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Egypt Country Report

ON
CO_2 ABATEMENT LINKED TO INCREASED ENERGY EFFICIENCY IN THE EGYPTIAN POWER SECTOR

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1. INTRODUCTION

Over the years, the Power Sector has always played a substantial role to enhancing economic development in Egypt via0 securing the domestic energy demand for electricity. Limited primary energy resources are available in Egypt with varying potentialities. The most important of these resources are oil, natural gas, and hydropower. In addition, renewable energy resources, particularly solar and wind, have a good potential.

For several years, Egyptian energy policies have been developed with focus on supporting energy efficiency policies and measures. The major objectives of these policies is to address some of the national concerns regarding expansion of life expectancy of conventional energy resources, diversifying the energy supply mix and having significant impact on limiting future increases in greenhouse gas (GHG) emissions.

This last objective, particularly, has been driven by the fact that although Egypt's contribution to climate change is relatively minimal, the potential social and economic impact of climate change could be devastating for the country's future.

If the demand for energy services is met sustainably i.e. the energy interventions are addressed correctly, the resulting impact will improve food security, alleviate deforestation, combat desertification, ensure integrated land-use management, create jobs, economic growth and lead to sustainable livelihoods and sustainable human development.

Energy efficiency strategies can effectively reconcile sustainable development with mitigation of GHG emissions.

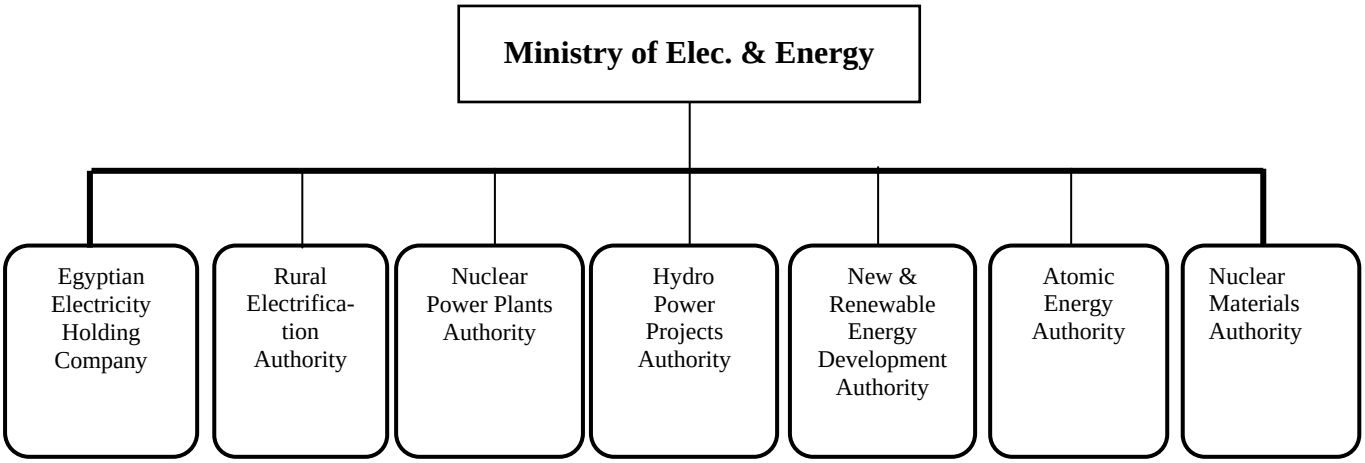
1. EEHC = Egyptian Electricity Holding Company

This Report outlines Egypt's energy efficiency policies and measures in the power sector that has contributed significantly in reducing CO_2 and other GHG emissions. It demonstrates a developing country's efforts for better managing power generation for attaining both domestic electrical energy needs and mitigation of environmental impacts.

2. EGYPT'S POWER SECTOR

Electric energy generation, transmission and distribution in Egypt is under the umbrella of the Ministry of Electricity and Energy. Activities are undertaken by many organizations as shown in Fig.1. In 1991, the distribution and construction activities were annexed to the Ministry of Public Enterprises Sector as a step towards liberalization of these activities. In March 1998, the distribution companies were annexed back again to the Ministry of Electricity & Energy, under the Egyptian Electricity Holding Company, as a further step towards liberalization.

