Mediterranean and National Strategies for Sustainable Development
Priority Field of Action 2: Energy and Climate Change

Energy Efficiency and Renewable Energy
Libya - National study

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Mediterranean and National Strategies for Sustainable Development
Priority Field of Action 2: Energy and Climate Change,
energy efficiency and renewable energy

Energy And Sustainable Development
In Libya

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PART ( I )

THE COUNTRY ENERGY SITUATION

February 2007
1-1 The country energy situation

Oil and natural gas are the main sources of energy in Libya. Libya is an important oil country particularly to European countries. Libya had total proven oil reserve of 35 billion barrels at the end of 2005 and 53 TCF proven natural gas reserves [1]. Libya's export revenues have increased sharply in recent years to $34 billion by the end of 2006 up from only $5.3 billion in 2001 [2].

Oil export revenues are extremely important to the economic development of the country as they represent 90.0% of the total revenue [2].

Area of Libya is 1,759,540 km² with a popular of 5,853,000 (2005). Due to Libya oil export revenue, Libya experienced strong economic during 2003, 2004 and 2005 with the real gross domestic product (GDP) of 46 billion (US $97) in 2005 which made Libya one of the highest per capita GDPs in Africa.

Libya is hoping to reduce its dependency on oil on the country source of income, and to increase investment in tourism, fisheries, mining and natural gas. Libya also is attempt to position itself as a key economic intermediary between Europe and Africa.

As illustrated in Fig (1), Total revenue (as percentage of GDP) has increased very rapidly between 2001 to 2004. This attributed to the rapid growth of the oil sector and its influence on the economic and social development.

It is noticeable from Fig (1) that the total revenue on a percentage of GDP has decreased in 2005 due to the fact that there are other sources of income rather than oil.

1-2 TOTAL PRIMARY ENERGY SUPPLY (TPES)

TPES has increased from 9.7 Mte in 1990 to 17.7 Mte in 2003 with an average annual growth of 4.7%. Fig (2) shows that the oil has a largest share of TPES (57-66%) during 1990-2000 with a little decrease in last years because of using more natural gas in electrical power generation.

Fig (2) share of oil and gas in TPES
Fig (3), shows the trends for TPES, GDP (US $ 1997) for the period from 1986 to 2005.

![GDP & TPES From 1986 To 2005](image)

GDP has increased from 25 billion $ in 1986 to 46 billion $ in 2005 with an average annual growth rate of 4%.

1-3 Energy Demand

Energy demand in oil sector

The total energy demand has increased from 5.4 Mte in 1990 to 9.1 Mte in 2003 with growth of 60% as shown in fig (4). Fig (4) shows also that the oil sector has highest consumption with 61% of total consumption in 2003. Primary studies shows that the Future Energy demand in 2010 will be 11.5 Mte as shown in fig (5).[3]

![The Energy Demand In Oil Sector](image)

![Forecasted Energy demand](image)

Electrical Energy Demand

The electric energy sector has been developed during the last decade, become the economic and social development. The peak load has increased from 1595 MW in 1990 to 3875 MW in 2005 while the total installed capacity has increased from 3352 MW in 1990 to
512MW in 2005, and the generated electric energy from 9851 GWh in 1990 to 22500 GWh in 2005. The contribution of steam power plants 65%. Natural gas represents 32% of the fuel supply for electric power plants and 33% heavy oil fuel and 35% light oil. Fig (6) shows the growth of peak load during the period from 1992 to 2006, and its forecast until 2020.

The energy consumption per capita has increased from 1493 kwh/c in 1990 to 3119kwh/c in 2005. The national electric network is accessible to 99% of the population. Most of electric network is concentrated on the coast, where most of the inhabitants live. Fig(7) shows the locations of the electrical power plants in Libya.
The electric energy demand is expected to grow very rapidly. Its expected that electrical energy will be double by the year 2014 and it will be more than two and half by the end of year 2020 [4] , as shown in fig (8). The total number of customers in electric system in Libya is about one million distributed among seven categories. Residential sector represents 39% of the total consumption followed by commercial with 14% as shown in fig(9).

As you can see that the residential sector represents the highest share in electrical energy demand in Libya. The share of residential load is about 40 % of the overall peak load of electrical power system in Libya.

The electric system in Libya is run by the state- owned general electric company of Libya (GECOL). GECOL responsible for generation, transmission and distribution of electricity for entire Libya. GECOL also responsible for water desalination plants in Libya. GECOL planned to install desalination plants with amount of one million meter cube per day for the period from 2007 to 2012 , this will need about 1.8 TWh/year. This mean that the water desalination plants will be a major drive for energy demand in Libya.
1-4 Environment

Libya is a Non-Annex I country under the United Nations Framework Convention on Climate Change (ratified June 14th, 1999) and it is a signatory to the Kyoto Protocol. Thus, Libya currently is eligible to the CDM. GECOL has already started contacts with international agencies and investors to use CDM for renewable energy development, the Libyan government has already issued a law to encourage foreign investors for all sectors.

The main emitters of CO₂ in 2003 in Libya, as shown in fig (9), are fuel combustion in the power generation sector (38%), in the transport sector (20%) and in industry (8%). Other sectors represent 34%. In total, energy-related emissions are responsible for almost 100% of CO₂ emissions in the country [4].

In 2003 petroleum accounts for more than 60% of carbon emissions in Libya and natural gas is responsible for around 40% [5]. The increasing reliance on natural gas should work to lower carbon emissions. Libya’s energy-related CO₂ emissions increased by more than 78% , from less than 18.7 Mte in 1980 to around 50 Mte in 2003 (8% average annual growth between 2001 to 2003), mostly due to increased energy supply Fig(10).
Part II

Rational Use Of Energy
( RUE )
2-1 Energy Intensity:

Several studies have investigated the potential impact of improved energy use efficiency in Libya. Bullut and Ekhat [6] have indicated that the potential impact of improved energy utilization efficiency and energy management can be quite significant, amounting to reduce the demand by about 50 million barrels of oil in the year 2020 (20%).

Similarly, the country's electricity generation could be significantly reduced if improved energy utilization efficiency by the major energy sectors is achieved. This could amount to 2160 MW reduction in capacity to be added by the year 2020.[6]

Figure (11), shows Total Energy Intensity and per sector. It is clearly shown that the total energy intensity almost constant during 1995 – 2002.

Figure (11), Energy Intensity (Total & Per Sectors)

The analysis of the present energy situation in Libya clearly indicates that there is no programs toward rational use of energy especially in the industrial sector and transportation sector. This situation related to many factors summarized as follow:

1- low electricity tariff specially for residential sector.
2- cheap oil prices for transportation.
3- lack of national policy toward the conservation of energy.
4- lack of specialized national institution which deals with the rational use of energy
5- lack of detailed and deep studies which help the decision makers to adopt RUE programs.
PART ( III )

RENEWABLE ENERGY
3.1. RENEWABLE RESOURCES

Libya is located in the middle of North Africa with 88% of its area considered to be desert areas, the south is located in the Sahara desert where there is a high potential of solar energy which can be used to generate electricity by both solar energy conversions, photovoltaic, and thermal.

