**“Renewable Energy Technology” Working Group**
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**1250001-5 RETs Theme**

# Final Report on

# Renewable Energies Technologies Contribution and Barriers to Poverty Alleviation in

# Jordan, Syria, and Lebanon

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# Executive Summary

## 1 Background

Within the initial RETs assessment, two main stages are considered. The first stage of the study aims at the identification of the *Demand-side* issues related to the unsatisfied energy needs and the energy sources that can be used. Up-to-date information about the energy uses and frequencies in each country are included in the analysis, considering when possible the urban and rural problems in each case. The second stage will emphasize those aspects related to the renewable technology *Supply-side issues that include* conditions of the supply, local capacity, analysis of the productive chains, environmental impacts, financing, and barriers to use renewable technologies. The objectives of the work include: i) identification of important and relevant energy requirements and to which extent the satisfaction of each of them contributes to poverty alleviation and welfare in the selected target countries; ii) selection of appropriate RETs and assessment of their associated R&D needs; iii) description and analysis of past or potential case studies that have potential impact on poverty; iv) identification of the niches at the national level in the target countries; and v) analysis and assessment of barriers and policies and tools developed to overcome them.

The results of the assessment formed the basis for starting the policy consultation process in the region in order to propose policy options and feasible strategies for implementation of renewable energy technologies in the target countries. One of the main objectives of the theme on RETs is the *identification of their contribution to poverty alleviation and the provision of concrete policy guidance to identify opportunities and to overcome previously identified barriers and other subtle obstacles acting behind them.* The potential contribution of the aforementioned sources to the improvement of the population's conditions of life will be examined. These outputs will be aimed at policy and decision makers, energy policy analysts, NGOs and researchers. The RETs policy outline has been proposed and stakeholders' reaction has been solicited on the proposed policies and the instruments and activities that will help implement these policies to solve the identified problems in the initial assessment.

## 2 Rationale and Motivation

For developing countries the availability of sustainable energy resources is a main and urgent to support the needed development through better energy use. The energy issue has posed a difficult challenge for countries that lack conventional commercial energy resources such as Jordan and Lebanon and places a burden on their national economies due to the high cost of imported oil and the high energy investment needed for economic and social development of these countries.

The development and use of such forms of energy help sustainable development through economic growth and pollution control. The replacement of fossil fuel by renewable and clean forms of energy would relieve the environment from serious types of pollution. Investment in renewable forms of energy would at least partially relieve Jordan, Syria, and Lebanon from burdens of oil imports as well as the creation of new job opportunities for the selected target countries of this study. Despite significant interest in the development of alternative energy sources, their actual contribution to the energy consumption of selected target countries (Jordan, Syria, and Lebanon) is rather limited. In 1993, the share provided by solar water heaters in Jordan (by far the main form of utilization of renewable energy) was between 1.7 and 1.8 %; photovoltaic systems gave 0.0016 %; hydropower provided 0.060%; and wind power contributed 0.007 %. Oil shale, by far the largest indigenous energy resource, did not contribute any power since its development is still at the planning stage. In Syria renewable energy uses consists of pilot projects with limited impact and require governmental and international capital investment.

The challenge is to how to ensure sustainable energy development. Current energy systems are polluting and generally unsustainable, inequity in consumption and access to modern energy is a widespread reality and economic growth is pushing on energy as an essential engine to guarantee future development.

# 3 Initial Assessment

## *3.1 Characterization of populations and zones*

Jordan has a market-oriented free economy, where ownership of business entities is largely private. The main earners of foreign currency for the Kingdom are expatriate remittance, exports and tourism. Jordan's economy is service-oriented. The remaining third is contributed by the agricultural and industrial sectors. In 2002, the GDP was US$ 9.295 billion at current prices achieving a growth of 3.5% since 2001.

The economy of Syria relies mainly on oil production and export, agricultural products such as cereals, cotton, and fruits, in addition to tourism. The gross domestic product for year 2001 at current market prices of year 2002 was US$ 21.871 billion, thus, achieving a growth of 3.5% since year 2001. For the year 2000, the main economic sectors contribution to the GDP is agriculture (26%), and industry and export (27%).

The Lebanese economy is an open economy where the services and banking sectors predominate, constituting 67% of the country's gross national product. Agriculture constitutes 12% and the industrial sector constitutes the remaining 21%.

Table 2 provides the GDP, GDP growth, and GDP per capita for the three countries for the year 2002. Table 3 shows the composition of the GDP according to the main economic sectors [5-7].

**Table 1:** Land area, population size, and population per square meter, rural distribution and growth of Jordan, Syrian Arab Republic, and Lebanon in 2002 [5-7].

| Country | Area ($Km^2$) | Total Population (in thousands) | Population per square kilometer | Percentage rural (%) | Annual Population growth (%) |
|---|---|---|---|---|---|
| Jordan | 89,500 | 5,239 | 59 | 20 | 2.8 |
| Syrian Arab Republic | 185,517 | 17,130 | 92 | 49.8 | 3.1 |
| Lebanon | 10,452 | 3,596 | 344 | 10 | 1.8 |

**Table 2:** GDP, GDP growth, and GDP per capita in Jordan, Syria, and Lebanon (2002) [5-7]

| Country | GDP *(billion US$)* | GDP (real growth rate) | GDP /capita |
|---|---|---|---|
| Jordan | 9.295 | 3.5% | $1,797 |
| Syrian Arab Republic | 21.871 | 3.5% | $1,067 |
| Lebanon | 19.3 | 1.5% | $4,240 |

**Table 3:** GDP composition by sector (2001) [5-7]

| Country | Agriculture | Industry | Services |
|---|---|---|---|
| Jordan | 3.5% | 27% | 69.5% |
| Syrian Arab Republic | 27% | 23% | 50% |
| Lebanon | 12% | 21% | 67% |

## *3.2 Needs and Energy requirements*

In Jordan, the percentage of rural population provided with electricity was 99.8 at the end of the year 2002. The government is working on providing the rest of the residential areas in the Jordanian countryside with electricity through the Rural Electrification Program. The latter is financed via taxation of electricity bills. Also important to note that some residential areas in the Kingdom were provided with electricity by solar cell systems with the help of the National Energy

Research Center [12]. There is a PV village electrification system in remote areas with system capacities varying from 1 KWp to 4.5 KWp. Water pumps for Bedouins with capacities varying between 1.4 to 6.3 KWp per system have been installed [4].

In Syria, there is a general orientation to develop the countryside socially and economically and decrease migration to urban areas. A strategy was followed aiming at providing the Syrian remote and rural areas with electricity. Through the activities of the Energy Planning and Conservation Project, statistics have been collected to help develop rural areas and increase the utilization of sustainable energy systems. The main energy resources in rural areas are wind, solar and biomass resources in addition to liquefied gas and kerosene [13]. There is a PV pumping system of 3.25 KWp capacity currently used to lift 120 $m^3$/day of water at 43 m head in Dummar near Damascus, in addition to a 5 kW PV-pumping and desalination station. PV village electrification was demonstrated in 1994 in two villages totaling 6.35 KWp capacities. Additionally, a PV home electrification system of 35 KWp-capacity is used to supply 44 houses in the village of Zarzita in Aleppo and individual stand-alone PV systems used to supply electricity to 65 houses in certain villages in Aleppo were successfully demonstrated [13].

In Lebanon, rural areas are for the most supplied with energy and have access to other commercial energy resources. Some Palestinians refugee camps are not paying for their electricity bills thus presenting a burden on the already difficult financial status of the Electricity De Liban (EDL) which the government seeks to privatize. The high energy cost in the country is burdening low-income families that sometimes rely on electricity theft to supply their needs [14]. Total losses in the electric power system in Lebanon amounted to 55% (15% technical and 40% non-technical) of the electricity generated in 1997 and reached 68% in 1994 [15]. In 2002, the non-technical losses dropped to 23% with improved measures for bill collection and penalties on theft of electricity [16].

Electricity production in Jordan, Lebanon and Syria is still predominantly based on thermal power plants, primarily using fuel and gas oil. Syria has a fair proportion of hydroelectric resources on the Euphrates. Lebanon has several small hydroelectric facilities the bulk of which are on the Litani in the Bekaa valley. The tendency to move towards natural gas utilization is increasing due to the economic and environmental benefits of natural gas especially that gas networks are becoming increasingly available in Syria and Jordan. The installed capacities for the year 2001 in Jordan, Syria and Lebanon were 1657 MW, 6804 MW, and 2225 MW, respectively. The total energy consumption and forecast in Jordan, Syria, and Lebanon (Table 4) shows a continuous increase in energy demand in the three countries, which brings up the challenge to find ways to manage this increase. Table 5b shows the energy production and use, and GDP per unit energy use.

**Table 4:** Electric Energy Demand and Forecast (GWh) in Jordan, Syria, and Lebanon

| Country | 1 995 | 2 000 | 2005 | 2010 | 2015 |
|---|---|---|---|---|---|
| Jordan | 4 778 | 5 810 | 7 596 | 8 849 | 10 159 |
| Lebanon | 5 484 | 8 630 | 10 284 | 12 512 | 14 087 |
| Syria | 14 661 | 2 0580 | 32 843 | 44 366 | 59 372 |

In 2001, residential electricity consumption in Jordan was 2110 GWatt-hr which is 31% of the total electricity consumption in the kingdom (Appendix A provides tables on domestic energy requirements). The percentage of rural households provided with electricity was 99.8% through the Rural Electrification Program [20]. In 2001, the Jordanian industrial sector consumed 2024 GWatt-hr whereas the commercial sector consumed 880 GWatt-hr, thus representing 32% and 14% of the total electricity consumption in the kingdom, respectively. In 2001, water pumping consumed 981 GWatt-hr, which is 15% of the total electricity consumption.

The Syrian residential sector consumption was 9668 GWH in 2002. In rural areas, 96.69% of households are connected to the electricity grid. Some families use diesel and kerosene for their energy needs. The ministry of electricity is committed to provide villages and farms with light. The main energy resources in rural areas are liquefied gas and kerosene in addition to fuel oil. In rural areas, diesel is used for heating (99.4%) and water heating (41.6%). Kerosene is used for cooking, water heating, and lighting (67.19%). Some families use wood and other biomass products. No solar heaters are domestically used in rural areas due to their relatively high prices [21].

The analysis of the electricity structure and consumption for both residential and commercial sectors is based on a study done in 1998 for Lebanon [23]. From this analysis, the most consuming equipment ,which represent 80% of the total electricity consumption, are reported as: electric heaters (for space heating) 31%; electric domestic hot water systems 22% (same terminology is used for hot water used for sanitary purposes in commercial & residential sectors); Air conditioning A/C 13%; Lighting 8.5%; Refrigerator 6%. The average residential subscriber consumes about 450 KWH [4] and thus pays a total of about $30/month. This may not represent the total energy bill paid by the Lebanese residents. Despite significant improvements to the electricity distribution network since 1993, power shortages and rationing are still widespread. In 1996-97, nearly 10 percent of all buildings were equipped with private power generators (mostly in Beirut (13.8% and Mount Lebanon 11.6%) [25]. The industrial sector in Lebanon consists of small-scale industries primarily involved in light manufacturing. Energy consumption for heat and power generation in the manufacturing industries amounted to 39.67 $\times 10^6$ GJ in 1994, thus amounting to 70% of the total industrial GHG emissions where the cement, asphalt, and steel production are responsible for upwards of 98% industrial processes related GHG emissions [28]. The energy bill of industries in Lebanon is already high compared to regional electricity tariffs and there is an urgent need to provide cheaper energy for industries to help in their development by this boosting the economy, while at the same time providing a cleaner and healthier environment.

### *3.3 Technologies*

Solar energy has two primary applications; *thermal* and *photovoltaic*. Solar thermal energy is used either for direct applications such as heating water and drying grain, or for indirect applications such as generating steam for producing electricity. Photovoltaic (PV) energy is used to produce DC (Direct Current) electricity directly from sunlight. Wind energy technologies can be used as standalone units. Table 5 lists the applicable renewable energy technologies in target countries. Appendix B lists the tables that rate the impact and potential of various renewable energy technologies that would apply to the selected countries of this study. A summary is presented in this section.

**Table 5**: Applicable Renewable Energy Technologies in Target AC Countries (Jordan, Syria, and Lebanon)

| **Category** | **Requirements** | **Renewable technologies** | **Compatibility with users** | **Competing non-renewable** |
|---|---|---|---|---|
| Residential | Lighting | PV, Wind, hybrid Wind/PV, hybrid Diesel/PV, Biomass | High | Kerosene, gas lamp, Auto Battery |
| | TV | | | Auto battery |
| | Refrigerator | | | None |
| | Washing machine | | | None |
| | Kitchen equipment | | | Kerosene, diesel fuel, liquid gas |
| | Domestic Water Heating | Solar hot water heaters | High | Diesel, electricity |
| Productive | Water pumping for drink water | Wind, PV (for pumping heads not more than 40 m), hybrid wind/PV, hybrid Diesel/PV | High | Diesel engines |
| | Water pumping for crop | | | |
| | irrigation | | | |
| | Water pumping for animals | | | |
| | Water desalination | PV | High | None |

| | | | | |
|---|---|---|---|---|
| Social/Community Services | Refrigeration for vaccine conservation | PV, Wind, hybrid Wind/PV hybrid Diesel/PV | High | Diesel engines |

### *3.4 Renewable energy resources*

Jordan is one of the sun-belt countries according to the international classification since the average annual solar radiation per day is (3.8) KWH/m$^2$ in winter to more than (8) KWH/m$^2$ in summer. The total direct annual solar radiation ranges from (2400) KWH/m$^2$ to more than (2700) KWH/m$^2$ which facilitates building investment projects utilizing solar energy for the generation of electricity. Jordan has rich wind energy resources. Studies on the wind potential have been made for several years and the available wind resources were assessed and based on which a Wind Atlas has been prepared, which shows that there is a potential of several hundreds of Megawatts of wind power installations in the country. The oil shale reserve in Jordan is estimated to be more than 50 billion metric tons containing an equivalent of 50 billion barrels of crude of oil [4]. Studies and experiments have shown that oil shale in Jordan can be used by direct burning to produce electricity, or by distillation to produce oil. The government gives great importance to the exploitation of this energy resource by carrying out the continuous technical and economic studies needed. Only few studies have been prepared and indicated that animal and MSW can represent an energy potential of about 100,000 tons of oil equivalent distributed as municipal wastes and animal waste. Jordan produces 1500 tons of municipal water per day, and is capable of producing 16 million cubic meters of biogas per annum equivalent to 8800 TOE. It is also estimated that animal waste resources can be used to produce about 90 million cubic meters of biogas annually. (*Appendix C*).

The average global horizontal solar radiant flux in Syria is approximately 5 KWH/m$^2$/day or 18 MWH/m$^2$/Year. The average daily radiant flux varies from 4.4 KWH/m$^2$/day in the mountainous areas in the west to 5.2 kWh/m$^2$/day in the desert regions of the Badia. The annual sunshine hours also vary between 2,820 hours to 3,270. Wind energy is also abundant in Syria with wind speeds ranging from 4.5 m/s -11 m/s. A Wind Atlas for Syria was published in 1999 through cooperation between Syrian officials and the Danish RISO Institute [35]. The Wind Atlas is mainly based on data collected by 49 wind-monitoring stations established around the country. Most of the available hydropower potential has been harnessed (Installed hydro generation is about 1600 MW) and there is not much scope for harnessing small, medium or large-scale hydropower.

In Lebanon, renewable energy available include resources such as solar, wind, hydro, and biomass resources, but still these resources are not widely used. Lebanon aims at maximizing its benefits from the existing water resources through studying the possibility of constructing dams along the Lebanese rivers in all the regions of Lebanon. The use of solar energy is still very limited, and apart from relatively modest hydroelectric resources and the import of 50-100 MW of electricity from the Syrian Arab Republic, all energy needs are met with imports of petroleum products. Current data indicate that the installed capacity of hydropower plants is about 283 MW, however due to seasonal variation, the actual capacity can be much less. For example, the total electricity generated from the installed hydropower plants capacity was 736, 786 and 330 GWh for the years 1997, 1998 and 1999 respectively. Table 6 summarizes the solar, wind and biomass energy resources in Jordan, Syria, and Lebanon; and Table 7 gives information on installed and potential hydropower in the three selected countries.

**Table 6:** Renewable energy resources in Jordan, Syria, and Lebanon

| Country | Global solar radiation kWh/m$^2$/day | Direct normal solar radiation kWh/m$^2$/day | Wind energy Average wind speed (m/s) | Biomass and fuel wood (mtoe/year) |
|---|---|---|---|---|
| Jordan | 5-8 | 5-7 | 5.5 – 10 | 0.74 |
| Lebanon | 4-6 | 4-6 | 3.5 – 6 | 0.59 |
| Syrian Arab Republic | 5-6 | - | 4.5 – 11 | 1.24 |

**Table 7:** Installed and potential hydropower in the selected countries

| Country | Installed hydropower, MW | Potential hydropower, MW |
|---|---|---|
| Jordan | 7 | 50 |
| Syrian Arab Republic | 1505 | 1236 |
| Lebanon | 283.1 | 533 |

### *3.5 Case studies*

Jordan and the Syrian Arab republic have tired to exploit these resources and there are some case studies in this domain. In contrast, Lebanon still has not taken any steps to study the impact of renewable energy on the social and economic development of the country. Lebanon can benefit from the experiences of Jordan and the Syrian Arab republic to start its own case studies in the future.

In Jordan, PV systems were demonstrated and used for a total capacity of about 150 kWp used to provide electricity, water pumping, and desalination services. Demonstrated applications included emergency telephones, rail radio communication systems, relay station for radio telephone communication, provision of minimal basic energy needs for remote communities, and water pumping in remote areas. Practical examples include: (1) Five repeater stations for civil defense with a capacity of 160 Wp each, (2) Water pumps for Bedouins with capacities varying between 1.4 to 6.3 kWp per system, (3) PV village electrification system in remote areas with system capacities varying from 1 KWp to 4.5 KWp, and (4) PV signaling systems, train crossing signal of 1760 WP power, and radio transmitter situated at the Dead Sea of 3 KWp capacity [4].

In Syria, a 150 kW grid connected wind turbine was set up in 1994 at the Qunetra south of Syria producing 300 MWH/year. There are also stand-alone wind systems installed in Syria for battery charging, water pumping and defrost (750 W to 50 kW) which are locally manufactured (since 1990) by private company (SAC) located at Adra, near Damascus. The wind generators are fully designed, manufactured and installed by this company. The total capacity production by the company is 600 kW [6].

### *3.6 Assessment of Capacities*

Renewable energy and energy efficiency are essential factors that will contribute to reduction of the energy bill and conservation of natural resources. The development of renewable energy use in the three countries can contribute effectively to the efforts directed to the diversification of energy resources, and it will result in important savings of fossil fuels. Although there is no population in extreme poverty conditions, there is a need for socio-economic development and poverty alleviation to improve the standard of living in the region’s poor and rural areas. RETs could be selectively applied to various rural and urban applications, potentially generating income, improving health and educational quality, improving the GDP, achieving gender equity, and increasing labor productivity. Table 8 below provides a summary table of capacity assessment, its problems, needed measures and priorities.

**Table 8:** Capacity assessment

| Stakeholder | Function/Activities | Capacity Status / Problems | Capacity Development (CD) Measures | Magnitude of CD needs / Priority |
|---|---|---|---|---|
| 1. Legislative authorities, elected officials | Set national political priorities; social, economic, and environmental goals; legal framework conditions. | *Lack of knowledge about economy and energy issues in general<br>*Lack of knowledge about RETs potential in particular<br>*Perception as unreliable and not serious | *Election law to be modernized and higher requirements needed; to hold more events on RETs and concentrate on presence of these authorities; to present successful projects.* | *Very high* |
| 2. Government macroeconomic and development planners | Define development goals and macro policy; general economic policies; cross-cutting issues; subsidies and trade policy; sustainable development goals, and frameworks. | *Lack of qualified strategic planners<br>*Decision makers and consequently planners focus around fossil fuel resources and ignore RETs | Intensive courses on RETs for decision makers and strategic planners. It should be focused on the role of renewables utilization in poverty alleviation and meeting economic sectoral planning goals | Very high |
| 3. Government energy authority or ministry | Set sectoral goals; technology priorities; policymaking and Standard-setting functions; legal and regulatory framework;<br>Incentive systems; federal, state, and local level jurisdiction. | *Resource and energy planning in Syria are organized by the Higher Planning Council (HPC) and by the Supreme Energy Committee (SEC).<br>*Absence of an **effective** organization which acts as a driving force for RETs development with clear responsibility to develop policy, legislation and regulatory evolution in Syria and Lebanon | Developing the recently established centre for energy studies to become an effective organization for development of RETs provided that the right staff is employed (Syria)<br>Establish a Renewable Energy Center for Lebanon | Very high for Syria and Lebanon<br>Jordan is far advanced at this level |
| 4. Energy regulatory bodies | Establish monitoring and oversight functions; implement a regulatory framework; administer fees and incentives; dispatch entities; have operational coordination functions | *Interest only in conventional energy sources for both Syria and Lebanon | Solution depends on concerns of decision makers | High (Syria and Lebanon) |
| 5. Market coordination agencies | Interface with industry investors; information brokers. | Such stakeholders are not available | Establishment of these agencies | High in the three countries (Syria, Lebanon and Jordan) |
| 6. Non-energy governmental authorities/ministries | Energy policies; public sector energy consumers; require energy inputs for social services provision. | *Renewable energy activities and projects have been carried out by several Government of Syria entities, with little co-ordination among them. | As in 3. | High in the three countries (Syria, Lebanon and Jordan) |
| 7. Energy supply industry | Private companies and public utilities; manage energy supply, electricity generation; fuels management and transport; finance some R&D. | *Only public utilities exist in Lebanon and Syria. There is no grid code. R&D is rare. System losses are > 30% in both countries. | Deregulation of electric energy market. Jordan is already moving toward privatization | High |

| Stakeholder | Function/Activities | Capacity Status / Problems | Capacity Development (CD) Measures | Magnitude of CD needs / Priority |
|---|---|---|---|---|
| 8. Entrepreneur and productive industry | Business development; economic value added; employment generation; private sector energy consumers. | Not available | When needed | Low |
| 9. Energy equipment and end-use equipment manufacturers | Supply equipment for the energy industry and other industries, including vehicles and appliances; impact energy end-use efficiency; adapt/disseminate technology; finance some R&D. | * Lack of favorable import duties for renewable energy products and components and well as conducive policies to promote renewable energy developments; This is applicable in the three AC. | | |
| 10. Energy equipment O&M services | Provide O&M. Feedback on performance and feasibility | *Syria and Lebanon do not have the availability of a fully skilled and experienced human resource base to support the integration, service and operation of such technologies<br>*Jordan has developed this capacity through its training centers at the Royal Scientific Society and the National renewable Energy Center | CD is needed when RETs are starting to be applied widely. | |
| 11. Credit institutions | Financing options for large- and small-scale energy generation; capital provision for energy using enterprises; financing options for household energy consumers. | *Weak banking system yet. There has been no major financing for renewable energy systems by the Syrian banks although finance can be obtained in theory from some of the banks. | Developing financial mechanisms and instruments to encourage renewable energy manufacture or use by providing credit to consumers, especially rural applications, or even start-up manufacturing ventures. | Medium |
| 12. Civil society / NGOs | Consumer participation and awareness; oversight and monitoring; environmental and social advocacy; equity considerations | *Not effective NGOs and absence of NGO for RETs | Establishing a NGO for RETs | Medium |
| 13. Users | Users of renewable energy systems. Providers of feedback and knowledge about resources, cultural traits, technology performance, friendliness and suitability. | *There are some users of solar heating systems and some others using small wind turbines (10kW). The most users are satisfied with their systems | Interviews with users in media as a promotion measure | Medium |
| 14. Energy specialists and consultant firms | Strategic advice, problem definition and analysis; systems development; specialist services delivery; options analysis; information sharing. | *Very rare because such jobs are not requested | Capacity building of such specialists according to demand | Low |

| Stakeholder | Function/Activities | Capacity Status / Problems | Capacity Development (CD) Measures | Magnitude of CD needs / Priority |
|---|---|---|---|---|
| 15. Academia and research organizations | R&D, knowledge generation, and sharing; formal and informal education; technical training; technology adaptation, application, and innovation. | *Syria: Limited scope for R&D institutions to interface with international bodies and to share expertise already existing within the sector. Research, Development and *Demonstration (R&D) programs in renewable energy have been carried out primarily by the Higher Institute for Applied Science and Technology (HIAST), Ministry of Electricity, Atomic Energy Commission and the Scientific Studies and Research Centre (SSRC). The RD&D in the four Syrian universities have been rather limited, owing to the lack of infrastructure and finances. The RD&D programs have so far focused on solar thermal applications and PV.<br>Lebanon: RD&D is carried out by the American University of Beirut, Lebanese University, Lebanese American University and the National Council for Scientific research. Some research funding is provided by international organization, but is very limited.<br>Jordan: Universities, and National research Centers have developed renewable energy research programs. The problem is making use of the results of the research and making the research more relevant to the community | The scope of the RD&D should be enlarged to include several more renewable energy technologies. The technologies, which are to be included in the RD&D program, should be oriented towards strengthening local industry and research institutions, developing better market information and acquiring operational experience. RD&D programs need to focus on technology adaptation and applications, thereby serving the needs of the countries' renewable energy industry. | Very high |
| 16. Media | Awareness raising, advocacy; information sharing; journalistic inquiry, watchdog functions; monitoring, public transparency. | | Creating mechanisms for the media to provide accurate information on the technical, economic and social viability of RETs to support awareness raising on options that do exist and can be harnessed to address the multiple dimensions of sustainable development | |

### 3.7 Renewable Energy Niches

Success conditions can sometimes be created through appropriate government policy measures or through social awareness. In Jordan the renewable energy industry is more advanced than that in Syria. Lebanon is still lacking behind. There is an urgent need for entrepreneurial policies that will encourage the investments of the private sector in renewable energy and energy efficiency with the help of the public sector and civil societies. This can only be done if it is only complimented with good financial policies and economic instruments.

It is clear from the assessment of renewable energy resources and use as presented in some case studies that renewable energies can play a definite role in providing basic energy needs to the rural areas. Pilot projects in Syria and Jordan on wind energy have been successful with local capacity for installation, operation and maintenance being developed in Jordan. The use of domestic solar water heaters in Jordan is another niche that both Lebanon and Syria can learn from where electricity is accessible and at a low cost. Backup policies by government need to address these issues as will be presented in the recommendation section. Table 9 presents a number of demonstration projects that were a success in Syria.

**Table 9:** Sustainable RETS demonstration projects in Syria

| **Description** | **PV – stand alone** | **Grid connected wind turbines** |
|---|---|---|
| Objective | Demonstrating the feasibility and the applicability of the PV systems in Syria through the comprehensive economic and social analysis before and after the installation of the Photovoltaic systems- | Demonstrating the feasibility and the applicability of the electro-wind systems in Syria |
| Goals | Electrification of 4 villages with a total of 103 households with a total power of 66 KWp | Installation of a wind turbine in a grid connected mode in a promising area |
| **Suitability/Viability/Sustainability** | | |
| Affordability | Low | Low |
| Effectiveness | Medium | Medium |
| Risk of obsolescence | Low | Low |
| Flexibility | Medium | Medium |
| Technological capability | Medium | Medium |
| Suitability and urgency | high | High |
| Resilience | Low | Low |
| Adaptability | Medium | Medium |
| Environmental impacts | Very low | Very low |
| Social acceptance | good | Good |

Table 10 presents another experience for electrification of four villages in Aleppo area using stand-alone systems. The field performance showed a good reliability of the various PV systems used. A valuable know-how was gained by the PV Lab team throughout the execution of the project. The various applications of the installed systems created the training environment for engineers and technicians involved in the project from the government in and NGO's. Later the JICA study team investigated the degree of satisfaction of the residents of the four villages with the overall performance of the systems. The results were as follows: irrespective of generation, a little over 60 % indicated satisfaction. About 25 % were fairly satisfied and less than 9 % were dissatisfied. A lot of work remains to be done regarding the coherent approach towards further involvement of national parties to cover the institutional and financial aspects needed to settle this technology in Syria.

