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RENEWABLE ENERGY FOR SUSTAINABLE DEVELOPMENT IN EGYPT

by

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1- Introduction

All development programmes aim to improve living conditions, create income-generating activities, and preserve the environment; in other words, the development process should be sustainable. Any sustainable development program must be concerned with intergenerational equity – that is, with ensuring that future generations have the same capacity to develop as the present generation. A development path is sustainable only if it ensures that the stock of overall capital assets remains constant or increases over-time.

Sustainable development has many objectives. The broad one is to raise people standard of living. This includes: reducing poverty, expanding access to health services, increasing educational levels, helping to ensure a clean environment, promoting intergenerational equity, etc.

The role of energy in sustainable development agenda is essential as energy facilitates all human life. Energy is used for heating, cooking, illumination, health, storage of food, education, industrial production and transportation...It has a crucial role to play for achieving any of the above goals. Meanwhile the conventional production, conversion and consumption of energy have its environmental impacts.

Traditionally, rural energy needs have been met mainly by extending electricity distribution network out of the cities and towns already electrified to rural settlements. As the years go by, however, the cost of bringing power to new consumers has increased because of lower consumer density in the new rural areas being served. As extension of the grid to rural areas became more and more expensive, the need arose for cheaper options to be explored.

One option that has become popular in recent times is the use of renewable energy. The upsurge in the popularity of renewable energy can be attributed to three main reasons – declining costs, commercial maturation and environmental protection (limiting the environmental effects of energy use). Renewable energy (RE) is defined as an energy resource that replaces itself within a human lifetime. Examples include, solar energy, wind energy, running water, biomass energy, geothermal energy, tidal power, wave energy, and Ocean Thermal Energy Conversion (OTEC).

RETs offer a greater prospect of meeting the cardinal goals of sustainable development than conventional energy sources. This is because not only can RETs contribute to energy service needs; they also do so in an environmental-friendly way. There are however some limitations and barriers to the adoption and utilization of RETs

Egypt is facing many challenges, most of which stem from the high population growth rate. Efforts to improve the standard of living require the development of Egypt's economic, technical, community, electricity and energy infrastructures. Electricity & Energy Sector plays the main role to satisfy the national development plans. Therefore, the electric energy demand has increased more than 15 fold over the past three decades. Requiring development of sound national electric energy policies based on rational use of

indigenous resources, which are unfortunately limited. Realization of such policies faces some economic and social constraints, all of which need great efforts to overcome.
From this point of view, diversifying resources to save the limited conventional ones and enhancing the utilization of renewable energy applications to abate electric power plants emissions are considerable factors in the national electric energy planning.

This paper presents the electric energy strategy, policies, current situation and future plans in the field of renewable energy utilization as an integral part of energy planning for sustainable development.

2- Egyptian Specific Challenges

Many of Egypt's requirements and problems stem form the high population growth rate. Over the past decade the population has increased from nearly 43 millions in 1980 to about 60 millions in 1995, and 64 million in 2000. It is not only the size of the population that is a problem but also the fact that about 50% of the population is under 20 years of age. All efforts to slow this growth in population have met with little success.

With an area of about 1 million-kilometer squared, Egypt is considered a relatively large country. However, less than 10% of this area is inhabited, the rest is desert. The majority of the population lives on or near the rich lands of the Nile Delta, the Nile valley and along the Suez Canal. About on fourth of the population lives in the metropolitan Cairo area and continuos migration contributes greatly to the problems of urban pressure. Accordingly, a long-term policy was set to suppress the growth of existing urban centers and to create new communities and centers. Such centers are either new industrial oriented cities or communities on new reclaimed lands in the desert. To realize these aims many and complex challenges, including the development of social, economic and technical infrastructures, are of prime importance as an infrastructure for electricity supply, which is needed for all types of development.

Egypt also has limited capability for expanding agricultural production. It has had to change its economy from being agriculturally based to one, which is principally based on industry and service activities. E.g. tourism. Achieving these goals also required and continues to require substantive development of Egypt's economic, transport, communications, community, electricity and energy infrastructures; this means facing further challenges and generating even more electricity.