3.1.1 Solar radiation

The solar radiation in Libya considered being very high the direct radiation on the horizontal plan is shown in figure 12., the total energy received on horizontal plan reach up to 7.1 KWh/m² per day, while Figure 13 shows a map for Libya indicating the radiation Level.

Figure: 12 The average monthly Daily global radiation on the horizontal surface

Figure: 13 the average global radiation on the horizontal plane
3.1.2 Wind Potential
The measured of wind energy showed high potential of wind energy in Libya, figure 14 shows the potential wind energy measured data on 40 m height for the coastal side of Libya.

![Wind potential map for the Libyan coast area](image)

Figure: 14 Wind potential for the Libyan coast area

3.1.3 Other sources
Other renewable sources are available in Libya like geothermal, Biomass, tidal waves, all these sources have less potential in Libya.

3.2. RESOURCES ESTIMATION FOR LIBYA

The renewable energy sources estimated for Libya according to the MED-CSP scenario is shown in Table: 1, while the electric consumption and its sources in year 2050 are shown in Figure: 15

<table>
<thead>
<tr>
<th>Type</th>
<th>Potential</th>
</tr>
</thead>
<tbody>
<tr>
<td>Solar electricity</td>
<td>140,000 TWh/y</td>
</tr>
<tr>
<td>Wind electricity</td>
<td>15 TWh/y</td>
</tr>
<tr>
<td>Biomass</td>
<td>2 TWh/y</td>
</tr>
<tr>
<td>Total</td>
<td>157,000 TWh/y</td>
</tr>
</tbody>
</table>
3.3. RENEWABLE ENERGY APPLICATIONS

The use of renewable energies have been introduced in wide applications due to its convenience use and being economy effective in many application, the renewable energy used in Libya consists of photovoltaic, solar thermal application, wind energy, and Biomass.

3.3.1 Photovoltaic

The use PV systems started in 1976, and since then many projects have been erected for different sizes and applications. The first project put into work was a PV system to supply a cathodic protection to protect the oil pipe line connecting Dahra oil field with Sedra Port. Projects in the field of communication was started 1980 where a PV system was used to supply energy to a microwave repeater station near Zella. Projects in the field of water pumping was started 1983 where PV pumping system was used to pump water for irrigation at El-Agailat. The use of PV systems for rural electrification and lighting was started in 2003. Water pumping projects was also erected beginning in 1984. The role of PV application was grown in size and type of application.

3.3.1.1 PV in Microwave Communication Networks

The Libyan Microwave communication networks consist of more than 500 repeater stations. Only 9 remote stations were running by photovoltaic systems till the end of 1997 with a total peak power of 10.5 KWp. four of these stations are still running after 26 years of work, the batteries which are of open type batteries were replaced three times with an average life time of eight years.
It was the success of the PV systems technically and economically that pushes the changing of all possible diesel stations to PV stations in the Libyan communication networks. The total number of stations running by PV in the field of communications exceeding 100 stations. The total installed photovoltaic peak power installed by the end of the year 2006 is around 690 KWp. Figure 16, showing the accumulated installed photovoltaic systems in the communication networks in the period 1980-2006.

![Figure 16: The accumulated installed PV peak power 1980-2006.](image)

Gained and remarks that were drawn from the past experience of PV systems are as follows.

1. No spare parts had been used for PV systems which are installed 26 years ago.
2. No failure has been registered for the systems installed 26 years ago.
3. Very low cost or no running cost for most of the PV systems.
4. Batteries have been changed after about ten years from installation.
5. Lack of knowledge; People in developing countries should be made aware of PV systems through increased their understanding of this technology.
6. The average production energy for systems of 1.2 KWP is 6 KWh/day.
7. The AC option of electricity for rural electrification was the best convenience choice.
8. The closed type batteries option was the best convenience choice.

### 3.3.1.2 PV in Cathodic protection

The first system in this field was put into work in 1976, the accumulated total power of PV systems in this field is second to PV systems in communications, the total PV systems in this field is around 320 system by the end of 2006, with a total installed PV systems of 650 KWp.

PV technology is considered to be a relatively new in developing countries; the problem we are facing not dealing with the technology rather how other people dealing with it. We are experiencing some vandalisms issues.

![Figure 17: The accumulated installed PV peak power in the period 1976-2006.](image)
The experienced advantages of using PV solar generators can be summarized as follows:
- Low running cost.
- High reliability.
- Durability of the system.
- Fewer services visits.
- Low maintenance cost.
- Less number of thefts.
- No communication stops.
- Vandalisms.

3.3.1.3 PV IN Rural Electrification

Problems facing the electrification of all regions in any country are low population, and being away from the electric networks. It is so expensive to extend high line voltage through desert to electrify few hundred inhabitants. In low population countries electricity is only available in the cities and no electric network is used to power its rural areas, where as powering rural areas are not easy or available. The electric network in low population countries may not be available within a reaching distance of the needed places.

The Libyan national plane to electrify rural areas consists of electrifying scattered houses, villages, and water pumping. The PV supply systems for ten villages was introduced as a project to electrify remote areas some of these villages are:
- a-Mrair Gabis village as an example of scattered houses.
- b-Swaihat village as an example of scattered houses.
- c-Intlat village as an example of scattered houses.
- d-Beer al-Merhan village as an example of scattered houses.
- e-Wadi Marsit village as an example of a village having diesel generator.
- f- Intlat village.

The installation of photovoltaic systems started in the middle of 2003. The total number of systems installed by the General Electric Company of Libya (GECOL) are 340 with a total capacity of 220 kWp, while that which was installed by Center of Solar Energy Studies (CSES) and Saharian Center is 150 systems one of the system is a hybrid system with diesel generator to supply a village of 200 inhabitants. The total peak power is 125 KWp, other involved in using PV has installed 50 PV systems with a total capacity of 60 KWp. In these applications 440 systems have been installed with total peak power of 405 KWp.
Fig (19) PV isolated system in Emrier-Gabes

Fig(20) Location Of PV Systems (GECOL)
3.3.1.4 PV for Water pumping

Water pumping was considered as one of the best PV applications in Libya as remote wells which are used to supply water for human animals in rural places. The water pumping project consists of installing of 40 PV systems with a total estimated peak power for this application is 120 KWp.
These PV systems proved to be reliable and justified economically for these types of applications. Table 2 showing the total installed PV capacity in Libya by the year 2006.

