by the project contains ammonia which is harmful to human health, and the treatment of this is needed from the viewpoint of pollution prevention. Although the concentration of ammonia in purge gas is less than 3%, the smell of ammonia pervades inside and outside the plant and it cannot be denied that this is causing an adverse impact on the surrounding environment. Limiting the atmospheric discharge of ammonia trough implementing the project is significant for preventing air pollution and means that the project will realize co-benefits.

DRAFT PROJECT IDEA NOTE (PIN)

Name of Project: Banias Refinery Flaring Reduction and Gas Utilization

Location: Banias, Syria

Date submitted: 5th March 2008

OBJECTIVE OF THE PROJECT	Flare Gas reduction and energy utilization at Banias Refinery
PROJECT DESCRIPTION AND PROPOSED ACTIVITIES	The project's aim is to use gases that have been flared heretofore, to supplant some of the refinery's internal energy needs. The refinery's GHG emissions are reduced by utilizing the flared gas as a replacement for heavy fuel oil.
TECHNOLOGY TO BE EMPLOYED[1]	- Diversion of the waste gas stream before it reaches the flare. Quantity is about 350 kg/h with 78% Hydrocarbon content. - Installation of a special device to avoid compromising the security of the refinery in the form of a valve that automatically provides full bypass capacity to the security flare in case of overpressure through a tube with a diameter of 1m. - Transport tube for the flare gas to the internal boilers. - Gas metering and analyzer for the flare gas flowing to the boilers. - Gas burner in addition to the existing burners for heavy fuel oil for a capacity of about 145 000GJ per year. The project results in reduced heavy fuel oil usage of about 3400 tons p.a., equivalent of 22 000 Barrels of oil.
TYPE OF PROJECT	
Greenhouse gases targeted CO_2/CH_4/N_2O/HFCs/PFCs/ SF	CO2
Type of activities Abatement/CO_2 sequestration	CO2 reduction through replacement of fuel oil with previously flared refinery gas.
Field of activities	6a and 9a
LOCATION OF THE PROJECT	
Country	Syria
City	Banias
Brief description of the location of the project *No more than 3-5 lines*	The project facility is built on a 4 Ha plot of land facing the oil transport facility. The refinery is only 1km away from the city of Banias.
PROJECT PARTICIPANT	
Name of the Project Participant	Energy Solutions offshore sal
Role of the Project Participant	a. Project Operator b. Owner of the site or project c. Owner of the emission reductions d. Seller of the emission reductions e. <u>Project advisor/consultant</u> f. Project investor

1 Please note that support can only be provided to projects that employ commercially available technology. It would be useful to provide a few examples of where the proposed technology has been employed.

	g. Other, please specify:_________________
Organizational category	a. Government b. Government agency c. Municipality d. Private company e. Non Governmental Organization f. Other, please specify: _________________
Contact person	Karim Nini
Address	1135,Allenby street, Beirut central district
Telephone/Fax	+9613236766
E-mail and web address, if any	Karim.nini@energyso.com
Main activities	ES identifies CDM projects, provides necessary studies and documentation for the certifier and the UNFCCC and will closely cooperate with the project owners during the whole CDM project period. ES acts as a trustee for registration and handling of emission rights in the EU.
Summary of the financials *Summarize the financials (total assets, revenues, profit, etc.) in not more than 5 lines*	ES is capable to provide sufficient private equity from a number of dedicated institutions in Europe and the GCC for CDM project realization. Project finance will be settled well before project approval and communicated in detail.
Summary of the relevant experience of the Project Participant	ES provides specialized advisory services for the CDM since 1999 and is therefore one of the earliest companies completely dedicated to CDM. ES cooperates with several well known German companies that provide engineering services in the fields of electric power generation, biogas, landfill gas and energy efficiency.
Please insert information for additional Project Participants as necessary.	
EXPECTED SCHEDULE	08
Earliest project start date *Year in which the plant/project activity will be operational*	Time required for detailed engineering: 2 months Time required for financial commitments: 2 months. Time required for legal matters: 1 month. Time required for construction: 5 months.
Estimate of time required before becoming operational after approval of the PIN	10 month, depending on availability of supplies.
Expected first year of CER/ERU/VERs delivery	Early 2009
Project lifetime *Number of years*	10 years minimum
For CDM projects: Expected Crediting Period *7 years twice renewable or 10 years fixed*	10 years