Such development of the electric energy system should always be compatible with the broader national objectives that have dictated some of the major fundamental changes in the social and institutional structures relating to Egypt's economic system, management authorization, pricing system, etc.
How were we able to meet the electric energy requirements under such complex conditions? And what strategy did we adopt?

Before these points are discussed it is necessary to review the electric energy demands and the resources that contribute towards satisfying such demands.

3- The Energy Situation In Egypt

The Energy resources in Egypt are oil, natural gas, hydropower and non-commercial fuels as firewood, agricultural wastes and dried dung. The total primary energy production from oil and natural gases has increased from 33 Million Ton Oil Equivalent (MTOE) in 80/1981 to 59.69 MTOE in 99/2000. Natural gas is used as a fuel and as a raw material in petrochemical and fertilizers industries. More emphases are placed on natural gas production as an energy source. Coal was discovered in Egypt since 1959 in Sinai. The quantity of coal extracted is not sufficient to be used as a fuel in power plants.

Petroleum fuels i.e., oil and natural gas, are the most important energy sources of Egypt at present and for many years to come. Their consumption is distributed more evenly among the different economic sectors.

Proven oil reserves were estimated in 99/2000 to be 3.8 billion barrel of oil equivalent "BBOE", while the present production of oil is in the order of 36.4 MTOE. Although Egypt is not a member in Organization of Petroleum Exporting Countries (OPEC), oil exports represent one of the main foreign currency incomes of Egypt. The contribution of the petroleum sector is about 6.0 % of the total governmental revenues of Egypt in 99/2000, which indicates the relevant importance represented by that sector in the state budget.

The second major primary energy source in Egypt is the natural gas. The reserves of which are estimated to be about 9 BBOE. The sharing level of the gas production is in the order of 20 MTOE sharing by 33.5% of the total production of primary energy sources in 99/2000. It is anticipated that natural gas will play an increasing role in the country Hybrid energy mix in the near future, especially for electricity generation.

The third major primary energy source is hydropower generated from the high dam, the old Aswan Dams (1 & 2), Esna barrage and Nag Hammady power stations. The generated electricity from those five hydro power stations is 14.7 TWh sharing by 5.43% of primary energy production in 99/2000.

Hydropower resources have been utilized to supply 20% of electric energy consumption in 99/2000.

Hydropower played a significant role in satisfying Egypt's energy needs in the seventies by providing more than two thirds of the electricity demand. Since late eighties, the situation has been completely reversed with oil and gas providing more than two thirds of the electricity demand.

Table (1) shows the installed capacity, total produced electric energy and the final consumption in 99/2000 compared to the last two years.

Table (1) Electricity (Production & Consumption)

Items	97/98	98/99	99/2000
Installed Capacity (MW)	**13303**	**13935**	14582
Total Energy Production (TWh):	**62.336**	**68**	73.31
Hydro	12.222	15.286	14.659
Thermal	50.114	52.694	58.628
Final Energy Consumption (TWh):	**52.977**	**56.600**	60.86
Industry	22.079	22.9	23.43
Household & Commercial	20.471	23.2	25.46
Agriculture	2.131	2.2	23.75
Government & utilities	8.296	8.3	9.59

Source: Energy In Egypt 99/2000 (Organization for Energy Planning)

The total primary energy consumption is about 42 MTOE, as shown in table (2)

Table (2) Primary Commercial Energy Consumption

Energy Source in (MTOE)	98/99	99/2000	Growth rate
Oil	25.1	24.5	- 2.33 %
Natural Gas	12.8	15.7	22.7 %
Hydro	3.36	3.24	- 3.7 %
Hard Coal	0.93	0.59	- 36 %
Total	**42.19**	**44.05**	**5.61%**

Source: Energy In Egypt 99/2000 (Organization for Energy Planning)

The sectoial primary energy consumption in 98/1999 is shown in Table (3).