Fig. 1- Schematic Organization of the Egyptian Electricity Sector



The Egyptian Electricity Holding Company (EEHC) is the country's national electric utility and is responsible for electricity production, transmission and distribution, as well as bulk sales. The EEHC is responsible for assessing electrical energy resources, estimating electricity requirements of the different sectors of the economy, and planning the most economical and reliable medium-and long-term system expansions to meet future energy demands.

Energy efficiency and conservation among both suppliers and end-users are among the most important goals to be achieved by the EEHC over the next decade and beyond.

3. NATIONAL ENERGY – ENVIRONMENT STRATEGY

A national energy and environment strategy was formulated in the mid eighties as an integral element of long – term national energy planning.

The strategy targeted the following:

- to save 10% of the projected energy consumption through the implementation of energy conservation measures and improvement in efficiency of existing facilities; therefore decreasing the energy – environment impacts;
- to phase out energy subsidies by 1995/1996;
- to develop renewable energy technologies to supply 5% of the national primary energy by the year 2005/2006, mainly from solar, wind and biomass;
- to regulate the quantitative aspects of energy use;
- to establish relevant data bases;
- to give environmental protection much more serious attention than in the past; and
- to carry out environmental impact assessments (EIA) for the new energy and industrial projects.

Policy Framework

In order to a chive strategic goals, and to satisfy the energy needs of the country's development plans, the Government of Egypt (GOE) has directed intensive efforts since the 1980`s towards the following:

- assessment of energy consumption in each economic sector and identification of energy conservation and efficiency improvement options, particularly in the industrial, electricity, transport and household sectors;

- assessment of energy resources and identification of short, medium and long term programs for their development and effective utilization;

- identification of appropriate mechanisms and formation of specialized bodies to effectively implement national plans in the area of energy-environment interactions;

- coordination of national efforts and actions towards the realization of strategic objectives; and

- as much as possible, adopting measures that can help abatement of the negative environmental impacts of the energy sector.

Intervention Measures

A number of measures and technologies have been identified for decreasing the GHG emissions in Egypt. The majority of these measures are based on the following techniques:

- energy conservation measures;
- fuel substitution;
- use of renewable energy sources;
- materials replacement;
- increasing of GHG sinks.

Most efforts have been focused on energy – conservation measures, particularly in industry, power generation and transport sectors, because of their cost effectiveness and also their potentials are quit high. Fuel substitution is mainly limited to replacing petroleum products by natural gas. Use of renewable energy is applied mainly in the power production, household and agriculture sectors. Materials replacement is proposed to reduce the use (and production) of construction materials, mainly cement and lime. Also, under materials replacement could be the replacement of nitrogen based fertilizer by compost obtained from municipal and agricultural wastes.

4. POWER SECTOR STRATEGIC GOALS

Since late 1970`s, the environmental considerations have been promoted from a peripheral role in the formulation of EEHC`s energy policies and programs to a more coherent role consistent with the global environmental concerns. The power sector, forwarded by nationwide environmental goals as well as national guidelines for sustainable development, has crystallized, at the inception of 1980`s, a long term strategy to guarantee the capability of meeting entirely the growing demand while preserving the environment from pollution and other adverse impacts. The strategy formulated the basic national goals for the power sector in the following:

- Securing cost-effective reliable supply of electricity to different sectors of the national economy.
- Optimizing indigenous energy resources.
- Maximizing utilization of non-combustible resources, e.g. hydro renewable sources of energy, and also, mini-hydro, as well as any hydro-pumping storage to utilize efficiently available thermal & natural gas-fired combined cycle plants.
- Maximizing utilization of natural gas as a benign fuel, taking macro-economic considerations in effect.
- Achieving continuous socially modified energy pricing reform.
- Efficient use of resources on production side as well as on conversion, transmission, and utilization side.
- Obtaining most efficient and most modern environmentally oriented technologies for new plants, and for the end use equipment.
- Restructuring the power sector for saving investments and improving service.
- Soliciting private finance resources with best contractual conditions.
- Promoting regional energy partnership for creating opportunities for Egypt and its neighbors and enhancing across border cooperation, e.g. electrical interconnections, for the Arab countries and Mediterranean as well as for huge hydro-resources in Africa which would be environmentally acceptable and a solution for depletable resources.
- Maximizing local contribution in design, installation and manufacture of electrical equipment.