Table: 2 Total installed PV capacity in Libya by the year 2006

<table>
<thead>
<tr>
<th>Applications</th>
<th>Number of systems</th>
<th>Total power [ KWp]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Communication</td>
<td>120</td>
<td>690</td>
</tr>
<tr>
<td>Cathodic protection</td>
<td>320</td>
<td>650</td>
</tr>
<tr>
<td>Rural Electrification</td>
<td>440</td>
<td>405</td>
</tr>
<tr>
<td>Water pumping</td>
<td>40</td>
<td>120</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>920</strong></td>
<td><strong>1865</strong></td>
</tr>
</tbody>
</table>

3.3.2 Thermal Conversion

The use of domestic solar heater started in 1980 by installing a pilot project of 35 systems, follows by some other projects. There are all together about 6000 solar heaters in Libya. The use of evacuated tubes for solar haters has been started for some hotels and homes and expected to grow up soon. Water heating energy consumption is about 12% of the national electricity production. The use of solar heaters has not spread in all country due to

1. No national or personal industry has been established for local individuals.
2. Lack of Knowledge for the people.
3. Low electric energy tariff.

3.3.3 Solar Bond Demonstration Project

A solar bond was installed in 1994 as a pilot project for water desalination Unit with production of 5 m3/Day, the size of which is 800 square meter.

3.3.4 Wind Energy in Libya

Wind energy was utilized for water pumping in many oasis beginning 1940, sizes of 50 – 1000W, the use of this energy has not been developed as the wind-mills need some maintenance from time to time. A demonstration project of one unit of size 10 KW was installed 1993. In 2004 measurement of the wind speed for wind potential has been conducted. The measurements showed that there is a high potential for wind energy in Libya and the average wind speed at a height of 40 meter is between 6- 7.5 m/s. Figure 23 shows Wind potential for the Libyan coast area.

![Wind potential for the Libyan coast area](image)
The use of wind energy for electricity production has not started yet in Libya, but a project was contracted for installing 25 MW as a pilot project to be erected in two years time. A project to present two Atlases that provide fact access to reliable solar and wind data throughout Libya is also been contracted for. The Atlases allow for accurate analysis of the available wind and solar resources anywhere in Libya, and is therefore very valuable for planning profitable wind farms and solar projects.

3.4. NATIONAL RENEWABLE ENERGY STRATEGY

From the experience gained in utilizing PV systems, a proposed national Renewable Energy plan that aims toward bringing RE into the main stream of the national energy supply system with a target contribution of 10% of the electric energy demand by the year 2020. a.

3.4.1 short term plan for utilization for using Renewable Energy

The proposed plan calls for a wide spectrum of Renewable energy applications. Table 3 shows short term plan for renewable energy contribution in the energy supply for Libya

Table: 3 Proposed plan for the next five years (2006-2010)

<table>
<thead>
<tr>
<th>Technology</th>
<th>2006</th>
<th>2007</th>
<th>2008</th>
<th>2009</th>
<th>2010</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>PV</td>
<td>1</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>3</td>
<td>10Map</td>
</tr>
<tr>
<td>Wind</td>
<td>15</td>
<td>30</td>
<td>30</td>
<td>35</td>
<td>40</td>
<td>150MW</td>
</tr>
<tr>
<td>Water heating</td>
<td>2000</td>
<td>4000</td>
<td>4000</td>
<td>4000</td>
<td>6000</td>
<td>20,000m2</td>
</tr>
<tr>
<td>Thermal electricity</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>20</td>
<td>20MW</td>
</tr>
<tr>
<td>Thermal Desalination</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>20,000</td>
<td>20,000 m3</td>
</tr>
<tr>
<td>Hydrogen</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>10</td>
<td>10</td>
<td>20KW</td>
</tr>
</tbody>
</table>

3.4.2 Long term plan for Renewable Energy

A long term plan for 2005-2010 will make use of all possible renewable sources, table 4 shows the contribution of each source for the years 2006-2020.

Table: 4 proposed plan (2010-2020).

<table>
<thead>
<tr>
<th>Technology</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>PV</td>
<td>10 MWp</td>
</tr>
<tr>
<td>Wind</td>
<td>150 MW</td>
</tr>
<tr>
<td>Thermal Water heating</td>
<td>20,000 m2</td>
</tr>
<tr>
<td>Thermal electricity</td>
<td>20 MW</td>
</tr>
<tr>
<td>Thermal Desalination</td>
<td>20,000 m3</td>
</tr>
<tr>
<td>Hydrogen</td>
<td>20 KW</td>
</tr>
</tbody>
</table>
3.4.3 strategy objectives

The objectives of implementing this strategy are summarized as follows:

1. To improve energy efficiency and energy conservation
2. Capacity building
3. Coordination of national efforts towards the achievement of the strategy target for renewable energy
4. Support of renewable energy market penetration
5. Support of renewable energy technology transfer
6. Support of R&D, education and training in the field of renewable energy

3.4.4 Actions Required to Promote RE

- **Regulations:**
  - Incentives
  - Quality Insurance

- **Finance:**
  - Support of R&D
  - Investment in Projects/Studies

- **Technology:**
  - Demo projects
  - Pilot Projects
  - Manufacturing

- **Supportive: Training**
  - Education
  - Information

3.4.5 Research and Development (R&D) Facilities

To help implement the renewable energy strategy, some kind of R&D facilities are needed. There are three research centers, five universities, and two companies which have some kind of renewable energy activities, the most active in this is Renewable Energy and Water Desalination Research Center. The R&D facilities in this center are:

- **Solar Thermal Laboratories**
  - Mobile Liquid Solar Collector Performance Test Facilities.
  - Solar Collector Qualification Test Lab.
  - Mobile Solar Liquid Heating Test Lab.
  - Liquid Solar Thermal Storage Tank Facilities.

- **Photovoltaic Laboratories**
  - Semiconductors and Solar cells Lab.
Solar Cells and PV Modules Testing Lab.
PV Outdoor testing Facilities

General Purposes Laboratories
- Optical Properties Test Facilities.
- Steady State Solar Simulator.
- Metrological Sensors Calibration Lab.

Wind Energy Lab Laboratories
- Wind Energy Converter System Test Station
3.5. FUTURE PROSPECTS OF PV IN LIBYA

There is a great potential to use PV systems and other renewable energy sources in Libya, the following are some of the projects planned for.

3.5.1 Desalination pilot project powered from renewable energy sources:

General Electricity Company of Libya is planning to install a pilot plant for Sea Water Reverse Osmosis desalination powered from Renewable Energy Sources. The nominal production of the plant will be 300 m³/d for the supply of a village with potable water. Both wind energy conversion and photovoltaic (PV) power generation will be integrated into a grid connected power supply for a Reverse Osmosis (RO) desalination plant with power recovery.

3.5.2 One MW PV pilot plant in Libya

GECOL is now planning a PV project of 1 MW capacity grid connected system. The site of the plant is already decided.

This pilot PV project is intended to accommodate know-how on PV technology and on the operation, maintenance and management of a large PV system, in preparation for larger-scale installations in the future. The consulting firm is already selected employed to prepare detailed design of the pilot plant, to produce a tender specifications for selecting the supplier and to supervise the project implementation.

3.5.3 Water pumping Systems
A plan was made to install around 100 PV systems to pump water for irrigation of date trees in the desert of Libya.