*Table (3) Final Energy Consumption (MTOE)**

Items	97/98	98/99	99/2000
Industry **	13.782	13.743	14.02
Household & Commercial	5.202	5.652	6.02
Transportation	8.236	9.113	9.65
Agriculture	0.317	0.32	0.329
Government & utilities	0.713	0.714	0.825
Total	**28.250**	**29.541**	**30.848**

* Includes Non Energy Use

** Includes Coal

Source: Energy In Egypt 99/2000 (Organization for Energy Planning)

The pattern of energy consumption by end users in Egypt in 2000 was roughly 45.3% for industry, 1.07% for agriculture, 19.53% for residential and commercial sectors, 31.3% for transport sector and 2.67% for Government & utilities.

The thermal power plants in the power sector consumed about 13 MTOE of natural gas and Oil in 99/2000 to generate about 58.6 TWh. The Hybrid fuel system of the thermal

electricity generation consists of oil and natural gas, which represents about 14.3 % of oil production and 62.9 % of Natural Gas production in Egypt.

To satisfy the growing need for electric energy, tremendous effort was required, including systematic planning, top priority governmental support and large investments.

The Egyptian Government has adopted a long-term strategy, which is periodically revised and updated in view of the projections for possible RE technologies/application options, available financing sources and investment opportunities in the field energy. This strategy targets

1- To diversify the fuel resources using an optimum mix of the existing energy resources available in Egypt.
2- To conserve energy and improve efficiency of converting systems and to implement programs for energy conservation.
3- To utilize the new and renewable energy resources available in Egypt.
4- To encourage investors to finance energy systems with emphasis on joint local manufacturing of energy equipment.

4. Renewable Energy in Egypt

4.1 Strategy and Policy

The government of Egypt realized in early 1980's the fact that the traditional energy resources will fall short to satisfy their future needs. A national strategy for the development of energy conservation measures and renewable energy applications was formulated in 1982 as an integral element of national energy planning. The New & Renewable Energy Authority (NREA) was established in 1986 to be a focal point for renewable energy activities in Egypt. The renewable energy strategy targets to supply 3% of the electricity production from renewable resources by the year 2010.

It is obvious that the implementation of such strategy will be an essential element of the national plans for achieving sustainable development and protection of the environment via upgrading energy efficiency and replacing conventional polluting resources.

To achieve these strategic goals, satisfy the energy needs for the country's development plans, and make sure that renewable energy takes its proper place in the sustainable supply and use of energy for greatest benefit of all, the Government has made a commitment to the following:

(a) Consider renewable energy as an integral part of the country's energy mix,
(b) Adopt technologies and applications that are approaching maturity and may be replicated widely,
(c) Link renewable energy and energy efficiency program,
(d) Upgrade local industrial capabilities to accommodate renewable energy technologies,

(e) Maximize the use of renewable energy sources within the electric power sector where feasible.

5- Renewable Energy Activities, Achievements And Future Plans

During the last decade, Egypt has been one of the developing countries following successful programs for the development of renewable energy resources, with special emphasis on solar, wind and biomass. The following describes the milestone achievements in the different fields of activities, almost focusing on solar and wind energy resource assessment and applications with long term plans.

5-1 In the Field of Resource Assessment

Since the early 1980s, a significant progress has been done on data base development and resource assessments for Solar, Wind and Biomass. The achievements include:

5-1-1 **Solar Atlas** and a Typical Meteorological year were issued in Year 1991 covering all Egypt's climatic zones. Egypt enjoys excellent solar radiation most of the year. The average annual global radiation varies between (1900-2600) KWh/m2/year from Northern to Southern parts of Egypt, while the direct normal solar radiation reaches (1970-3200) KWh/m2/year with low levels of cloudiness.

5-1-2- **A Wind Energy** measuring network includes 35 sites have been installed. A preliminary wind map was developed in 1988. The map indicates the high wind regime that Egypt has, particularly on the Red Sea Coasts. A wind Atlas for the Gulf of Suez Coast was issued in 1997.

Currently the Atlas is being expanded to cover the whole Egypt, focusing on the New Valley and East Owienat, through financial support from the Danish International Development Agency (DANIDA). It is expected to be issued in 2003.