Current status or phase of the project *Identification and pre-selection phase/opportunity study finished/pre-feasibility study finished/feasibility study finished/negotiations phase/contracting phase etc.* *(mention what is applicable and indicate the documentation)*	MOU approved by BRC and awaiting Ministers signature to go ahead. Scope of CDM activities clear. Volume of fuel reduction and emission reduction established. Detailed engineering about to be commissioned.
Current status of acceptance of the Host Country *Letter of No Objection/Endorsement is available; Letter of No Objection/Endorsement is under discussion or available; Letter of Approval is under discussion or available* *(mention what is applicable)*	Formalities and approach to obtain Letter of No Objection are known and will be engaged in due time.
The position of the Host Country with regard to the Kyoto Protocol	Syria is a non-Annex I country and has ratified the Kyoto Protocol on the 27th of January 2006

METHODOLOGY AND ADDITIONALITY

ESTIMATE OF GREENHOUSE GASES ABATED/ CO_2 SEQUESTERED *In metric tons of CO_2-equivalent, please attach calculations*	Annual (if varies annually, provide schedule): 10 000 tCO_2-equivalent Up to and including 2012: 40 000 tCO_2-equivalent Up to a period of 10 years: 100 000 tCO_2-equivalent. Calculation: 350 kg of refinery gas are utilized per hour. 145 000 GJ are made available per year. 145 GJ are the equivalent of 3400t or 22 000 Barrels of fuel oil. Amount of CO2 emitted by 3400 t of fuel oil is around 10 000t CO2.
BASELINE SCENARIO CDM/JI projects must result in GHG emissions being lower than "business-as-usual" in the Host Country. At the PIN stage questions to be answered are at least: • Which emissions are being reduced by the proposed CDM/JI project? • What would the future look like without the proposed CDM/JI project?	Combustion of 3400t of fuel oil per year. Combustion of 350 kg of flare gas per hour. The combustion of 3400t of fuel oil causes about 10 000t of CO2 emissions. The project replaces 3400t of fuel oil with flare gas. The flare gas is virtually emission neutral as it is flared in the baseline. The flare gas would continue to be flared. Fuel oil would be used for thermal purposes.
Additionality Please explain which additionality arguments apply to the project: (i) there is no regulation or incentive scheme in place covering the project (ii) the project is financially weak or not the least cost option (iii) country risk, new technology for country, other barriers (iv) other	i) Banias Refinery complies with all Syrian regulation. The flaring of the waste gases is a security measure and represents standard industrial practice. iii) This is a new technology for Syria. There is considerable technical risk that could lead to interruptions in the refinery's operations. Special attention has to be accorded to security concerns.
SECTOR BACKGROUND Please describe the laws, regulations, policies and strategies of the Host Country that are of central relevance to the proposed project, as well as any other major trends in the relevant sector.	Syria is faced with an increasing amount of gases being flared both at refineries and oil wells. Gas flaring in Syria generates CO2 emissions of 3,453,000 annually. The technology used in the Banias Refinery is based on a pre-1990 Rumanian design. CO2 reduction was not taken into consideration during the construction of the plant.
METHODOLOGY Please choose from the following options: For CDM projects: (i) project is covered by an	i) Small Scale CDM methodology III.P *Recovery and utilization of waste gas in refinery facilities.* There was no official recording of the amount of waste gases that have been flared in the past, as there was no meter installed.

existing Approved CDM Methodology or Approved CDM Small-Scale Methodology (ii) project needs a new methodology (iii) projects needs modification of existing Approved CDM Methodology	The plant has all design parameters available that indicate the volume of gas flared in the baseline. A gas meter will be installed before the implementation of the project to measure the volume of the gas flared. The amount of flare gas utilised as fuel can be assessed without any problems ex-post.