**Table 10:** Assessment of using PV stand-alone system for electrification of 4 villages in Syria

| **JICA Project for electrification of 4 villages by PV stand-alone systems** | |
|---|---|
| **Criteria** | **Description** |
| Objectives | * Demonstrating the feasibility and the applicability of the PV systems in Syria through the comprehensive economic and social analysis before and after the installation of the Photovoltaic systems- |
| Goals | Electrification of 4 villages with a total of 103 households with a total power of 66kWp |
| Results obtained | * The field performance showed the good reliability of the various PV systems. |
| Population target | Rural population; most lives on mountains living at a distance of 3-10 km from grid and 35-80 km from Aleppo |
| Population benefited | 820 |
| Weak points | * Incorporating the PV systems into the national grid<br>* Establishing management and financial system |
| Capacity status assessment of the project stakeholders | Medium |
| Zones | Aleppo region |
| Replicability | Medium:<br>* From this pilot investment the Government of Syria is expected to finance the extension of supply and services to other villages.<br>* Prospects for PV Village Electrification in Syria till 2010 are about 4000 stand-alone systems of 600 WP, 120 mini-grid systems of 10 KWP, 3750 Solar Home systems of 80 WP, and 10,000 Solar lanterns of 10 WP. |
| Potential population benefited | 5000 |
| **Suitability/Viability/Sustainability** | |
| Affordability | Low |
| Effectiveness | Medium |
| Risk of obsolescence | Low |
| Flexibility | Medium |
| Technological capability | Medium |
| Suitability and urgency | high |
| Resilience | Low |
| Adaptability | Medium |
| Environmental impacts | Very low |
| Social acceptance | good |
| Income generation | Medium |

### *3.8 Overall Assessment and Identification of Problems*

The switching to renewable energy resources requires integrated actions for the internalization of external costs, provision for funding of research, development of low emission technologies, and provision of temporary incentives for early market introduction of these technologies. Numerous measures have been taken in planning and implementing rural energy initiatives in Jordan and the Syrian Arab Republic, in contrast rural energy initiatives in Lebanon remain undefined and largely unattended. Energy policies and institutional modifications should be launched to improve energy conditions and achieve rural development.

The level of electrification in rural and poor areas is already high so the cost of RETs should be competitive compared to other energy resources and the electricity supplied by the grid. Affordability of

RETs is essential for the wide spread of the technology in rural communities. RETs are known to usually have relatively high costs compared with other energy technologies, but if initiatives based on fossil fuels are carefully considered and short-tem financial hardships against long-term economic advantages are weighed RETs might be a favorable and affordable solution on the long run.

This strategy can lead to a successful spread of RETs in the productive sector that has higher turnovers than households, and where cash flows are stable allowing affordability of RET maintenance thus leading to the sustainability of these systems. Numerous micro-enterprises that can benefit from RETs exist in rural areas, for example, beer brewing, baking, crop drying, and agro-processing industries that require large portions of mechanized and thermal energies.

Policies that will contribute to poverty alleviation in term of money savings and new business development in poor regions (both rural and suburbs) are summarized as follows:

1. Revise Electricity subsidies in all sectors to change consumers' behavior.
2. Install Electric meters for all households and use better control mechanisms to eliminate theft, particularly in Lebanon.
3. Use more efficient electricity generation technology and use LPG coming from Syria, improve efficiency in electricity distribution lines, and implement an Energy Management plan for the whole country.
4. Encourage, as a first stage, RET technology transfer and later develop it to meet specific needs and then export the technology when it becomes mature.
5. Use economic instruments (tax credit, Reduce initial cost of electric appliances and equipment, etc.) to encourage consumers to buy more efficient and environmental friendly electric appliances and products.
6. New RETs manufacturing should be targeted in rural regions. Governments need to update their infrastructure in rural areas to ensure the successful implementation of such industry. Such industry will not only contribute to energy savings only but also will help in reducing unemployment in poor regions. Rural municipalities in rural areas can play an effective role in policy implementation.
7. Promote the use of renewable energy in water desalination and treatment.
8. Encourage the use of more efficient electrical appliances and fixtures including public, commercial, and households, and when possible, use RETs such solar water heaters. The government should institute a national program to support and encourage energy efficiency in urban areas.
9. More control mechanisms must be instituted to reduce electric theft from government lines and this reduces the electric bill on household.

The government in Jordan is currently working on the necessary regulations, tariff structure, low tax considerations, and incentives to encourage RET utilization and decrease high import and custom duties on RETs. In addition, it is encouraging local manufacturers of these technologies by giving them incentives to make their activities profitable. Lebanon and Syria are in need to improve their tariff structure, in addition to sponsoring and piloting RET projects to introduce the technology to operators, promoters, and consumers.

It is essential to sponsor the local manufacturing and assembling of RETs such as small hydro, wind, and solar equipment e.g. PV for water pumping. Cheap water pumping technologies can increase cattle and crop productivity while utilizing local resources in designing, manufacturing and assembling the water pumps locally.

The transfer or acquisition of RETs know-how and the interests of local entrepreneurs should be protected and supported by a legal framework to guarantee the safety and durability of the imported or locally manufactured RETs. This should be backed in the education system that should provide focus for energy issues, introduce energy training programs, and enhance the engineering and sciences of renewable energy.

## 4 Strategic Policies Outlines

The development of renewable energy resources in Lebanon, Syria, and Jordan can greatly contribute to the socio-economic growth in these countries. First, renewable energy allows for a diversification of energy resources and helps in reduction of use of fossil fuels. Second, the development of renewable energy technologies will assure increased accessibility of available and affordable energy services to contribute in improving the education and health care in many rural areas. Third, renewable energy technology will open many job opportunities for manufacturing, distribution, operation and maintenance, thus create income opportunities. Fourth, renewable energy can play a very strategic role in improving women's situation in Lebanon, Syria, and Jordan. This is achieved by the provision of small electrification systems for households, clinics and schools, such as water pumping and water desalination units. By improving the living conditions in the rural areas, women work, education and health care will all be improved, therefore ensuring balanced services for women, men and children.

The national strategy of the Jordanian Government targets, firstly, the development of local energy resources and technologies to supply 28% of national primary energy by the year 2010 and secondly, the improvement of energy efficiency and encouragement of energy conservation. In this respect, the government adopted a number of policy issues to encourage RE development. It mainly includes the following:

- Development and adoption of RE technologies relevant to Jordan's development needs particularly in remote areas.
- Upgrading R&D local capabilities.
- Increasing designs and production capabilities for RE equipment.
- Building testing facilities for RE equipment.

In Syria, the national strategy target is to save 5% of the country's total energy consumption around 2010 from solar and wind resources. To achieve this strategy the following measures have been considered:

- Coordination of national efforts towards the achievement of the strategy target for RE
- Support of RE market penetration
- Support of R&D, education and training in the field of RE.
- To determine RE potential in Syria
- To direct research and development in the area of RE
- To diversify energy consumption through a better use of available various energy resources.

In Lebanon only policy guidelines encouraging R&D in the renewable energy field have been recorded, which cannot constitute the necessary mechanism towards integration of RE within the overall national energy policies and plans.

The energy sector of Lebanon, Syria, and Jordan has to meet two common policy challenges

1. The need to move to a more sustainable production and use of energy;
2. The need to strengthen links and promote regional and international coordination in the fields.

Therefore, to face the above challenges, the countries should further develop policies and plans, taking into account their national circumstances. Efforts should continue to be directed towards

1. Establishing national and regional agreements for promoting energy accessibility within their countries, and providing the basic needs especially in the rural areas.
2. Developing a cost effective mixed systems that operate on fossil fuels combined with renewable energy sources.
3. Promoting conservation in energy consumption, and sustainable development of both cleaner fuels and more advanced fossil fuel technologies.
4. Taking into consideration the impact of the energy sector on the environment, water distribution/use, and on health.
5. Enhancing regional coordination for energy transfer and investments to achieve an acceptable level of sustainable development.

Several renewable energy technologies are approaching maturity and can be used for small-scale applications as much as it can be used for large-scale applications, in particular, electricity generation. Meanwhile, Lebanon, Syria, and Jordan enjoy the availability of various renewable energy resources such as wind energy, solar energy and biomass.

## 5 Summary of Key Findings and Recommendations

1- Policies for renewable energy development were not sufficiently integrated with the overall energy planning process and objectives.

2- Limited investments were made available for making renewable energy systems affordable to end-users.
3- The limited partnership among different parties in the same country makes it difficult to use renewable energy systems.
4- Lack of awareness among different parties involved in the development and use of the renewable energy resources about the benefits of such technology and the way of improving its use.
5- Limited regional cooperation and financing forces countries to go to foreign financing agencies and technologies.
6- The region proximity to countries that are mainly dependant on oil and gas revenues, there is an apparent false conflict of interest between the oil and gas community in the region and the promotion of renewable energy.

## 6 Suggestions for Future Actions

According to Dincer [45-46] there are many important parameters that can help in successfully achieving sustainable development in many countries around the region. These include public awareness, information, environmental education and training, innovative energy strategies, financing, and evaluating and monitoring tools. Because each country in the region has a different economic, social, and political structures, policies must be devised carefully to fit the specifics of each country. The following are the actions needed to foster renewable energy development:

1- There is a need to develop national strategies and action programs with specific targeted contributions of clean and nonpolluting renewable energy technologies to the total energy consumption.
2- Raise awareness and provide sufficient information for promoting renewable energy systems and sustainable use of energy resources.
3- Promote innovative financing arrangements aimed at reducing up-front costs or equipments with particular attention to the needs of the rural and poor areas.
4- Develop appropriate energy transfer arrangements with enhance national and regional contributions and regional coordination and cooperation through existing mechanisms.
5- Strengthen national and regional institutions that develop, implement and operate programs on renewable energy development and energy for sustainable development.
6- Strengthen human resources development in the area of renewable energy including educational programs at different levels, promotion of training programs for decision makers, engineers and technicians, and development of hands-on experience for specialists and technicians.

## 7 Stakeholders Reaction to Proposed RETS Policy Outline

A stakeholders meeting on renewable energy and energy efficiency policy outline for the region where members from academia, UNDP project managers, together with members from the professional and governmental community interested in energy issues.

1- Generate funds to help low income access to non-intermittent electricity
2- Water access should be dealt with in the same manner as energy, thus applying the same approach can for both water and energy in the planning.
3- To attract the private sector to energy production and distribution, there should be laws and regulations so that the sector can serve in the region. Laws in both Syria and Lebanon are not supportive to make it feasible. Regulations are to be in place to attract investment in the energy industry.
4- There has to be a strategy that includes conservation and renewable energy use in the region. In Jordan, the extensive conservation programs implemented have led to a direct saving in energy estimated at about 80 thousand tons of oil equivalent per year.
5- Much can be learned from Jordan experience in privatization of the energy generation sector as demonstrated by the Jordanian paper and the effect of the reforms on the energy bill of the low income people. All policies are at the bottle neck at funding. Signing the Kyoto Protocol will provide funding mechanisms to Lebanon and Syria. Jordan is already using this fund for energy savings.
6- Rural electrification is not needed, but we need renewable energy for grid connection to cover up supply shortages. We need to have large scale solar hot water systems to reduce use of valuable energy on domestic uses.

7- Attention to the poor will be given in the policy development and legislation. Study of electricity Tariff's will take into consideration the effect of Tariff on the poor and their quality of life. A Current UNDP project is considering the impact on the poor so that poor do not immigrate to cities. The poor and the average population will benefit if performance and energy efficiency is implemented to reduce the production cost in the first place. Privatization is to be implemented.
8- Privatization encourages a more efficient delivery of energy; however its very nature is profit-motivated leading it to ignore by necessity the plight of the poor and "pick the low hanging fruit". Privatization should be accompanied by government programs that ensure the poor receive at least certain minimum access to energy necessary for modern life. Florida's Solar Weatherization Assistance Program can be used as a model for assisting the poor, to be adapted to the Lebanese cultural and social environment.
9- Perhaps a revision/overhaul study of existing hydro installed capacity in Lebanon might be in order to reduce water and energy leakage, and replace inefficient equipment. However, although the installed capacity is reasonable, the value of water for human use may exceed its value as an energy source, and power production may take second priority to irrigation and potable water supply. Other domestic sources such as wind and solar, including concentrating solar, should be investigated and tabulated as part of the resource database.

Characterization of the present situation in Lebanon, Jordan, and Syria and analysis leading to the identification of problems, their magnitude and priority is summarized in Table 11 where the identified problems in the renewable energies sector are presented with stated objectives that present the desired solution and the proposed policy to reach the objectives, in addition to the instruments to implement and articulate the policy outlines with the objectives and the proposed activities and actions to put into practice the selected instruments. The problems are ranked based on priorities as was deduced from the reactions of the energy stakeholders. The instruments and activities are accordingly modified.

**Table 11: RETs – Policy Summary Table (Lebanon – Jordan – Syria)**

| | Problems | Objectives | Policies | Instrument | Activities |
|---|---|---|---|---|---|
| **1** | - The limited coordination and lack of communication among different parties such as renewable energy development bodies, implementers and users, especially in the rural areas, makes it difficult to promote renewable energy systems on a large scale.<br>- Lack of an independent authority in Lebanon in particular that believes in the value of RETs economically and environmentally.<br><br>This problem is not as significant in Jordan where a National Renewable Energy Center is following up on projects related to RETs and its finances. Syria and Lebanon are not as effective in addressing RETs problems. | - To establish or strengthen the authority that oversees the applications of RETs and proposes policies to promote renewable energy technologies and energy conservation practices and regional collaborations.<br>- Coordination between different parties through the proposed central RETs authority to enhance the usage and involvement of RETs in rural areas. | - RETs authority should establish guidelines for resource allocation for RETs to different sectors compile success implementation of RETs projects and provide needed studies for updates or introduction of new energy policies.<br>- Government should update their infrastructure and work closely with the municipalities in rural areas to ensure successful implementation of such industry. Such a policy will not only contribute to energy savings only, but will also help in reducing unemployment in poor regions. | - Create special authorized and trained teams that work locally in rural areas to promote RETs and conservation practices and report continuously to municipals that in turn report to the government. | - Collect feedback from RE users and suppliers of service through surveys, interviews, and evidence based information from municipalities.<br>- Distribute the necessary information for the promotion of RETs. |

| | Problems | Objectives | Policies | Instrument | Activities |
|---|---|---|---|---|---|
| **2** | - Urban areas contribute to major energy waste due to the use of less efficient electrical appliances and fixtures including public, commercial, and households.<br>- Lack of interest of professionals and public to invest in RETs as economically feasible solutions in rural or urban areas. | - To develop guidelines and policies for energy conservation in common waste sources in residential, commercial and productive sectors.<br>- To have in place successful case studies and demonstration projects. | - Introduce Labeling of Appliances and Equipment.<br>- Develop tax incentives for more efficient high quality appliances and fixtures in public, commercial, and household applications, and when possible, use RETs such solar water heaters. Governments should institute national programs to support and encourage energy efficiency in urban areas.<br>- More awareness of people for the efficient use of energy, and thus reducing waste.<br>- Introduce policies that require local testing and certification of local energy products | - The availability of RET appliances and equipment for these urban areas with appropriate labeling, low cost and tax. Incentives.<br>- Encourage people to use more efficient energy appliances.<br>- Finance practical case studies in the various sectors as applicable (examples include PV and small wind turbines for commercial applications).<br>- Presentation and documentation of successful projects<br>- Pilot projects to be used for building the know-how and the expertise to install and operate RETs systems.<br>- Establish or promote funding to have testing and certification centers for energy products including RETs. | - Conduct educational training for professionals and provide guidelines and programs that enhance the energy efficiency awareness of the people in these areas.<br>- Involve higher education institutions in development of curricula and guidelines for efficient energy practices.<br>- Specialized agencies should become available to professionals and personnel working in municipalities and other organizations.<br>- Promote efficient practices using the media and publicizing the economic impact.<br>- Develop financial mechanisms either through governmental banks or private lending organizations to provide credit to research and development programs. |

| | Problems | Objectives | Policies | Instrument | Activities |
|---|---|---|---|---|---|
| **3** | - Lack of knowledge on the economic value of energy in some levels of energy policy makers and lack of knowledge about RETs economic potential in particular. This creates weak links in the chain of policy development and eventual implementation. | - To create the technical and effective knowledge to reinforce the weak links in the chain of policy development from community leaders and representatives to government and legislation bodies.<br>- To disseminate the know how to a wider professional and governmental community. | - All personnel involved in energy policies, energy generation, distribution, utilization should get minimum certification and training on the economic value of energy and periodically update their skills or knowledge.<br>- Involve energy experts in the decision making process with more professional opinions sought. | - Prepare an organizational chart for the energy decision making process in the involved ministries and other stakeholders in the process.<br>- Identify key personnel for training and type of training needed within available resources and with dependence on local expertise to develop and deliver the training. | - Universities and NGOs in cooperation with Governments prepare certification programs for different levels: 1) Policy level (high officials, general directors and strategic planning committees), 2) Professional level (engineers and municipality officers), 3) skilled technicians, 4) audit clerical workers, and 5) business owners and small industry investors. |
| **4** | - Biomass is often used in rural areas for energy supply but the utilization is not efficient and it might not be sustainable. Current practices should be examined especially in Lebanon where the country suffers from the problem of deforestation and substitutes for this kind of resources have to be sought | - More awareness of this renewable energy resource.<br>- Exploitation of biomass energy from solid waste in large scale applications. | - Involvement of governmental and NGOs in research for realizing and development of this energy resource by financing practical economically feasible projects.<br>- Developing partnerships with governmental organizations to help develop the facilities and the know how for utilization of biomass solid waste into an energy resource.<br>- | - The development of integrated waste management systems of recycling, compositing, and land filling.<br>- Limiting or even banning unauthorized utilization of biomass products (especially wood) in rural areas. | - Make use of resource assessment, and R&D projects to construct landfills and upgrade old incinerators to fit international standards.<br>- Introducing small domestic projects like methane gas production for domestic use from house organic waste. |

| | Problems | Objectives | Policies | Instrument | Activities |
|---|---|---|---|---|---|
| **5** | - In Lebanon, control mechanisms are not effectively applied to reduce electricity theft from the electric network. Theft reduction has direct impact on the income of the electric utility and indirectly on the government to reduce public debt. | - To reduce as much as possible electricity theft | - Apply the laws and fines impartially on violators.<br>- Revise electricity subsidies and tariff with focus on reducing hardship for low income people.<br>- Impose fines that are proportional to amount of electricity theft. | - Adoption of a program to cut non-technical losses and to continue to improve collections.<br>- Rehabilitation of the distribution network. | - Collection improvement plan such as increasing the collecting personals.<br>- Supply necessary equipment and meters for stations and substations to assess the amount of energy loss. |
| **6** | - Many locations of the target countries are facing water shortages and fossil water from underground reservoirs are being rapidly depleted. Consequently, the need for desalination units is expanding rapidly. | - Expanding RET applications to be applied in small but numerous desalination projects especially in rural areas. | - Encourage water conservation and tax for use of renewable resources for desalination in rural areas. | - Secure funding on national level to promote research in this domain. | - Demonstrated small scale applications of photo voltaic and wind energy technology in remote off grid areas for desalination projects. |
| **7** | There are limited industrial capabilities and services for promoting renewable energy and energy efficiency programs in Syria and Lebanon. | - Wide spread of the use of RE programs with organized promotion if this technology through industry and public awareness.<br>- Build local and regional capacities and the know how in the field. | - Support of RE market penetration by introducing RETs favorable taxation policies and incentives to customers and to local manufacturers of RETs equipment.<br>- Raise awareness and provide sufficient information for promoting RE systems.<br>- Regional collaboration with Jordan that has a good experience and lessons to learn from. | - Establishment of agencies responsible for the interface with industry investors and the market, such as “Market Coordination Agencies”. | - Thorough study of the market penetration status of RETs.<br>- Introducing incentives to potential customers and manufacturers. |

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## List of Acronyms and Abbreviations

| | |
|---|---|
| AC | Arab Countries |
| A/C | Air Conditioning |
| AUB | American University of Beirut |
| CFL | Compact Fluorescent Lamp |
| CNG | Compressed Natural gas |
| DC | Direct Current |
| DHW | Domestic Hot Water |
| DSWH | Domestic Solar Water Heater |
| DWH | Domestic Water Heater |
| EDL | Electricity de Liban |
| EPU | Executive Privatization Unit |
| ERG | Energy Research Group (American University of Beirut) |
| ESCWA | Economic and Social Commission for Western Asia |
| GDP | Gross Domestic Product |
| GEF | Global Environmental Facility |
| Gg | Gigagram |
| GNESD | Global Network for Sustainable Development |
| GWatt-hr | GigaWatt hour |
| HIAST | Higher Institute for Applied Science and Technology |
| HPC | Higher Planning Council |
| IPP | Independent Power Producer |
| JBCO | Jordan Biogas Company |
| JICA | Japan International Cooperation Agency |
| JBC | Jordan Biogas Company |
| KW | KiloWatt |
| kWH | KiloWatt hour |
| KWP | Kilo Watt Peak |
| LCC | Life-cycle cost |
| LF | Labor Force |
| MEMR | Ministry of Energy and Mineral Resources |
| MEW | Ministry of Energy and Water |
| MOE | Ministry of Energy |
| MSW | Municipal Solid Waste |
| MW | MegaWatt |
| NCSR | National Council of Scientific Research |
| NERC | National Energy Research Center |
| NGO | Non-governmental Organization |
| O&M | Operation and Maintenance |
| PR | Performance Radio |
| PV | Photovoltaic |
| R&D | Research and Development |
| RD&D | Research Development and Demonstration |
| RE | Renewable Energy |
| REO | Renewable Energy Office |
| REP | Rural Electrification Program |
| RERC | Renewable Energy Research Council |
| RET | Renewable Energy Technology |
| RSS | Royal Scientific Society |
| SAC | Syrian private company that manufacture stand-alone wind systems installed for battery charging, water pumping |
| SEC | Supreme Energy Committee |

| | |
|---|---|
| SSRC | Scientific Studies Research Center |
| TOE | Ton of Oil Equivalent |
| TW | TerraWatt |
| UNDP | United Nations Development Program |
| UNFCCC | United Nations Framework convention on climate change |
| USAID | United State Agency for International Development |
| WP | Watt Peak |

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## 8 Background

Sustainable energy development involves problems related to international policy and economic relations, the satisfaction of human needs for hundreds of millions of persons who live in subsistence conditions, the reorganization of the economic structures of countries, problems of availability and depletion of non-renewable energy resources, a better use of renewable resources, the development and large scale application of new technologies, adequate management of the environment, and other equally important factors.

For developing countries this issue is a main and urgent concern, since sustainable development requires more and better energy use. The energy issue has posed a difficult challenge for countries that lack conventional commercial energy resources such as Jordan and Lebanon and places a burden on their national economies due to the relatively high cost of imported oil and the high energy investment needed for economic and social development of these countries.

Renewable energy includes the energy sources that do not consume the resource permanently. These are currents of energy occurring naturally in the environment. These include wind, solar, hydro, geothermal, tides, waves, and biomass.

The development and use of such forms of energy help sustainable development through economic growth and pollution control. The replacement of fossil fuel by renewable and clean forms of energy would relieve the environment from serious types of pollution. Investment in renewable forms of energy would at least partially relieve Jordan, Syria, and Lebanon from burdens of oil imports as well as the creation of new job opportunities for the selected target countries of this study. Despite significant interest in the development of alternative energy sources, their actual contribution to the energy consumption of selected target countries (Jordan, Syria, and Lebanon) is rather limited. In 1993, the share provided by solar water heaters in Jordan (by far the main form of utilization of renewable energy) was between 1.7 and 1.8 %; photovoltaic systems gave 0.0016 %; hydropower provided 0.060%; and wind power contributed 0.007 %. Oil shale, by far the largest indigenous energy resource, did not contribute any power since its development is still at the planning stage. In Syria renewable energy uses consists of pilot projects with limited impact and require governmental and international capital investment.

The challenge is to how to ensure sustainable energy development. Current energy systems are polluting and generally unsustainable, inequity in consumption and access to modern energy is a widespread reality and economic growth is pushing on energy as an essential engine to guarantee future development.

In this report, analysis of the general energy consumptions among all sectors is presented. In addition, major developments in the energy and renewable energy sectors are described. The role of renewable energy technologies in alleviating poverty is also examined. The report is prepared to meet one of the main objectives of the theme on RETs for the provision of concrete policy guidance to identify opportunities and overcome barriers. Furthermore, it will provide a guide as to where and how to engage in the policy dialogue process.

## 9 Rationale and Motivation

The objective of the current work is to perform initial assessment of renewable energies in the selected target Arab countries of Jordan, Syrian, and Lebanon. The work plan follows the renewable technologies theme set by the Global Network for Sustainable Development

(GNESD: www.gnesd.org). According to GNESD, decades of efforts and work to introduce renewable energies in our societies have not succeeded in providing a sustainable provision of renewable energy, particularly to those who need it most. While serious resources have been devoted to the analysis of renewable energies, and to the planning and implementation of projects worldwide with identification of barriers and opportunities, advancement has been limited and negative experiences are numerous.

The initial activity under GNESD was to form a working group of interested centers that would provide a policy guidance tool aimed at relevant stakeholders. As with the "Energy Access" Theme, this theme would address sub-themes such as the role of renewable energy services for poverty alleviation in the context of other tools, household renewable energy services for productive uses, renewable energy services for regional development, and financing mechanisms for renewable energy services.

Within the initial assessment, two main stages are considered. The first stage of the study aims at the identification of the *Demand-side* issues related to the unsatisfied energy needs and the energy sources that can be used. Up-to-date information about the energy uses and frequencies in each country are included in the analysis, considering when possible the urban and rural problems in each case. The second stage will emphasize those aspects related to the renewable technology *Supply-side issues that include* conditions of the supply, local capacity, analysis of the productive chains, environmental impacts, financing, and barriers to use renewable technologies. The objectives of the work include: i) identification of important and relevant energy requirements and to which extent the satisfaction of each of them contributes to poverty alleviation and welfare in the selected target countries; ii) selection of appropriate RETs and assessment of their associated R&D needs; iii) description and analysis of past or potential case studies that have potential impact on poverty; iv) identification of the niches at the national level in the target countries; and v) analysis and assessment of barriers and policies and tools developed to overcome them.

The task of performing the initial assessment by ERG is based mainly on its accumulated experience, its researchers and available literature. The results of the assessment formed the basis for starting the policy consultation process in the region in order to propose policy options and feasible strategies for implementation of renewable energy technologies in the target countries. One of the main objectives of the theme on RETs is the *identification of the contribution of RETs to poverty alleviation and the provision of concrete policy guidance to identify and profit on opportunities and to overcome previously identified barriers and other subtle obstacles acting behind them.* The potential contribution of the aforementioned sources to the improvement of the population's conditions of life will be examined. These outputs will be aimed at policy and decision makers, energy policy analysts, NGOs and researchers. The RETs policy outline has been proposed and stakeholders' reaction has been solicited on the proposed policies and the instruments and activities that will help implement these policies to solve the identified problems in the initial assessment.

# 10 Initial Assessment

## *10.1 Characterization of populations and zones*

The Arab countries (AC) are spread over a vast region extending from west Asia through North Africa. Many AC still have a significant proportion of their population live in rural and remote areas. In the ESCWA region, for instance, the high-income countries are 80% urbanized, with a large percentage of the population living in cities and towns. The rate of urbanization in the middle-income and low-income countries is 50% and 40%, respectively [1-2]. A factor that affects rural development in AC is the restricted and expensive supply of energy, a matter that asserts the importance of renewable energy development as an essential option for sustainable development in the region [3-4].