5-1-3 **Biomass resources** both for rural and urban areas have been the subject of several studies. Over 20 million tons of agricultural residues are produced in Egypt annually as well as very large quantities of urban wastes which varies between 0.5 to 0.7 kg/capita/day depending on locations and type of economic activities, with 25-40% moisture content. Sewage sludge is being assessed and evaluated. Biogas from Sugar-cane industry and rice husks offer two important sources of energy for their processing industries. About 70% of the estimated annual production of 3 million tons of bagasse are used as fuel on the sugar production sites and 40000 tons of rice husks are used off-site as fuel in red brick making.

5.2 In the Field of Solar Photovoltaic

Photovoltaics power utilization has been addressed within the Ministry of Electricity & Energy (MOEE) as early 1979. Most of the efforts were early concentrated on field-testing and demonstration rather than commercialization and market penetration until the last few years.

Most of the Photovoltaic applications were demonstrated and field tested as Water pumping, desalination, clinical refrigerators, village electrification...etc, while

telecommunication systems, navigation and airport aid lights and highway advertising boards are already commercialized. The capacity of the PV projects presently in operation amounts to about 2 MWp.

These activities can be summarized as follows:

5.2.1 Photovoltaic System for Water Pumping

- A PV-Powered pumping system was installed at Wadi El-Natroun, a remote desert area about 100 Km far from Cairo, was installed with a capacity of 14 kWp as a part of the Egyptian-German Cooperation. The system is a stand-alone combined AC & DC one, producing about 70-100 m^3/day of water for irrigation.
- A portable Photovoltaic water-pumping unit was installed at West Nobareya, near Alexandria, with a capacity of 2.2 kWp for drip irrigation system.

5.2.2 Photovoltaic System for water desalination

- A stand-alone PV - Powered Reverse Osmosis system was 18 kWp installed along the Red Sea_Coast, south of Hurghada, with a total capacity of .It produces 60 m^3/day of fresh water.
- PV - Powered Reverse Osmosis system was also installed at the High voltage laboratory /Giza Governorate, with a capacity of 7 kWp to produce 6-8 m^3/day of fresh water.
- PV/ Diesel Hybrid ice making plant was installed at Wadi El-Raiyan Lake, a remote desert area which is about 12 Km far from the nearest rural area. It produces 6 ton/day of flake ice to preserve fish during the fishing season. The system is designed such that a 38 kWp PV array operates at sunshine hours, while a diesel unit of 50 kW operates at night.

5.2.3 PV Remote & rural electrification

- A pilot project for electrification was installed at a remote isolated satellite village. The project includes houses, street lighting and water pumping systems.
- NREA has completed a study for PV electrification of 10 Villages at Sinai through the joint project INTERSUMED between NREA and European Union (EU).
- The Egyptian Government has decided to electrify 33 isolated villages in South Sinai using PV system, funded by Social Monetary Fund for development. 5 of those villages have been selected to start as a first stage.

In response to the remote areas demand and market penetration, private investors started looking for the local manufacture of PV modules where two factories importing PV cells and assembling PV modules, each with a capacity of 300-500 kWp / year. However, the economic constraints still need to be tackled.

5.3 In the Field of Solar Thermal Applications and Energy Conservation Systems

Egypt has given a due consideration with serious efforts to develop and promote both low and medium temperature applications such as solar heaters and Solar Industrial Processes Heat (SIPH) combined with waste heat recovery, while the Bulk Renewable Energy Electricity Production Program (BREEPP) included a sub-program for high temperature applications in Solar Thermal Electricity Generation (STEG).

5.3.1 Domestic Solar Water Heaters (DSWH)

Since early 1980s, low temperature Domestic Solar Water Heaters (DSWH) are produced locally through joint ventures. Currently, eight companies are active in the field of production, design and installation as well as competing to adapt products to the local conditions. The annual production capacity exceeds 25,000 m^2 of collectors. Over 300,000 m^2 have been installed and operated particularly in new cities and touristic villages. As well, the government has adopted measures to support market promotion through mandatory use of "DSWH" in new communities. Egyptian standard specifications and codes of practice for "DSWH" were issued in 1986. NREA is providing technical expertise and services for the design, testing, development, applications and supervision of solar water heating systems.