5. VIABLE POLICY ACTIONS FOR ABATING GHG EMISSIONS IN THE POWER SECTOR

5.1 Full Utilization of Available Hydropower

The River Nile is the only significant source of surface water in Egypt. Up to 1986, about 90% of the Nile hydropower potential had already been utilized with the installation of nearly 2715 MWe at the complex of the High Dam and Aswan Dam (I) & (II) power plants.

Isna and Nag-Hammadi, with about 95 MWe were the only hydro addition in 1990`s, while all system expansion has been totally dependent on oil and natural gas. With continuous addition of thermal power generating facilities, the share of hydropower has been reduced from 68% in 1970 to only 14% in 2005/2006.

During the present five year plan (2002-2007), it is anticipated that the construction of the Assuit and Nag-Hammadi Barrages and their power plants would add some 100 MWe of hydro to the National System. Other mini-hydro power stations at several sites along the river branches and the main canals are being considered.

Pumped storage projects at Algalala and Ataka on the Gulf of Suez are being studied with a view to work as peak load pumped storage stations.

5.2 Maximizing Use of Natural Gas

Recently, natural gas has been playing a key role in Egypt's energy policy. Given its unique economic and environmental advantages, increased use of natural gas would improve the overall energy efficiency and environmental quality of Egypt. As a versatile source of energy, natural gas offers a number of economic and environmental advantages over competing fuels.

As is well recognized that the primary energy resources in Egypt are nearly petroleum based in addition to some other limited resources, and that proven natural gas reserves are relatively more abundant than oil. Energy policy of Egypt has been developed to promote the expansion of natural gas substitution in various economic sectors. Strategies include: developing gas infrastructure, where the national gas pipeline grid has expanded from 1000 to more than 2900 km, expanding local gas market and developing domestic gas demand. The market share of natural gas in the total hydrocarbon consumption has reached about 48% in 2005/2006. The share of electricity sector was the highest share representing about 60.9% of the total natural gas consumption in Egypt in 2005/2006/2006. Such consumption is expected to increase rapidly during next years as a result of the power sector and the petroleum sector policies.

Optimum Utilization of Natural Gas Resources for Electricity Generation

The electrical generation from hydro resource has given a high priority. Maximization of the use of natural gas was achieved through following regime:

- The use of natural gas to substitute heavy fuel oil in steam power plants.
- Efficient utilization of natural gas supplies allocated for the electricity sector.
- The EEHC's operational policy has been formulated to minimize thermal production cost considering three categories of constraints:

- Hydro generation constraints.
- Thermal generation constraints.
- Security constraints.

The hydro scheduling is carried out based on the following scheme:

- Aswan Dam 1,2 are base loaded to meet hourly irrigation fixed discharge.
- Isna is base loaded at the run off the river.
- High Dam is peak shaving daily load curve.

Thermal scheduling is based on the following practice:

- Thermal units are committed based on their merit order and their fuel constraints to maximize utilization of natural gas.

Security constraints (voltage limits, branch flows limits) are checked and violations, if any, are alleviated.

Coordination with Fuel Suppliers

Coordination with fuel suppliers is usually organized considering the following dimensions:

- **Long term Planning (5 years or more):**

EEHC and the ECs prepare the requirements from different fuel types (NG,HFO,LFO) for the existing and future plants. EGPC and its affiliated companies include such requirements in their action plan.

- **Short Term Planning (1 years):**

HFO and LFO quantities are supplied in storage tanks to insure one week operation on full capacity if natural gas is not available. Natural gas is coordinated among the operators at the gas control center and the national energy control center.

- **BOOT Projects:**

The BOOT projects (Sidi Krir, Port Said East and Suez Gulf) are directly contracted to the gas company, GASCO according to the terms of the fuel supply agreement (FSA).

Future of Natural Gas in Power Production

Natural gas utilization reached 92% of total fuel for all power plants connected to the gas grid. The Egyptian Holding Company for Natural Gas (EGAS) plans to cover 100% gas supplies for all plants connected to the gas grid by the year 2010.

5.3 Promoting Power System Efficiency

Optimal utilization of installed capacity requires, among other things, a reduction in system losses and the more efficient use of electrical energy by the end-user. Increasing the efficiency of the power system therefore involves making improvements in both supply-side and demand-side efficiencies.