On the other hand, global environmental issues such as Climate Change still have low priorities compared to national economic development and growth in AC. Over 180 nations have already ratified the UNFCCC since it was adopted in the Rio Summit. Apart from Iraq and the Palestinian Authority, all AC have signed the treaty on the convention and have been classified as Non-Annex I Parties.

Jordan lies in the Middle East within latitude 29°11 and 33°22 north and longitude 34°59 and 39° east. The total area of the kingdom is 89,500 $Km^2$ (55900 $miles^2$). The climate is mostly arid desert with a rainy season in the west (November to April). At the end of 2002, the population of the kingdom was 5.329 million compared to 5.182 million at the end of 2001, i.e. a growth of about 2.8%. Eighty percent of the population occupies 20% of the total Kingdom area whereas the rest live in the remaining 80% of land [5].

The Syrian Arab Republic lies on the eastern coast of the Mediterranean Sea within latitude 32.3° and 37° north and longitude 36° and 42.4° east Greenwich. The total area of the Syrian Arab Republic is 185,517.971$Km^2$: 60,000 $Km^2$ is arable land whereas the rest consists of mountains (2500-1100m) and deserts. The climate is mostly desert hot with dry sunny summer days (June-August) and mild rainy winters (December to February) along the coast and cold weather with cold or sleet periodically in Damascus. The population of the Syrian Arab Republic in the middle of year 2002 was 17.13 million distributed as follows: urban population 50.2% and rural population 49.8% [6].

Lebanon is located on the eastern shores of the Mediterranean Sea between the North Latitudes 33° 03’ 38’’ and 34° 41’ 35’’ and East Longitudes 35° 06’ 22’’ and 36° 37’ 22’’ between Syria and Occupied Palestine. Lebanon covers an area of 10,452 $Km^2$ of which arable land constitutes 18.6 %. The climate in Lebanon is Mediterranean; mild to cool with wet winters and hot, dry summers. The Lebanese Mountains experience heavy winter snows. The population of Lebanon in July 2003 was 3.727 million with 90% residing in urban areas with Beirut housing nearly half of the country’s population [7-9].

Table 1 shows the land total area, population, population per square meter, rural distribution, and population growth in Jordan, the Syrian Arab Republic, and Lebanon for the year 2002 [5-7].

Table 1: Land area, population size, and population per square meter, rural distribution and growth of Jordan, Syrian Arab Republic, and Lebanon in 2002 [5 - 7].

| Country | Area ($Km^2$) | Total Population (in thousands) | Population per square kilometer | Percentage rural (%) | Annual Population growth (%) |
|---|---|---|---|---|---|
| Jordan | 89,500 | 5,239 | 59 | 20 | 2.8 |
| Syrian Arab Republic | 185,517 | 17,130 | 92 | 49.8 | 3.1 |
| Lebanon | 10,452 | 3,596 | 344 | 10 | 1.8 |

Jordan has a market-oriented free economy, where ownership of business entities is largely private. The main earners of foreign currency for the Kingdom are expatriate remittance, exports and tourism. Jordan's economy is service-oriented. The remaining third is contributed by the agricultural and industrial sectors. In 2002, the GDP was US$ 9.295 billion at current prices achieving a growth of 3.5% since 2001.

The economy of Syria relies mainly on oil production and export, agricultural products such as cereals, cotton, and fruits, in addition to tourism. The gross domestic product for year 2001 at current market prices of year 2002 was US$ 21.871 billion, thus, achieving a growth of 3.5% since year 2001. For the year 2000, the main economic sectors contribution to the GDP is agriculture (26%), and industry and export (27%).

The Lebanese economy is an open economy where the services and banking sectors predominate, constituting 67% of the country's gross national product. Agriculture constitutes 12% and the industrial sector constitutes the remaining 21%.
Table 2 provides the GDP, GDP growth, and GDP per capita for the three countries for the year 2002. Table 3 shows the composition of the GDP according to the main economic sectors [5-7].

Table 2: GDP, GDP growth, and GDP per capita in Jordan, Syria, and Lebanon (2002) [5-7]

| Country | GDP *(billion US$)* | GDP (real growth rate) | GDP /capita |
|---|---|---|---|
| Jordan | 9.295 | 3.5% | $1,797 |
| Syrian Arab Republic | 21.871 | 3.5% | $1,067 |
| Lebanon | 19.3 | 1.5% | $4,240 |

Table 3: GDP composition by sector (2001) [5-7]

| Country | Agriculture | Industry | Services |
|---|---|---|---|
| Jordan | 3.5% | 27% | 69.5% |
| Syrian Arab Republic | 27% | 23% | 50% |
| Lebanon | 12% | 21% | 67% |

### 10.1.1 Poverty and energy status in rural areas

Population growth and poor economic performance in both developed and developing countries has increased poverty and environmental degradation in these countries. Half the world lives on $2 a day or less [10]. Ending poverty has been an international aim since 1960. After significant advances between 1970 and 1990, the rate of poverty reduction in the 1990s fell to only one third of the pace required to meet the United Nations' commitment to halve poverty levels by 2015 [11].

In Jordan, the percentage of rural population provided with electricity was 99.8 at the end of the year 2002. The government is working on providing the rest of the residential areas in the Jordanian countryside with electricity through the Rural Electrification Program. The latter is financed via taxation of electricity bills. Also important to note that some residential areas in the Kingdom were provided with electricity by solar cell systems with the help of the National Energy Research Center [12]. There is a PV village electrification system in remote areas with system capacities varying from 1 KWp to 4.5 KWp. Water pumps for Bedouins with capacities varying between 1.4 to 6.3 KWp per system have been installed [4].

In Syria, there is a general orientation to develop the countryside socially and economically and decrease migration to urban areas. A strategy was followed aiming at providing the Syrian remote and rural areas with electricity. Through the activities of the Energy Planning and Conservation Project, statistics have been collected to help develop rural areas and increase the utilization of sustainable energy systems. The main energy resources in rural areas are wind, solar and biomass resources in addition to liquefied gas and kerosene [13]. There is a PV pumping system of 3.25 KWp capacity currently used to lift 120 $m^3$/day of water at 43 m head in Dummar near Damascus, in addition to a 5 kW PV-pumping and desalination station. PV village electrification was demonstrated in 1994 in two villages totaling 6.35 KWp capacities. Additionally, a PV home electrification system of 35 KWp-capacity is used to supply 44 houses in the village of Zarzita in Aleppo and individual stand-alone PV systems used to supply electricity to 65 houses in certain villages in Aleppo were successfully demonstrated [13].

In Lebanon, rural areas are for the most supplied with energy and have access to other commercial energy resources. Some Palestinians refugee camps are not paying for their electricity bills thus presenting a burden on the already difficult financial status of the Electricity De Liban (EDL) which the government seeks to privatize. The high energy cost in the country is burdening low-income families that sometimes rely on electricity theft to supply their needs [14]. Total losses in the electric power system in Lebanon amounted to 55% (15% technical and 40% non-technical) of the electricity generated in 1997 and reached 68% in 1994 [15]. In 2002, the non-technical losses dropped to 23% with improved measures for bill collection and penalties on theft of electricity [16].

Table 4 presents poverty and social indicators in Lebanon, Syria, and Jordan. The poverty in these countries ranges between 20 and 30 percent of the population with an average annual population increase between 1.4 and 3 percent. The poverty percentage is based on an income between $10-12/day [17-18]. Even though Lebanon has a higher percentage of population living in urban areas, all three countries have developed poor neighborhoods that are heavily dense. In addition, these countries host on their territories thousands of Palestinian refugees who live in poorly managed camps often located on the outskirts of major cities. This puts pressure on the already poor existing infrastructure especially that the camp population in Lebanon (approximately a population of 500,000) does not pay for electric energy services.

The World Bank Poverty Assessment for Jordan (1994) outlines both headcount index (percentage of the population whose expenditure falls below the poverty line) and a poverty gap index (the additional money that the poor individual needs to reach the poverty line). The study concludes with a profile of the poor and makes correlation between large household size and large number of young children, low wages and agricultural work, illiteracy and work. According to the 1996 Living Conditions Survey, pockets of poverty are expanding in the urban areas of the Governorate of Amman, lrbid and Zarqa while in more rural Governorate of the south as Mafraq, Karak, Balqa and Ma'an, the incidence of poverty is higher. Over 400,000 people –about one Jordanian in ten -live in low-income urban areas -28 squatter settlements and 13 refugee camps. (These areas are characterized by lower living standards than other higher income areas with regard to conditions of housing roads, water supply and sanitation, health facilities, schools). The physical infrastructure serving the rural poor is deficient, though the dispersed nature of poverty makes it less apparent. This indicates that while poverty has to be addressed in rural areas, there is an increasing demand for services and social assistance in urban areas as well. The social community network in rural areas can function as "a safety net" while in urban areas families and communities are broken up [12]. For an average family of 6.8 persons, the severe poverty line for Jordan in 1993 prices was estimated at $85 per month per household [19].

The Government's policy in Jordan to alleviate rural poverty has shifted from assistance policy providing cash or in kind assistance towards a development policy promoting local self-reliance. The Government of Jordan has developed an extensive and multi-faceted social safety net supported by the government and non governmental organizations. This strategy has progressively oriented its activities to grass-root and welfare associations, which are now recognized as the potential community beneficiaries [12]. According to the Jordanian Ministry of Social Development, 5.3% of Jordanian families are severely poor and 18.3% are poor. The highest incidence of severe poverty was estimated for Karak (8.2%), and the lowest for Amman (3.8%). As for absolute poverty, the highest incidence of poverty was estimated for Mafraq (23.8%) [19].

The characterization of population by zones in each of the target country is outlined in *Appendix A* where tables of rural population characterization are provided by zone and income. The zones are defined by various governmental districts. Similarities do exist whereby capital cities have higher income families with much of the low income concentrated in rural areas. In Lebanon for example the low income population (less than $10/day) is 5.8% of the total population, while in the south and north, the low income percentage is 10.5 and 8.5% of the total, respectively. In Syria, eight of the fourteen zones have rural population above 60%. These zones have higher population growth compared to the country average.

Table 4: Poverty and Social Indicators

| Country | Lebanon | Syria | Jordan |
|---|---|---|---|
| Average annual growth, 1996-02 | | | |
| Population (%) | 1.4 | 2.5 | 3 |
| Labor force (%) | 2.6 | 4 | 4 |
| Most recent estimate (latest year available, 1996-02) | | | |
| Poverty (% of population below national poverty line) | 28 | 25 | 30 |
| Urban population (% of total population) | 90 | 52 | 79 |
| Life expectancy at birth (years) | 71 | 70 | 72 |
| Infant mortality (per 1,000 live births) | 26 | 23 | 25 |
| Child malnutrition (% of children under 5) | 3 | N/A | 5 |
| Access to an improved water source (% of population) | 100 | 80 | 96 |
| Illiteracy (% of population age 15+) | 13 | 24 | 9 |
| Gross primary enrollment (% of school-age population) | 99 | 109 | 101 |
| Male | 101 | 113 | 101 |
| Female | 97 | 105 | N/A |

Sources: World Bank (www.worldbank.org) and USDS (www.usds.gov).

Rural population densities are generally low and the cost of energy supply is high compared with densely populated areas. All three countries should adopt development policies that will reverse the population migration from rural to urban areas, sustain good economic growth, and reduce negative environmental impact. This should result in poverty reduction.

Options for decentralized electrification either through diesel or renewable energy resources should be evaluated. Renewable energy has distinct advantages over diesel as it has much lower running costs, uses local energy resources, does not run out, is cleaner and thus, does not contribute to global warming. For many remote areas, RETs offer cost-effective and competitive supply options that may contribute to offering access to modern energy services.

## *10.2 Needs and Energy requirements*

### 10.2.1 Country General Energy Status

Today, over two billion people in the developing world have no modern energy services. Energy is essential for human society, economics and social development in general, and in far poor rural areas in particular. It powers industries and provides residential and social services, but if current trends of fossil fuel consumption continue the world will face the prospect of a climatic catastrophe. This is primarily caused by the industrialized world's fossil fuel consumption. However, developing country emissions are also rising quickly. Energy is fundamental to the great challenge facing the world: how to eliminate poverty without further polluting the planet or worsening climate change.

Electricity production in Jordan, Lebanon and Syria is still predominantly based on thermal power plants, primarily using fuel and gas oil. Syria has a fair proportion of hydroelectric resources on the Euphrates. Lebanon has several small hydroelectric facilities the bulk of which are on the Litani in the Bekaa valley. The tendency to move towards natural gas utilization is increasing due to the economic and environmental benefits of natural gas especially that gas networks are becoming increasingly available in Syria and Jordan. The installed capacities for the year 2001 in Jordan, Syria and Lebanon were 1657 MW, 6804 MW, and 2225 MW, respectively. The total energy consumption and forecast in Jordan, Syria, and Lebanon (Table 5a) shows a continuous increase in energy demand in the three countries, which brings up the challenge to find ways to manage this increase. Table 5b shows the energy production and use, and GDP per unit energy use.

Table 5a: Electric Energy Demand and Forecast (GWh) in Jordan, Syria, and Lebanon

| Country | 1 995 | 2 000 | 2005 | 2010 | 2015 |
|---|---|---|---|---|---|
| Jordan | 4 778 | 5 810 | 7 596 | 8 849 | 10 159 |
| Lebanon | 5 484 | 8 630 | 10 284 | 12 512 | 14 087 |
| Syria | 14 661 | 2 0580 | 32 843 | 44 366 | 59 372 |

Table 5b: Commercial energy production, use and GDP per unit of energy use (2003)

| | Jordan | Syria | Lebanon |
|---|---|---|---|
| Commercial energy production (kt of oil equivalent) | 286 | 32,889 | 170 |
| Commercial energy use (kg of oil equivalent) | 5,185 | 18,407 | 5,058 |
| GDP per unit of energy use (PPP $/kg of oil equivalent) | 3.603243 | 2.8836 | 3.5487 |

Sources: World Development Indicators Database 2003

ESCWA studies have shown that the residential, industrial, and transport sectors were the highest end-use consumers in the ESCWA region [4]. The energy requirements in the residential, productive, transport and social sectors are discussed below.

#### 10.2.1.1 Residential

Although electricity consumption in this sector does not have a market value, it is indispensable for many activities in the household. This sector is considered a large consumer of energy, in particular, electric energy. Energy consumption trends vary in each country depending on its geographic, meteorological, economic, social, population, and living conditions. With the increase in energy production cost, household energy management should be practiced in addition to seeking new cheaper options to provide energy. Energy in households is used for lighting, television, reading, water heating, air conditioning, cooking, and other activities. Usually electricity is too expensive for cooking in rural and poor communities, so it is mainly used for lighting, radio, and television while 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.

In 2001, residential electricity consumption in Jordan was 2110 GWatt-hr which is 31% of the total electricity consumption in the kingdom (Appendix A provides tables on domestic energy requirements). The percentage of rural households provided with electricity was 99.8% through the Rural Electrification Program [20]. The government works on providing the rest of the Jordanian countryside with electricity. It is also important to note that some residential areas in the kingdom were provided with electricity by solar cell systems. Almost, 99% of Jordan population receives electricity. The electricity tariff is constructed to be at low cost to the poor. This can be shown by the Tariff of the first block for ordinary costumers. The range stretches from 4.5 cents to 12 cents/KWH as shown in Table 6a for the residential sector [17]. Table 6b shows the number of residential consumers during the period of 1991-2001.

Table 6a: Electricity Tariff for Residential Consumers (1 fils = 0.14 cent ($0.0014))

| Block Number | Amount | Cost |
|---|---|---|
| First block | 1 - 160 KWH | 31 Fils/KWH |
| Second block | 161 - 300 KWH | 55 Fils/KWH |
| Third block | 301 - 500 KWH | 64 Fils/KWH |
| Fourth block | above 500 KWH | 80 Fils/KWH |

Table 6b: Number of residential consumers in thousands.

| | **1991** | **1992** | **1993** | **1994** | **1995** | **1996** | **1997** | **1998** | **1999** | **2000** | **2001** |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Household | 448 | 469 | 495 | 525 | 553 | 586 | 616 | 644 | 686 | 715 | 756 |

The Syrian residential sector consumption was 9668 GWH in 2002. In rural areas, 96.69% of households are connected to the electricity grid. Some families use diesel and kerosene for their energy needs. The ministry of electricity is committed to provide villages and farms with light. The main energy resources in rural areas are liquefied gas and kerosene in addition to fuel oil. In rural areas, diesel is used for heating (99.4%) and water heating (41.6%). Kerosene is used for cooking, water heating, and lighting (67.19%). Some families use wood and other biomass products. No solar heaters are domestically used in rural areas due to their relatively high prices [21]. Table 7a presents a summary of the residential energy requirements of the rural population in the Syrian Arab Republic and Table 7b gives the average electricity tariff and the life line tariff up to year 2002. The electricity tariff in Syria is far below those of Jordan and Lebanon, since Syria produces its own needs of fuel.

Table 7a: Summary of the residential energy requirements in Syrian Arab Republic

| **Category** | **Type of requirements** | **Energy requirements** Annual kWh/capita | **Group** | **Priority** |
|---|---|---|---|---|
| Residential | Lighting | 210 | Rural | High |
| | TV | 50 | | High |
| | Refrigerator | 130 | | High |
| | Washing machine | 45 | | Medium |
| | Iron | 6 | | Low |
| | Kitchen equipment | 65 | | Medium |
| | Vacuum cleaner | 8 | | Low |
| | Miscellaneous | 50 | | |

Table 7b: Electricity Tariff in Syrian Arab Republic

| **Indicators** | Unit | **1996** | **1997** | **1998** | **1999** | **2000** | **2001** | **2002** |
|---|---|---|---|---|---|---|---|---|
| Average Electricity tariffs (Current $) | USc/KWH | 1.547 | 1.426 | 1.396 | 1.367 | 1.340 | 1.314 | 1.673 |
| Lifeline tariff | USc/KWH | 1.087 | 1.064 | 1.042 | 1.02 | 1.00 | 0.980 | 0.962 |
| Lowest tariff class | KWH | 50 | 50 | 50 | 50 | 50 | 50 | 50 |

In Lebanon, the energy bill has become a considerable burden on the economy both at the national and household levels due to a large use of energy consuming appliances making electricity consumption in the residential sector around 50% of total electric energy supplied. Of total household electricity consumption, water heaters consume around 22%, and the $CO_2$ contribution to the environment of this sector is 534.25 Gg. There are no special plans concerning supplying rural households with energy [22]. The analysis of the electricity structure and consumption for both residential and commercial sectors is based on a study done in 1998 for Lebanon [23]. From this analysis, the most consuming equipment ,which represent 80% of the total electricity consumption, are reported as: electric heaters (for space heating) 31%; electric domestic hot water systems 22% (same terminology is used for hot water used for sanitary purposes in commercial & residential sectors); Air conditioning A/C 13%; Lighting 8.5%; Refrigerator 6%. Table 8a presents the structure of low voltage electricity demand for household equipment residential and commercial [14], Table 8b presents the electricity demand in the residential sector in Lebanon for energy efficiency scenarios at 3% growth rate and 6% growth rates [14], and Table 8c presents the Tariff currently used by EDL for residential consumers [24]. The average residential subscriber consumes about 450 KWH [4] and thus pays a total of about $30/month. This may not represent the total energy bill paid by the Lebanese residents. Despite significant improvements to the electricity distribution network since 1993, power shortages and rationing are still widespread, particularly during summer and following major storms. As a result, people have reverted to alternative power supply systems as backup UPS systems for computers and private power generators. Neighborhood power generators are back in business and supply electricity to subscribers *informally*. In 1996-97, nearly 10 percent of all buildings were equipped with private power generators (mostly in Beirut (13.8% and Mount Lebanon 11.6%) [25]. Appendix A has detailed tables of residential energy requirements with the use of possible energy efficient and RETs scenarios [26]. The average household family size in the greater Beirut area (where 30% of the population of Lebanon lives) is 4.1 compared to the maximum of 5.5 in the Northern rural area [27].

Table 8a: Structure of low voltage electricity demand for household equipment residential and commercial

| Equipment | Number in thousand | Unit consump. in kWh | Total consump. in Tj | Number in thousand | Unit consump. in kWh | Total Consump. in Tj | In Tj | In % | Total $CO_2$ in Gg |
|---|---|---|---|---|---|---|---|---|---|
| Lighting | 720.8 | 371.5 | 964.0 | 201.4 | 432.0 | 313.2 | 1277.2 | 8.5 | 78.1 |
| Refrigerator | 720.8 | 342.1 | 887.7 | 201.4 | 51.8 | 37.6 | 925.4 | 6.2 | 56.6 |
| Freezer | 720.8 | 77.8 | 201.9 | 201.4 | 36.3 | 26.3 | 228.2 | 1.5 | 13.9 |
| Iron | 720.8 | 205.2 | 532.5 | 201.4 | 0.0 | 0.0 | 532.3 | 3.6 | 32.5 |
| Extractor | 720.8 | 34.2 | 88.7 | 201.4 | 27.0 | 19.6 | 108.4 | 0.7 | 6.6 |
| Electric oven | 720.8 | 54.0 | 140.1 | 201.4 | 36.0 | 26.1 | 166.4 | 1.1 | 10.2 |
| Electric boiler | 720.8 | 29.7 | 77.1 | 201.4 | 27.0 | 19.6 | 96.5 | 0.6 | 5.9 |
| Laundry washer | 720.8 | 97.2 | 252.2 | 201.4 | 27.0 | 19.6 | 271.7 | 1.8 | 16.6 |
| Hair dryer | 720.8 | 8.1 | 21.0 | 201.4 | 0.0 | 0.0 | 21.0 | 0.1 | 1.3 |
| Radio | 720.8 | 18.6 | 48.3 | 201.4 | 4.3 | 3.1 | 51.5 | 0.3 | 3.1 |
| TV B/W | 720.8 | 17.6 | 45.7 | 201.4 | 2.9 | 2.1 | 47.7 | 0.3 | 2.9 |
| TV color | 720.8 | 103.7 | 269.1 | 201.4 | 17.3 | 12.5 | 281.6 | 1.9 | 17.2 |
| Table fan | 720.8 | 18.6 | 48.3 | 201.4 | 43.2 | 31.3 | 79.4 | 0.5 | 4.9 |
| Roof fan | 720.8 | 10.5 | 27.2 | 201.4 | 16.2 | 11.7 | 38.9 | 0.3 | 2.4 |
| A/C | 720.8 | 540.0 | 1401.2 | 201.4 | 810.0 | 587.3 | 1988.5 | 13.3 | 121.5 |
| DWH | 720.8 | 1166.4 | 3026.7 | 201.4 | 324.0 | 234.9 | 3261.5 | 21.8 | 199.3 |
| Electric heater | 720.8 | 1296.0 | 3363.0 | 201.4 | 1800.0 | 1305.1 | 4668.1 | 31.2 | 285.3 |
| Other household | 720.8 | 0.0 | 0.0 | 201.4 | 1296.0 | 939.7 | 939.5 | 6.3 | 57.4 |
| Total | 720.8 | 4391.2 | 11394.6 | 201.4 | 4951.0 | 3589.7 | 14984.3 | 100.0 | 915.7 |

Table 8b Electricity demand in the residential sector in Lebanon: energy efficiency cases ($10^6$ Gigajoules) (3% low growth rate and 6% high growth rates scenarios) [14]

| Year | 1994 | | 2005 | | 2015 | |
|---|---|---|---|---|---|---|
| | Low Case | High Case | Low Case | High Case | Low Case | High Case |
| Solar DHW ** | 0.00 | 0.00 | 0.39 | 0.57 | 1.26 | 1.16 |
| Electric DHW | 3.09 | 3.09 | 10.29 | 10.49 | 10.3 | 11.88 |
| Refrigerator | | | | | | |
| Classic Ref | 0.90 | 0.90 | 2.21 | 2.19 | 2.45 | 2.10 |
| Efficient Ref | 0.00 | 0.00 | 0.35 | 0.48 | 2.65 | 0.91 |
| Freezer | 0.20 | 0.20 | 0.81 | 0.97 | 1.11 | 1.30 |
| Iron | 0.54 | 0.54 | 1.54 | 1.63 | 2.01 | 2.01 |
| Extractor | 0.09 | 0.09 | 0.17 | 0.18 | 0.22 | 0.23 |
| Electric Oven | 0.14 | 0.14 | 0.33 | 0.44 | 0.49 | 0.62 |
| Electric Kettle | 0.08 | 0.08 | 0.07 | 0.07 | 0.05 | 0.05 |
| Laundry Washer | 0.25 | 0.25 | 0.95 | 1.03 | 1.40 | 1.49 |
| Electric Heater | | | | | | |
| Convectors | 3.38 | 3.38 | 3.42 | 3.42 | 2.67 | 2.67 |
| A / C Cool | 0.07 | 0.07 | 0.10 | 0.11 | 0.13 | 0.14 |
| A/C Cool + Heat | 0.80 | 0.80 | 3.67 | 4.13 | 4.89 | 5.37 |
| Roof Fan | 0.03 | 0.03 | 0.05 | 0.05 | 0.06 | 0.06 |
| Table Fan | 0.05 | 0.05 | 0.05 | 0.05 | 0.06 | 0.06 |
| TV Color | 0.27 | 0.27 | 0.43 | 0.46 | 0.57 | 0.57 |
| TV B / W | 0.05 | 0.05 | 0.02 | 0.02 | 0.00 | 0.00 |
| Radio | 0.05 | 0.05 | 0.06 | 0.06 | 0.06 | 0.06 |
| Lighting | | | | | | |
| Incandescent | 0.88 | 0.88 | 0.86 | 0.79 | 0.77 | 0.62 |
| CFL * | 0.00 | 0.00 | 0.03 | 0.04 | 0.05 | 0.06 |
| Total | 10.88 | 10.88 | 25.88 | 27.26 | 29.32 | 31.48 |

* CFL: Compact fluorescent lamp

** DHW: Domestic hot water used for sanitary purposes in residential and commercial sectors

Table 8c: Tariff currently used by EDL for residential consumers (based on $1 = 1507 L.L. of Lebanese currency)

| Consumption fraction (KWH) | 0-100 | 101-300 | 301-400 | 401-500 | >500 |
|---|---|---|---|---|---|
| Cost (cents/KWH) | 2.33 | 3.67 | 5.33 | 8 | 13.3 |

#### 10.2.1.2 Productive

In Jordan, much manufacturing activity is related to exploitation of natural resources and to the mining sector. Ninety percent of both small and large manufacturing entities are concentrated in the north industrial belt. The main productive activities are petroleum refining, fertilizer, potash, iron, steel, and fabricated metal products, in addition to smaller industries such as publishing, glass and rubber products, electrical equipment, and machinery. In 2001, the Jordanian industrial sector consumed 2024 GWatt-hr whereas the commercial sector consumed 880 GWatt-hr, thus representing 32% and 14% of the total electricity consumption in the kingdom, respectively. In 2001, water pumping consumed 981 GWatt-hr, which is 15% of the total electricity consumption. The electricity Tariff for productive activities that are subsidized in Jordan is given in Table 9 [5].

Table 9: Electricity Tariff for the Productive Sector in Jordan (1 Fils = 0.14 cent ($0.0014))

| Type | Constraint | Cost |
|---|---|---|
| Commercial | | 62 Fils/KWH |
| Small Industries | | 38 Fils/KWH |
| Medium Industries | Day energy | 35 FILS/KWH |
| | Night energy | 25 FILS/KWH |
| | Peak demand | 3.05 JD/KW/Month |
| Agriculture | | 26 Fils/KWH |
| Water Pumping | | 38 Fils/KWH |
| Radio and TV Stations | | 60 Fils/KWH |
| Hotels | | 60 Fils/KWH |
| Street Lighting | consumption that exceeds the Average level of 1988 consumption | 25 Fils/KWH |

In 2002, the productive sector in the Syrian Arab Republic consumed energy as follows: industry 886 thousand tons, commercial and construction 797 thousand tons, petroleum transport and refining thousand tons, agricultural sector thousand tons. Therefore, the productive sector represents 34.35% of the total energy consumption of 12,051 thousand tons. Nearly 75% of the total export revenues are from oil and oil products [20].