3.5.4 Grid connected PV Systems

Due to the performance of stand alone PV systems GECOL is planning to erect a project of 10 PV systems grid connected in the year 2007.

This pilot PV project is intended to accommodate know-how on PV technology and on the operation, in preparation for larger-scale installations in the future.
PART (V)

CASE STUDIES ON
UTILIZING RENEWABLE
ENERGY IN LIBYA
4.1. CASE STUDY ON
RURAL ELECTRIFICATION USING PHOTOVOLTAIC SYSTEMS

The electrification of rural areas and villages is one of the problems facing electric company in all countries, it is a known fact that it is very costly to extend local electric network to the places that fare away. The use of diesel generators will not be the best solution as it has a high running cost and need special handling. Thus it will be more practical to use other possible sources of energy, as renewable sources. The General Electrical Company of Libya (GECOL), which is the electric company responsible for electrification, has conducted a survey to estimate the real need of inhabitants living in the remote areas. Based on the real needs, the suitable type of source was selected as an AC current, the batteries was chosen to suite the people, in this case closed type of batteries was chosen which do not need any maintenence , the project planed to electrify about ten villages , A case study of this project is Mrraig-Gabis. The village was electrified in the year 2003.

4.1.1 Mrraig-Gabis  Location and Activities

Mrraig-Gabis village was selected as a village which has no electric power supply, the village is located about 250 km west of Benghazi city and nearest city is Gdabia which is 50 Km away. The climate in this selected region is the Mediterranean Sea; the ambient temperature ranges between -5°C and 45°C. The population of the village is counted as 39 families totaling of 350 inhabitances scattered in an area of about 15 sq. km. This population is living either in houses or huts, in addition to a school for the students from the first to the ninth grad. The main activity of this village is livestock pasturing and agricultural.

4.1.2 Options to Electrify the Village

The main options for electric energy production for the selected site are:
  a- electric grid
  B-diesel generation
  c- PV generation

  a-The Electric Grid Option.
The expected daily energy consumption; using the national grid; may reach 1000 KWh for the whole village and this amount will grow by about 25% by the end of the expected life time of the system which is assumed to be 20 years.
Looking to the geographical map of the site, there is one way to supply the required electric energy from the national grid. It is to construct a high line voltage of 66 KV for 50 km from Gdabia.
Referring to the prices of delivery and installing 66 KV lines given by the general electric company; 66/11 KV substations of about 0.5 MVA, the village 11 KV network, the 11 KV substations, and the distribution network. Accordingly the capital investment is 2,401,102 LD, in addition to maintenance, this will come 3,100,400 LD. This will give a cost of 0.62 LD/KWh.
b-The Diesel Generation Option

The proposed life time of diesel generators are about 12 years, however, the local experience showed that the average life time ranges between 7 to 8 years only. This is mainly due to the severe climatic conditions. It is to be noted that several problems arise with diesel generators resulting in long down times. The fuel transportation through difficult desert ways adds other problems to this way of generation of electrical energy. To electrify the village with diesel generators, this will required two 0.5 MV generators, beside a local distribution network, taking into account the maintenance running cost which we take it to be a yearly 35% of the installation cost. The total cost becomes over 20 years will be 3,598,000 LD. This will give a cost of 0.72 LD/KWh.

C-PV Generation

Two options were considered to generate the required amount of energy using the direct conversion of solar energy; mainly the central and distributed sources. The central way of energy production was omitted firstly due to the geographical nature of the site; secondly to get rid of having a distribution network and the problems arises with any fault in the network and/or other load problems in spite of the main advantage of it, namely the reduced storage capacity required. It was decided to use the A.C supply system to be consistent with the available appliances in the local market. The electricity produced by PV conversion of solar energy will not be used in the same way as that which has been designed to be supplied by electric grid.

4.1.3 Load Estimation to supply remote areas houses By PV systems

A survey was conducted to estimate the real need of inhabitants living in the remote areas. Based on the real needs, the suitable type of supply was selected as an ac current, the batteries was chosen to suite the people, in this case closed type of batteries was chosen which do not need any maintenance, the load is defined as follows.

The load was calculated for each type of living places based on general assumptions. The load was estimated for average house as given in Table, 5, and for average hut as given in Table 6. The total energy for house is taken to be 3.5 KWh/day, for the huts of type a taken to be 2 KWh/day.

Table 5 : load estimation for an average house

<table>
<thead>
<tr>
<th>Load type</th>
<th>No of units</th>
<th>Unit power (w)</th>
<th>Working factor</th>
<th>Power Watt</th>
<th>Working hours/day</th>
<th>Energy/day Wh/day</th>
</tr>
</thead>
<tbody>
<tr>
<td>Indoor Lighting</td>
<td>4</td>
<td>20</td>
<td>50%</td>
<td>40</td>
<td>6</td>
<td>240</td>
</tr>
<tr>
<td>Outdoor lighting</td>
<td>2</td>
<td>20</td>
<td>100%</td>
<td>40</td>
<td>3</td>
<td>120</td>
</tr>
<tr>
<td>Refrigeration</td>
<td>1</td>
<td>150</td>
<td>100%</td>
<td>150</td>
<td>12</td>
<td>1800</td>
</tr>
<tr>
<td>TV set</td>
<td>1</td>
<td>120</td>
<td>100%</td>
<td>120</td>
<td>4</td>
<td>480</td>
</tr>
<tr>
<td>Water pump</td>
<td>1</td>
<td>400</td>
<td>100%</td>
<td>400</td>
<td>1</td>
<td>400</td>
</tr>
<tr>
<td>Radio</td>
<td>1</td>
<td>10</td>
<td>100%</td>
<td>10</td>
<td>3</td>
<td>30</td>
</tr>
<tr>
<td>Fans</td>
<td>2</td>
<td>70</td>
<td>50%</td>
<td>70</td>
<td>2</td>
<td>140</td>
</tr>
<tr>
<td>Other</td>
<td>1</td>
<td>100</td>
<td>100%</td>
<td>100</td>
<td>3</td>
<td>300</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td></td>
<td></td>
<td>930</td>
<td></td>
<td>3510</td>
</tr>
</tbody>
</table>
Table 6: Load estimation for an average hut

<table>
<thead>
<tr>
<th>Load type</th>
<th>No of units</th>
<th>Unit power (watts)</th>
<th>Working factor</th>
<th>Power Watt</th>
<th>Working hours/day</th>
<th>Energy/day Wh/day</th>
</tr>
</thead>
<tbody>
<tr>
<td>Indoor Lighting</td>
<td>4</td>
<td>20</td>
<td>50%</td>
<td>40</td>
<td>6</td>
<td>240</td>
</tr>
<tr>
<td>Outdoor lighting</td>
<td>1</td>
<td>20</td>
<td>100%</td>
<td>20</td>
<td>3</td>
<td>60</td>
</tr>
<tr>
<td>TV</td>
<td>1</td>
<td>100</td>
<td>100%</td>
<td>100</td>
<td>4</td>
<td>400</td>
</tr>
<tr>
<td>Fans</td>
<td>1</td>
<td>70</td>
<td>100%</td>
<td>70</td>
<td>2</td>
<td>140</td>
</tr>
<tr>
<td>Others</td>
<td>1</td>
<td>110</td>
<td>100%</td>
<td>110</td>
<td>10</td>
<td>1100</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td></td>
<td></td>
<td>340</td>
<td></td>
<td>1940</td>
</tr>
</tbody>
</table>

The house of 3.5 KWh was designed with 1200 Wp, while the houses of 2 KWh was designed with 750 Wp.