5.3.2 Solar Industrial Processes Heat (SIPH)

The sectorial energy consumption in Egypt has always shown that the highest consumption is in the industrial sector, which consumes almost 45.4 % of the total national primary energy consumption. Such consumption reached 30.85 MTOE in 99/2000 distributed among oil fuel 65.76%, electricity 17 %, natural gas 15.34% and others 1.9 %. Moreover, studies have proven that about 20-30% of the industrial energy consumption is wasted due to low maintenance, inefficient processes and other reasons.

Industrial process heat consumes more than 60% of the total industrial energy consumption distributed among the different types of industry with waste heat being the largest source of waste.

To satisfy the strategic objectives, NREA implemented two "SIPH" pilot projects of low temperature in the food and textile industries. They are integrated with waste heat recovery systems and co-financed with United State Agency for International Development (USAID). Their objectives were to demonstrate and field testing Solar Industrial Process Heat and Waste Heat Recovery Systems in different sectors. Each one included local manufactured flat plate collectors with total surface area 356 m^2 producing 26 m^3/day of hot water at 50 – 65°C. The two projects have been operating successfully since 1990, 1993 respectively, saving about 1800 TOE/Year.

In the frame of comprehensive planning of Solar Industrial Processes heat and waste heat recovery systems for medium temperature in Egypt (1997 -2012), NREA performed a study to forecast, through field Energy Audits, the potential of SIPH and

waste heat recovery systems for six industrial sub sectors. The study was financed by the African Development Fund (ADF). As a result of this study, A Pharmaceutical Company has been selected to host a pilot project for medium/ high temperature (up to 175°C).

The project is currently under implementation, using parabolic concentrators with single axis tracking system.

The project mainly consists of:

- Solar plant (parabolic trough collectors) for process steam generation at 175°C/8bar.
- Energy conservation for condensate steam returns system, insulation of steam network and burners of boilers.

The project is planned to start operation by 2002 with expected fuel saving rate of about 1200 TOE/Year, and.

5.3.2 Solar Thermal Electricity Generation (STEG)

The expected rapid growth in the national electricity demand necessitates the addition of at least 8000 MW through the period 2001-2010. This gives a plenty of room for a considerable share of electricity generation from solar and wind energies

Encouraged by that and by the current tremendous development in renewable energy electricity generation technologies, NREA has formulated its Bulk Renewable Energy Electricity Production Program (BREEPP) for large-scale power generation.

The BREEPP has two main components for both grid-connected large-scale solar and wind electricity generation plants and forecasted to push ahead both technologies to the market place.

As far as the solar electricity is concerned, NREA has completed in 1995, an assessment and identification study for the Solar Thermal Electricity Generation "STEG" potentials which concluded that:

1. The total accessible potential for national grid connected "STEG" systems in Egypt is tremendous and far exceeds all practical expectations for implementation. Priority is given to the areas having higher direct solar radiation intensity (2200–2600 kWh/m^2/year) and access to both electrical grids & natural gas networks.
2. The Integrated Solar Combined Cycle System "ISCCS" using parabolic trough solar technology with a conventional gas turbine combined cycle is considered the most appropriate system for Egypt's first plant. The choice of solar technology for the next plants will depend upon the state of art at the time of commencing the implementation procedure.

In 1996, the Egyptian Cabinet of Ministers has approved on the establishment of the first "ISCCS" pilot power plant of about 100-150 MW capacities.

The natural gas will be used as a fossil fuel for the gas turbine and the peak period supplementary firing in the Waste Heat Recovery Boiler (WHRB).

The first plant is anticipated to be implemented through Build-Own-Operate-Transfer (BOOT) Or Build-Own-Operate (BOO) contract.

In 1997, two pre feasibility studies were performed for the first "ISCCS" plant at Kuraymat with a capacity of about (150) MW. The studies were based on parabolic trough concentrator and central tower receiver technologies as alternates. Egypt has officially requested The Global Environment Facility (GEF) to support the project.