The industrial sector in Lebanon consists of small-scale industries primarily involved in light manufacturing. The industries range from those that transform raw material into a more refined form to those that produce highly finished products. Energy consumption for heat and power generation in the manufacturing industries amounted to $39.67 \times 10^6$ GJ in 1994, thus amounting to 70% of the total industrial GHG emissions where the cement, asphalt, and steel production are responsible for upwards of 98% industrial processes related GHG emissions [28]. The energy bill of industries in Lebanon is already high compared to regional electricity tariffs and there is an urgent need to provide cheaper energy for industries to help in their development by this boosting the economy, while at the same time providing a cleaner and healthier environment. The electricity Tariff has a flat rate of 9.3 cents/KWH for the public sector and 7.6 cent/KWH for the small industries and the agriculture sector. The industrial sector in Lebanon suffers from low efficiency in the use of energy. The mechanisms for improving efficiency were recognized as part of the climate change mitigation study for Lebanon and are classified into [14]:

1- Reduction of Energy Intensity in the separate process steps, which include conservation, process change or use of efficient devices.

2- Energy source switching which refers to electricity generation fuel source, and the potential for co-generation and use of renewable energy in processes that require low quality heating in the food industry.
3- Development of a loan system for credit sales on energy performing equipment at low rates for the industrials, contractors and consumers.
4- Integration in the energy pricing the notion of the "environmental cost".

The commercial sector energy needs and future projections in Lebanon were reported as part of the final report of Lebanon on climate change [14] and its mitigation. High and low growth scenarios for energy demand have been reported using efficient systems and integrating when possible RETs as given in table 10.

Table 10: Electricity demand in the commercial sector: energy efficiency cases ($10^6$ Gigajoules) (3% low case growth rate and 6% high growth rates scenarios) [14]

| Year | 1994 | | 2005 | | 2015 | | 2040 | |
|---|---|---|---|---|---|---|---|---|
| | Low Case | High Case | Low Case | High Case | Low Case | High Case | Low Case | High Case |
| Other Household | | | | | | | | |
| Photocopier | 0.94 | 0.94 | 3.27 | 4.11 | 5.44 | 9.12 | 11.83 | 40.66 |
| Electric Heater | | | | | | | | |
| Convectors | 1.31 | 1.31 | 1.52 | 1.91 | 0.68 | 1.14 | 0.00 | 0.00 |
| D.H.W. ** | | | | | | | | |
| Electric DHW | 0.24 | 0.24 | 1.52 | 1.80 | 4.03 | 4.82 | 4.83 | 11.09 |
| Solar DHW | 0.00 | 0.00 | 0.06 | 0.10 | 0.39 | 1.10 | 2.68 | 10.54 |
| A/C | | | | | | | | |
| A/C Cool + Heat | 0.33 | 0.33 | 2.03 | 2.56 | 3.48 | 5.83 | 8.33 | 28.61 |
| A / C Cool | 0.03 | 0.03 | 0.05 | 0.07 | 0.09 | 0.15 | 0.22 | 0.75 |
| Electric Proof | 0.01 | 0.01 | 0.03 | 0.04 | 0.04 | 0.07 | 0.08 | 0.28 |
| Table Fan | 0.03 | 0.03 | 0.02 | 0.03 | 0.02 | 0.03 | 0.03 | 0.11 |
| TV Color | 0.10 | 0.01 | 0.13 | 0.16 | 0.20 | 0.34 | 0.44 | 1.51 |
| TV B / W | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Radio | 0.00 | 0.00 | 0.02 | 0.02 | 0.03 | 0.04 | 0.05 | 0.19 |
| Laundry Washer | 0.02 | 0.02 | 0.11 | 0.13 | 0.18 | 0.30 | 0.41 | 1.41 |
| Electric Kettle | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.03 | 0.04 | 0.15 |
| Electric Oven | 0.03 | 0.03 | 0.10 | 0.12 | 0.19 | 0.32 | 0.39 | 1.36 |
| Freezer | 0.03 | 0.03 | 0.14 | 0.18 | 0.38 | 0.63 | 1.15 | 3.95 |
| Refrigerator | | | | | | | | |
| Classic Ref | 0.04 | 0.04 | 0.55 | 0.64 | 1.00 | 1.55 | 1.63 | 4.47 |
| Efficient Ref | 0.00 | 0.00 | 0.09 | 0.14 | 0.28 | 0.52 | 0.99 | 4.07 |
| Lighting | | | | | | | | |
| CFL * | 0.00 | 0.00 | 0.01 | 0.02 | 0.03 | 0.05 | 0.08 | 0.34 |
| Incandescent | 0.29 | 0.29 | 0.38 | 0.44 | 0.39 | 0.53 | 0.41 | 0.57 |
| | | | | | | | | |
| Total | 3.32 | 3.32 | 10.05 | 12.51 | 16.86 | 26.58 | 33.61 | 110.00 |

* CFL: Compact fluorescent lamp
** DHW: Domestic hot water used for sanitary purposes in residential and commercial sectors

#### 10.2.1.3 Transport

In Jordan, the transport sector plays an important role in the economic and social development. All transport vehicles in urban and rural areas operating on fuel oil products (Benzene and Diesel) are considered to be a source of global warming gases. In 2002, the final energy consumption of the transport is in continuous increase where in 2001 it was 1411 thousand tons and in 2002 it was 1435, i.e. an annual increase of 1.7%. This consumption is a burden on the economy and the environment, and the government tries to promoting car sharing to decrease fuel consumption in addition to improving traffic flow systems, and working on using higher quality fuel by introducing unleaded gasoline and limiting the percentage of Sulfur in Diesel [29].

In the Syrian Arab Republic, the transport sector consumed 2774 thousand tons of final energy. Studies have been prepared to implement an experimental project in Damascus where 5000 taxi cars were modified to work on gas instead of liquefied fuel, in addition to 400 buses for internal transport operating on compressed natural gas (CNG). The amount of gas expected to be used in this project is around 250 thousand $m^3$ daily, thus allowing an equivalent amount of Benzene can be exported. The use of CNG leads to a decrease in the negative environmental effects resulting from the use of benzene since it does not contain sulfur and lead in addition to being nontoxic and being cheaper than Benzene Studies are being prepared to investigate the possibility of using electricity for trains in addition to using metros. Other studies are investigation the modification of tourist cars and buses to become capable of working on gas [4].

In Lebanon, the transport sector is essential for the economic and social development of the country. All transport vehicles in urban and rural areas operating on fuel oil products (Benzene and Diesel) which harm the environment in the GHG gases they emit upon combustion. In 1994, the transport sector in Lebanon produced 3957.12 Gg of $CO_2$. Recently, public transport (small vans and buses) are becoming more available by this reducing the use of private cars. In the summer of 2002, the government banned the use of diesel in most public transport cars and vans by this reducing the harming effect of diesel on the environment and humans. Research is currently being performed to study the possibility of using gas for public transport cars and buses [30].

#### 10.2.1.4 Social and community services

Hospitals and health clinics require a considerable amount of energy to fight sickness and decrease mortality rate. Some of the activities requiring electricity include powering modern hospital equipment, vaccine and medicine refrigeration, lighting, and computer/Internet for telemedicine. Currently, there are no RETs used for providing energy requirement in this sector. Other community services including schools for the illiterate and other welfare organizations that help in the development of poor and rural areas usually rely on electricity grids for their energy supplies. A rural electrification project (REP) has been implemented in Jordan which has electrified (999) rural villages inhabited by 1,863,000 people. This program depends on adding 2 fils/KWH on electricity bell. The collected money pays to REP. Table 11 presents the number of electrified villages and their population [29].

Table 11: Rural Electrification

| Rural Electrification | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 |
|---|---|---|---|---|---|---|---|
| No. of Electrified villages | 883 | 898 | 905 | 929 | 982 | 988 | 999 |
| Electrified Population ( 000's) | 1511 | 1574 | 1635 | 1696 | 1759 | 1810 | 1863 |

Three rural areas in Syrian Arab Republic, namely Homs, Hama and Elhassakeh have used RETs to electrify schools, veterinary practices, Bedouin residents with use of PV, wind energy and hybrid systems to generate electricity. In addition, many wells in those areas are operated using RETs to pump water to the inhabitants [31]. Lebanon does not provide any social and community services based on RETs.

## *10.3 Technologies*

Solar energy has two primary applications; *thermal* and *photovoltaic*. Solar thermal energy is used either for direct applications such as heating water and drying grain, or for indirect applications such as generating steam for producing electricity. Photovoltaic (PV) energy is used to produce DC (Direct Current) electricity directly from sunlight. Wind energy technologies can be used as standalone units. Table 12 lists the applicable renewable energy technologies in target countries. Appendix B lists the tables that rate the impact and potential of various renewable energy technologies that would apply to the selected countries of this study. A summary is presented in this section.

Table 12: Applicable Renewable Energy Technologies in Target AC Countries (Jordan, Syria, and Lebanon)

| Category | Requirements | Renewable technologies | Compatibility with users | Competing non-renewable |
|---|---|---|---|---|
| Residential | Lighting | PV, Wind, hybrid Wind/PV, hybrid Diesel/PV, Biomass | High | Kerosene, gas lamp, Auto Battery |
| | TV | | | Auto battery |
| | Refrigerator | | | None |
| | Washing machine | | | None |
| | Kitchen equipment | | | Kerosene, diesel fuel, liquid gas |
| | Domestic Water Heating | Solar hot water Heaters | High | Diesel, electricity |
| Productive | Water pumping for drink water | Wind, PV (for pumping heads not more than 40 m), hybrid wind/PV, hybrid Diesel/PV | High | Diesel engines |
| | Water pumping for crop | | | |
| | irrigation | | | |
| | Water pumping for animals | | | |
| | Water desalination | PV | High | None |
| Social/Community Services | Refrigeration for vaccine conservation | PV, Wind, hybrid Wind/PV hybrid Diesel/PV | High | Diesel engines |

### 10.3.1 Wind energy

Wind energy is a new means for clean, renewable and sustainable electricity generation. Grid-connected wind generation can be injected in distribution network (embedded generation) enabling utilities to save on transmission and other costs, while stand-alone wind generation can be used for water pumping.

The minimum requirements for this application is moderate to high wind regime, the availability of suitable sites, applicability of international standards such as IEC 1400-1 and 1400-2, and upgrading. The costs in Syria and Jordan are 700-1000 USD/KW and 4-6 cents/KWH. Wind plant costs have been falling steadily and this trend is likely to continue as machines become more reliable and efficient. Wind energy prices for high wind regime areas as in Syria and Jordan, are within ranges quoted to thermal plants. In Syria, more than 60% of system can be locally manufactured, creating new jobs and contributing o poverty alleviation. Wind Energy has some disadvantages such as its high O&M costs compared to PV systems and the increase in energy cost associated with storage batteries required for stand-alone wind generation for domestic loads. The degrees of maturity and penetration of this technology in Syria and Jordan are both high, while it is not mature in Lebanon.

### 10.3.2 Solar Energy

#### 10.3.2.1 Photovoltaic

Solar radiation all three countries satisfy the PV systems that can be economic in many aspects. PV systems are more economic than kerosene for lamps and battery for TV which are sometimes used in rural areas. PV systems operate automatically and require no input, thus they have nil operational costs. Maintenance is also free since PVs have no moving parts. PV systems are environment-friendly being pollution and noise-free. PV systems are more economic than diesel generators when the number of households is small. With the increase in world production of PV cells in the last 5 years, the cost of PV has decreased.

For water pumping systems, PV systems are more suitable than grid extension in the case where the grid extension is greater than 3 km. It can be installed without battery storage therefore there is less cost. Small-scale PV pumping is more economical than diesel generators in case of heads less than 50m and pumped water less than 20m$^3$ per day. Despite many advantages PV has some disadvantages such as its high initial investment cost and the necessary storage required in cases other than water pumping.

The system price in Syria is currently 6000$/KWp. PV is not competitive for larges scale applications unless the system price becomes less that 1-1.5$/Wp (module price 0.5-1$) resulting in an electricity cost between 5 and 10$/KWH depending on the isolation and the financing scheme. In Syria, the total capacity of demonstrated PV systems is around 80 KWp used for water pumping and in some pilot scientific cooperation projects for desalination as well as for supplying electricity to houses in certain villages. PV power is also demonstrated in Jordan for a total capacity of about 184 KWp. Demonstrated applications include emergency telephones, rail radio communication systems, relay stations for radio telephone communication, provision of minimal basic energy needs for remote communities, and water pumping in remote areas. In addition, 100 photovoltaic systems are used in remote areas throughout Jordan [5].

The degrees of maturity and penetration of this technology in Syria and Jordan are both medium. Solar photovoltaic power production capacity totals approximately 30 KWp used mainly for park lighting, seashore beacons and a few water-pumping stations [9]. Photovoltaic technology is unlikely to penetrate the market in the near future due to several barriers including high transaction and initial investment costs, the lack of an established market and successful business models of the technology, and unwillingness of utilities to provide off-grid electricity service [32].

The prospects of PV applications in Jordan and Syrian are promising particularly for remote areas which can effectively contribute to poverty alleviation and improve the quality of life for women and children. Utilizing renewable resources for energy can yield positive environmental impact and furthermore create job opportunities for industry, O&M personnel, in addition to improvement of living conditions in rural and remote areas.

#### 10.3.2.2 Domestic Solar Water Heaters (DSWH)

DSWH have been demonstrated with different penetration levels, types, capacities and fields of applications. For example, in Syria [6] and Jordan [5], the installed DSWH are estimated to be around 15000-20000, and 200000 units, respectively. Jordan has more than 25 manufacturers producing locally designed solar water heaters systems, while in Syria they are produced presently by more than 50 small private workshops with a total annual production capacity of about 150,000 m$^2$. In some cases inappropriate designs and/or manufacturing processes are used, resulting in systems with relatively low quality. In Lebanon, the installation rate of DSWH is increasing but has not reached the level that affects the energy utilization mode on the country level. An estimated 50,000 m$^2$ of domestic solar water heaters are presently installed in Lebanon [9]. The current market demand is about 3000 heaters (9000 m$^2$) annually; however, market penetration studies predict that the volume will increase significantly in the future.

### 10.3.3 Biomass technology

In Jordan, the biomass activities were limited to the construction of an experimental biogas digester in 1992 with a capacity of 16 cubic meters per day, where limited number of private firms built similar units. A techno-economic feasibility study for electric power generation from municipal solid waste was carried out in cooperation with the UNDP and GEF. Jordan has adopted a special program for Bio-energy by which pre-feasibility studies for the utilization of Municipal Solid Wastes for electricity generation have been prepared since 1993 through cooperation with GEF. The outcome of these studies resulted in implementing the first biogas project in Jordan and in the region with a capacity of about (1) MW of electricity. Jordan Biogas Co. continues to generate electricity by utilizing methane gas from decomposed organic waste which generated 5.4 GWH in 2002, which is equivalent to saving (1774) tons diesel fuel at an estimated cost of $350,000. This project is owned, operated and maintained by the Jordan Biogas Company (JBCO), and is going to be expanded up to 5 MW by the year 2005 [5]. Table 13 shows biogas production in Jordan.

Table 13: Biogas Production in Jordan (JBC, 2003) [33]

| Year | Biogas Produced ($m^3$) | Methane Utilized ($m^3$) |
|---|---|---|
| 2001 | 2654606 | 1396188 |
| 2002 | 2992734 | 1570588 |
| 2003 | 3458606 | 1852953 |
| Total | 9105946 | 4819729 |

In Syria, only theoretical assessment coupled with minor demonstration pilot projects has been carried out so far, although the potential for generating energy from biomass is great.

In Lebanon, agricultural waste that is typically burned has some limited applications that have been initiated by non-governmental organizations (NGOs) by establishing biogas digesters for rural areas within the framework of community development projects financed by United Stated Agency for International Development (USAID), and have been operating efficiently [4].

### *10.4 Renewable energy resources*

Most ESCWA countries are rich with energy resources like fossil resources, which have the major contribution in energy production, and tremendous clean non-depletable renewable resources particularly solar, wind and biomass. During the past two decades, efforts have been made to. Many countries such as Jordan and Syria have researched and experimented with the possibility of developing and exploiting renewable resources furthermore. Many encouraging national policies and strategies concerning renewable energy utilization been introduced to promote renewable sources of energy. Jordan and the Syrian Arab republic have taken steps to design and install specialized networks to measure solar and wind energy through advanced methods to assess their renewable resources.

Jordan is one of the sun-belt countries according to the international classification since the average annual solar radiation per day is (3.8) KWH/$m^2$ in winter to more than (8) KWH/$m^2$ in summer. The total direct annual solar radiation ranges from (2400) KWH/$m^2$ to more than (2700) KWH/$m^2$ which facilitates building investment projects utilizing solar energy for the generation of electricity. Solar energy is mainly used in Jordan for domestic solar water heating (about 30% of the houses in the country) [3-5].

Jordan has rich wind energy resources. Studies on the wind potential have been made for several years and the available wind resources were assessed and based on which a Wind Atlas has been prepared, which shows that there is a potential of several hundreds of Megawatts of wind power installations in the country. There are three high potential sites of wind. Two of them are in the southern part of Jordan and the third is in the northern part of Jordan.

The resources of hydro energy are very limited in Jordan. There is only one hydro plant for electric power generation with an annual capacity of 25 GWh at King Talal Dam. High-quality oil shale is found in huge quantities in many parts of the country. The oil shale reserve in Jordan is estimated to be more than 50 billion metric tons containing an equivalent of 50 billion barrels of crude of oil [4]. Studies and experiments have shown that oil shale in Jordan can be used by direct burning to produce electricity, or by distillation to produce oil. The government gives great importance to the exploitation of this energy resource by carrying out the continuous technical and economic studies needed. The government asked local and international private-sector companies to present offers to exploit Jordanian oil shale through distillation and direct burning to produce electric energy. Only few sites of geothermal resources with a low potential have been identified. Biomass data are scarce in Jordan. Only few studies have been prepared and indicated that animal and MSW can represent an energy potential of about 100,000 tons of oil equivalent distributed as municipal wastes and animal waste. Jordan produces 1500 tons of municipal water per day, and is capable of producing 16 million cubic meters of biogas per annum equivalent to 8800 TOE. It is also estimated that animal waste resources can be used to produce about 90 million cubic meters of biogas annually. *Appendix C* has a summary of renewable energy resources data and maps for Jordan.

The average global horizontal solar radiant flux in Syria is approximately 5 KWH/m$^2$/day or 18 MWH/m$^2$/Year. The average daily radiant flux varies from 4.4 KWH/m$^2$/day in the mountainous areas in the west to 5.2 kWh/m$^2$/day in the desert regions of the Badia. The annual sunshine hours also vary between 2,820 hours to 3,270. In 1994 the Meteorological Department and Scientific Studies and Research Centre (SSRC) issued the Solar Atlas of Syria. The atlas is based on tabulated data and maps of theoretical values of different components of solar irradiation for twenty-two sites in the various regions of Syria [34]. Wind energy is also abundant in Syria with wind speeds ranging from 4.5 m/s -11 m/s. A Wind Atlas for Syria was published in 1999 through cooperation between Syrian officials and the Danish RISO Institute [35]. The Wind Atlas is mainly based on data collected by 49 wind-monitoring stations established around the country. These have collected data for many years (5-12 years) at each site in the period 1965-1993. Geothermal energy resources are available in the Aleppo and Palmyra regions. Data on renewable resources of wind, solar and biomass are given in Appendix C.

Although the Syrian Arab Republic relies on locally produced traditional energy resources like oil and gas, other renewable resources exist such as wind and solar energy. Syrian hydropower resources are limited by the low precipitation and flow from internal rivers. Most of the available hydropower potential has been harnessed (Installed hydro generation is about 1600 MW) and there is not much scope for harnessing small, medium or large-scale hydropower. Further studies have to be carried out to analyze the scope for micro-hydro power starting with the 32 sites in the coastal region surveyed under the Romanian study in the 80s. These can be stand-alone power stations or linked together to form a mini grid in the region assuming the period of availability of water justifies the investments. There are hydro energy resources available on the Euphrates River effectively being used with an annual production capacity of 1.4-2.1 TW, in addition to other stations and dams available. Other resources are considered for future electricity production such as oil shale which currently has a high extraction cost and is found in the south and other regions. Estimates of the main biomass resources carried out by the author for the year 1999 show that there are about 577,365 tons of dry animal dung; 360,000 tons of dry chicken droppings; 230,000 tons of dry human waste; and 34,000 tons of dry kitchen residues available every year [3, 6].

In Lebanon, renewable energy available include resources such as solar, wind, hydro, and biomass resources, but still these resources are not widely used. Lebanon aims at maximizing its benefits from the existing water resources through studying the possibility of constructing dams along the Lebanese rivers in all the regions of Lebanon. The use of solar energy is still very limited, and apart from relatively modest hydroelectric resources and the import of 50-100 MW of electricity from the Syrian Arab Republic, all energy needs are met with imports of petroleum products. The use of biomass fuel in Lebanon is minor and was confined in 1994 inventory of the greenhouse gas emissions by sources and sinks to the use of 100,000 tons of wood, 1560 tons of charcoal and 180,000 tons of cooking coal [36-37]. A potential biomass energy source in Lebanon is methane from solid waste. Another source of biomass is agricultural waste that can be converted into electricity through gasification, biogas digestion or combustion processes. Data on renewable energy resources are given in Appendix C for Lebanon. Solar measurements were done by meteorological centers, universities, and research centers in support of their R&D activities. Lebanon has 40 streams, 14–17 of which are classified as perennial rivers depending on the source of information, while the remaining streams are seasonal [38]. The runoff distribution from these rivers is highly influenced by the topography and the soil type of the water basin. Steep slopes and narrow coastal strips result in a relatively quick transfer of the incoming rainfall volume to the sea. Several rivers and major streams have been dammed to generate electricity, which is linked to the country's existing electric network. Current data indicate that the installed capacity of hydropower plants is about 283 MW, however due to seasonal variation, the actual capacity can be much less. For example, the total electricity generated from the installed hydropower plants capacity was 736, 786 and 330 GWh for the years 1997, 1998 and 1999 respectively. Table 14a summarizes the solar, wind and biomass energy resources in Jordan, Syria, and Lebanon; and Table 14b gives information on installed and potential hydropower in the three selected countries.

Table 14a: Renewable energy resources in Jordan, Syria, and Lebanon

| Country | Global solar radiation $kWh/m^2/day$ | Direct normal solar radiation $kWh/m^2/day$ | Wind energy Average wind speed (m/s) | Biomass and fuel wood (mtoe/year) |
|---|---|---|---|---|
| Jordan | 5-8 | 5-7 | 5.5 – 10 | 0.74 |
| Lebanon | 4-6 | 4-6 | 3.5 – 6 | 0.59 |
| Syrian Arab Republic | 5-6 | - | 4.5 – 11 | 1.24 |

Table 14b: Installed and potential hydropower in the selected countries

| Country | Installed hydropower, MW | Potential hydropower, MW |
|---|---|---|
| Jordan | 7 | 50 |
| Syrian Arab Republic | 1505 | 1236 |
| Lebanon | 283.1 | 533 |

## *10.5 Case studies*

Jordan, the Syrian Arab Republic, and Lebanon share many similarities in terms of energy requirements. In all three countries, the demand of energy is increasing with the increase in population and the main energy sources to satisfy this demand are fossil fuels with a minimum contribution of renewable resources. Jordan and the Syrian Arab republic have tired to exploit these resources and there are some case studies in this domain. In contrast, Lebanon still has not taken any steps to study the impact of renewable energy on the social and economic development of the country. Lebanon can benefit from the experiences of Jordan and the Syrian Arab republic to start its own case studies in the future.

The development of the capacity needs budget, governmental concern, and optimal use of international aid. Suitable financing mechanisms should be devised with focus on micro finance. For the expansion in utilization of the wind technology banks and funding agencies should be developed to finance electro-wind project on a sustainable basis.

RD&D programs that focus upon technology adaptation through applied research, operational testing, and concept demonstration are needed and will require substantial support from the Syrian and Jordanian governments. The participation of the private sector is very important, in this case, key measures should be taken to provide a more favorable climate for foreign investment, duty reduction, excise takes, and export incentives.

Jordan has implemented several policies to encourage RE development including development. Many RETs relevant to Jordan's needs have been adopted, particularly in rural and remote areas, in addition to upgrading local R&D capabilities, and increasing national capabilities for design production of RE equipment. More than 12 demonstration projects totaling 1620 kW of wind turbines were implemented, tested and evaluated for (1) water pumping, and (2) electricity generation (a 320 kW grid connected Danish wind energy plant was installed in 1988 with annual energy production reached 0.75 million kWh. Also the Hofa wind farm consists of five 225kW turbines producing an average annual energy about 2.5 million kWh). Based on the promising results of those projects, the Ministry of Energy and Mineral Resources (MEMR) has issued the call for proposals for the development of a 75-90 MW wind IPP project, where two proposals are received and under evaluation. Wind Energy use for water pumping in Jordan utilizes locally manufactured mechanical windmills [39]. The National Energy Research Center is designing and developing turbine blades while cooperating with the private sector to manufacture these blades from fiberglass that can be used for the production of wind energy systems of small capacity not exceeding (2000) watt for use in remote areas.

In Jordan, PV systems were demonstrated and used for a total capacity of about 150 kWp used to provide electricity, water pumping, and desalination services. Demonstrated applications included emergency telephones, rail radio communication systems, relay station for radio telephone communication, provision of minimal basic energy needs for remote communities, and water pumping in remote areas. Practical examples include: (1) Five repeater stations for civil defense with a capacity of 160 Wp each, (2) Water pumps for Bedouins with capacities varying between 1.4 to 6.3 kWp per system, (3) PV village electrification system in remote areas with system capacities varying from 1 KWp to 4.5 KWp, and (4) PV signaling systems, train crossing signal of 1760 WP power, and radio transmitter situated at the Dead Sea of 3 KWp capacity [4].

In Syria, a 150 kW grid connected wind turbine was set up in 1994 at the Qunetra south of Syria producing 300 MWH/year. There are also stand-alone wind systems installed in Syria for battery charging, water pumping and defrost (750 W to 50 kW) which are locally manufactured (since 1990) by private company (SAC) located at Adra, near Damascus. The wind generators are fully designed, manufactured and installed by this company. The total capacity production by the company is 600 kW [6].

One case study is presented for Jordan. In the Syrian Arab Republic, three case studies are provided to examine the impact that RETs can have on the rural and Bedouin population according to the requirements and potentials of each region.

### 10.5.1 Jordan Case Study 1

Objective:

A photovoltaic cell system for lighting in remote villages has been implemented under the Jordanian Badia project for lighting Rawdat Al-Bindan in Ruwaished district in cooperation with the Rural Electrification Project & the National Energy Research Center.

Expected Results:

The project was commissioned in October 2002, as a pilot project in the development of rural areas. The total cost of the project reached (J.D. 45.000 ≈ $63,000). Efforts are also underway to implement similar one at Thaghrat Aljob Village in Ma'an governorate and Al-Faida village in Ruwaished district. The National Energy Research Center implemented as well a pilot desalination project by using the photovoltaic cells in cooperation with U .S. Energy Center with a capacity of 30 cubic meters of desalinated water daily.

### 10.5.2 Jordan Case Study 2

Introduction:

Central Electric Generation Co. (CEGCO) produce electric energy using wind turbines at Hofa station comprising of 5 turbines with a capacity of (225) KW each and Al-Ibrahimiyyah station comprising (4) turbines with a capacity of (80) KW each. The electric power output of both stations for 2002 was (3045) MWH [5].