4.1.4 Results of PV System Sizing

All houses in the village have been chosen to be of 1.2 KWp. The PV system assumed to have a life time of 25 years, and the batteries of eight years, no electronic parts expected to be replaced. The total cost for this type is 24,190 LD.

From the actual data we have experienced in electrifying Mrrair-Gabis village we calculated the actual cost of the KWh. The calculation was based on the actual energy production of the PV system for houses of 1.2 KWp, the recorded average energy production over years of working for some of the systems is 6 KWh/day. This will give a cost of 0.44 LD/KWh. Figure(24), showing a comparison between the cost per KWh for the three types of the generations.

From Figure 1, it is clear why it was decided to take the option of PV systems to electrify remote areas.

4.1.5 PV Systems Performance

Forty systems were installed in Mrrair-Gabis village since 2003. Due to the importance of evaluating the performance the PV systems installed, we selected thirty systems of the over all systems installed; all systems were equipped by a data logger” ENERPACK”.

To help evaluating the performance of this type of PV systems, we collected the data from Jan 2004 to July 2006. The performance analyses was based on the PV system
performance ratio introduced by International Energy Agency (IEA PVPS), and usage factor introduced by Didier Mayer and Michael Herdernreich.

To evaluate the potential energy we found that the average potential energy of all systems is 5.43 KWh/d, systems with potential energy more than 5.6 KWh/day are shown in Fig. 2. The maximum potential energy recorded in one day is 7.32 KWh/d and a maximum monthly average of 6.75 KWh/d.

4.1.5.1. Potential Energy
To evaluate the potential energy we found that the average potential energy of all systems is 5.43 KWh/d, systems with potential energy more than 5.6 KWh/day are shown in Fig. 25. The maximum potential energy recorded in one day is 7.32 KWh/d and a maximum monthly average of 6.75 KWh/d.

4.1.5.2. Array output Energy
To evaluate the array output energy we found that the average array energy of all systems is 3.32 KWh/d, systems with array energy more than 4.0 KWh/day are shown in Fig. 26. The maximum array energy recorded in one day is 6.28 KWh/d and a maximum monthly average of 5.6 KWh/d.

Fig 25 System With Potential Energy More Than 5.6 Kwh/D

Fig( 26) System With Array Output Energy More Than 4 KWh/D
4.1.5.3. Load performance

To evaluate the load energy we found that the average load energy of all systems is 3.25 KWh/d, systems with load energy more than 3.6 KWh/day are shown in Fig. 27. The maximum load energy recorded in one day is 6.4 KWh/d and a maximum monthly average of 5.6 KWh/d.

![Fig 27 systems with load energy more than 3.6 KWh/d](image)

4.1.5.4. Usage Factor Performance

In evaluating the system’s usage factor we found that the average usage factor of all systems is 61%, systems with usage factor more than 70% are shown in Fig. 28. The maximum usage factor recorded in one month is of 96%.

![Fig (28) systems with usage factor more than 70%](image)
4.1.5.5. Global efficiency

In evaluating the system’s global efficiencies we found that the average global efficiency of all systems is 48%, systems with usage factor more than 55% are shown in Fig. 29. The maximum global efficiency recorded in one month is of 80%.

The performance figures show the average potential energy is almost five times the peak power, the average system losses 0.06 KWh/d which indicate that the losses due to the system components is very small, the average capture losses is 2.7 KWh/d which means that the system is not capturing almost half it’s potential energy (production factor 50.5%), the average usage factor is 61% which is considered good for this type of SAS, the average performance ratio is 49% which is considered also very high, the overall performance of these systems are quite high as it has quite high usage factor, and performance ratio, while it has high capture losses, the overall performance are more than reasonable for these kind of systems. We noticed that no break down has been recorded from any system and the load energy in summer is more than that in the winter.

Fig(29) systems with global eff. More than 55%
4.1.6 EXPERIENCE FROM RURAL ELECTRIFICATION

The use of PV systems becomes more visible, and a greater attention was given to its use for developing remote areas in low population countries, therefore the PV systems will be the way to electrify rural areas.

As a first step in the direction of using PV systems, it is essential that people be made aware of the technology through increasing the understanding of the processes and the fundamental principles on which it is based. The following are some remarks which has been noticed from the projects which installed in the year 2003.

1. People in this villages in spite of being not knowledgeable with the technology yet they are dealing with the systems with care.
2. In spite that PV systems does not have energy meters to disconnect the load when the energy drawn by the house holder more than designed , non of the systems went over discharge.
3. The PV systems which are installed in all villages are working without any system failure.
4. The average production energy for systems of 1.2 KWP is 6 KWh/day.
5. The a.c option of electricity was the best choice.
6. The closed type batteries option was the best choice for the rural areas people.
7. More and more remote areas people asking for PV system.
8. The people in the villages started to have night gatherings.
9. The people start to watch TV and using refrigerator.
10. The PV systems performance at the local environment proved to be highly reliable and cost competitive.
11. Children should be aware of the PV systems through their schools.
12. Repeated visits should be done to inshore the correct use of the PV systems.
13. All systems have been installed by local engineering and technicians.

4.1.7 SOCIAL IMPACTS OF PV SYSTEMS

Since this technology is considered as relatively new; we are experiencing a lot of social changes; among these; the settlement of Bedouins in some locations started even before starting the installation of the PV systems, we are expecting that some small industries will be started. The availability of power supply will give a good chance to involve the populations of such remote areas in increasing their knowledge and be familiar with the modern society daily life.

The existence of electrical power supply motivates the population to use more appliances like TV sets, refrigerators that are normally in use in grid connected areas. As a result we
have noticed load increase in some houses which exceed the maximum capacity of the PV supply systems.
We also noticed due to the availability of electrical energy some population start to move back to these remote areas resulting in adding new houses and loads that area not planned.
It is expected that the increase in population will drop the family income and this may drive some family members to move to other places looking for new jobs. The reception of TV programs may change the way of family life resulting in low productivity.
We also noticed due to the availability of electrical energy some population start to move back to these remote areas resulting in adding new houses and loads.
The reception of TV programs may change the way of family live resulting in lower productivity.
We have not experience any vandalism, and the only problem reported in one of the system in which the inverter stopped due over load which may be considered to be due to the equipment itself.
4.2. CASE STUDY ON USING PHOTOVOLTAIC SYSTEMS IN COMMUNICATION NETWORKS

As more information needed to be distributed around, more and more telecommunication networks have to be extended. The only problem facing the wide distribution of information is the availability of electric power in rural areas where powering of telecommunication systems are not easy or available. The need to increase rural telecommunications becomes more and more important and as more rural telecommunications needed, more dependent, and reliable sources of energy are needed. The electric network in developing countries may not be available within a reaching distance of the needed places. It will be very costly to extend local electric network to the places where it is required. Thus it will be more practical to use other possible sources of energy, which will be either diesel generators or renewable sources. The use of diesel generators will not be the best solution as it need skilled personal, a routine maintenance, and fuel delivery, which will not suit the developing countries.