FINANCE

TOTAL CAPITAL COST ESTIMATE (PRE-OPERATIONAL)	
Development costs	0,2 US$ million (Feasibility studies, resource studies, etc.)
Installed costs	(to be established) US$ million (Property plant, equipment, etc.)
Land	No
Other costs (please specify)	0,05 US$ million (Legal, consulting, etc.)
Total project costs	(to be established) US$ million
SOURCES OF FINANCE TO BE SOUGHT OR ALREADY IDENTIFIED	
Equity Name of the organizations, status of financing agreements and finance (in US$ million)	To be established after detailed engineering study and quotations b equipment suppliers.
Debt – Long-term Name of the organizations, status of financing agreements and finance (in US$ million)	To be established after detailed engineering study and quotations b equipment suppliers.
Debt – Short term Name of the organizations, status of financing agreements and finance (in US$ million)	To be established after detailed engineering study and quotations b equipment suppliers.
Carbon finance advance payments	To be established after detailed engineering study and quotations b equipment suppliers.
INDICATIVE CER/ERU/VER PRICE PER tCO_2e *Price is subject to negotiation. Please indicate VER or CER preference if known*	US $ 15
TOTAL EMISSION REDUCTION PURCHASE AGREEMENT (ERPA) VALUE	
A period until 2012 (end of the first commitment period)	600 000US$
A period of 10 years	1 500 000 US$ / €

EXPECTED ENVIRONMENTAL AND SOCIAL BENEFITS

LOCAL BENEFITS E.g. impacts on local air, water and other pollution.	Reduction of air pollution from the usage of heavy fuel oil
GLOBAL BENEFITS Describe if other global benefits than greenhouse gas emission reductions can be attributed to the	Reduction in the emission of greenhouse gases. Resource efficiency.

project.	
SOCIO-ECONOMIC ASPECTS	
What social and economic effects can be attributed to the project and which would not have occurred in a comparable situation without that project? Indicate the communities and the number of people that will benefit from this project.	The community in which the project is located benefits from new jobs and an emission reduction. The Banias area benefits from reduced pollution now generated by the refinery's operations.
What are the possible direct effects (e.g. employment creation, provision of capital required, foreign exchange effects)?	Reduction of 22 000 Barrel of Oil consumption. Influx of foreign investment for the equipment.
What are the possible other effects (e.g. training/education associated with the introduction of new processes, technologies and products and/or the effects of a project on other industries)?	The management and personnel at Banias Refinery will implement modern gas flow and analysis methodologies, recording of metering data according to CDM standards, receive training in estimation of energy efficiency potential for further possible CDM projects at the refinery. The successful implementation of this project can initiate further energy efficiency measures in the Syrian refining sector.
ENVIRONMENTAL STRATEGY/ PRIORITIES OF THE HOST COUNTRY A brief description of the project's consistency with the environmental strategy and priorities of the Host Country	Syria is faced with an increasing amount of gases being flared both at refineries and oil wells. 3,453,000 tons of CO_2 are generated from gas flaring in Syria. Therefore energetic utilization of flared gases is a priority issue for the Syrian Oil and Gas industry. The currently used technology was designed having exclusively production in mind and did not regard for fuel efficiency or other environmental concerns.

DRAFT PROJECT IDEA NOTE (PIN)