Objective:

Due to the successful operation of these two stations, the Ministry of electricity and Mineral Resources announced a competitive tender to the specialized international firms to implement a project for generating electricity by using wind energy at a total capacity of (75-90) Mw under Build, Own & Operate (B.O.O) plan by the private sector at three selected sites in the Kingdom: Hofa/Irbid; Al-Fujaij/ Al-Shobak, and Wadi Araba/Aqaba special Economic Zone, as part of governmental support to clean electricity generation.

Expected Results:

Delenova Energy Company is doing a feasibility study for implementation of 40 Mw at Hofa and Al-Ebraheemiah sites in North of Jordan. There are two pilot projects at both sites. The capacity of both is around 1.4 Mw. The main features of the existing projects and the proposed expansion projects are summarized in Table 15a. Table 15b gives statistics for the population as well as number of houses in the area of the project that will be covered by the project. The total expected capacity of the project is around 40 MW, which is 2.5% of the total power capacity in Jordan. Projects at this scale require strong governmental support.

Table 15a: Existing Projects and Proposed Expansion

| **Project** | **Wind Turbines** | **Turbine Technology** | **Rating, kW** | **Rotor Diameter, m** | **Completed** |
|---|---|---|---|---|---|
| Al-Ibrahimiyya | 4 each Tellus T-17 | Fixed pitch, constant speed | 80 | 17 | 1988 |
| Hofa | 5 each Vestas V-27 | Variable pitch, constant speed | 225 | 27 | 1996 |
| Expansion | ~20 each GE 1.5sl | Variable pitch, variable speed | 1500 | 77 | future |

Table 15b: Statistics for the population as well as number of houses in the Hofa and Al-Ebraheemiah sites

| Area Name | Populations | # of Houses | Category |
|---|---|---|---|
| Edoun - Irbid | 14560 | 1918 | Urban |
| Ketem – Irbid | 4157 | 548 | Rural |
| Total | 18717 | 2466 | |

### 10.5.3 Syria Case study 1

Objective
The objective is to provide residential energy requirements to household in rural and Bedouin area using renewable energy technologies.

Outcomes
The three rural and Bedouin areas in Homs, Hama, and AL-Hassakek of the study have 9,460, 11,344, and 2,080 Bedouin inhabitants, respectively, with 1100, 1418, and 2510 households, respectively. The residential houses are supplied with electricity using small PV, wind turbines hybrid systems. The residential energy requirement per month is 200 KWh for every household for different household activities such as lighting, TV, refrigerator, kitchen equipment, and others. The percentage of energy requirements to be supplied by RETs is 100.

### 10.5.4 Syria Case study 2

Objective
The objective is to provide energy requirements to the commercial and community services in rural and Bedouin area using renewable energy technologies.

Outcomes
The three rural and Bedouin areas in Homs, Hama, and AL-Hassakek of the study have 9,460, 11,344, and 2,080 Bedouin inhabitants. The RETs electrification project in the three communities consists of 34 schools, 7 shops, and 3 veterinary practices. Each school requires 150 KWH per month. Electrification of 3 veterinary practices and 7 shops 150 KWh/month for every practice or shop. This can be 100 % supplied by PV, Wind, and hybrid Wind/PV

### 10.5.5 Syria Case study 3

Objective
The objective is to provide energy requirements to water pumping from wells in the agriculture productive sector rural and Bedouin area using renewable energy technologies.

Outcomes
The first rural and Bedouin area is in Homs and uses RETs electrification for water pumping for 30 wells with heads greater than 100m where the energy requirement is 0.2725 $KWH/m^3$. The percentage to be covered with RETs is 100 using PV, wind, and hybrid PV/Wind. There are 37 wells with heads greater than 100m requiring 0.8175 - 1.635 $kWh/m^3$. Fifty percent can be covered using wind and hybrid diesel/wind technologies.

The case of the productive sector Hama is similar to Homs project. Water pumping for 20 wells with heads greater than 100m can be achieved where the energy requirement is 0.2725 $KWH/m^3$. The percentage to be covered with RETs is 100 using PV, wind, and hybrid PV/Wind. There are 33 wells with heads greater than 100m requiring 0.8175 - 1.635 $KWH/m^3$. Fifty percent can be covered using wind and hybrid diesel/wind technologies.

In Alhassakeh, water pumping for 33 wells with heads greater than 100m can be achieved where the energy requirement is 0.2725 $KWH/m^3$. The percentage to be covered with RETs is 100 using PV, wind, and hybrid PV/Wind. There are 92 wells with heads greater than 100m requiring 0.8175 -1.635 $kWh/m^3$. Fifty percent can be covered using wind and hybrid diesel/wind technologies.

## *10.6 Assessment of Capacities*

### 10.6.1 Role of RETs in alleviating poverty

Renewable energy and energy efficiency are essential factors that will contribute to reduction of the energy bill and conservation of natural resources. The electrification level in the three studied countries is more than 95% so almost all communities rural and urban are connected to the electricity grid; therefore, there is a need to look for resources other than the conventional ones such as renewable to supply cheaper and cleaner energy requirements for Jordan, the Arab Syrian Republic, and Lebanon.

The development of renewable energy use in the three countries can contribute effectively to the efforts directed to the diversification of energy resources, and it will result in important savings of fossil fuels. For the oil-and gas-exporting countries such as the Syrian Arab Republic, such savings could be maintained for export thereby increasing foreign revenues or savings resources. For countries that do not have local oil resources, such savings would help limit the growth of energy imports and hence save on energy expenditures. Although there is no population in extreme poverty conditions, there is a need for socio-economic development and poverty alleviation to improve the standard of living in the region’s poor and rural areas. RETs could be selectively applied to various rural and urban applications, potentially generating income, improving health and educational quality, improving the GDP, achieving gender equity, and increasing labor productivity.
Below are some of the services and income-generating activities that RETs can provide for different life sectors to help in the economic development of the poor population. ***Appendix E*** provides a summary table of capacity assessment, its problems, needed measures and priorities. The table provides data for Syria and comments on the activities that are relevant to Lebanon and Jordan.

#### 10.6.1.1 Residential

Many household activities require energy such as cooking, water heating, and heating, and the first energy priority of poor people is to meet their household energy needs. For the poor, electricity is usually too expensive to be used for cooking and biomass and kerosene is mostly used for cooking, lighting, and heating due to lack of other affordable energy resources. Provision of domestic solar heaters for poor communities will greatly contribute to reduction of electricity and environmental bill. Better illumination from PV systems, though more expensive than traditional fuel, can allow more productive time used for reading for example. Jordan has supportive policies to market penetration for solar water heating where currently 30% of the homes use solar energy for domestic water heating. In Syria and Lebanon, the use of solar water heating is still far below potential. In Syria, electricity is heavily subsidized and no incentives exist to facilitate and help in the capital cost of the investment. In Lebanon, although electricity Tariff is high, the rate of collection is not more than 30% on the average. In low income household areas around the cities and in rural areas, electricity theft is not controlled, nor the population informed on conservation. Market penetration becomes an issue under these constraints with no policies or executive bodies that control electricity theft. RETs in Lebanon is more for the affluent population.

#### 10.6.1.2 Productive

Productive uses of renewable energy could increase incomes of poor and provide development benefits to rural and urban areas. As incomes increase, households will be able to afford consuming more energy. Therefore, renewable energy should be able to provide income-generating activities fuelled by energy technologies. Mini-grids or stand-alone systems can power small industries and provide substantial local income and jobs. Manufacturing industry for quality solar collectors is emerging as a productive industry in Jordan. This is a low tech industry that is now quality controlled by National Certification Centers. In Jordan and Syria, some of the used RETs are manufactured locally but not on a wide-scale. With the increase in the local RTE utilization, investors will be encouraged in building industries for manufacturing in all three countries. The local manufacture will lead to the growth of small and micro-enterprises for rural and poor people. The use of RETs in water pumping has been successful in both Syria and Jordan. Food processing is another area where renewable energy can provide this requirement through cost-effectively while also helping in generating income for many food processing activities such as: Meat and fish drying, spice drying, plant drying, cereal grain processing, grain mills and lighting for processing plants. RETs can satisfy the energy in clinics such as lighting, refrigeration for vaccine and medicine conservation, medical equipment power, and computer/internet for telemedicine. RET can help in promoting education and eradicating illiteracy by providing lighting to schools, computer and internet, TV, and radio.

### 10.6.2 Standards, Testing and Certification

In Jordan, the responsibility moved to the National Energy Research Center (NERC). At NERC, the focus was on the development of standards together with establishment of advanced testing and certification laboratories, as follows:

- Indoor-outdoor solar collector testing facility according to national and international standards.
- A solar water heater system testing facility which is capable of testing the performance of complete solar water systems according to ISO TC 180 SC4 standards.
- A hot water storage testing facility.
- A power electronics laboratory to simulate the performance of solar systems (5-10 kW) and any wind energy system (up to 20kW)
- A PV outdoor testing facility
- A mechanical and electrical wind pump testing facilities.

In Syria, standards and codes of practice for DSWH components and systems have been developed and implemented since 1993. This task was the results of a joint effort between the "Syrian Arab Organization for Standardization and Metrology" and the “Renewable Energy Office". The activities on testing and evaluation of RE equipment and systems have been carried out by several test stations and laboratories. These include an outdoor liquid flat-plate collector test facility in 1984, and an outdoor air collectors test facility in 1992, the Abou-Sorra PV test station, and the PV laboratory in Aleppo which includes an indoor simulator for testing solar cells and modules prior to assembling and encapsulation [4].

In Lebanon, there are still no field testing facilities but some indoor laboratory sets for testing and developing PV, DSWH and other renewable energy applications exist. It is worth mentioning that Lebanon has no legislation that affects the import of renewable energy or other electric or thermal devices and has no policies for appliance or equipment labeling related to energy consumption. Also Lebanon has no national testing protocols nor does it have any facility to verify equipment compliance with energy standards [37].

### 10.6.3 Elements of Capacity Assessment

#### 10.6.3.1 Legislative authorities and elected officials

National political priorities should be set such as social, economic, and environmental goals within legal framework conditions. Currently there is lack of knowledge about economy and energy issues in general and RET potential in particular. Perception is still unreliable and not serious. Some capacity development measures should be taken. It is of very high priority that election laws be modernized and more events on RETs are held while concentrating on presence of these authorities. Finally, successful projects should be presented to encourage further experiences in RETs.

#### 10.6.3.2 Government macroeconomic and development planners

Their role is to define development goals and macro policy, general economic policies, cross-cutting issues, subsidies and trade policy, sustainable development goals, and frameworks. At present, there is a lack of qualified strategic planners and decision makers and consequently planners focus around fossil fuel resources and ignore RETs. It is of extra high priority that intensive courses on RETs for qualification of decision makers and strategic planners are given, focusing on the role of renewable resources utilization in meeting poverty reduction and sector planning goals such as health, education, and agriculture development.

#### 10.6.3.3 Government energy authority or ministry

Sector goals should be set concerning technology priorities, policymaking, standard-setting functions, legal and regulatory framework, incentive systems, and federal, state, and local level jurisdiction.

Resource and energy planning in Syria are organized by the Higher Planning Council (HPC) and by the Supreme Energy Committee (SEC). In addition to managing the present energy resources, the HPC and SEC also examine the potentials of renewable energy as an alternative to fossil fuels. There is no effective organization which acts as a driving force for RET development with clear responsibility to develop policy, legislation and regulatory evolution within the Government of Syria. It is of high priority in Syria, to develop the recently established centre for energy studies to become an effective organization for development of RETs provided that the right staff is employed.

In Jordan, the institutional frame work is well developed. In Lebanon, there are only guidelines to energy efficient policies and polices that address the needs of the poor. Table 16 lists the institutions involved in Sustainable Development [4].

Table 16: Major institutions involved with sustainable energy [4].

| Country | Institution | Renewable energy field of activity |
|---|---|---|
| Jordan | 1. The National Energy Research Center (NERC)<br>2. Ministry of Energy and Mineral Resources (MEMR) Renewable Energy Department<br>3. The Royal Scientific Society (RSS), Renewable Energy Research Center (RERC)<br>4. Private Industry | • NERC is responsible for RE development and field promotion of RE electricity generation with emphasis on wind generation<br>• RERC/RSS performs R&D activities, demonstration, project, testing and certification, in addition to supporting local industries through the development of components and system designs. |
| Syrian Arab Republic | 1. Ministry of Electricity The Syrian Ministerial Cabinet Renewable Energy Office (REO)<br>2. Scientific Studies and Research Center (SSRC)<br>3. Ministry of Industry; Private | Coordinates RE activities<br>REO coordinates plans and identifies implementation priorities<br>• Develops analytical simulation models for RE systems and equipment standards |

| Country | Institution | Renewable energy field of activity |
|---|---|---|
| | industry<br>4. The Syrian Arab Organization for Standardization and Measurement | • Manufactures DSWH and windmills<br>• Develops standard specifications for RE equipment |
| Lebanon | 1. Ministry of Energy and Water (MEW), Electricité Du Liban (EDL)<br>2. National Council for Scientific Research (NCSR)<br>3. American University of Beirut (AUB), Lebanese university and other universities<br>4. Non-governmental organizations<br>5. Mercy Corporation | • Plans studies on RE contribution to energy and coordinates efforts in RE field<br>• Coordinates renewable energy activities, conducts research and development (R&D) in the field of renewable energy, and develops renewable energy equipment testing facilities.<br>• R&D and education<br>• Promotion and awareness-rising activities<br>• Development activities, including those related to the development and installation of renewable systems, especially biogas systems for rural households. |

#### 10.6.3.4 Energy regulatory bodies

They should have monitoring and oversight functions, implement the regulatory framework, and administer fees and incentives. In Syria and Lebanon, the regulatory bodies are only interested in conventional energy resources. They have a very important role, and the solution would depend on the concern of decision makers. Jordan has taken much further steps in promoting RETs.

#### 10.6.3.5 Market coordination agencies

They are dispatch entities that have operational coordination functions, and interface with industry investors, in addition to information brokers. Such stakeholders are not found yet. It is of very high priority that these agencies be established.

#### 10.6.3.6 Non-energy governmental authorities/ministries

These deal with sector policies, cross-cutting issues, inter-relation with energy policies, public sector energy consumers and require energy inputs for social services provision.
In Syria, renewable energy activities and projects have been carried out by several Government of Syria entities, such as the Scientific Studies and Research Centre, Atomic Energy Commission, Universities, the Ministry of Electricity, Ministry of Environment, Ministry of Irrigation, Ministry of Agriculture and Agrarian Reform, Ministry of Industry, Ministry of Petroleum and Mining Resources. These activities have been carried out with little co-ordination among the implementing ministries. It is of extra high priority in Syria, to develop the recently established centre for energy studies to become an effective organization for development of RETs provided that the right staff is employed. In Lebanon, there are very limited activities on RETs projects, even though many assessment studies have been completed under international development agencies.

#### 10.6.3.7 Energy supply industry

This includes private companies and public utilities that manage energy supply, electricity generation, fuel management and transport, and finance some R&D. In Syrian and Lebanon, only public utilities exist. There is no grid code. R&D is rare. System losses are greater than 30%. It is of high priority that the electricity market be deregulated. Jordan on the other hand has taken serious steps toward privatization where the government set up a special unit within the Prime Ministry in July 1996, called the Executive Privatization Unit (EPU), under the supervision of a higher council chaired by the prime minister with the membership of several ministers and heads of concerned departments. In a nutshell, the EPU is responsible for privatization operations within the government's overall policy. As such it performs several tasks, including selection of projects to be privatized, project assessment, election of appropriate form of privatization, preparation of offers for interested parties, and appraisal of submitted offers of privatization. Privatization of government institutions and corporations is already on its way

#### 10.6.3.8 Energy equipment O&M services

Syria does not have fully skilled and experienced human resource base to support the integration, service and operation of renewable energy technologies and does not have a ready made training infrastructure to rapidly develop this resource. Capacity development will be needed when RETs start to be used more widely. Jordan does have the human resources and training infra structure through the National Renewable Energy Research Center. Lebanon has the human resources, but lack the infra structure for training. Lebanon has no certification centers.

#### 10.6.3.9 Credit institutions

The provide financing options for large- and small-scale energy generation, capital provision for energy using enterprises, and funding options for household energy consumers. In Syria, the banking system is still weak. There has been no major financing for renewable energy systems by the Syrian banks although, theoretically, finance can be obtained from some of the banks. Financial mechanisms and instruments to encourage renewable energy manufacturing should be developed either through government banks or private lending organizations to provide credit to consumers, especially rural applications, or even start-up manufacturing ventures.

#### 10.6.3.10 Civil society / NGOs

They are responsible for consumer participation and awareness, oversight and monitoring, environmental and social advocacy, and equity considerations. In Syria, NGOs are either not effective or not concerned with RETs. In Lebanon, the NGOs play a more effective role, but have more concerns on the environmental impact of solid, and liquid waste disposal, and air pollution from the transport sector.

#### 10.6.3.11 Education, Academia and research organizations

Their role is in R&D, knowledge generation, and sharing, formal and informal education, technical training, and technology adaptation, application, and innovation. Renewable energy technologies knowledge is being integrated into research and higher education programs in Lebanon, and Jordan. Renewable energy education is not directly offered in primary and secondary schools of the region other than mentioning it in brief. Introducing the concepts of RETs in the national education curriculum would contribute to the increase of awareness and use of renewable energy.

Currently in Syria, there is limited scope for RD&D institutions to interface with international bodies and to share expertise already existing within the sector. Research, Development and Demonstration (RD&D) programs in renewable energy have been carried out primarily by the Higher Institute for Applied Science and Technology (HIAST), Ministry of Electricity, Atomic Energy Commission and the Scientific Studies and Research Centre (SSRC). The RD&D in the four Syrian universities have been rather limited, owing to the lack of infrastructure and finances. The RD&D programs have so far focused on solar thermal applications and PV.

It is of very high priority that the scope of the RD&D should be enlarged to include several more renewable energy technologies. The technologies, which are to be included in the RD&D program, should be oriented towards strengthening local industry and research institutions, developing better market information and acquiring operational experience.

RD & D programs need to focus on technology adaptation and applications, thereby serving the needs of the renewable energy industry.

As compared to other countries of the region, Jordan has relatively good potential to utilize the biogas from solid waste. Recently, Jordan through a grant from UNDP, GEF and DANIDA has successfully constructed a pilot biogas plant at Russaifah landfill, which is the largest landfill in the country [5]. Currently, the plants generate about 1 MW of power, by drilling more gas extraction wells, it will be possible to reach 5 MW, However, to promote this technology, it is necessary to build a local capacity in the area of biogas technology, so as to get qualified personnel, who should be capable to manage and promote this technology. The right place to implement this task is universities. Jordan University of Science and Technology (JUST) through its civil, biosystems, and mechanical Engineering Departments is working on this project to enhance the capacity building in the field of biogas technology by introducing the biogas technology concepts into the university curriculum [5]. The energy group at Jordan University of Science & Technology (JUST) is studying how these renewable energy sources and advanced systems can be used in the form of electricity and we are trying to improve the efficiency of these energy sources. At Jordan University of Science & Technology, There has been collaborative effort between faculty from Electrical, Mechanical, and Environmental Engineering programs on areas like solar, wind, biomass, and geothermal energy. Recently, a Tempus Joint European Project (MEDA 2002/ 30057) started at JUST with 250,000 Euro funding to create an energy educational center at JUST. This center has the objectives of (i) providing high quality education on the master level in the field of energy and its interaction with other social, political, scientific, economical and other issues and (ii) organizing workshops and training programs in all aspects related to the energy and its interaction with other issues. The project The project is a joint program between three partners: 1) Jordan University of Science and Technology (Jordan). 2) The Royal Institute of Technology (Sweden). And 3) Centre of Research for Energy Resources and Consumption (Spain).

Higher education institutions in Lebanon are also involved in renewable energy technologies research and development but with limited funding and resources. Several on going research and development projects are done at the American University of Beirut to address the needs of the rural community. One of the ongoing projects assess the thermal performance of currently available space heating stove designs in the Lebanese market that are used in rural houses to provide a valuable opportunity to optimize common designs for improved thermal comfort in the room with lower energy consumption due to smaller fuel burning rates in the stove. A common practice in Lebanese rural houses during the cold season is to burn fossil combustibles, wood, lignite or olive refuse in various stove designs ranging from the open firebox of the “kanoon” to the chimney-equipped closed iron stove popularly known as the “soba”. The stove functions as a heating unit for the room and is utilized also as a cooking device. The existing stoves in the Lebanese market are produced by local manufacturers and come in many shapes with very little done to optimize their design and operation for maximum heat transfer to the room (net fuel conversion efficiency) and to provide best comfort in the living space [40]. Another relevant project addresses the use of a thermoelectrically-fitted wood stove to provide a continuous small but useful electric power supply in the course of its primary use as a home heater. The aims of the work were to a) develop a low-cost high-performance TEG module, and b) to test the TEG in various configurations using a common wood-burning stove and off-the-shelf finned heat-sink in order to determine the performance potential of this simple system [41]. Assessment of the use of solar assisted desiccant dehumidification system in residential buildings to improve energy efficiency in air-conditioning systems has also been an ongoing project that can reduce commercial energy bill [42]. Research funding to develop relevant use of renewable energy is not available at the levels that allow advancing the research to the point where an end product is produced.

#### 10.6.3.12 Media

Their role is in raising awareness, advocacy, information sharing, journalistic inquiry, watchdog functions, and monitoring public transparency. Mechanisms for the media should be created to provide accurate information on the technical, economic and social viability of RETs to support raising awareness on options that do exist and can be harnessed to address the multiple dimensions of sustainable development.

### 10.6.4 Barriers to Implementing Renewable Energy Technologies

The two main barriers for the quick development of the renewable energy technologies in Lebanon, Syria and Jordan are mainly the high prices of the equipment on the local market, and the relatively low cost of the electricity. These two main barriers lead often to high payback times (8 years for the solar domestic hot water system). As a result of lack of institutional point responsibility as well as relatively low energy pricing, a low level of general and specific awareness and motivation exists on the part of both consumers and industrial and commercial managers towards energy efficiency and renewable energy technologies. There is no general public awareness of issues pertaining to energy efficiency and conservation in Lebanon and Syria. There are no dedicated financing schemes or special incentives provided for RETs initiatives. This barrier is especially important due to the high capital investment costs needed of some interventions that require the installation of specialized equipment. With insufficient financial incentives to invest in energy efficiency equipment, no local market has developed for energy efficient measures and equipment in Lebanon and Syria. Other barriers come from the lack of policies related to energy conservation and tax incentive to encourage use of RETs. Most of the renewable energy activities in Lebanon, Syria, and Jordan have been implemented through bilateral of multilateral cooperation with developed countries and international agencies with very little cooperation among the countries in the region. The renewable energy development is tightly bonded to the implementations of bilateral and international cooperation programs. The bilateral activities with foreign countries were mainly with the United States, Denmark, France, Germany, Italy, and Japan. The main regional and international organizations that have been active in promoting and developing renewable energy in the region are the Arab League, ESCWA, European Union, UNDP, UNEP, FAO and GEF.

## *10.7 Renewable Energy Niches*

For ready acceptance, RETs should replace or complement energy resources or technologies currently used by rural and low income people. The technology used must be simple, give comfort, save resources (energy, time) and increase labor productivity. Success conditions can sometimes be created through appropriate government policy measures or through social awareness. In Jordan the renewable energy industry is more advanced than that in Syria. Lebanon is still lacking behind. There is an urgent need for entrepreneurial policies that will encourage the investments of the private sector in renewable energy and energy efficiency with the help of the public sector and civil societies. This can only be done if it is only complimented with good financial policies and economic instruments. More studies are needed to determine the correct development path of using renewable energy and energy efficiency in order to alleviate poverty in both rural and urban areas in Lebanon, Syria, and Jordan. There are several success factors and criteria that allow the spread of RET:

- **Technical resources** of the site such as utilizable wind speed, solar radiation, and availability of biomass. These conditions cannot be created through human intervention, but from the study of the resources of Jordan, the Syrian Arab Republic, and Lebanon, there is a high potential of renewable energies.

- **Quality standards** for RETs fixed by the government or by private institutions. In Jordan and the Syrian Arab republic many standards and codes of practice have been implemented and deployed while Lebanon is still lacking behind as was discussed previously.

- **Appropriate technology** should be utilized to match the economic and social needs of users. For example, low population density and dispersed settlement structure, such as rural areas in Jordan and Lebanon that have low rural population densities, are favorable for the supply of electricity through decentralized RETs such as small hydro biomass or wind rather than through extension of the national power grid.

- **Local replicability** includes the local availability of materials and resources required to manufacture RETs.

- **Financial feasibility** that can be assisted by governments who can initiate incentives for promoting RE projects such as abolition of import duties, tax relief and concessionary grants. In all three countries, RETs are still not affordable for the poor due to the high capital costs and currently the poor are not benefiting from these technologies. Poverty cannot be alleviated unless the poor can afford RETs at least in terms of the maintenance and operation costs. The ability of target users to afford the cost of the technology is the first essential for the wide spread of energy technology systems in rural areas.

- **Public awareness** about the benefits and risks of RETs through information campaigns and lobbying by NGOs and RE business associations. Other steps might be by the integration of RETs into the national education system and promotion of scientific studies which measure the potential for RE such as the solar weather atlas which was published in 1989 in Syria and in Jordan [43 -44].

- **Institutional incentives** by integrating RE into energy policies such as establishing RE targets as in Jordan (28% of national energy requirements by 2010), and the Syrian Arab Republic (save 5% of the total energy consumption through RE by 2010). Other incentives might be allowing power production by IPPs as in the case of Jordan wind IPP project. Governments should always give RE projects preference over conventional energy projects. Examples of such institutions include the ministries of energy in the three countries, National Energy Research Center in the Syrian Arab Republic, and Council for Development and Reconstruction in Lebanon.

- **Cultural harmony** and **social equitability** of the technology to be accepted and integrated in the three countries who share similar beliefs and habits.

It is clear from the assessment of renewable energy resources and use as presented in some case studies that renewable energies can play a definite role in providing basic energy needs to the rural areas. Pilot projects in Syria and Jordan on wind energy have been successful with local capacity for installation, operation and maintenance being developed in Jordan. The use of domestic solar water heaters in Jordan is another niche that both Lebanon and Syria can learn from where electricity is accessible and at a low cost. Backup policies by government need to address these issues as will be presented in the recommendation section. Table 17 presents a number of demonstration projects that were a success in Syria. These projects (**presented in detail in appendix F**) show that the use of standalone PV systems and electro-wind systems that are connected to the grid can be an income generating activity that can be sustained. Jordan has already taken its wind and PV projects to large scale projects that are sustained with expansion plans as was presented earlier on current renewable technologies status.

Table 17: Sustainable RETS demonstration projects in Syria

| **Description** | **PV – stand alone** | **Grid connected wind turbines** |
|---|---|---|
| Objective | Demonstrating the feasibility and the applicability of the PV systems in Syria through the comprehensive economic and social analysis before and after the installation of the Photovoltaic systems- | Demonstrating the feasibility and the applicability of the electro-wind systems in Syria |
| Goals | Electrification of 4 villages with a total of 103 households with a total power of 66 KWp | Installation of a wind turbine in a grid connected mode in a promising area |
| **Suitability/Viability/Sustainability** | | |
| Affordability | Low | Low |
| Effectiveness | Medium | Medium |
| Risk of obsolescence | Low | Low |
| Flexibility | Medium | Medium |
| Technological capability | Medium | Medium |
| Suitability and urgency | high | High |
| Resilience | Low | Low |
| Adaptability | Medium | Medium |
| Environmental impacts | Very low | Very low |
| Social acceptance | good | Good |

## *10.8 Assessment of Other Experiences*

Table 18 presents another experience for electrification of four villages in Aleppo area using stand-alone systems. The field performance showed a good reliability of the various PV systems used. A valuable know-how was gained by the PV Lab team throughout the execution of the project. The various applications of the installed systems created the training environment for engineers and technicians involved in the project from the government in and NGO's. Later the JICA study team investigated the degree of satisfaction of the residents of the four villages with the overall performance of the systems. The results were as follows: irrespective of generation, a little over 60 % indicated satisfaction. About 25 % were fairly satisfied and less than 9 % were dissatisfied. A lot of work remains to be done regarding the coherent approach towards further involvement of national parties to cover the institutional and financial aspects needed to settle this technology in Syria.