Thus the use of PV systems becomes more visible, and a greater attention should be given to its use for developing telecommunication networks in developing countries, and so the PV system will be the way to develop the telecommunication networks.

The use of photovoltaic systems as a power generator in communication was first established in the industrial countries but it is also established in the developed ones, where PV systems were used in communications field as a power supply in microwave networks, VSAT stations, and railway communications.

As a first step in the direction of using PV systems, it is essential that developing countries be made aware of the technology through increasing the understanding of the processes and the fundamental principles on which it is based.

4.2.1 Options available for powering remote telecommunications networks

There are four options available for electricity generation in remote and isolated areas, namely electric network, diesel generators, wind energy, and photovoltaic systems. The electric network may not be available at the place needed beside in developing countries the electricity from the national grid is subjected to stops without notice, in addition you have to think about a reliable back up system, which means that you either use batteries or diesel generators. Therefore if you are thinking to power a rural station you may not be able to use electric network as an option in most of developing countries.

The use of wind energy in this type of applications will not be a reliable source as wind energy is not a continues supply, beside the use of wind source need maintenance personal, and so this option has to be omitted as a power supply. Finally we end up with two technologies that can be used for rural telecommunications. The diesel generators option has been used in many countries as a power supply for rural telecommunication but it was found that it is not suitable for developing countries, as it needs maintenance, skilled personal which not available for developing countries, its high running cost and reliability made this option not preferable for the developing countries. We left with the PV systems utilization, which considered as a new technology for developing countries and as a new technology it has some obstacles.
4.2.2 Obstacle opposing popularization of PV system option

There are some obstacles opposing fast and widespread spread of PV systems in the developing countries, these because of lack of knowledge, experience, and confidence in using this type of energy. Table 7 showing some of these obstacles and some solutions.

Table 7 showing obstacle facing the wide spread of PV technology in the developing countries.

<table>
<thead>
<tr>
<th>Obstacle</th>
<th>Solutions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lack of knowledge</td>
<td>Developing countries should be made aware of the technology through increased their understanding and appreciation of this technology.</td>
</tr>
<tr>
<td>Lack of experience</td>
<td>Exchange experience between developing countries</td>
</tr>
<tr>
<td>Lack of prestige</td>
<td>Prestige awards and events for persons and organization in developing countries</td>
</tr>
<tr>
<td>Disregard</td>
<td>Exchange of information between the countries and organization who have implemented PV systems</td>
</tr>
<tr>
<td>Marketing</td>
<td>Implement strategies to facilitate the developing of market in developing countries</td>
</tr>
<tr>
<td>Developing countries policies</td>
<td>Make loans of free interest available to PV system buyers</td>
</tr>
<tr>
<td>Cost</td>
<td>Cost reduction on PV prices for PV systems users</td>
</tr>
<tr>
<td>Quality control of product</td>
<td>Improving the technical performance of PV system used in developing countries</td>
</tr>
<tr>
<td>Services</td>
<td>Make services available to users in his country</td>
</tr>
<tr>
<td>Operation and maintenance</td>
<td>Make training available to users from developing countries</td>
</tr>
<tr>
<td>Oil prices</td>
<td>Take out the subsidizing of oil prices in developing countries</td>
</tr>
<tr>
<td>Taxation policies</td>
<td>Developing countries should exclude this technology from any kind of taxes</td>
</tr>
</tbody>
</table>

4.2.3 CASE STUDY

To reflect the importance of using PV systems in the field of telecommunication, we introduce the use of PV systems in telecommunication networks in Libya. In this case study we introduce the importance, the advantageous of using PV systems, and experience gained in utilizing the photovoltaic systems in rural telecommunication.

In repeater stations, which are away from cities, or away from general electric grid, diesel generators have been used as a power supply. The diesel power system in most of the repeater stations consists of two diesel generators, each generator works for one week, while the other is standby. The diesel generators need a constant supply of fuel, continuous maintenance, skilled labor, special handling machines, and cause standing of communication.

4.2.4 PV systems for powering Libyan communication network:

The use of PV systems were first started in Libyan communication network as a pilot project in 1980 where ten small repeater stations were put into work. The use of the PV systems proved to be suitable for this type of application, the stations which is running by PV systems did not stop due to lack of fuel or maintenance problems, and the stations are still running. Table 8 summarizes the operating technical experience gained from the pilot stations running by diesel in comparison with stations running by solar in the last 26 years of work.
**Table: 8** Technical comparison between stations running on diesel and on solar

<table>
<thead>
<tr>
<th>Diesel generators</th>
<th>PV Solar generators</th>
</tr>
</thead>
<tbody>
<tr>
<td>Need special machines for installation or</td>
<td>No need for special machines</td>
</tr>
<tr>
<td>replacement</td>
<td></td>
</tr>
<tr>
<td>Experience more theft cases, in fuel and</td>
<td>No theft problems</td>
</tr>
<tr>
<td>spare parts</td>
<td></td>
</tr>
<tr>
<td>More communication stops due to power</td>
<td>No power failure</td>
</tr>
<tr>
<td>failure</td>
<td></td>
</tr>
<tr>
<td>Need qualified personal for maintenance</td>
<td>Experience no maintenance</td>
</tr>
<tr>
<td>Need spare parts</td>
<td>No spare parts ever used</td>
</tr>
<tr>
<td>Stops due to fuel theft</td>
<td>No fuel</td>
</tr>
<tr>
<td>Stops due to fuel run out</td>
<td>No need for fuel</td>
</tr>
<tr>
<td>Rate of stops is 1.5 days per month per link</td>
<td>No power failure</td>
</tr>
</tbody>
</table>

**4.2.5 PHOTOVOLTAIC POWER SYSTEMS AS POWER SUPPLIES**

The excellent performance of the pilot PV project dictate the use of PV solar energy instead of diesel generators. The outcome of the pilot project convinced The General Post and Telecommunication of Libya (GPTC) to plan to use PV systems as power supply rather than diesel generators. The GPTC put a plan to change all repeater stations which running by diesel generators to PV solar generator, seventy stations of medium size (about 15 kwh/day). It was the success of the PV systems technically and economically that pushes the changing of all possible diesel stations to PV stations. The total number of stations running by PV in the field of communications is 75 stations; the increase in the number of PV stations counter a decrease of the number of stations running on diesel. Figure 30, shows the increase of PV stations and the decrease in the diesel stations in the Libyan communication Networks.