Name of Project: Damascus Landfill Gas Capture and Utilization

Location: Damascus, Syria

Date submitted: 5th March 2008

OBJECTIVE OF THE PROJECT	Reduce GHG emissions and foul odors from the existing landfill. Provide a source of CO2 neutral fuel for energy production.
PROJECT DESCRIPTION AND PROPOSED ACTIVITIES	Extraction of landfill gas, its combustion and energetic utilization.
TECHNOLOGY TO BE EMPLOYED[2]	Vertical landfill gas wells and horizontal collector system with HDPE pipes. Gas demister unit. Blowers for landfill gas that create a vacuum in the collector system. System for continuous monitoring of methane concentration and quantity as well as supervision of flare functions. High-temperature flare system. Power generation with containerized gas-engines.
TYPE OF PROJECT	
Greenhouse gases targeted CO_2/CH_4/N_2O/HFCs/PFCs/SF_6 *(mention what is applicable)*	CH4 (from landfill gas emissions) CO2 (from replaced grid power)
Type of activities Abatement/CO_2 sequestration	4a and 1b
Field of activities	Landfill gas extraction and energetic utilisation
LOCATION OF THE PROJECT	
Country	Syria
City	Damascus
Brief description of the location of the project	South of the village Najha 33 O 19´North 36 O 26´East
PROJECT PARTICIPANT	
Name of the Project Participant	Energy Soltuions offshore sal
Role of the Project Participant	h. Project Operator i. Owner of the site or project j. Owner of the emission reductions k. Seller of the emission reductions l. Project advisor/consultant m. Project investor n. Other, please specify:_________________
Organizational category	g. Government h. Government agency i. Municipality

	j. Private company k. Non Governmental Organization l. Other, please specify: __________________
Contact person	Karim Nini
Address	Energy Solutions,1135 allenby street,beirut-lebanon
Telephone/Fax	+9611985448
E-mail and web address, if any	Karim.nini@energyso.com
Main activities *Describe in not more than 5 lines*	ES identifies CDM projects, provides necessary studies and documentation for the certifier and the UNFCCC and will closely cooperate with the project owners during the whole CDM project period. ES acts as a trustee for registration and handling of emission rights in the EU.
Summary of the financials *Summarize the financials (total assets, revenues, profit, etc.) in not more than 5 lines*	ES is capable to provide sufficient private equity from a number of dedicated institutions in Europe and the GCC for CDM project realization. Project finance will be settled well before project approval and communicated in detail.
Summary of the relevant experience of the Project Participant	ES provides specialized advisory services for the CDM since 1999 and is therefore one of the earliest companies completely dedicated to CDM. ES provided capacity building for the first German CDM certifier TUEV-Sued. ES cooperates with several well known German companies that provide engineering services in the fields of electric power generation, biogas, landfill gas and energy efficiency. ES has sufficient experience in landfill gas CDM.
PROJECT PARTICIPANT	
Name of the Project Participant	Administration of Damascus
Role of the Project Participant	b. Project Operator c. Owner of the site or project d. Owner of the emission reductions e. Seller of the emission reductions f. Project advisor/consultant g. Project investor h. Other, please specify: __________________
Organizational category	a. Government b. Government agency c. Municipality d. Private company e. Non Governmental Organization f. Other, please specify: __________________
Contact person	
Address	
Telephone/Fax	
E-mail and web address, if any	
Main activities	Waste collection and disposal
Summary of the financials *Summarize the financials (total assets, revenues, profit, etc*	No financial contribution to this project
Summary of the relevant	No experience in landfill gas extraction.

experience of the Project Participant	
EXPECTED SCHEDULE	
Earliest project start date *Year in which the plant/project activity will be operational*	October 2008
Estimate of time required before becoming operational after approval of the PIN	Time required for financial commitments: 3 months Time required for legal matters: 1 months Time required for construction: 4 months
Expected first year of CER/ERU/VERs delivery	2009
Project lifetime *Number of years*	Above 21 years
For CDM projects: Expected Crediting Period *7 years twice renewable or 10 years fixed*	7+7+7 = 21
Current status or phase of the project *Identification and pre-selection phase/opportunity study finished/pre-feasibility study finished/feasibility study finished/negotiations phase/contracting phase etc.*	Project identified. Feasibility study in preparation.
Current status of acceptance of the Host Country *Letter of No Objection/Endorsement is available; Letter of No Objection/Endorsement is under discussion or available; Letter of Approval is under discussion or available*	Syrian DNA requested for project registration.
The position of the Host Country with regard to the Kyoto Protocol	Syria is a non-Annex I country and has ratified the Kyoto Protocol on the 27th of January 2006

METHODOLOGY AND ADDITIONALITY

ESTIMATE OF GREENHOUSE GASES ABATED/
CO_2 SEQUESTERED
In metric tons of CO_2-equivalent, please attach calculations