Table 18: Assessment of using PV stand-alone system for electrification of 4 villages in Syria.

| **JICA Project for electrification of 4 villages by PV stand-alone systems** | |
|---|---|
| **Criteria** | **Description** |
| Objectives | * Demonstrating the feasibility and the applicability of the PV systems in Syria through the comprehensive economic and social analysis before and after the installation of the Photovoltaic systems- |
| Goals | Electrification of 4 villages with a total of 103 households with a total power of 66kWp |
| Results obtained | * The field performance showed the good reliability of the various PV systems. |
| Population target | Rural population; most lives on mountains living at a distance of 3-10 km from grid and 35-80 km from Aleppo |

| JICA Project for electrification of 4 villages by PV stand-alone systems | |
|---|---|
| **Criteria** | **Description** |
| Population benefited | 820 |
| Weak points | * Incorporating the PV systems into the national grid<br>* Establishing management and financial system |
| Capacity status assessment of the project stakeholders | Medium |
| Zones | Aleppo region |
| Replicability | Medium:<br>* From this pilot investment the Government of Syria is expected to finance the extension of supply and services to other villages.<br>* Prospects for PV Village Electrification in Syria till 2010 are about 4000 stand-alone systems of 600 WP, 120 mini-grid systems of 10 KWP, 3750 Solar Home systems of 80 WP, and 10,000 Solar lanterns of 10 WP. |
| Potential population benefited | 5000 |
| **Suitability/Viability/Sustainability** | |
| Affordability | Low |
| Effectiveness | Medium |
| Risk of obsolescence | Low |
| Flexibility | Medium |
| Technological capability | Medium |
| Suitability and urgency | high |
| Resilience | Low |
| Adaptability | Medium |
| Environmental impacts | Very low |
| Social acceptance | good |
| Income generation | Medium |

## *10.9 Overall Assessment and Identification of Problems*

Switching to renewable energy resources provides beneficiary management strategies from the economic, as well as environmental points of view. Renewable energy technologies are very important and should be recommended when the cost of such technologies is competitive. However, integrated actions are essential for the internalization of external costs, provision for funding of research, development of low emission technologies, and provision of temporary incentives for early market introduction of these technologies. The success of the integrated actions is also dependent on public opinion and attitude, and attempts to direct them towards efficient energy usage and conservation.

### 10.9.1 Actions needed for RET spread

Energy is crucial for rural development. Numerous measures have been taken in planning and implementing rural energy initiatives in Jordan and the Syrian Arab Republic, in contrast rural energy initiatives in Lebanon remain undefined and largely unattended due to the civil war and the current economic crisis. Energy policies and institutional modifications should be launched to improve energy conditions and achieve rural development. Lack of rural energy will remain a chief cause of underdevelopment and poverty unless efficient interventions are made. Investment in energy is as important as investing in health rural roads, education and other services sectors.

Current energy policies with regards to rural energy initiatives should be reviewed while giving the rural economic activities high priority. All three countries are rich with renewable energy resources that are still not totally exploited and are yet to attract potential developers. The level of electrification in rural and poor areas is already high so the cost of RETs should be competitive compared to other energy resources and the electricity supplied by the grid. Affordability of RETs is essential for the wide spread of the technology in rural communities. Opportunities exist for introduction a range of RETs depending on the utilization purpose. A renewable energy strategy that relies on a wide range of renewable technologies must be adopted to ensure that the poor select the technology that best fits their needs and their income.

First, it is very important that countries set a target for renewable electricity generation such as in the case of Jordan and the Syrian Arab Republic as was mentioned earlier. Currently, Lebanon still has no set target for this purpose. If RETs are to be introduced as chief components in rural energy plans, it is very important that the economic and financial considerations, the financial implications involved in recuperating costs, the associated payback periods and recuperating costs, and the associated payback periods be taken into account. RETs are known to usually have relatively high costs compared with other energy technologies, but if initiatives based on fossil fuels are carefully considered and short-tem financial hardships against long-term economic advantages are weighed RETs might be a favorable and affordable solution on the long run.

Biomass is often to be used in rural areas for energy supply but the utilization is not efficient and it might not be sustainable. Current practices should be examined especially in Lebanon where the country suffers of the problem of deforestation and substitutes for this kind of resource have to be sought. Initiatives for conserving and rationalizing the remaining biomass energy resources of the country should be coordinated between various ministries and organizations.

PV can be used for to light schools homes and hospitals, but high costs are associated with the implementation of PV technologies consequently making them unaffordable for the poor and low-income population. In the three countries, governments and donors are usually forced to provide large interfere to make the systems affordable to rural and poor communities. A possible solution to this might be to target income-generating activities in the agricultural sectors, for example, while disseminating modern energy in rural areas. This strategy can lead to a successful spread of RETs in the productive sector that has higher turnovers than households, and where cash flows are stable allowing affordability of RET maintenance thus leading to the sustainability of these systems. Numerous micro-enterprises that can benefit from RETs exist in rural areas, for example, beer brewing, baking, crop drying, and agro-processing industries that require large portions of mechanized and thermal energies.

Policies that will contribute to poverty alleviation in term of money savings and new business development in poor regions (both rural and suburbs) are summarized as follows:

#### 10.9.1.1 General policies

10. Revise Electricity subsidies in all sectors to change consumers' behavior.
11. Install Electric meters for all households and use better control mechanisms to eliminate theft (particularly in Lebanon) in order to reflect the true social cost of electricity generation.
12. Use more efficient electricity generation technology and use LPG as the main energy source when possible (For example Lebanon can utilize LPG coming from Syria). Improve efficiency in electricity distribution lines. Energy Management plan for the whole country is needed.

13. Encourage, as a first stage, RET technology transfer and later develop RET technology locally to meet specific needs and then export the technology when it becomes mature. Entrepreneurial policies must be developed by the government with the cooperation of local financial institutions, research institutions, private sector, and NGOs. International organizations such as the UN, World Bank, EU, etc. can help in developing the best model in selecting the appropriate RET technologies suitable for each country and in providing initial financial assistance for starting pilot project and in building the human capacity and the infrastructure to sustain such new RETs manufacturing sector. This new sector should be targeted toward poor regions.

#### 10.9.1.2 Rural Areas Policies

1. Promote the use of RET technologies (water heaters, pumping, etc.).
2. Use economic instruments (tax credit, Reduce initial cost of electric appliances and equipment, etc.) to encourage consumers to buy more efficient and environmental friendly electric appliances and products.
3. New RETs manufacturing should be targeted in rural regions. Governments needs to update its infrastructure in rural areas to ensure the success implementation of such industry. Such industry will not only contribute to energy savings only but also will help in reducing unemployment in poor regions. Rural municipalities in rural areas can play an effective role in policy implementation.
4. promote the use of renewable energy in water desalination and treatment.

#### 10.9.1.3 Urban Areas Policies

1. Encourage the use of more efficient electrical appliances and fixtures including public, commercial, and households, and when possible, use RETs such solar water heaters. The government should institute a national program to support and encourage energy efficiency in urban areas. Poorer population can benefit from the savings to improve their way of life. National programs to develop standards have already started in the region with UNDP supported projects to develop cross-sectoral energy planning centers in Lebanon, and Syria. Jordan has already developed a national program for energy efficiency in urban areas [4].
2. More control mechanisms must be instituted to reduce electric theft from government lines and this reduces the electric bill on household. Savings can be used to improve social status. This is applicable to Lebanon in particular where electricity theft is an inherent problem from the years of the civil war that lasted fourteen years and ended in 1990.

Government in Jordan is currently working on the necessary regulations, tariff structures, low tax considerations and incentives to encourage RET utilization and decrease high import and custom duties on RETs, in addition to, encouraging local manufacturing of these technologies by giving manufacturers incentives to make their activities profitable. Lebanon and Syria are in need to improve their tariff structure, in addition to sponsoring and piloting RET projects to introduce RET operations and uses to operators, promoters, and consumers.

It is essential to sponsor the local manufacturing and assembling of RETs such as small hydro, wind, and solar equipment e.g. PV for water pumping and drinking water. Cheap water pumping technologies can increase cattle and crop productivity while utilizing local resources. Wind pumping machines can be designed, manufactured and assembled locally. The financial returns can be high. In Lebanon, the use of wind pumping machines would not be feasible since water depth in wells vary from 300-600 meters unlike shallow underground water in Jordan and Syria [20-21].

The transfer or acquisition of RETs and the interests of local entrepreneurs should be protected and supported by legal specifications to guarantee the safety and durability of the imported or locally manufactured RETs. To successfully implement rural energy initiatives the issue of human resources and technical capability should be studied. Qualifications and awareness should be built within the shortest time possible. At post secondary school level and even at school level, national energy issues should be integrated into the curriculum. It is also possible to introduce energy training programs. Engineering and sciences of renewable energy sub-sector should be enhanced especially those that can help develop local manufacturing. There is a strong relationship between education and the energy provided for rural communities. Transfer of technology such as the installation, maintenance, and operation of RETs requires literacy-level and minimum technical expertise otherwise exploiting renewable resources will remain remote and unachievable [45].

## 4. Strategic Policies Outlines

The development of renewable energy resources in Lebanon, Syria, and Jordan can greatly contribute to the socio-economic growth in these countries. First, renewable energy allows for a great deal of diversification of energy resources and helps in reduction of use of fossil fuels. Therefore, in the case of the four countries who are importers of fossil fuels (except Syria for a minor production of oil and natural gas). Such reduction will contribute to the limit of the growth of energy imports and save on energy expenditures.

Second, socio-economic development is one of the priorities in these three countries. The development of renewable energy technologies will assure increased accessibility of available and affordable energy services to contribute in improving the education and health care in many rural areas. Third, renewable energy technology will open many job opportunities for manufacturing, distribution, operation and maintenance, thus create income opportunities. Forth, renewable energy can play a very strategic role in improving women’s situation in Lebanon, Syria, and Jordan. This is achieved by the provision of small electrification systems for households, clinics and schools, such as water pumping and water desalination units. By improving the living conditions in the rural areas, women work, education and health care will all be improved, therefore ensuring balanced services for women, men and children.

Finally, It is worthy to mention that many regions of these countries are facing water shortages, and fossil water from underground reservoirs is being rapidly depleted. Consequently, the need for desalination units is expanding rapidly and renewable energy systems can greatly contribute to the operation of such desalination units.

### 13.1 National Strategies for Sustainable Development

The national strategy of the Jordanian Government targets

(1) The development of local energy resources and technologies to supply 28% of national primary energy by the year 2010, and
(2) Improvement of energy efficiency and encouragement of energy conservation.

In addition, the government adopted a number of policy issues to encourage RE development. It mainly includes the following:

- Development and adoption of RE technologies relevant to Jordan's development needs particularly in remote areas.
- Upgrading R&D local capabilities.
- Increasing designs and production capabilities for RE equipment.

- Building testing facilities for RE equipment.

In Syria, the national strategy target is to save 5% of the country's total energy consumption around 2010 from solar and wind resources. To achieve this strategy the following measures have been considered:

- Coordination of national efforts towards the achievement of the strategy target for RE
- Support of RE market penetration
- Support of R&D, education and training in the field of RE.

The higher committee on RE has adopted a number of recommendations and guidelines for RE promotion. Mainly:

- To determine RE potential in Syria
- To direct research and development in the area of RE
- To diversify energy consumption through a better use of available various energy resources.

In Lebanon only policy guidelines encouraging R&D in the renewable energy field have been recorded, which cannot constitute the necessary mechanism towards integration of RE within the overall national energy policies and plans.

### 13.2 Factors and Activities Affecting the Sustainable Energy Development

Sustainable development is very important for countries like Lebanon, Syria, Palestine, and Jordan. Even more important is the sustainable energy which is encouraged through sustainable and stable supply of energy throughout these countries and through carefully studied pricing policies. There are many factors that can positively contribute to a sustainable energy development of these countries. According to Dincer (46-47) these factors are research and development, technology assessment, standard development, and technology transfer. Therefore, the question to be asked is to what degree Lebanon, Syria, and Jordan have managed to address the above issues.

***On the research and development level:*** during the last two decades, renewable energy technologies and their applications have been the subject of several R&D activities in the region. Most of the research work was done by universities and research centers and was linked to demonstration projects implemented through co-operation with donor countries or agencies and directed towards the evaluation of components and systems performance under local conditions. Efforts directed to planning studies and evaluation of the potentials for RE technology/application options were limited and differ from country to country. An important observation is that research effort did not constitute a driving element in the decision making process related to widespread penetration of renewable energy technologies and applications.

***On the technology assessment level:*** Through the bilateral and multilateral cooperation programs, several RE technologies were demonstrated for different applications in the region. Some of the demonstrated projects were effectively evaluated and programs for the development of the relevant technologies were implemented or being planned (e.g. DSWH, SIPH, systems, PV rural systems and wind turbines). Other demonstrations were just used as pilot projects, which may have been tested but not yet further developed nor replicated.

***On the standards development level:*** The majority of the countries under investigation have not developed yet standards for RE components and systems, nor have they established testing and certification laboratories in order to support the development and manufacturing of RE technologies. Exception applies to DSWH components and systems, which have been developed and issued in Jordan, and Syria. One main testing and certification center exists in Jordan which tests and certifies RE components and systems according to the international standards and codes of practice.

***On the technology transfer level:*** Various RE technologies have been operating for several years in Jordan and to a less extent in Syria. Applications include water heating, water pumping, rural electrification, desalination, and others. Such applications have been satisfied by mature RE technologies including PV, wind turbines, biomass and small scale hydro power plants. However, in Lebanon and Palestine, only solar water heating systems were effectively demonstrated and applied on large scale. Therefore, technology transfer is urgently needed to all of these countries to identify the most cost effective renewable energy options.

### 13.3 Policy Issues

The energy sector of Lebanon, Syria, and Jordan has to meet two common policy challenges

3. The need to move to a more sustainable production and use of energy;
4. The need to strengthen links and promote regional and international coordination in the fields.

Therefore, to face the above challenges, the countries should further develop policies and plans, taking into account their national circumstances. Efforts should continue to be directed towards

6. Establishing national and regional agreements for promoting energy accessibility within their countries, and providing the basic needs especially in the rural areas.
7. Developing a cost effective mixed systems that operate on fossil fuels combined with renewable energy sources.
8. Promoting conservation in energy consumption, and sustainable development of both cleaner fuels and more advanced fossil fuel technologies.
9. Taking into consideration the impact of the energy sector on the environment, water distribution/use, and on health.
10. Enhancing regional coordination for energy transfer and investments to achieve an acceptable level of sustainable development.

Several renewable energy technologies are approaching maturity and can be used for small-scale applications as much as it can be used for large-scale applications, in particular, electricity generation. Meanwhile, Lebanon, Syria, and Jordan enjoy the availability of various renewable energy resources such as wind energy, solar energy and biomass.

On the other hand, some of these countries have established specialized renewable energy institutions while in others, this is still undertaken by universities [4]. It has to be noted that although several organizations are involved in renewable energy development, they are in many cases specialized in some specific aspects rather than being concerned with renewable energy development in an integral sense. The few existing institutions that are related to renewable energy planning have upgraded their capabilities in different fields, such as education, information, testing and certification, operation and maintenance.

## 5. Summary of Key Findings and Recommendations

In spite of the developed policies and strategies, together with the institutional arrangement and programs achieved, the process of promoting renewable energy technologies has been faced by different constraints as outlined below:

1- Policies for renewable energy development were not sufficiently integrated with the overall energy planning process and objectives.
2- Limited investments were made available for making renewable energy systems affordable to end-users. This owes the fact that, in spite of several bilateral and multilateral cooperation and financial programs directed for the promotion of renewable energy, the essence of financial resources was directed to conventional systems. This is apparent in Lebanon and Syria where major expansion in power plant capacities took place in the past decade.
3- The limited partnership among different parties in the same country such as planners, implementers and users, especially in the rural areas, makes it difficult to use renewable energy systems.
4- There are a limited industrial capabilities and services for promoting renewable energy and energy efficiency programs.
5- Lack of awareness among different parties involved in the development and use of the renewable energy resources about the benefits of such technology and the way of improving its use.
6- There is a problem in the communication among renewable energy development bodies such as manufacturers, institutions, dealers and end-users.
7- Limited regional cooperation and financing, which obliges these countries to go to foreign financing agencies and technologies.
8- The region proximity to countries that are mainly dependant on oil and gas revenues, there is an apparent false conflict of interest between the oil and gas community in the region and the promotion of renewable energy.

## 6. Suggestions for Future Actions

According to Dincer [45-46] there are many important parameters that can help in successfully achieving sustainable development in many countries around the region. These include public awareness, information, environmental education and training, innovative energy strategies, financing, and evaluating and monitoring tools. Because each country in the region has a different economic, social, and political structures, policies must be devised carefully to fit the specifics of each country. For example, the use of public media and information dissemination are very restricted in some countries, and therefore, public awareness and information must be done from top down through related public agencies. In addition, financing might prove to be a problem because many countries in the region have limited resources. Initially, some demonstration projects should be sponsored by international organizations in order to prove the worthiness of such projects in order to convince local financing and investments in renewable energy projects.

Based on the constraints described above that Lebanon, Syria, and Jordan are facing the following are the actions needed to foster renewable energy development:

7- There is a need to develop national strategies and action programs with specific targeted contributions of clean and nonpolluting renewable energy technologies to the total energy consumption.

8- Raise awareness and provide sufficient information for promoting renewable energy systems and sustainable use of energy resources.
9- Promote innovative financing arrangements aimed at reducing up-front costs or equipments with particular attention to the needs of the rural and poor areas.
10- Develop appropriate energy transfer arrangements with enhance national and regional contributions and regional coordination and cooperation through existing mechanisms.
11- Strengthen national and regional institutions that develop, implement and operate programs on renewable energy development and energy for sustainable development.
12- Strengthen human resources development in the area of renewable energy including educational programs at different levels, promotion of training programs for decision makers, engineers and technicians, and development of hands-on experience for specialists and technicians.

## 7. Stakeholders Reaction to Proposed RTES Policy Outline

A stakeholders meeting on renewable energy and energy efficiency policy outline for the region where members from various partner universities was held on January 24, 2005 at the American University of Beirut. The meeting included members from academia, UNDP project managers, together with members from the professional and governmental community interested in energy issues. In addition, the members of the Regional collaboration Steering Committee on Energy Efficiency and Renewable Energy Technology attended the meeting. Invited faculty from Jordan University of Science and Technology attended the meeting. Two members from Syria attended the meeting from Damascus University and the Ministry of Energy. The program for the Stakeholders meeting is given in Table 19.

Table 19: Stakeholders Meeting Agenda.

| **Time** | **Title/Speaker** |
|---|---|
| Moderator: Dr. Farid Chaaban | |
| 9:00 a.m. – 9:15 a.m. | Opening speech, (briefing on GNESD objectives) |
| 9:15 a.m. – 9:30 a.m. | Presentation on Energy Access projects I & II,<br>Dr. Sami Karaki |
| 9:30 a.m. – 10:00 a.m. | Efforts for poverty alleviation in the Region (ESCWA) |
| 10:00 a.m. – 10:20 a.m. | Jordanian paper on National Energy Policies (Dr. Fayez Abdulla) |
| 10:20 a.m. – 10:40 a.m. | Lebanese paper on National Energy Policies<br>(Mr. Kamar, Consultant. Ministry of Energy) |
| 10:40 a.m. – 11:00 a.m. | Discussion |
| 11:00 a.m. – 11:30 a.m. | Coffee Break |
| Moderator: Dr. Moutasem El-Fadel | |
| 11:30 a.m. – 10:50 a.m. | Syrian paper on National Energy Policies,<br>Mr. Abdel Raouf Yehia |
| 11:50 a.m. – 12:10 a.m. | Thermal Standards for Buildings,<br>Ms. Matilda Khoury, Project Manager |
| 12:10 a.m. – 12:25 p.m. | Presentation on Renewable Energy Technologies Project,<br>Dr. Riad Chedid |
| 12:25 p.m. – 1:00 p.m. | Discussion on impact of adaptive energy policies that address poverty and improvements in quality of life in the region |
| 1:00 p.m. – 2:00 p.m. | Recommendations and approval of proposed national and regional Energy Policies |

The general issues brought up in the discussion included the following:

10- Improve communication with public and secure funds to finance the investment plan in energy efficiency
11- Improve management structure and effectiveness at Electric Utilities.
12- The electricity tariff in Lebanon is the highest in the region. It needs restructure to help low income access to electricity. The focus in Lebanon has been directed since 2002 to energy planning and conservation.
13- Reduce Theft by security forces.
14- Generate funds to help low income access to non-intermittent electricity
15- Water access should be dealt with energy in the same manner as energy. The same approach can be applied for both water and energy in the planning.
16- Most supply of hydro power is in winter for Lebanon- The possibility of photovoltaic for street lighting.
17- To attract the private sector to energy production and distribution, there should be laws and regulations so that the sector can serve in the region. Laws in both Syria and Lebanon are not supportive to make it feasible. Regulations are to be in place to attract investment in the energy industry.
18- There has to be a strategy that includes conservation and renewable energy use in the region. The Jordanian model can be studies and used as a successful case study. Energy conservation is considered as a new energy source due to its potential in energy savings in Jordan. The extensive conservation programs implemented have led to a direct saving in energy estimated at about 80 thousand tons of oil equivalent per year. One of the primary functions of the conservation program is to inform the public about energy savings by collecting and disseminating information about energy conservation. Activities include holding seminars, advertising, preparing and distributing publications on energy conservation. A second major activity of the Jordan National Energy Research Center is that of conducting energy audits and providing technical advice based on on-site inspections. The advice has encompassed using thermal insulation, designing passive-solar heated buildings, installation solar water heaters and using more efficient electrical equipment
19- Much can be learned from Jordan experience in privatization of the energy generation sector as demonstrated by the Jordanian paper and the effect of the reforms on the energy bill of the low income people. All policies are at the bottle neck at funding. Signing Kyoto Protocol will provide funding mechanisms to Lebanon and Syria. Jordan is already using this fund for energy savings.
20- Rural electrification is not needed, but we need renewable energy for grid connection to cover up supply shortages. We need to have large scale solar hot water systems to reduce use of valuable energy on domestic uses.
21- Attention to the poor will be given in the policy development and legislation. Study of electricity Tariff's will take into consideration the effect of Tariff on the poor and their quality of life. A Current UNDP project is considering the impact on the poor so that poor do not immigrate to cities. The poor and the average population will benefit if performance and energy efficiency is implemented to reduce the production cost in the first place. Privatization is to be implemented.

Additional recommendations were proposed by the technical US advisor, Mr. Mark Thornbloom from Florida Solar Energy Center who attended the workshop and participated in the discussions:

1- Help reduce Lebanon's transmission and distribution losses by recommending distributed generation (whether micro-turbine, fuel cell, reciprocating or solar).
2- Reduce dependence on imported fuels and electricity by encouraging domestic power generation using domestic fuels of biogas, wind, solar and hydro. As demand worldwide for natural gas grows and as LNG facilities come on line allowing export over long distances, the value of NG will increase possibly pricing itself outside the

ability/desire to pay for it with in the region. Cultivation of domestic renewable resources helps insulate against this trend.

3- Consider solar power plants for peak-shaving of loads during mid- and late-day in the cities, when the solar resource is well-matched to the load peak
4- Evaluate the economics of solar power generation, starting with the American and European estimates but redefining the solar economics for each national economic situation, bearing in mind that economics on an individual basis may not encourage use of solar or even energy conservation due to subsidized power. However, the burden on the local or national government to supply that power may lend itself very favorably to using solar technologies.
5- Privatization encourages a more efficient delivery of energy. However its very nature is profit-motivated leading it to ignore by necessity the plight of the poor and "pick the low hanging fruit". Privatization should be accompanied by government programs that ensure the poor receive at least certain minimum access to energy necessary for modern life. Florida's Solar Weatherization Assistance Program can be used as a model for assisting the poor, to be adapted to the Lebanese cultural and social environment.
6- Perhaps a revision/overhaul study of existing hydro installed capacity in Lebanon might be in order to reduce water and energy leakage, and replace inefficient equipment. However, although the installed capacity is reasonable, the value of water for human use may exceed its value as an energy source, and power production may take second priority to irrigation and potable water supply. Other domestic sources such as wind and solar, including concentrating solar, should be investigated and tabulated as part of the resource database.

### 7.1 Issues Arising from the workshop

a) Tariff Structure to encourage conservation and address the access of poor to energy
b) The need of large scale pilot projects for effective use of renewable energy in conservation, energy production and income generating activities.
c) Standardization and labeling is a priority for all common equipment and devices that use electricity. The regional market is flooded with inefficient appliances. Government should provide/encourage testing and certification facilities to remove barriers for the use of efficient energy products and warn the consumer.
d) Increase public awareness on energy conservation in a manner similar to the Jordanian program.
e) The social development in the region is dependent of adaptive energy policies that take into consideration the needs of the poor. Audit and monitoring for any policies and its implementation, and energy planning should be set on a comprehensive basis with an authority that coordinates the planning with other centers.

Characterization of the present situation in Lebanon, Jordan, and Syria and analysis leading to the identification of problems, their magnitude and priority is summarized in Table 20 where the identified problems in the renewable energies sector are presented with stated objectives that present the desired solution and the proposed policy to reach the objectives, in addition to the instruments to implement and articulate the policy outlines with the objectives and the proposed activities and actions to put into practice the selected instruments. The problems are ranked based on priorities as was deduced from the reactions of the energy stakeholders. The instruments and activities are accordingly modified.