GEF has shown a positive response being available to provide a grant fund to cover a substantial part of the incremental cost in comparison to the least cost conventional alternative producing the same annual electric energy, and assigning the World Bank as an implementing Agency

The consulting services were divided into two phases as fallow:

Phase I:

To conduct a feasibility study covering the technical, economic, financial, aspects including identifying the appropriate configuration, plant size, solar fraction, suitable solar technology and conceptual design of the plant, with estimation of the incremental cost in comparison with a reference conventional (C.C) plant producing the same annual electric energy.

This phase has additionally included:

- The assessment of private developers level of interest in the project
- Short listing of qualified interested developers

In 1999, NREA contracted the qualified consulting firm to perform the first phase of consulting services. The final feasibility study report was submitted in June 2000 concluding:

- The capacity of the power plant is 127MW.
- The solar contribution is 31 MWe
- The annual produced electric energy by the integrated plant is about 900 GWh.
- The solar contribution represented 9.1% of the total electric energy production
- CO_2 saving is 7.1%

Phase II:

The consulting services include:

- Preparation of the Request for Proposals (RFP) for private developers or any other documents as required.

- Assisting EEA/NREA in the evaluation of the offers, including support in negotiations with the successful bidder.

The second phase of consulting services is expected to be completed by end of 2001.

The plant is planned to be operative in 2004.

The ISCCS power plant (127MW) is considered as a first of series of hybrid solar fossil fuel power plants targeting to install about 750 MW capacity in an overlapped time frame based on BOOT system by the year 2010.

This plan was based on the following favouring factors: -

1. Abundant solar resource, almost flat desert areas, continuously expanding unified electric grid, natural gas pipe line networks, availability of the expertise and local manufacturing capabilities, all coupled with the governmental supportive policies to the development of clean energy.
2. Plans-under implementation- to interconnect the national power grid to the Mediterranean basin networks, and hence to the European grid in general.
3. The State Policy encouraging the private developers to establish privately financed and owned power plants as Independent Power Producers (IPPs) based on concession agreements and according to BOOT system.
4. The growing interest and support given by the various international financing institutions to the clean energy development, within the framework targeting to reinforce the international cooperation for sustainable development and protecting the global environment.

Table (4) Solar Thermal Electricity Generation Plan

5 Years Development Plans	Installed Capacity			Cumulative Capacity (MW)	Annual Energy Generation at the end of the period GWh/Year
	No. of Plants	Power Capacity (MW)	Total Capacity (MW)		
1997-2002	-	-	-	-	-
2002-2007	1	127	127	127	900
2007-2010	2	300	600	727	4600
After 2010	Dissemination according to cost reduction and the level of interest of private developers				

5.4 Wind Energy.

Egypt is endowed by huge wind energy potentials where the coastal areas particularly the Red Sea Coast and the South Western parts of the country have high wind velocities reaching 10 m/s and 7 m/s respectively. Wind resources in coastal areas of Egypt have proven to be feasible both for mechanical pumping and electricity generation. Several organizations have directed efforts towards utilization of such resource.

Encouraged by the high wind regime at the Red Sea, the first steps of exploiting wind energy have been started by limited pilot projects.

The activities and main achievements can be summarized as follows:

5.4.1 Pilot Projects.

- In 1988, the First Wind Farm with a capacity of (400KW) was installed in Ras Ghareb on the Red Sea Coast serving one of the oil companies. The Wind Farm consists of 4 units, 100 kW each.

  Fully imported wind turbines were used.

- In 1992, the second wind farm is 4X100 kW each at Hurghada on the Red Sea Coast. 45% of the wind turbine components were locally manufactured, mainly blades, towers and other mechanical parts. The farm has been connected to the local network of Hurghada city. In 1998, the network has been connected to the National grid.