Calculated with USEPA Landgem tool for landfill gas calculation in arid climatic conditions, following results were achieved.
However it can be assumed that the real values are much lower.
A annual quantity of 200 000t of CO2 equivalent reductions is a better conservative estimate.

	year	Baseline t CH4	Baseline t CO2	Reductions with 50% efficiency of collection t CO2
2009	1	20517	430.854	**215.427**
2010	2	21310	447.516	**223.758**
2011	3	22065	463.365	**231.682**
2012	4	22783	478.441	**239.220**
2013	5	23466	492.781	**246.391**
2014	6	24115	506.423	**253.211**
2015	7	24733	519.399	**259.699**
2016	8	25321	531.742	**265.871**
2017	9	25880	543.483	**271.741**
2018	10	26412	554.652	**277.326**
2019	11	26918	565.275	**282.638**
2020	12	27399	575.381	**287.691**
2021	13	27694	581.569	**290.784**
2022	14	26343	553.205	**276.603**
2023	15	25058	526.225	**263.113**
2024	16	23836	500.561	**250.281**
2025	17	22674	476.148	**238.074**
2026	18	21568	452.926	**226.463**
2027	19	20516	430.837	**215.418**
2028	20	19515	409.825	**204.912**
2029	21	18564	389.837	**194.919**

BASELINE SCENARIO
CDM/JI projects must result in GHG emissions being lower than "business-as-usual" in the Host Country. At the PIN stage questions to be answered are at least:
- Which emissions are being reduced by the proposed CDM/JI project?
- What would the future look like without the proposed CDM/JI project?

About 1500t of municipal waste are deposed every day.
Start of operation in 1985. Up to 9 million ton of MSW in place.
The site will be used until 2020. Future daily MSW quantity is estimated 1800t.
From 2008-2020 there are additional 6 Million tons.
The allover capacity is therefore up to 15 000 tons.
Assumed power production capacity of 5 MW: 35 000 MWh and 0,5 t CO2 per MW grid carbon intensity would provide additional emission reductions of
17 000 tons per year.
For conservative calculations, 200 000 t CO2 equ. are used as average annual reductions.

Additionality
Please explain which additionality arguments apply to

i) There is no regulation of landfill gas emissions in Syria.
ii) The income situation for power production is not clear.
iii) The technology of landfill gas extraction is not yet

the project: (i) there is no regulation or incentive scheme in place covering the project (ii) the project is financially weak or not the least cost option (iii) country risk, new technology for country, other barriers (iv) other	introduced in Syria.
SECTOR BACKGROUND Please describe the laws, regulations, policies and strategies of the Host Country that are of central relevance to the proposed project, as well as any other major trends in the relevant sector. Please in particular explain if the project is running under a public incentive scheme (e.g. preferential tariffs, grants, Official Development Assistance) or is required by law. If the project is already in operation, please describe if CDM/JI revenues were considered in project planning.	There are now laws and regulations for landfill gas. Current recycling activities are limited to reclaiming of metals and PET. There are no public funds involved in the project.
METHODOLOGY Please choose from the following options: For CDM projects: (i) project is covered by an existing Approved CDM Methodology or Approved CDM Small-Scale Methodology (ii) project needs a new methodology (iii) projects needs modification of existing Approved CDM Methodology	Baseline Methodology: ACM 0001 No modifications

FINANCE

TOTAL CAPITAL COST ESTIMATE (PRE-OPERATIONAL)	
Development costs	Engineering US$ 200 000 PDD creation: US$ 30 000 Registration fee US$ 50 000
Installed costs	About US$ 3 million (Property plant, equipment, etc.)
Land	No
Other costs (please specify)	US$ 1 million for each MW of electric capacity. US$ 0,5 for gas cleaning plant.