**Table 20: RETs – Policy Summary Table (Lebanon – Jordan – Syria)**

| | Problems | Objectives | Policies | Instrument | Activities |
|---|---|---|---|---|---|
| **1** | - The limited coordination and lack of communication among different parties such as renewable energy development bodies, implementers and users, especially in the rural areas, makes it difficult to promote renewable energy systems on a large scale.<br>- Lack of an independent authority in Lebanon in particular that believes in the value of RETs economically and environmentally.<br><br>This problem is not as significant in Jordan where a National Renewable Energy Center is following up on projects related to RETs and its finances. Syria and Lebanon are not as effective in addressing RETs problems. | - To establish or strengthen the authority that oversees the applications of RETs and proposes policies to promote renewable energy technologies and energy conservation practices and regional collaborations.<br>- Coordination between different parties through the proposed central RETs authority to enhance the usage and involvement of RETs in rural areas. | - RETs authority should establish guidelines for resource allocation for RETs to different sectors, compile success implementation of RETs projects and provide needed studies for updates or introduction of new energy policies.<br>- Government should update their infrastructure and work closely with the municipalities in rural areas to ensure successful implementation of such industry. Such a policy will not only contribute to energy savings only, but will also help in reducing unemployment in poor regions. | - Create special authorized and trained teams that work locally in rural areas to promote RETs and conservation practices and report continuously to municipals that in turn report to the government. | - Collect feedback from RE users and suppliers of service through surveys, interviews, and evidence based information from municipalities.<br>- Distribute the necessary information for the promotion of RETs. |

| | Problems | Objectives | Policies | Instrument | Activities |
|---|---|---|---|---|---|
| **2** | - Urban areas contribute to major energy waste due to the use of less efficient electrical appliances and fixtures including public, commercial, and households.<br>- Lack of interest of professionals and public to invest in RETs as economically feasible solutions in rural or urban areas. | - To develop guidelines and policies for energy conservation in common waste sources in residential, commercial and productive sectors.<br>- To have in place successful case studies and demonstration projects. | - Introduce Labeling of Appliances and Equipment.<br>- Develop tax incentives for more efficient high quality appliances and fixtures in public, commercial, and household applications, and when possible, use RETs such solar water heaters. Governments should institute national programs to support and encourage energy efficiency in urban areas.<br>- More awareness of people for the efficient use of energy, and thus reducing waste.<br>- Introduce policies that require local testing and certification of local energy products | -The availability of RET appliances and equipment for these urban areas with appropriate labeling, low cost and tax. Incentives.<br>-Encourage people to use more efficient energy appliances.<br>-Finance practical case studies in the various sectors as applicable (examples include PV and small wind turbines for commercial applications).<br>-Presentation and documentation of successful projects<br>-Pilot projects to be used for building the know-how and the expertise to install and operate RETs systems.<br>-Establish or promote funding to have testing and certification centers for energy products including RETs. | - Conduct educational training for professionals and provide guidelines and programs that enhance the energy efficiency awareness of the people in these areas.<br>- Involve higher education institutions in development of curricula and guidelines for efficient energy practices.<br>- Specialized agencies should become available to professionals and personnel working in municipalities and other organizations.<br>- Promote efficient practices using the media and publicizing the economic impact.<br>- Develop financial mechanisms either through governmental banks or private lending organizations to provide credit to research and development programs. |

| | Problems | Objectives | Policies | Instrument | Activities |
|---|---|---|---|---|---|
| **3** | - Lack of knowledge on the economic value of energy in some levels of energy policy makers and lack of knowledge about RETs economic potential in particular. This creates weak links in the chain of policy development and eventual implementation. | - To create the technical and effective knowledge to reinforce the weak links in the chain of policy development from community leaders and representatives to government and legislation bodies.<br>- To disseminate the know how to a wider professional and governmental community. | - All personnel involved in energy policies, energy generation, distribution, utilization should get minimum certification and training on the economic value of energy and periodically update their skills or knowledge.<br>- Involve energy experts in the decision making process with more professional opinions sought. | - Prepare an organizational chart for the energy decision making process in the involved ministries and other stakeholders in the process.<br>- Identify key personnel for training and type of training needed within available resources and with dependence on local expertise to develop and deliver the training. | - Universities and NGOs in cooperation with Governments prepare certification programs for different levels: 1) Policy level (high officials, general directors and strategic planning committees), 2) Professional level (engineers and municipality officers), 3) skilled technicians, 4) audit clerical workers, and 5) business owners and small industry investors. |
| **4** | - Biomass is often used in rural areas for energy supply but the utilization is not efficient and it might not be sustainable. Current practices should be examined especially in Lebanon where the country suffers from the problem of deforestation and | - More awareness of this renewable energy resource.<br>- Exploitation of biomass energy from solid waste in large scale applications. | - Involvement of governmental and NGOs in research for realizing and development of this energy resource by financing practical economically feasible projects.<br>- Developing partnerships with governmental organizations to help | - The development of integrated waste management systems of recycling, compositing, and land filling.<br>- Limiting or even banning unauthorized utilization of biomass products (especially wood) in rural areas. | - Make use of resource assessment, and R&D projects to construct landfills and upgrade old incinerators to fit international standards.<br>- Introducing small domestic projects like methane gas production for domestic use from |

| | Problems | Objectives | Policies | Instrument | Activities |
|---|---|---|---|---|---|
| | substitutes for this kind of resources have to be sought | | develop the facilities and the know how for utilization of biomass solid waste into an energy resource. | | house organic waste. |
| **5** | - In Lebanon, control mechanisms are not effectively applied to reduce electricity theft from the electric network. Theft reduction has direct impact on the income of the electric utility and indirectly on the government to reduce public debt. | - To reduce as much as possible electricity theft | - Apply the laws and fines impartially on violators.<br>- Revise electricity subsidies and tariff with focus on reducing hardship for low income people.<br>- Impose fines that are proportional to amount of electricity theft. | - Adoption of a program to cut non-technical losses and to continue to improve collections.<br>- Rehabilitation of the distribution network. | - Collection improvement plan such as increasing the collecting personals.<br>- Supply necessary equipment and meters for stations and substations to assess the amount of energy loss. |
| **6** | - Many locations of the target countries are facing water shortages and fossil water from underground reservoirs are being rapidly depleted. Consequently, the need for desalination units is expanding rapidly. | - Expanding RET applications to be applied in small but numerous desalination projects especially in rural areas. | - Encourage water conservation and tax for use of renewable resources for desalination in rural areas. | - Secure funding on national level to promote research in this domain. | - Demonstrated small scale applications of photo voltaic and wind energy technology in remote off grid areas for desalination projects. |

| | Problems | Objectives | Policies | Instrument | Activities |
|---|---|---|---|---|---|
| **7** | There are limited industrial capabilities and services for promoting renewable energy and energy efficiency programs in Syria and Lebanon. | - Wide spread of the use of RE programs with organized promotion if this technology through industry and public awareness.<br>- Build local and regional capacities and the know how in the field. | - Support of RE market penetration by introducing RETs favorable taxation policies and incentives to customers and to local manufacturers of RETs equipment.<br>- Raise awareness and provide sufficient information for promoting RE systems.<br>- Regional collaboration with Jordan that has a good experience and lessons to learn from. | - Establishment of agencies responsible for the interface with industry investors and the market, such as “Market Coordination Agencies”. | - Thorough study of the market penetration status of RETs.<br>- Introducing incentives to potential customers and manufacturers. |

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# Appendix A

### *Characterization of the population by zones and energy requirements*

### Table 1a-Jordan: Rural Electrification in Jordan as of end 2002[29]

| Area | Total Villages | | Electrified Villages | | No. of Villages and Population Electrified as (%) of the total | |
|---|---|---|---|---|---|---|
| | Villages | Population (000's) | Villages | Population (000's) | Villages (%) | Population (%) |
| Amman & Balqa | 333 | 596 | 333 | 596 | 100 | 100 |
| Irbid and Mafraq | 345 | 850 | 345 | 850 | 100 | 100 |
| Jordan Valley | 72 | 165 | 72 | 164 | 100 | 99.4 |
| Karak | 118 | 178 | 118 | 177 | 100 | 99,4 |
| Ma'an, Aqaba & shoubak | 92 | 101 | 92 | 100 | 100 | 99 |
| Tafila | 39 | 41 | 39 | 40 | 100 | 97.6 |
| Total | 999 | 1931 | 999 | 1927 | 100 | 99.8 |

Table 1: Ministry of Social Development Poverty Lines (1JD = $1.4) [17]

| Description | 1989 | 1993 | 1993(2) |
|---|---|---|---|
| Mean Family Size (Persons) | 7.2 | 6.8 | 6.8 |
| Severe Poverty Line (JD) | 40.5 | 61.0 | 61.0 |
| Absolute Poverty Line (JD) | | | |
| Families Paying Rent | | 119 | 119 |
| Families Not Paying Rent | 89 | 97 | 97 |
| % of Families Below Severe Poverty line | 1.5 | 6.6 | 5.3 |
| % of Families Below Absolute Poverty line | 18.7 | 21.3 | 18.3 |

### **Table 2a-Jordan: Electricity Consumption by Sector (GWH)** [27]

| | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Household | 928 | 1074 | 1192 | 1317 | 1422 | 1562 | 1628 | 1780 | 1835 | 1981 | 2110 |
| industrial | 1181 | 1342 | 1449 | 1519 | 1677 | 1773 | 1799 | 1902 | 1915 | 1974 | 2024 |
| Commercial | 302 | 378 | 425 | 476 | 524 | 578 | 603 | 677 | 720 | 805 | 880 |
| Water Pumping | 548 | 688 | 702 | 768 | 885 | 921 | 963 | 945 | 973 | 990 | 981 |
| Street Lighting | 96 | 83 | 94 | 114 | 119 | 128 | 141 | 148 | 161 | 173 | 178 |
| Others | 86 | 109 | 119 | 136 | 151 | 160 | 174 | 182 | 206 | 210 | 219 |
| Grand Total | 3141 | 3674 | 3981 | 4330 | 4778 | 5122 | 5281 | 5634 | 5810 | 6133 | 6392 |
| Electricity Consumption by Sector (%) | | | | | | | | | | | |
| | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 |
| Domestic | 30 | 29 | 30 | 30 | 30 | 30 | 31 | 32 | 32 | 32 | 31 |
| industrial | 38 | 37 | 36 | 35 | 35 | 35 | 34 | 34 | 33 | 32 | 32 |
| Commercial | 10 | 10 | 11 | 11 | 11 | 11 | 11 | 12 | 12 | 13 | 14 |
| Water Pumping | 17 | 19 | 18 | 18 | 19 | 18 | 18 | 17 | 17 | 16 | 15 |
| Street Lighting | 3 | 2 | 2 | 3 | 2 | 2 | 3 | 3 | 3 | 3 | 3 |
| Others | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 4 | 3 | 3 |
| Grand Total | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |

## *Syria Characterization by District*

**Table 1a- Syria: Population in Syria by Muhafazat (Governorates or Districts) for 2001[2]**

| Indicators | Unit | Damascus | Damascus Rural | Aleppo | Homs | Hama | Lattakia | Deir Ezzor |
|---|---|---|---|---|---|---|---|---|
| Population | 1000 | 1632 | 2162 | 3622 | 1457 | 1305 | 861 | 891 |
| Percentage of total Popu. | % | 9.8 | 12.9 | 21.07 | 8.7 | 7.8 | 5.1 | 5.3 |
| Population Urban | % | 100 | 49.3 | 61.8 | 55.1 | 33.9 | 49.5 | 28.6 |
| Population Rural | % | 0 | 50.7 | 38.2 | 44.9 | 66.1 | 50.5 | 71.4 |
| Annual Growth Rate | % | 1.33 | 3.41 | 2.68 | 2.35 | 2.3 | 1.75 | 3.24 |
| Labor Force LF % of Popu. | % | 31 | 29.5 | 29.6 | 32.3 | 33.9 | 44.4 | 37 |
| Female % of total LF | % | 12.9 | 9.5 | 9.6 | 15.5 | 25 | 35.2 | 44.2 |
| Agriculture LF % of total LF | % | 0.6 | 13.3 | 25.8 | 22.7 | 47.9 | 30.6 | 66.4 |
| Industry LF % of total LF | % | 27.8 | 33.5 | 34.8 | 29.9 | 22.4 | 20.5 | 7.7 |
| Other LF % of total LF | % | 71.6 | 53.2 | 39.4 | 47.4 | 29.7 | 48.9 | 25.9 |
| Number of households total | | 317,024 | 385,852 | 616,675 | 247,420 | 205,937 | 188,486 | 116,155 |
| No. of households urban | | 317,024 | 197,295 | 404,158 | 141,198 | 77,849 | 99,716 | 39,338 |
| No. of households Rural | | 0 | 188,557 | 212,517 | 106,222 | 128,088 | 88,770 | 76,817 |
| Residential Electr. Cons. | GWh | 1,260.00 | 1,229.84 | 1,843.05 | 589.26 | 443.82 | 559.36 | 466.45 |
| Res. Electr. Cons./Capita | kWh | 772.059 | 568.844 | 508.849 | 404.434 | 340.092 | 649.663 | 523.513 |
| Res. Electr. Cons./household | kWh | 3,974.46 | 3,187.33 | 2,988.68 | 2,381.61 | 2,155.12 | 2,967.64 | 4,015.75 |
| Res. Electrification Level | % | 99 | 98 | 89 | 96 | 95 | 99 | n.a |

**Continued Table 1a-Syria: Population in Syria by Muhafazat (Governorates or Districts) for 2001**

| Indicators | Unit | Idleb | AlHassake | AlRakka | AlSweida | Daraa | Tartous | Quneitra |
|---|---|---|---|---|---|---|---|---|
| Population | 1000 | 1106 | 1235 | 674 | 302 | 758 | 664 | 64 |
| Percentage of total Popu. | % | 6.6 | 7.4 | 4 | 1.8 | 4.5 | 4 | 0.4 |
| Population Urban | % | 25.89 | 32.9 | 41.1 | 28.8 | 37.7 | 26.4 | 0 |
| Population Rural | % | 74.11 | 67.1 | 58.9 | 71.2 | 62.3 | 73.6 | 100 |
| Annual Growth Rate | % | 2.59 | 2.46 | 2.67 | 1.71 | 2.99 | 1.62 | 3.62 |
| Labor Force LF % of Popu. | % | 37 | 36 | 31.2 | 30.5 | 23.1 | 39 | 29.7 |
| Female % of total LF | % | 32.2 | 24.5 | 25.5 | 32.7 | 11.2 | 26.5 | 24.9 |
| Agriculture LF % of total LF | % | 53.2 | 47.9 | 57.5 | 26 | 15.9 | 26.1 | 16.6 |
| Industry LF % of total LF | % | 17 | 15 | 15.7 | 17.7 | 22 | 22.5 | 40 |
| Other LF % of total LF | % | 29.8 | 37.1 | 26.8 | 56.3 | 62.1 | 51.4 | 43.4 |

| Indicators | Unit | Idleb | AlHassake | AlRakka | AlSweida | Daraa | Tartous | Quneitra |
|---|---|---|---|---|---|---|---|---|
| Number of households total | | 184,696 | 164,117 | 100,695 | 65,261 | 108,009 | 146,070 | 10,879 |
| No. of households urban | | 49,948 | 58,140 | 42,484 | 19,900 | 40,577 | 44,831 | 0 |
| No. of households Rural | | 134,748 | 105,977 | 58,211 | 45,361 | 67432 | 101,239 | 10,879 |
| Residential Electr. Cons. | GWh | 335.4 | 318.64 | 238.63 | 94.85 | 263.27 | 245.61 | 18.72 |
| Res. Electr. Cons./Capita | kWh | 303.255 | 258.008 | 354.050 | 314.073 | 347.322 | 369.895 | 292.500 |
| Res. Electr. Cons./household | kWh | 1,815.957 | 1,941.542 | 2,369.830 | 1,453.395 | 2,437.482 | 1,681.454 | 1,720.746 |
| Res. Electrification Level | % | 96 | 85 | 90 | 100 | n.a | 99 | 100 |


Figure 1a: Map of Syria that shows the country Governorates or Districts (Mohafaza)

| Table 2a-Syria: Energy requirements for Syria | | | | | |
|---|---|---|---|---|---|
| **Category** | **Type of requirements** | **Energy requirements** | **Group** | **Impact** | **Priority** |
| | | Annual kWh/capita | | | |
| Residential | Lighting | 210 | Rural | 0.5% of total population could benefit | High |
| | TV | 50 | | | High |
| | Refrigerator | 130 | | | High |
| | Washing machine | 45 | | | Medium |
| | Iron | 6 | | | Low |
| | Kitchen equipment | 65 | | | Medium |
| | Vacuum cleaner | 8 | | | Low |
| | Miscellaneous | 50 | | | |
| **Category** | **Type of requirements** | **Energy requirements** kWh/m3/1m head | **Group** | **Impact** | **Priority** |
| Productive | Water pumping for household water | 0.002725 | Rural | Meeting drink water demand for 0.5% of total population | High |
| | Water pumping for crop irrigation | 0.002725 | Rural | Increased food production, increased income | High |
| | Water pumping for livestock | 0.002725 | Rural | Increased animal production, increased food, increased income | High |
| | Water desalination | 1-3 kWh/m3 | Rural | Enhancing water quality for both people and livestock less diseases | |
| **Category** | **Type of requirements** | **Energy requirements** | **Group** | **Impact** | **Priority** |
| Social/Community Services | Refrigeration for vaccine conservation | | Rural Community | Reduced mortality rate, better life quality | Very high |

### *Lebanon Population Characterization by Zone and Income*

Table 1a-Lebanon: Population Distribution by District (Mohafaza) and Income (2002) [17]
Income Category

| 1000 LL* | Total Lebanon (%) | Beirut (%) | Suburbs of Beirut (%) | Mount Lebanon (excl. Suburbs) (%) | The North (%) | The South (%) | Nabatieh (%) | Bekaa (%) |
|---|---|---|---|---|---|---|---|---|
| Income less than 300 | 5.8 | 4.1 | 2.8 | 3.6 | 8.5 | 10.4 | 7 | 7.5 |
| 300 - 500 | 13 | 10.3 | 9.6 | 7.8 | 17 | 22.8 | 14.5 | 13 |
| 500 - 800 | 21 | 15.9 | 21.5 | 15.5 | 23.3 | 24.5 | 25.4 | 22.4 |
| 800 - 1200 | 21.1 | 18.9 | 22.4 | 19.3 | 21.5 | 18 | 24 | 24.1 |
| 1200 - 1600 | 13.4 | 14.7 | 15.2 | 14.2 | 11.5 | 10 | 13.4 | 13.3 |
| 1600 - 2400 | 12.1 | 14.9 | 12.2 | 16.2 | 10.6 | 6.8 | 9.7 | 11.9 |
| 2400 - 3200 | 5.9 | 7.3 | 7.2 | 9.9 | 3.7 | 3.4 | 3.6 | 3.9 |
| 3200 - 5000 | 4.3 | 6.3 | 5 | 8.2 | 2.1 | 2 | 1.6 | 2.6 |
| 5000 & above | 3.1 | 6.7 | 3.8 | 8 | 1.5 | 1.6 | 0.6 | 1.3 |
| not specified | 0.3 | 0.8 | 0.3 | 0.2 | 0.3 | 0.4 | 0.2 | |
| Total | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |

* Exchange rate $1 = LL 1500

## Appendix B

### *Renewable Energy Technologies*

Table 2b: Energy technologies

| Technology<br><br>(from tables 2a and 1b) | Degree of maturity | Degree of penetration | Advantages | Disadvantages | Minimum requirements for application | Cost |
|---|---|---|---|---|---|---|
| **Wind**<br><br>**(Syria & Jordan)** | **High** | **High** | * Wind energy is a new means of clean, renewable and sustainable electricity generation<br>* Wind plant costs have been falling steadily and this trend is likely to continue<br>* Wind energy prices for high wind regime areas as in Syria, are within ranges quoted to thermal plants.<br>*Prices are falling faster, as machines become more reliable and efficient<br>* Grid-connected wind generation is usually injected in distribution network (embedded generation) enabling utilities to save on transmission and other costs<br>* More than 60% of system can be locally manufactured, creating new jobs and contributing to poverty alleviation<br>* Stand-alone wind generation for water pumping don't storage | * Stand-alone wind generation for domestic loads requires storage batteries which increases the energy cost<br>* With comparison to PV systems wind generation requires more O&M costs | * Moderate to high wind regime<br><br>* Availability of suitable sites 700-1000 USD/kW<br>* International Standards like IEC 1400-1 and 1400-2 upgrading | 4-6 Cents/kWh |

| Technology (from tables 2a and 1b) | Degree of maturity | Degree of penetration | Advantages | Disadvantages | Minimum requirements for application | Cost |
|---|---|---|---|---|---|---|
| **PV**<br><br>**Syria, Jordan, and Lebanon** | **Medium** | **Medium** | * PV system does not have any moving parts, hence maintenance is free<br>* PV system can operate automatically<br>* It does not require any input, hence operational costs are nil<br>* Noise-free and pollution-free<br>* In the last 5 years, world production of PV cells has increased by an average of over 25% resulting in significant cost reduction<br>* PV for water pumping can be installed without battery storage, hence less system cost<br>* PV systems are more economical than diesel generators when number of households is small<br>* PV system for lighting and TV is more economical than kerosene lamps and battery TV<br>* Small scale PV pumping is more economical than diesel generators in case of head<50m and pumped water <20m3 per day<br>* PV pumping system is more suitable than grid extension in case of distance for grid > 3 km. | * Initial investment is high<br>* Storage is necessary except for water pumping | | * System price is now $ 6000 /KWP [1]<br><br>* PV is not interesting for large scale applications till PV system price below 1-1.5 $/Wp (module price 0.5-1 $); resulting in electricity cost between 5 and 10 $/kWh, depending on insolation and financing scheme |
| **Solar Water Heating (thermal)** | High | Low | Affordable – Low tech – locally manufactured - | Market penetration is low with the low cost of electricity<br><br>(30% penetration is low in Jordan) Very low penetration rate in Syria and Lebanon | | 200 liter per day capacity ($500 per system) 20 years life time. |

[1] European Commission, PVNET European Roadmap for PV R&D, 2004

Table 3b. Research and Development Capacity

| Technologies | Capacity Category | Capacity Status | Capacity development needs |
|---|---|---|---|
| **Wind** | Basic research | Low | Budget, governmental concern, Optimal use of international aid |
| | Applied research | Low | Suitable financing mechanisms with focus on micro finance |
| | Pilot plants | Low | Above mentioned needs, Development of banks and funding |
| | Commercial model | Very low | agencies for funding electro-wind projects on a sustainable |
| | Technology adaptation | Very low | basis. In general what is needed is: |
| | Technology transfer | None | a RD & D (Research Development and Demonstration) |
| | O&M infrastructure | Low | projects with focus upon technology adaptation through applied |
| | Human resources | Low skilled people | Research, operational testing, and concept demonstration. |
| | Installed industrial capacity | None | The RD & D program will require substantial support from |
| **PV** | Basic research | Low | Government of Syria. Private sector investment requires the realization of key measures like providing a more favorable climate for foreign investment, reduced duty and excise taxes, export incentives etc. |
| | Applied research | Low | |
| | Pilot plants | Low | |
| | Commercial model | Very low | |
| | Technology adaptation | Very low | |
| | Technology transfer | Low | |
| | O&M infrastructure | Low | |
| | Human resources | Low | |
| | Installed industrial capacity | None | |
| **Hybrid Wind/PV** | As above | As above | |
| **Solar Water Heating (Domestic)** | High | High | |

## Appendix C

### *Renewable Energy resources*

Wind Energy maps

Jordan Wind Map

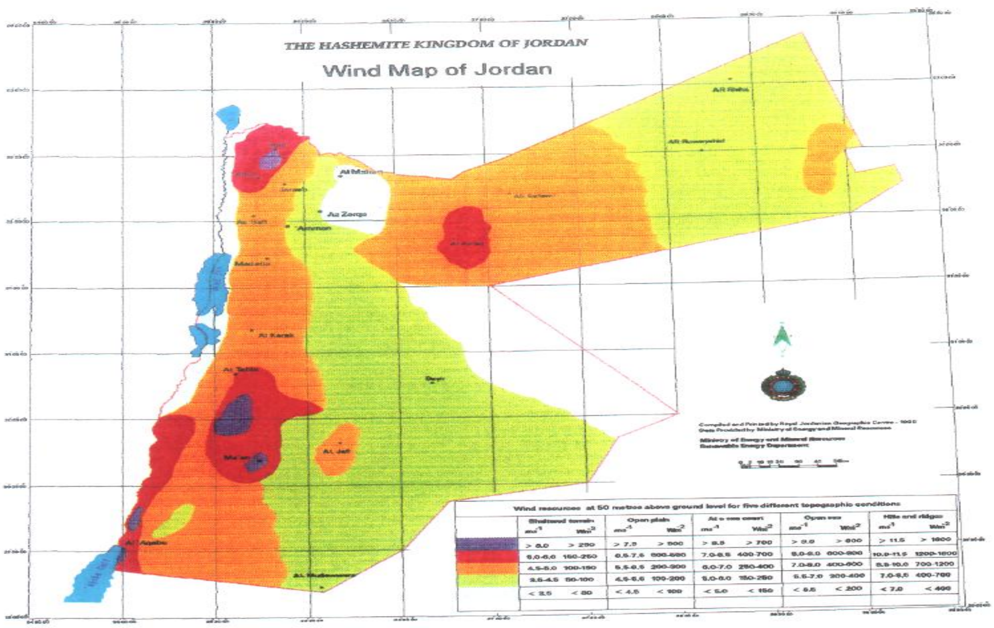


Figure 2 Jordan Wind Map

Table 1c-Jordan
Annual Performance of Existing Wind Projects (MWh generated per year)

| Year | Al-Ibrahimiyya | Hofa |
|---|---|---|
| 1989 | 651 | |
| 1990 | 729 | |
| 1991 | 776 | |
| 1992 | 705 | |
| 1993 | 640 | |

| | | |
|---|---|---|
| 1994 | 754 | |
| 1995 | 629 | |
| 1996 | 553 | |
| 1997 | 665 | 2519 |
| 1998 | 610 | 2360 |
| 1999 | 656 | 2405 |
| 2000 | 619 | 2226 |
| 2001 | 619 | 2262 |
| 2002 | 692 | 2344 |

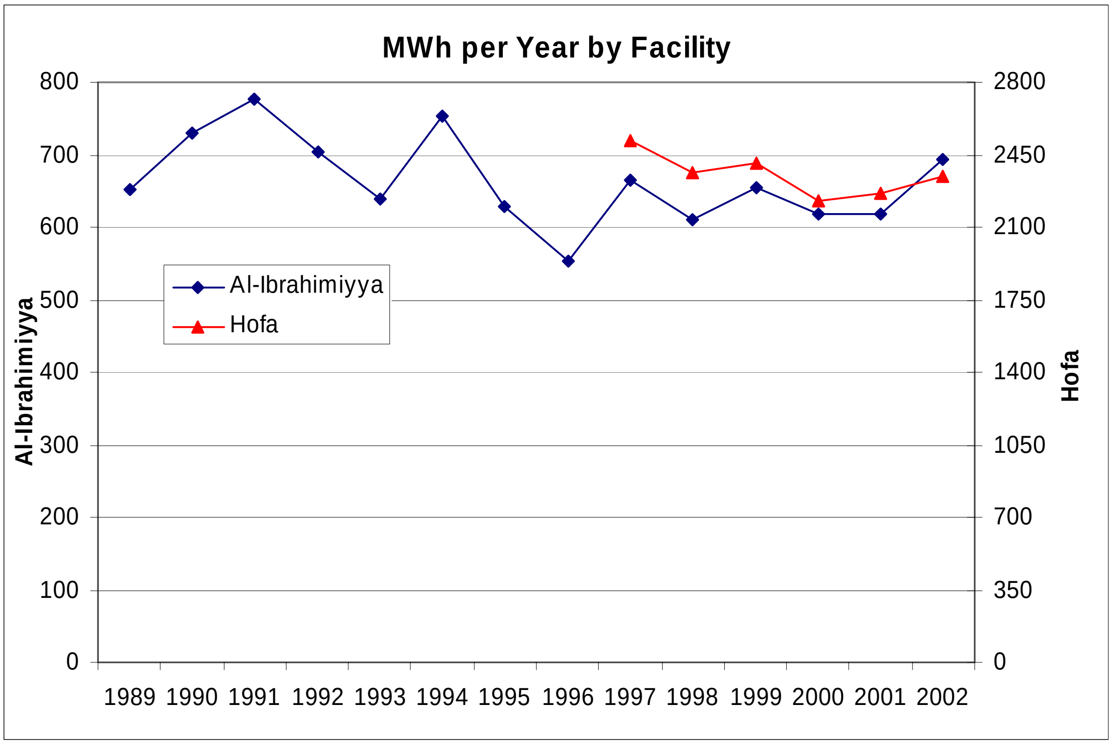


Figure 3: Annual Performance of Existing Wind Projects in Jordan

Table 2c: Performance of Existing Wind Turbines Within Projects in Jordan (1)

| | **Average MWh per Year** | | **Percent of Average** | |
|---|---|---|---|---|
| **Turbine** | **Al-Ibrahimiyya(2)** | **Hofa(3)** | **Al-Ibrahimiyya(2)** | **Hofa(3)** |
| 1 | 160 | 473 | 90% | 97% |
| 2 | 165 | 523 | 93% | 108% |
| 3 | 196 | 502 | 111% | 103% |
| 4 | 187 | 432 | 106% | 89% |
| 5 | -- | 502 | -- | 103% |

| | | | | |
|---|---|---|---|---|
| Project Average | 177 | 486 | 100% | 100% |

(1) Data are corrected to 100% availability to remove effects of component failures and focus differences on wind resource and equipment performance.
(2) Data cover period from 1990 to 1997.
(3) Data cover period from 1997 to 2001.