The a/m wind generated electricity is powering desalination units to produce 130 m^3/day of potable water to satisfy NREA' site facilities needs of water at Hurghada

5.4.2 A Grid connected 5 MW Wind Farm at Hurghada.

The farm consists of 38 wind turbines of different technologies (pitch regulated/stall regulated blades/ tubular/lattice towers) and ratings (of 100-300 kW). 50% of the components are locally manufactured. The farm has been connected to the local grid and operated successfully since 1993, producing about 10 million kWh/year.

This project allowed together with the Wind Energy Technology Centre (WETC) existing in the same site forms the real opportunity that allowed the national manpower involved in dealing with the different designs of windmills whether in the erection, operation & maintenance and applied researches for comparative performance evaluation to result in the creation of adequate group of national crews of technicians, engineers, planners, and researchers who are deeply motivated to acquire acquaintance with the up to date international technological development in the field .

This well trained manpower forms the driving force for the realization of the ambitious long-term Egyptian program as planned with high level of reliability and confidence in achieving success.

5.4.3 Large Scale wind Energy Development Plans.

An area of 80 Km^2 on the Gulf of Suez at Zafarana site has been allocated for NREA to start implementing the large-scale wind electricity programs.

The programs includes:

a) Projects under operation: -
   - The 1st phase (30 MW) of 60 MW wind farm in cooperation with the Danish International Development Agency (DANIDA) has been connected to the national grid and operated since Nov. 2000.

This phase produces electric energy of about 120 GWh/year

- The 1st stage (33 MW) of 85 MW wind farm in cooperation with German government has been connected to the national grid and operated since Feb. 2001. The annual electric energy production is about 130 GWh/year.

b) Projects under implementation

- The 2nd phase (30 MW) of 60 MW wind farm in cooperation with (DANIDA)

c) Projects under Preparation

- The other two stages (each 26 MW) of 85 MW wind farm in cooperation with German government (to be operative by 2002 & 2003 respectively).

d) Projects under Negotiations

- 120 MW wind farm at Zafarana (in 2 stages) in cooperation with Japan. The project is in the phase of negotiation, while feasibility study was performed for the project.

- 60 MW wind farm at Zafarana in cooperation with Spain. A memorandum of understanding was signed with the selected Spanish consulting firm was assigned to perform consulting services for the project. A tender document has been prepared during the year 2000, in parallel to continued negotiation with the Spanish Concerned Authorities for allocating an appropriate financial package to implement the project.

The program targets to accumulated a total installed capacity of 600 MW wind parks, 300 MW out of which will be undertaken by private sector based on BOOT system by the year 2010. The annual electric energy production will be increased to about 2.5 billion KWh, corresponding to fuel saving of 0.5 million TOE/Y.

Table (5) Wind Farms Planned Installed Capacities and Electric Energy Generation

5 Years Development Plans	Installed Capacity (MW)			Cumulative Capacity (MW)	Energy Generation Annual energy at the end of the period TWh/Year
	Red Sea	East of Oweinat	Total Capacity		
1997-2002	120	----	120	120	0.48
2002-2007	330	----	330	450	1.8
2007-2010	100	50	150	600	2.4

5.4.4 - Wind Energy Technology Center (WETC)

A wind energy technology center in Hurghada was established in cooperation with Denmark. It includes a mechanical & electrical workshop and a training center.

The main activities of the center are:

- Research and development.
  - Testing and certification for wind turbines' components
- Technical evaluation
- Training programs.

The center can serve local objectives and regional cooperation programs

5.5 Biomass

There is a good potential for the utilization of biomass energy resources in Egypt. This is based on the fact that Egyptian rural areas depend upon biomass resources to meet 50% of their energy needs. Biomass resources are currently used inefficiently due to poor technology applied as direct combustion in open fire stoves in villages. Most of the animal dung and sewage sludge are used without mature treatment as fertilizers.

Since the late 1970s, intensive research efforts were directed towards the assessment of biomass resources, development of local technology and adaptation of international technologies to the local conditions. Most of the activities were geared to biogas production from agricultural residues, animal dung and poultry farms. More than 500 household-biogas digestors for rural areas have been demonstrated and improved designs were developed. A biogas plant of 22000 m^3 digestors size constructed by General Organization for Sewage Treatment (GOST) is in operation since 1999, in El Gabal El-Asfer Sewage treatment plant (within Greater Cairo).