	Annual maintenance 0,5 million (plus service and operation for engines).
Total project costs	US$ 4- 10 million plus operation cost.
SOURCES OF FINANCE TO BE SOUGHT OR ALREADY IDENTIFIED	
Equity Name of the organizations, status of financing agreements and finance (in US$ million)	To be established after detailed engineering study and quotations b equipment suppliers.
Debt – Long-term Name of the organizations, status of financing agreements and finance (in US$ million)	To be established after detailed engineering study and quotations b equipment suppliers.
Debt – Short term Name of the organizations, status of financing agreements and finance (in US$ million)	To be established after detailed engineering study and quotations b equipment suppliers.
SOURCES OF CARBON FINANCE	To be established after detailed engineering study and quotations b equipment suppliers.
INDICATIVE CER/ERU/VER PRICE PER tCO_2e *Price is subject to negotiation. Please indicate VER or CER preference if known.*	$ 15
TOTAL EMISSION REDUCTION PURCHASE AGREEMENT (ERPA) VALUE	
A period until 2012 (end of the first commitment period)	4 year with 200 000 CER at $US 15 = US$ 12 million
A period of 10 years	US$ 30 Mio
A period of 7 years	US$ 21 Mio

EXPECTED ENVIRONMENTAL AND SOCIAL BENEFITS

LOCAL BENEFITS E.g. impacts on local air, water and other pollution.	Improvement of air quality by increasing the rate of landfill gas capture and combustion. Long-term (up to 21 years after closure) improved supervision and maintenance of the landfill.
GLOBAL BENEFITS Describe if other global benefits than greenhouse gas emission reductions can be attributed to the project.	Reduction of GHG. Resource efficiency.
SOCIO-ECONOMIC ASPECTS	
What social and economic effects can be attributed to the project and which would not have occurred in a comparable situation without that project? Indicate the communities and the number of people that will benefit from this project.	Creation of permanent employment for operation of the landfill gas plant and generators. Creation of business for local construction companies during construction maintenance. Provision of secure energy supply for important public infrastructure.
What are the possible direct effects (e.g. employment	Permanent employment for about 5 persons. Influx of foreign capital for investment.

creation, provision of capital required, foreign exchange effects)?	Increase of national utility capacity without national investment.
What are the possible other effects (e.g. training/education associated with the introduction of new processes, technologies and products and/or the effects of a project on other industries)?	Training of all employees. Public stake holder consultation. Building of awareness for climate change in Syrian public. Calculation of Syrian CO2 grid intensity will be useful for all upcoming CDM projects in Syria.
ENVIRONMENTAL STRATEGY/ PRIORITIES OF THE HOST COUNTRY A brief description of the project's consistency with the environmental strategy and priorities of the Host Country	Not published until now.

Annex 20

Useful Tables

Table (1): Energy Content for Different Types of Fuel used in Syria

Fuel	Heat / Calorific Value (Gj/kg)	Carbon emission factor (kg/Gj)	IPCC default Values [11]
Syrian HF	0.0402	21.00	21.1
Diesel	0.04	19	20.2
gasoline	0.04480	18	18.9
jet kerosene	0.04459	18.5	19.5
kerosene	0.04375	19	19.6
crude oil	0.04187	21.50	20
Asphalt	0.04019	20	20.9
Petroleum coke	0.03475	28.20	27.5
wood	0.00837	26.3	26
NG (wet) (Gj/CubM)	0.037679	18.5	17.2
LPG	0.0473086	15.8	15.3

Source:[8]

Table (2): Energy Content of Fuel (Diesel oil and LPG)

Fuel	Units	Gross calorific value	Net calorific value
Diesel	MJ/kg	45.9	43.1
	MJ/l	38.1	35.8
LPG	MJ/kg	50.0	46.1
	MJ/l	26.5	24.4

Source: Energy Audit Manual, New Zealand, June 2007, pdf file

Table (3): CO_2 Emission factor

CO_2 Emission factor			
Fuel	**Ref I**	**Ref II (for Syria)**	**Ref III [31]**
Natural gas	-	0.521 tCO_2/MWh	
Electricity	0.7 tCO_2/MWh	-	0.538 kg CO_2/kWh
Diesel #6	0.074 kg CO_2/MJ	0.832 tCO_2/MWh	2.54 kg CO_2/liter
Green Diesel, 50 ppm SO_2			
LPG	0.0713 kg CO_2/MJ	-	
All types		0.393 t CO_2/MWh	

Source: Ref I: Energy Audit Manual, New Zealand, June 2007, pdf file
Ref II : RETScreen Software
Ref III: [31]

Table (4): Carbon Emission Factors (CEF) for various conventional fuels

Fuel	CEF (t C/TJ)
Natural gas	15.3
LPG	17.2
Kerosene	19.6
Crude oil	20.0
Coal (anthracite)	26.8
Peat	28.9
Solid biomass*	29.9
* The CEF for Solid biomass assumes the biomass is harvested unsustainably and therefore is not carbon neutral.	