![Figure 30 No of PV and diesel stations in the communication network](image-url)
4.2.6 ECONOMIC COMPARISON BETWEEN SOURCE AVAILABLE OF ENERGY SOURCES

An economical study was conducted on using solar generators instead of diesel generators. The study was conducted between three different types of systems that can be used to supply power to the repeater stations, these are

a. Diesel generators.
b. General electric grid.
c. Stand alone PV solar system.

The study was done based on the following assumptions:

- The comparison period is 20 years, the lifetime of the PV solar system.
- Capitol and installation cost of the power system.
- The diesel generator lifetime has been set to seven years.
- The supply of energy by general grid network was considered only for stations not far more than 5 km, with one diesel generator as a backup.
- Running cost for diesel generators as, maintenance, fuel, distilled water, and Oil.
- Batteries lifetime has been set to 10 years for PV system.
- Batteries for startup of the diesel generators.
- Spare parts for diesel generators.
- Rectifier for diesel generator stations.

Figure (31) gives the results of the economical comparison between the three types of power supplies.

![Cost comparison between diesel, grid, PV solar generators.](image)

*Figure 31: Cost comparison between diesel, grid, PV solar generators.*
4.3. CASE STUDY ON
Pilot Wind Farm Project

4.3.1 introduction

Although being one of the greatest oil exporting countries Libya has identified the existence of potential renewable energy resources. In year 2000 the Libyan electricity utility GECOL began seeking professional engineering experts, which would help the company to qualify the country’s wind energy potential and build the first commercial wind farm to both generate electricity from a renewable energy source on economically reasonable terms and educate local engineers in understanding the requirements and interrelating subjects of wind farm development.

4.3.2 Project’s Objective

The project’s objective is to install a pilot wind farm with up to 25 MW nameplate capacity if at least one of the selected candidate sites proves to be an option for a technically and economically feasible wind farm operation. A technical knowledge transfer in the field of wind power technology.

The project is structured into four phases:

Phase 1: Preparation of Feasibility Study

- Preparation and survey of candidate sites
- Site investigation and installation of monitoring equipment
- Data processing and analysis of the wind and electrical measurements
- Evaluation of recorded climatic data
- Site layout and energy yield calculation for the wind farm preliminary feasibility study
- Documentation of all findings

Phase 2: Definition of technical specifications

- Identification of local conditions and limitations that require consideration when compiling the specifications of the prospective wind farm site
- Electrical grid facilities study
- Identification of special needs of GECOL
- Definition of the appropriate technical standards
- Geotechnical soil analysis
Analysis of the infrastructure requirements for the transport of shipped goods from the harbour to the site

- Definition of specifications for
  - Foundations
  - Access roads
  - Electrical transmission system, incl. cables, transformers, switches etc.
  - Wind turbines, incl. tower, blades, gearbox, computer aided remote control system, etc.
  - Preparation of tender documents

**Phase 3: Tenders and Contracts**

- Evaluation of all quotes for their compliances with the tender terms and specifications
- Preparation of a document comparing and summarizing the technical and economical differences of all received quotes
- Contract negotiations and conclusions for the purchase of goods and for engineering contractors

**Phase 4: Construction, Commissioning, Testing**

- Project management, including procurement, supervision of construction and commissioning
- Wind farm testing prior to grid connection, performance testing and provision of all collected data
- Technical assistance during the first year of operation
- Design of a monitoring program and conduction of a research program for the performance evaluation of the wind farm operation

**Phase 1 – Results**

Phase 1 has started in late 2001 with the identification of five candidate sites for measurements and a later wind farm along Libya’s coast line east of Tripoli. The measurements began in September 2002 using high quality measurement equipment. The sites were selected after inspections, considering accessibility and grid connection possibilities.

During the measurement period GECOL provided data about the grid connection nodes, which were used to calculate key figures indicating the stability of the grid and its potential of integrating wind generated electricity. It was found that at all sites the capability of the grid is sufficient from a network operator’s point of view. Though, at some sites the capacity is limited to take the wind power.

A preliminary survey of soil conditions was performed at all sites using international standard techniques and procedures. Seismicity was also investigated on a source study basis and incorporated in the findings and recommendations. The report states that all sites have good to acceptable bearing capacities with no or low additional requirements on the foundations of the wind turbines.

After one year of measurements all data have been processed, analyzed, corrected according to calibration figures and correlated to long term values. The values range from 6.4 m/s to
8.3 m/s in 50 m above ground level, meaning good to excellent wind conditions. Table 9 summarizes the results of phase 1. Layouts using three different wind farm sizes (5 MW, 15 MW, and 25 MW) and three wind turbine sizes (<1,000 kW, <1,500 kW, >1,500 kW) were created for all five candidate sites, and energy yields were calculated accordingly (using the European Wind Atlas Model). An economic model was constructed, applying MS Excel. Each individual site was assessed to determine the most suitable wind farm size with the corresponding wind turbine size from Table 9: Summary results of phase 1

<table>
<thead>
<tr>
<th>Site and height above ground level [m]</th>
<th>V_mean in m/s</th>
<th>Weibull-parameters</th>
<th>Power density in W/m²</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 - Misratah</td>
<td>6.8 m/s</td>
<td>7.6 m/s</td>
<td>305 W/m²²</td>
</tr>
<tr>
<td>2 – Sirt*</td>
<td>6.7 m/s</td>
<td>7.6 m/s</td>
<td>285 W/m²²</td>
</tr>
<tr>
<td>3 - Al Maqrin</td>
<td>7.4 m/s</td>
<td>8.4 m/s</td>
<td>399 W/m²²</td>
</tr>
<tr>
<td>4 - Tolmeha</td>
<td>6.4 m/s</td>
<td>7.2 m/s</td>
<td>365 W/m²²</td>
</tr>
<tr>
<td>5 - Dernah</td>
<td>8.3 m/s</td>
<td>9.3 m/s</td>
<td>504 W/m²²</td>
</tr>
</tbody>
</table>

An economical perspective taking into account an evaluation of the researched local factors such as wind resources, accessibility, subsoil conditions and the existing electricity transmission grid. The model output offers solid figures such as a variety of rates of return on investment and the corresponding wind energy production costs. These figures, which are backed up by highly scrutinized input data, give a first insight into the predicted project’s financial returns.

The conclusion of the sensitivity analysis is, that the Dernah site in Libya’s east is most feasible from both an economical and technical point of view. It has

- excellent wind conditions,
- good accessibility
  - Dernah has an own seaport,
  - the second largest seaport of Libya is Benghazi 200 km west of Dernah,
  - the coast highway crosses the site,
- easy terrain,
- good grid connection possibilities
  - in 12 km (66 kV) for 25 MW or more or
  - in 30 km (220 kV) for 100 – 150 MW,
- manageable logistical problems
  - crane availability for installation and repair must be secured
- high extension potential (100 – 150 MW)
- low additional foundation requirements in a homogenous soil environment

It furthermore has been found that the 25 MW wind farm size has the most economic
Benefits
The entire project aims to prepare and create a sustainable development of utilizing wind energy in Libya. Projects in comparable social and technically developed countries have shown that its success was less dependent on using latest technologies but on technical understanding and full commitment.
The wind farm pilot project is therefore based on the strategy to both
• plan and build a wind farm using best engineering experience from the leading countries in wind energy utilization and
• at the same time educate and train local engineers on “their” project and subsequently transfer substantial know-how to them during all phases.