Solid wastes (SW) treatment technologies have been the subject of several studies and demonstrations. SW assessment and evaluation were performed for more than 7 Governorates of Egypt. Low cost composting for fertilizers production and sanitary landfills were identified as feasible options for Egypt. Demonstration plants are being constructed using local designs. Large-scale projects are currently under negotiation between Giza, Alexandria and other Governorates with international private developers (investors). A number of small-scale incinerators for hospital hazard wastes with capacities between 450 - 1000 Kg / hr were built and tested.

Previous studies conducted by NRC during 1980s have estimated the theoretical potentials, which showed huge figures as theoretical possibility of gas production by digestors in rural areas.
The activities have started by technology transfer from India and China. However, local designs were developed and produced locally.

In 1996, NREA in cooperation with DANIDA conducted a study on "Biogas Sub-Sector Strategy for Egypt". The study concluded that Egypt could produce 4% of the present electricity consumption from biogas. In addition a similar amount of heat could be generated and used as industrial process steam.

In 2000, NREA in cooperation with DANIDA conducted a study on "Biogas Experience in Egypt" recommending the following:

- Setting up of a rehabilitation scheme for existing biogas plant, including technical advises and financial support;
- Develop framework for a strategy enabling the setting up of a proper maintenance service;
- Advocate of biogas techniques as environmental means for depollution with respect to large farms and industries.

Today, the dissemination of the technology is still limited and needs a lot of promotional activities as well as measures to remove barriers.

6- Renewable Energy Projects & Sustainable Development

For the above-mentioned projects and plans, the contribution to the sustainable development can be summarized as follows:

6.1 Reduction of fossil fuels consumption and GHG abatement up to 2010

In the field of wind energy the plan targets to implement 600 MW installed capacity, results in saving 500,000 TOE. As a result, more than 30,000-ton emissions will be reduced.

In the field of solar thermal electricity generation, the plan up to 2010 targets to implement about 750 MW installed capacity, results in saving about 140,000 Ton/annum GHG emissions (if the solar contribution is in the order of 9%).

The development of renewable energies would maintain increased amounts of oil and gas for export increasing foreign revenues or save as a reserve for better use opportunities rather than low oil prices prevailing nowadays.

6.2 Promotion of social and economic development

Socio-economic development has the priority, particularly in the rural regions where there is an urgent need to improve the standard of living through increased local economic development. The remote areas especially on the boarders of Egypt are in need to the RE applications to localize the Bedwians in the permanent settlements and to improve their living conditions.

In frame of creating job opportunities, it has been estimated that solar thermal, wind and PV power can create 248, 542, and 570 jobs/Year.

6.3 Renewable Energy and environmental protection

In order to limit CO_2 emissions, it is imperative to promote energy conservation and RE. Moreover, the related limitations of SO_x and NO_x would greatly benefit the local environmental. For example, solar electricity avoid (654) gm CO_2 / kWh produced. The main benefits go to local environment rather than global since, residential and industrial uses of energy are mostly in land, and its replacement by RE systems will be benefit local environment. The fossil-fueled power plants are located mostly along the coast where the

most adequate sites are needed for other purposes. On the country, power plants using RE are located in remote regions and this does not create constraints on the coastline.

7- Conclusions

In conclusion, Egypt not only has to carry its own burdens, but also those that arise from the unstable nature of the area in which it is located. In the midst of all these problems and considering all the challenges that it has to face, country has been able to realize a successful electric energy program. In addition to covering all the electricity demands a reserve capacity in the order of 10 % exists. All the electric energy projects have been implemented in a manner such that local and international standards for the environment have to a great extent been satisfied.

The development of RE systems can highly contribute to local employment. Moreover, the manufacturing plants could be located in specific regions of the countries where employment is most needed.

We are concerned with our own and the global environment. Within long-term policies, looking ahead to interconnecting our grid with the European grid with a view to tapping clean energy sources. Protection of the environment has a very high priority in planning and it always will.

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