Source:[34]

Annex 21

Revised 1996 IPCC Guidelines: Sectoral Approach

Step 1	Estimating sectoral fuel consumption
Step 2	Converting to a common energy unit (common energy unit: TJ)
Step 3	Multiplying by carbon emission factors
Step 4	Calculating carbon stored
Step 5	Correcting for carbon unoxidised
Step 6	Converting to CO_2 Emissions (tonnes of CO_2)

Step 1: Estimating sectoral fuel consumption

MODULE	ENERGY					
SUBMODULE	CO_2 FROM FUEL COMBUSTION (TIER I SECTORAL APPROACH)					
WORKSHEET	STEP BY STEP CALCULATIONS					
SHEET	MANUFACTURING INDUSTRIES AND CONSTRUCTION*					
	Step 1	Step 2				
Manufacturing Industries and Construction	A** **Consumption**					
Crude Oil						
Natural Gas Liquids						
Gasoline						
Jet Kerosene						
Other Kerosene						
Gas/Diesel Oil						
Residual Fuel Oil						
LPG						

***Separate sheet filled out for each sector:**
Main activity producer electricity and heat,
Unallocated autoproducers,
Other energy industries,
Manufacturing industries and construction,
Transport of which: road,
Other sectors of which: residential
** Units: Could be in natural units (e.g. 1000 tonnes) or in energy units (e.g. TJ)

Step 2: Converting to a common energy unit

MODULE	ENERGY					
SUBMODULE	CO_2 FROM FUEL COMBUSTION (TIER I SECTORAL APPROACH)					
WORKSHEET	STEP BY STEP CALCULATIONS					
SHEET	MANUFACTURING INDUSTRIES AND CONSTRUCTION					
	Step 1	Step 2				
Manufacturing Industries and Construction	A Consumption	**B*** **Conversion Factor (TJ/unit)**	**C** **Consumption** **(TJ)**			
			C=(AxB)			
Crude Oil						
Natural Gas Liquids						
Gasoline						
Jet Kerosene						
Other Kerosene						
Gas/Diesel Oil						
Residual Fuel Oil						
LPG						

*****Selected Net Calorific Values:

Refined petroleum products	**Factors ($TJ/10^3$ tonnes)**
Gasoline	44.80
Jet Kerosene	44.59
Other Kerosene	44.75
Shale oil	36.00
Gas/Diesel Oil	43.33
Residual Fuel Oil	40.19
LPG	47.31
Ethane	47.49
Naphtha	45.01
Bitumen	40.19
Lubricants	40.19
Petroleum coke	31.00
Refinery feedstocks	44.80
Refinery gas	48.15
Other oil products	40.19
Other products	
Coal oils and tars derived from coking coals	28.00
Oil Shale	9 40
Orimulsion	27.50

Step 3: Multiplying by carbon emission factors

MODULE	ENERGY					
SUBMODULE	CO_2 FROM FUEL COMBUSTION (TIER I SECTORALAPPROACH)					
WORKSHEET	STEP BY STEP CALCULATIONS					
SHEET	MANUFACTURING INDUSTRIES AND CONSTRUCTION					
	Step 1	Step 2		Step 3		
Manufacturing Industries and Construction		B Conversion Factor (TJ/unit)	C Consumption (TJ)	**D* Carbon Emission Factor (t C/TJ)**	**E Carbon Content (t C)**	**F Carbon Content (Gg C)**
			C=(AxB)		E=(CxD)	$F=(Ex10^{-3})$
Crude Oil						
Natural Gas Liquids						
Gasoline						
Jet Kerosene						
Other Kerosene						
Gas/Diesel Oil						
Residual Fuel Oil						
LPG						