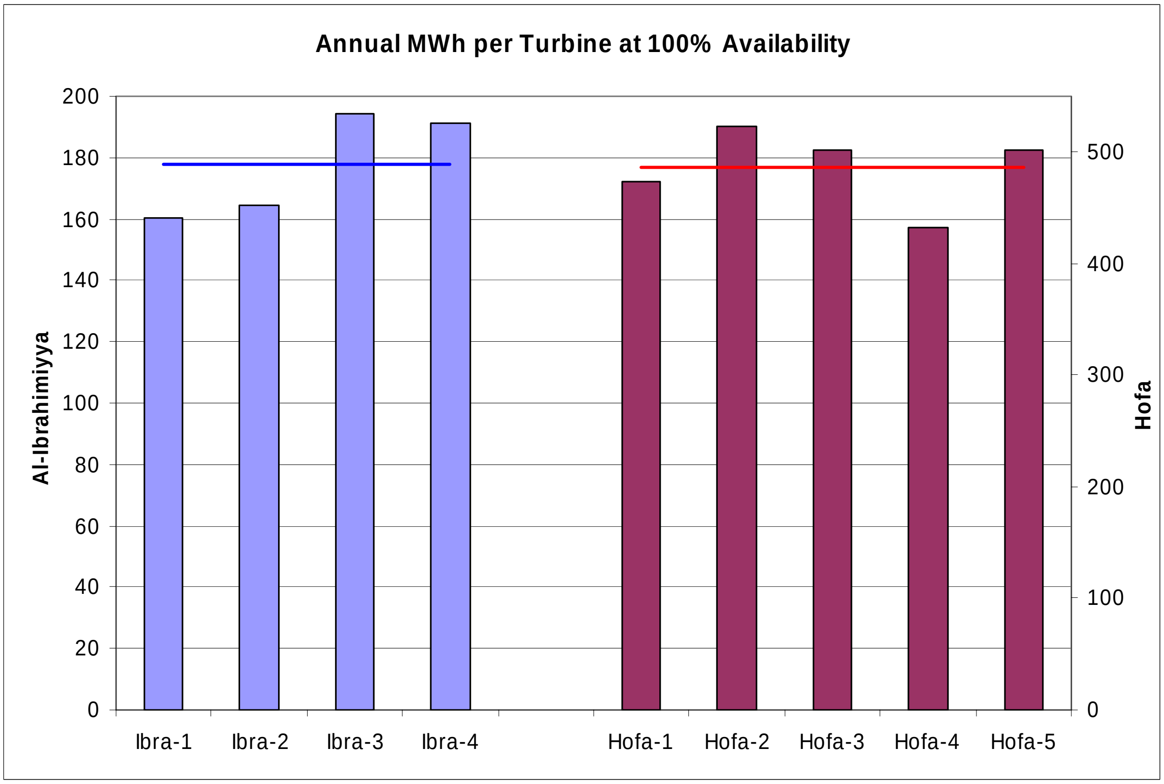


Figure 4: Performance of Existing Wind Turbines within Wind Energy Projects in Jordan

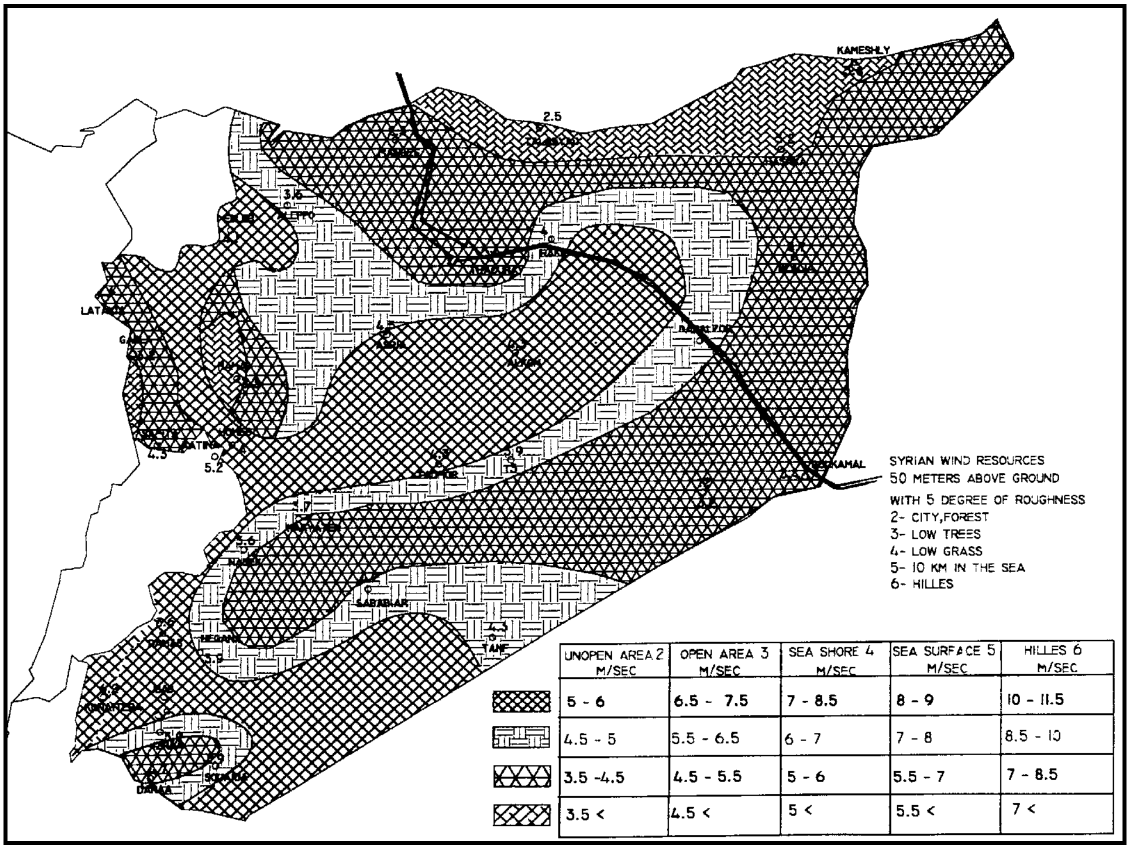


Figure 5 Syrian wind resources 50 m above ground

Table 1c-Syria: Annual averages of wind speeds at 50 m height in SYRIA

| Site | m/sec | Site | m/sec |
|---|---|---|---|
| Qonaitra | 6.2 | Raka | 4.0 |
| Kattiene | 5.2 | Soueda | 3.9 |
| Daraa | 4.7 | Damascus | 3.6 |
| Asry | 4.5 | Nabek | 3.6 |
| Safita | 4.3 | Aleppo | 3.6 |
| Tadmur | 4.3 | Kamishly | 3.6 |
| Tanf | 4.3 | Boukamal | 3.4 |
| Edlib | 4.1 | Hama | 3.3 |
| Thaora | 4.1 | Gabla | 3.2 |
| Homs | 4.0 | Hasaka | 3.2 |
| Latakia | 4.0 | Talabiad | 2.5 |

Table 2c-Syria: Syrian Renewable energy resources

| Resources | | Idleb | Palmyra | Tartous | Alsweida | Aleppo | Hama | Homs | Quneitra |
|---|---|---|---|---|---|---|---|---|---|
| Solar | Total in January (Wh/m2/day) | 1986 | 2666 | 2324 | 2031 | 1990 | 2162 | 2243 | 2500 |
| | Total in July (Wh/m2/day) | 7404 | 7348 | 6976 | 6485 | 7453 | 7483 | 7348 | 7100 |
| Wind | Height above ground (m) | 12 | 10 | 13.7 | 1080 | 8.5 | 12.5 | 12 | 11 |
| | Average wind speed (m/s) | 3.8 | 4.1 | 3.2 | 3.9 | 3.6 | 3.3 | 3.7 | 5.9 |
| Biomass | Urban solid waste 1998 Ton/yr/capita | 0.185 | 0.183 | 0.183 | 0.183 | 0.182 | 0.183 | 0.182 | 0.184 |
| **Resources** | | **Deraa** | **Damascus Mezza** | **Damascus Airport** | **Deir Ezzor** | **Alhassaka** | **Alrakka** | **Lattakia** | **Country average** |
| Solar | Total in January (Wh/m2/day) | 2888 | 2795 | 2775 | 2583 | 2241 | 2327 | 2203 | 2380.93 |
| | Total in July (Wh/m2/day) | 7095 | 7438 | 7341 | 7121 | 7149 | 7308 | 6701 | 7183.33 |
| Wind | Height above ground (m) | 10.8 | 10.6 | 10 | 10.8 | 11 | 11.8 | 14.4 | |
| | Average wind speed (m/s) | 3.6 | 3.6 | 3.9 | 3.1 | 2.8 | 3.1 | 4 | 3.71 |
| Biomass | Urban solid waste 1998 Ton/yr/capita | 0.182 | 0.185 | | 0.182 | 0.180 | 0.182 | 0.182 | 0.182685 |

Table 3c-Syria: Total potential of biomass in the Syrian Arab Republic per year[2].

| Total biomass potential = 25.8 million tons per year | |
|---|---|
| Agriculture | 60% |
| Forests | 13% |
| Human | 12% |
| Animal | 10% |
| Industrial | 5% |

Table 4c-Syria: Geothermal Energy Resources in Syrian Arab Republic

| Name of Well | Location | Surface temperature °C | Water Discharge $m^3/h$ |
|---|---|---|---|
| Aldabiat – Sukneh | Palmyra central region | 61 | 42 |
| Aboureah – Gareten | Palmyra central region | 50 | Dry air |
| Almauh Swamp | Palmyra central region | 45 | 320 |
| Alyadude | Daraa – South region | 44 | 7.72 |
| Raas Alain | North east region | 40 | 31.3 |
| Alsfera | Aleppo – North region | 38 | 980 |

[2] UNDP and Ministry of Electricity of Syria, Renewable Energy Master Plan 2002

Table 1c-Lebanon: Wind data for Lebanon [37]

| | Jan | Feb | Mar | Apr | May | June | July | Aug | Sep | Oct | Nov | Dec | Avg/ Year |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Beirut-Airport | 4.6 | 4.9 | 5.2 | 4.4 | 3.9 | 4.3 | 4.6 | 4.0 | 3.5 | 3.2 | 3.2 | 4.2 | 4.17 |
| Cedars | 2.9 | 3.1 | 3.4 | 3.0 | 3.3 | 2.9 | 2.7 | 2.4 | 2.1 | 2.8 | 2.3 | 2.8 | 2.81 |
| Rayak | 3.4 | 3.8 | 4.3 | 3.9 | 3.5 | 3.7 | 3.7 | 3.4 | 3.2 | 3.1 | 3.2 | 3.2 | 3.53 |
| Ksara | 3.2 | 3.8 | 4.2 | 3.9 | 4.5 | 4.8 | 4.2 | 3.4 | 2.6 | 2.4 | 2.9 | 3.68 | |
| Khalde | 3.35 | 2.97 | 3.26 | 2.72 | 2.42 | 2.85 | 3.45 | 2.86 | 2.08 | 2.07 | 2.06 | 3.04 | 2.76 |
| Marjayoun | 4.24 | 4.16 | 4.88 | 4.24 | 4.59 | 5.19 | 5.78 | 5.4 | 4.6 | 4.07 | 3.84 | 3.93 | 4.58 |
| Qlaiat | 5.33 | 5.51 | 5.41 | 4.19 | 3.74 | 3.75 | 4.16 | 3.57 | 3.47 | 3.89 | 4.41 | 5.56 | 4.42 |
| Tripoli-Mina | 4.23 | 4.38 | 5.12 | 4.35 | 3.76 | 4.68 | 4.72 | 3.72 | 2.65 | 2.51 | 3.01 | 3.74 | 3.91 |
| Dahr-El-Baidar | 4.67 | 4.87 | 5.63 | 5.06 | 3.98 | 4.59 | 5.05 | 4.48 | 3.33 | 3.1 | 2.96 | 4.44 | 4.35 |

Table 2c-Lebanon: Energy content in landfill gas [37]

| **Year** | **1994** | **2005** | **2015** | **2040** |
|---|---|---|---|---|
| Mass of $CH_4$ generation potential, Gg | 43 | 85 | 123 | 269 |
| Volume of $CH_4$ generation potential, $10^6$ $Nm^3$ | 60 | 119 | 172 | 377 |
| Caloric value, $10^{12}$J | 2153 | 4247 | 6160 | 13500 |
| Oil value, $10^3$ tons | 50 | 100 | 143 | 313 |
| Thermal value, $GW\text{-}hr_{th}$ | 600 | 143 | 1717 | 3763 |
| Electric value, $GW\text{-}hr_{el}$ | 180 | 313 | 513 | 1130 |

Table 3c-Lebanon: Solar data for Lebanon [37]

| Month | Coastal Insolation, $kWh/m^2/day$ | Interior Insolation, $kWh/m^2/day$ | Coastal sunshine hours (Hrs) | Interior sunshine hours (Hrs) | Day length, (Hrs) |
|---|---|---|---|---|---|
| January | 2.4 | 2.4 | 4.6 | 4.5 | 10 |
| February | 3.2 | 3.4 | 5.6 | 5.5 | 10.8 |
| March | 4.1 | 4.4 | 6.4 | 6.4 | 11.8 |
| April | 5.5 | 5.9 | 7.7 | 8.5 | 12.9 |
| May | 6.6 | 7.2 | 10.1 | 10.5 | 13.8 |
| June | 7.3 | 8.5 | 11.5 | 13.1 | 14.2 |
| July | 7.0 | 8.4 | 11.4 | 13.2 | 14 |
| August | 6.3 | 7.7 | 10.6 | 12.4 | 13.2 |
| September | 5.3 | 6.5 | 10.4 | 11.2 | 12.1 |
| October | 4 | 4.7 | 8.1 | 9 | 11 |
| November | 2.9 | 3.3 | 6.4 | 6.7 | 10.2 |
| December | 2.3 | 2.4 | 5 | 4.8 | 9.8 |

## Appendix D

### *Case Studies*

Table 1d-Syria: Case Studies

| Data Case Study Nº1 -Homs | | | | | |
|---|---|---|---|---|---|
| **Category** | **Requirement** | **Energy req.** | **Technology** | **% covered with RETs** | **Target population** |
| **Residential** | Lighting, TV, Refrigerator, Kitchen equipment, Miscellaneous | 200 kWh/month per household | PV, Wind, Hybrid PV/Wind | 100% | Rural and Bedouins 9460 inhabitants |
| **Productive** | Water pumping for 30 wells, Head <100m | 0.2725 kWh/m3 | PV, Wind, Hybrid PV/Wind | 100 | |
| | Water pumping for 37 wells, Head >200m | 0.8175 -1.635 kWh/m3 | Wind, Hybrid Wind/Diesel | 50% | |
| **Community services** | Electrification of 12 schools | 150 KWH/school per month | PV, Wind, Hybrid PV/Wind | 100% | |
| | Electrification of 3 veterinary practices | 150 KWH/Practice/ month | | | |
| **Data Case Study Nº2 - Hama** | | | | | |
| **Category** | **Requirement** | **Energy req.** | **Technology** | **% covered with RETs** | **Target population** |
| **Residential** | Lighting, TV, Refrigerator, Kitchen equipment, Miscellaneous | 200 kWh/month per household | PV, Wind, Hybrid PV/Wind | 100% | Rural and Bedouins 11344 inhabitants |
| **Productive** | Water pumping for 20 wells, Head <100m | 0.2725 $kWh/m^3$ | PV, Wind, Hybrid PV/Wind | 100 | |
| | Water pumping for 33 wells, Head >200m | 0.8175 -1.635 kWh/m3 | Wind, Hybrid Wind/Diesel | 50% | |
| **Community services** | Electrification of 9 schools | 150 kWh/school/month | PV, Wind, Hybrid PV/Wind | 100% | |
| | Electrification of 3 shops | 150 kWh/shop/month | | | |
| **Data Case Study Nº3 - Alhassake** | | | | | |
| **Category** | **Requirement** | **Energy req.** | **Technology** | **% covered with RETs** | **Target population** |
| **Residential** | Lighting, TV, Refrigerator, Kitchen equipment, Miscellaneous | 200 kWh/month per household | PV, Wind, Hybrid PV/Wind | 100% | Rural and Bedouins 2080 inhabitants |
| **Productive** | Water pumping for 33 wells, Head <100m | 0.2725 kWh/m3 | PV, Wind, Hybrid PV/Wind | 100 | |
| | Water pumping for 92 wells, Head >200m | 0.8175 -1.635 kWh/m3 | Wind, Hybrid Wind/Diesel | 50% | |
| **Community services** | Electrification of 13 schools | 150 kWh/school/month | PV, Wind, Hybrid PV/Wind | 100% | |
| | Electrification of 4 shops | 150 kWh/shop/month | | | |

## Appendix E

### ***Assessment of Capacities***

**Table 1e. Capacity assessment**

| Stakeholder | Function/Activities | Capacity Status / Problems | Capacity Development (CD) Measures | Magnitude of CD needs / Priority |
|---|---|---|---|---|
| 1. Legislative authorities, elected officials | Set national political priorities; social, economic, and environmental goals; legal framework conditions. | *Lack of knowledge about economy and energy issues in general*<br>*Lack of knowledge about RETs potential in particular*<br>*Perception as unreliable and not serious* | *Election law should be modernized and higher requirements are needed*<br>*Holding more events on RETs and concentrating on presence of these authorities*<br>*Presentation of successful projects.* | *Very high* |
| 2. Government macroeconomic and development planners | Define development goals and macro policy; general economic policies; cross-cutting issues; subsidies and trade policy; sustainable development goals, and frameworks. | *Lack of qualified strategic planners *Decision makers and consequently planners focus around fossil fuel resources and ignore RETs | Intensive courses on RETs for qualifying of decision makers and strategic planners. It should be focused on the role of renewables utilization in meeting poverty reduction and sectoral planning goals such as health, education, agriculture... | Very high |
| 3. Government energy authority or ministry | Set sectoral goals; technology priorities; policymaking and Standard-setting functions; legal and regulatory framework;<br>Incentive systems; federal, state, and local level jurisdiction. | *Resource and energy planning in Syria are organized by the Higher Planning Council (HPC) and by the Supreme Energy Committee (SEC). In addition to managing the present energy resources, the HPC and SEC also examines the potential of renewable energy as an alternative to fossil fuels.<br>*Absence of an **effective** organization which acts as a driving force for RETs development with clear responsibility to develop policy, legislation and regulatory evolution within the Government of Syria. (Syria and Lebanon) | Developing the recently established centre for energy studies to become an effective organization for development of RETs provided that the right staff is employed (Syria)<br><br>Establish a Renewable Energy Center for Lebanon | Very high for Syria and Lebanon<br><br>Jordan is far advanced at this level |
| 4. Energy regulatory bodies | Have monitoring and oversight functions; implement the regulatory framework; administer fees and incentives.<br>Dispatch entities; have operational coordination functions; | Interest only in conventional energy sources for both Syria and Lebanon | Solution depends on concerns of decision makers | High (Syria and Lebanon) |
| 5. Market coordination agencies | interface with industry investors; information brokers. | Such stakeholders are not available | Establishment of these agencies | High in the three countries (Syria, Lebanon and Jordan) |

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| 6. Non-energy governmental authorities/ministries | energy policies; public sector energy consumers; require energy inputs for social services provision. | Renewable energy activities and projects have been carried out by several Government of Syria entities, such as the Scientific Studies and Research Centre, Atomic Energy Commission, Universities, the Ministry of Electricity, Ministry of Environment, Ministry of Irrigation, Ministry of Agriculture and Agrarian Reform, Ministry of Industry, Ministry of Petroleum and Mining Resources. These activities have been carried out with little co-ordination among the implementing ministries. | as in 3. | High in the three countries (Syria, Lebanon and Jordan) |
| 7. Energy supply industry | Private companies and public utilities; manage energy supply, electricity generation; fuels management and transport; finance some R&D. | Only public utilities exist in Lebanon and Syria. There is no grid code. R&D is rare. System losses are > 30% in both countries. | Deregulation of electric energy market.<br><br>Jordan is already moving toward privatization | High |
| 8. Entrepreneurs and productive industry | Business development; economic value added; employment generation; private sector energy consumers. | Not available | When needed | Low |
| 9. Energy equipment and end-use equipment manufacturers | Supply equipment for the energy industry and other industries, including vehicles and appliances; impact energy end-use efficiency; adapt/disseminate technology; finance some R&D. | * Lack of favorable import duties for renewable energy products and components and well as conducive policies to promote renewable energy developments; This is applicable in the three AC. | | |
| 10. Energy equipment O&M services | Provide O&M. Feedback on performance and feasibility | Syria and Lebanon do not have the availability of a fully skilled and experienced human resource base to support the integration, service and operation of such technologies and do not have a ready made training infrastructure to rapidly develop this resource.<br>Jordan has developed this capacity through its training centers at the Royal Scientific Society and the National renewable Energy Center | CD is needed when RETs are starting to be applied widely. | |
| 11. Credit institutions | Financing options for large- and small-scale energy generation; capital provision for energy using enterprises; financing options for household energy consumers. | Weak banking system yet. There has been no major financing for renewable energy systems by the Syrian banks although finance can be obtained in theory from some of the banks. | Developing financial mechanisms and instruments to encourage renewable energy manufacture or use either through Government banks or private lending organizations to provide credit to consumers, especially rural applications, or even start-up manufacturing ventures. | Medium |

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| 12. Civil society / NGOs | Consumer participation and awareness; oversight and monitoring; environmental and social advocacy; equity considerations | Not effective NGOs and absence of NGO for RETs | Establishing a NGO for RETs | Medium |
| 13. Users | Users of renewable energy systems. Providers of feedback and knowledge about resources, cultural traits, technology performance, friendliness and suitability. | There are some users of solar heating systems and some others using small wind turbines (10kW). The most users are satisfied with their systems | Interviews with users in media as a promotion measure | Medium |
| 14. Energy specialists and consultant firms | Strategic advice, problem definition and analysis; systems development; specialist services delivery; options analysis; information sharing. | Very rare because such jobs are not requested | Capacity building of such specialists according to demand | Low |
| 15. Academia and research organizations | R&D, knowledge generation, and sharing; formal and informal education; technical training; technology adaptation, application, and innovation. | Syria: Limited scope for RD&D institutions to interface with international bodies and to share expertise already existing within the sector. Research, Development and Demonstration (RD&D) programs in renewable energy have been carried out primarily by the Higher Institute for Applied Science and Technology (HIAST), Ministry of Electricity, Atomic Energy Commission and the Scientific Studies and Research Centre (SSRC). The RD&D in the four Syrian universities have been rather limited, owing to the lack of infrastructure and finances. The RD&D programs have so far focused on solar thermal applications and PV.<br>Lebanon: RD&D is carried out by the American University of Beirut, Lebanese University, Lebanese American University and the National Council for Scientific research. Some research funding is provided by international organization, but is very limited.<br>Jordan: Universities, and National research Centers have developed renewable energy research programs. The problem is making use of the results of the research and making the research more relevant to the community | the scope of the RD&D should be enlarged to include several more renewable energy technologies. The technologies, which are to be included in the RD&D program, should be oriented towards strengthening local industry and research institutions, developing better market information and acquiring operational experience. RD&D programs need to focus on technology adaptation and applications, thereby serving the needs of the countries' renewable energy industry. | Very high |

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| 16. Media | Awareness raising, advocacy; information sharing; journalistic inquiry, watchdog functions; monitoring, public transparency. | | Creating mechanisms for the media to provide accurate information on the technical, economic and social viability of RETs to support awareness raising on options that do exist and can be harnessed to address the multiple dimensions of sustainable development | |

## Appendix F

### *Assessment of Other Experiences*

| Experience (E) / Criteria | E 1: Abu Sorra & Al-Mucherfeh PV stand-alone Project | E 2: JICA Project for electrification of 4 villages by PV stand-alone systems | E3: Grid-connected wind turbine at Baath city |
|---|---|---|---|
| **Description** | | | |
| Objectives | Demonstrating the viability of small stand-alone PV systems for village electrification | * Demonstrating the feasibility and the applicability of the PV systems in Syria through the comprehensive economic and social analysis before and after the installation of the Photovoltaic systems- | Demonstrating the feasibility and the applicability of the electro-wind systems in Syria |
| Goals | Equipping some households with PV power in 2 villages near Damascus and setting up performance monitoring facilities. | Electrification of 4 villages with a total of 103 households with a total power of 66kWp | Installation of a wind turbine in a grid connected mode in a promising area |
| Results obtained | * Average performance ratio PR is 37%<br>* Mean PV array energy yield is about 2.34 kWh/kWp/day<br>* Average subsystem efficiency is about 74%<br>* Acceptance by users of AC solar electricity (centralized PV-system users) is much greater than users of DC<br>* Cost estimations indicate that PV system is cheaper than diesel generator set in the long run | * The field performance showed the good reliability of the various PV systems.<br>* A valuable know-how was gained by the PV Lab team throughout the execution of the project.<br>* The various applications of the installed systems created the training environment for engineers and technicians from various concerned authorities.<br>* Later the JICA study team investigated the degree of satisfaction of the residents of the four villages with the overall performance of the systems. The results were as follows: irrespective of generation, a little over 60 % indicated satisfaction. About 25 % were fairly satisfied and less than 9 % were dissatisfied. | * The wind turbine (WT) has been evaluated by the author according to the capacity factor, operation time analyses (production and down time), KWH generated to kW installed, and energy output for unit rotor swept area.<br>* The mean capacity factor is about 36% with an average Energy output of 300 MWh/year.<br>* The economic analysis for the wind turbine was based on the method of calculating Life-cycle cost LCC according to present value method. The calculated cost of generated kWh was 5.6 Cents.<br>It is obvious that the cost of wind energy in Syria is very competitive with that of the conventional generation systems. |
| Population target | Bedouins live about 50 km far from Damascus | Rural population; most lives on mountains living at a distance of 3-10 km from grid and 35-80 km from Aleppo | Not particularly (grid-connected mode) |
| Population benefited | 275 | 820 | |

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|---|---|---|---|
| Weak points | | * Incorporating the PV systems into the national grid<br>* Establishing management and financial system | |
| Capacity status assessment of the project stakeholders | Low | Medium | Medium |
| Zones | Damascus region | Aleppo region | Quneitra region |
| **Represent activeness** | | | |
| Replicability | Medium: Prospects for solar electrification for Bedouins till 2010 are 3750 Solar Home systems of 80 WP and 10,000 Solar lanterns of 10 WP. | Medium:<br>* From this pilot investment the Government of Syria is expected to finance the extension of supply and services to other villages.<br>* Prospects for PV Village Electrification in Syria till 2010 are about 4000 stand-alone systems of 600 WP, 120 mini-grid systems of 10 KWP, 3750 Solar Home systems of 80 WP, and 10,000 Solar lanterns of 10 WP. | <u>Prospects for wind energy developments in Syria by 2010</u><br>* 200 MW Stand-alone electro-wind turbines with major government support and involvement or 100 MW with moderate government support and involvement<br>* 600 MW Grid-connected wind farms with major thrust and support on private sector participation or 200 MW with moderate thrust and support on private sector participation |
| Potential population benefited | 5000 | 5000 | n.a |
| **Suitability/Viability/Sustainability** | | | |
| Affordability | Low | Low | Low |
| Effectiveness | Medium | Medium | Medium |
| Risk of obsolescence | Low | Low | Low |
| Flexibility | Medium | Medium | Medium |
| Technological capability | Medium | Medium | Medium |
| Suitability and urgency | high | high | high |
| Resilience | Low | Low | Low |
| Adaptability | Medium | Medium | Medium |
| Environmental impacts | Very low | Very low | Very low |
| Social acceptance | good | good | good |

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|---|---|---|---|
| CD requirements | A lot of work remains to be done regarding the coherent approach towards further involvement of national parties to cover the institutional and financial aspects needed to settle this technology in Syria | | |
| Income generation | Medium | Medium | High |