This success promising strategy allows Libya to gather experience in planning and operating in a safe environment and further develop the potential of wind energy in Libya.
A calculated net capacity factor of 35% means approximately 80,000,000 kWh for a 25 MW wind farm and a corresponding saving of 80,000 tons of CO₂ emission per year. The wind farm and its potential extension can significantly contribute to Libya’s measures to fulfill its Kyoto goals.

Phase 2-3 : Results
Almost phase 2 and phase 3 has been completed. The tasks which were performed in there two phases are as follow:
- defining the technical specifications of 25 MW wind farm.
- Preparation of the tender document
- Evaluation of the received quotes.

GECOL decided to give chance to many manufacture companies to revise their quotes. It is expected that the construction of 25 MW wind farm in Derna to start at the beginning of 2008.
SUMMARY AND CONCLUSION

Libya Energy Situation:

In Libya, the energy sector plays a vital role in achieving social and economic development through satisfying the energy needs of the different economic sectors, in addition to the sector’s effective contribution, particularly the oil and gas sector, to the GDP. In spite of such vital role, the sector has several features that can affect its contribution to the achievement of sustainable development this is mainly due to unsustainable energy production and consumption patterns, particularly in the end use sectors, the sector has its adverse environmental impacts on air, water and soil resources.

Libya is experiencing strong economic during last three years which made Libya one of highest per capita GDP in Africa.

Oil export revenues are extremely important to the economic development of the country as they represent 90% of the total revenue.

Libya has continues increasing in total primary energy supply with average annual growth of about 5 % and the oil has the largest share, while the total energy demand reached 9.1 Mte in 2003 with highest consumption in oil sector.

The electricity is covering more than 99% of population; PV systems are used to supply electricity to about 2000 inhabitants in rural areas.

The electric energy demand is expected to grow very rapidly in the next few years; water desalination plants will be the major drive for energy demand as Libya planned to install desalination plants with amount of one million meter cub per day in the next five years.

The share of renewable energy technologies in Libya up to now hold only a small contribution in meeting the basic energy needs, it is used to electrify rural areas for sustainable development, supply microwave repeater station, and in cathodic protection. A setup plane was planed for implementing renewable energy sources is to contribute a 10% off the electric demand by the year 2020. The short plane for renewable energy is to invest 500 million euro in the next five years.

During the past three decades, photovoltaic is the most technology which has been used in rural applications, particularly for small- and medium- sized remote applications with proven economic feasibility, several constraints and barriers, including costs exist. The experience raised from PV applications indicates that there is a high potential of building a large scale of PV plants in the sought of the Mediterranean.

There is a great potential for utilizing, home grid connected photovoltaic systems, large scale grid connected electricity generation using Wind farms, and solar thermal for electricity generation, with capacities of several thousands of MW. The high potential of solar energy in Libya may be considered as a future source of electricity for the northern countries of Mediterranean.
Solar energy resources in particular can be of great source of energy for Libya after oil and natural gas. Renewable energy resources offer good opportunities for technology transfer and international cooperation. The modularity and decentralised nature of renewable energy technologies make them particularly well suited for rural energy development. In this aspect, use can be made of the Clean Development Mechanism (CDM) adopted by Kyoto Protocol in renewable energy applications that would reduce greenhouse gases.

Libya is located in a place which can be considered as a good place for renewable energy technology and applications development. It is also has great a resources for photovoltaic basic industry and a solar cell technology which can be built with the share of international investors.

The usual practice in Libya showed low efficiencies in energy production and consumption, there is a real challenge to develop an efficient energy use in most sectors, with several barriers including: lack of access to technology, capacity building, and institutional issues.

Energy efficiency can be implemented in both energy consumption and production sides. Almost in all energy end-uses, sectors, the focus is on improving the efficiency of equipment that provides the services, such as heating and air conditioning equipment, appliances, lighting and motors. In contrast, supply-side energy management focuses on performance-based improvements resulting in more-efficient energy generation, improved industrial processes, co-generation and energy recovery systems. On the production side there is a great importance in increasing efficiency in large-scale energy production. Energy efficiency can help reducing cost, preserving natural resources and protecting the environment. Energy efficiency can also be enhanced through access to appropriate technology, capacity-building, and institutional issues.

Libya is non annex I country under the UN FCCC, and is signatory to the Kyoto protocol, thus Libya currently is eligible to the CDM. The main emitters of CO2 in 2003 are fuel combustion in the power generation sector. Libya's energy related CO2 emissions increased by more than 78% in one decade mostly due to increased energy supply.

The analysis of the present energy situation in Libya clearly indicates that there are no programs toward rational use of energy. This situation related to many factors summarized as follow:

1- Low electricity tariff specially for residential sector.
2- cheap oil prices for transportation.
3- Lack of national policy toward the conservation of energy.
4- Lack of specialized national institution which deal with the rational use of energy.
5- Lack of detailed and deep studies related to the rational use of energy (RUE).

Many studies have indicated that the country's energy demand generation could be significant reduced if improved energy utilization efficiency by the major energy sectors is achieved.
What is needed to promote RE & RUE are:

- Promote and exerting private investment in renewable energy technology transfers and services.
- Increase informal education on all energy aspects as in the formal education.
- More attention needs to be paid to social issues related to energy.
- Disseminate widely an approach that could be implemented widely in all applications of RE.
- Need to establish partnership at local, national and international levels in order to develop policies based on evidence of the impact on people.
- Courage the international investment to invest in the industry.
- International cooperation to develop and build large scale solar energy applications as a pilot project.
- To develop and support, technically, financially, and institutionally, the national research and application institutions concerned with issues relevant to energy for sustainable development.
- To develop national energy policies and regulatory frameworks that will help to create the necessary economic, social and institutional conditions in the energy sector to improve access to reliable, affordable, economically viable socially acceptable and environmentally sound energy services for sustainable development.
- Developing and implementing policies and programs to change the current energy production and consumption patterns, through improving energy efficiencies in all sectors, particularly the highest energy consuming sectors, as well as promoting the use of cleaner fuels and renewable energy resources.
- Supporting R&D, technology transfer and industrial development of sustainable energy technologies, utilizing the available bilateral, regional, and international technical cooperation and funding mechanisms.
- Calling on All Libyan organizations to put more emphasis on developing and implementing educational, capacity building and public awareness programs on energy for Sustainable Development.
References:

1- National Oil Company (NOC) information.
4- General Electric Company Of Libya, Annual Report.