*****Selected Carbon Emission Factors (CEF)

Fuel	**Carbon emission factor (t C/TJ)**
LIQUID FOSSIL	
Primary fuels	
Crude oil	20.0
Orimulsion	22.0
Natural gas liquids	17.2
Secondary fuels/products	
Gasoline	18.9
Jet Kerosene	19.5
Other Kerosene	19.6
Shale oil	20.0
Gas/Diesel Oil	20.2
Residual Fuel Oil	21.1
LPG	17.2
Ethane	16.8
Naphtha	(20.0)[a]
Bitumen	22.0
Lubricants	(20.0)[a]
Petroleum coke	27.5
Refinery feedstocks	(20.0)[a]
Refinery gas	(18.2)[b]
Other oil products	(20.0)[a]
SOLID FOSSIL	
Primary fuels	

Anthracite	26.8
Coking coal	25.8
Other bituminous coal	25.8
Sub-bituminous coal	26.2
Lignite	27.6
Oil shale	29.1
Peat	28.9
Secondary fuels/products	
BKB & patent fuel	(25.8)[a]
Coke oven / gas coke	29.5
Coke oven gas	(13.0)[b]
Blast furnace gas	(66.0)[b]
GASEOUS FOSSIL	
Natural gas (dry)	15.3

Step 4: Calculating carbon stored

MODULE	ENERGY					
SUBMODULE	CO_2 FROM FUEL COMBUSTION (TIER I SECTORALAPPROACH)					
WORKSHEET	STEP BY STEP CALCULATIONS					
SHEET	MANUFACTURING INDUSTRIES AND CONSTRUCTION					
	Step 4			Step 5		
Manufacturing Industries and Construction	**G* Fraction of Carbon Stored**	**H Carbon Stored (Gg C)**	**I Net Carbon Emissions (Gg C)**			
		H=(FxG)	I=(F-H)			
Crude Oil						
Natural Gas Liquids						
Gasoline						
Jet Kerosene						
Other Kerosene						
Gas/Diesel Oil						
Residual Fuel Oil						
LPG						

***** Default values: fraction of carbon stored:

Default values: fraction of carbon stored	
Gas/Diesel Oil	0.5
LPG	0.8
Ethane	0.8
Naphtha	0.8
Natural Gas	0.33

Step 5: Correcting for carbon unoxidised

MODULE	ENERGY				
SUBMODULE	CO_2 FROM FUEL COMBUSTION (TIER I SECTORALAPPROACH)				
WORKSHEET	STEP BY STEP CALCULATIONS				
SHEET	MANUFACTURING INDUSTRIES AND CONSTRUCTION				
	Step 4			Step 5	
Manufacturing Industries and Construction				**J* Fraction of Carbon Oxidised**	**K Actual Carbon Emissions (Gg C)**
					K=(IxJ)
Crude Oil					
Natural Gas Liquids					
Gasoline					
Jet Kerosene					
Other Kerosene					
Gas/Diesel Oil					
Residual Fuel Oil					
LPG					

***** Default values: fraction of carbon oxidised:

Default values: fraction of carbon oxidised	
Coal	0.98
Oil and oil products	0.99
Gas	0.995
Peat for elec. generation	0.99

Step 6: Converting to CO2 Emissions (tonnes of CO_2)

MODULE	ENERGY					
SUBMODULE	CO_2 FROM FUEL COMBUSTION (TIER I SECTORALAPPROACH)					
WORKSHEET	STEP BY STEP CALCULATIONS					
SHEET	MANUFACTURING INDUSTRIES AND CONSTRUCTION					
	Step 4			Step 5		Step 6
Manufacturing Industries and Construction						**L* Actual CO_2 Emissions (Gg CO_2)**
						L=(K x [44/12]
Crude Oil						
Natural Gas Liquids						
Gasoline						
Jet Kerosene						
Other Kerosene						
Gas/Diesel Oil						
Residual Fuel Oil						
LPG						

***** Multiply by 44/12 (the ratio of molecular weights CO_2 to C