On the supply side, measures undertaken to improve economic and technical efficiency have included maximizing the use of both hydropower and natural gas resources to reduce GHG emissions and free more oil for export. Further, rehabilitating old power plant units has directly resulted in increasing their operational efficiencies, and converting open-cycle combustion turbines to combined-cycle turbines has contributed significantly to fuel savings and an increase in overall efficiency. All of these efforts, along with the introduction of large units, led to a reduction in the Electricity Authority's average specific fuel consumption between 1981 and 2005/2006, from 346 to 223 grams (gm)/kWh, resulting in a considerable savings in fuel consumption over the time.

The efficiency of the transmission and distribution systems has been improved through a program for reducing losses within these networks. Facilitating the availability and installation of the required equipment has also allowed for the correction of the power factor, contributing further to system efficiency. Between 1981 and 2005/2006, total losses in the National Unified Power System (NUPS) declined from 19% in 1981 to 12% in 2005/2006.

5.3.1 Rehabilitation of Old Generating Units

Starting in 1981, EEHC elaborated a continuous program for rehabilitating old generating units which resulted in a continuous upgrading for their efficiencies as well as expanding life time of these old units. During the past few years, rehabilitation had been carried out for eleven steam power plants of 1977 MWe total capacity.

5.3.2 Using large New Generating Units

Since early 1980`s, EEHC generation expansion plans have been based on using large unit size of order 300 MWe and 600 MWe. Fuel consumption rates of these units range between 227 and 293 gm/kWh.

5.3.3 Conversion of Open Cycle Gas Turbines to Combined Cycle Modules

During 1989, conversion has been completed for Talkha power plant with total capacity of 292 MWe including two modules, each of 4x25 MWe gas turbines and 1x50 MWe HRSG.

In 1992, a new combined cycle project has been completed in Damietta with total capacity of 1215 MWe including three modules, each of 2x125 MWe gas turbines and 1x135 MWe HRSG units.

The conversion of El-Mahmoudia (8x24.5 MWe) and Damanhour (4x24.2MWe) gas turbines into combined cycle modules was completed in 1995 adding 2x56 MWe and 1x56 MWe capacity with no additional fuel.

Rehabilitation of existing old steam units at Cairo South (4x60MWe) was also completed and the plant was re-powered with new 3x110 MWe gas turbines operating as combined cycle, and new combined cycle module of (1x110 + 1x55) MWe capacity was also added.

In fact, utilizing exhaust heat of gas turbines was a strategic action adopted by EEHC since the commencement of 1980`s. This has significantly added extra generated power without adding any fuels. According to the technical statistics of operating NUPS, it was concluded that fuel savings during 1996 only exceeded 900,000 toe.

5.3.4 Increasing Combined Cycle Contribution to Electricity Generation Mix.

New additions to the combined cycle power plants (Cairo North Modules I&II of capacity 2x750 MWe and Nubaria Modules I&II of capacity 2x750 MWe) share significantly in raising contribution of efficient combined cycle modules in the NUPS. The EEHC generation expansion plan for the period 2002-2012 includes also El-Kureimat C.C. modules (2x750 MWe), Nubaria III C.C. module (750 MWe), Sidi Krir C.C. module (750 MWe), El-Atf C.C. module (750 MWe) and Sharm Esh-Sheikh C.C. module (750 MWe).

5.3.5 Decreasing Transmission & Distribution Losses

The decrease of transmission and distribution losses has been achieved via the following steps:

- Rehabilitation (renewal) of transmission and distribution networks.
- Installation of reactive power compensators in the 66/11 kV substations to improving the power factor which led to reducing losses and improving system loading conditions and voltage profile. More than 870 MVAR shunt capacitors have been installed and are in service in many 66/11 kV substations.

These measures have led to reducing the loses ratio in the NUPS from 19% in 1981 to 12% in 2005/2006.

5.4 Energy Conservation

Energy Conservation has been considered a national necessity for Egypt’s sustainable development. The numerous benefits of energy Conservation to the Egyptian economy include increasing oil surplus available for exports, enhancing profitability of industry and competitiveness in the world market, creating new jobs, curbing GHGs and improving environmental quality.

Egypt has taken an early step to improve its energy efficiency in the early eighties, when several studies have been conducted to recognize and well-understand the main features of Egypt’s energy system, and its interrelated links with the national economy. These studies have been a good vehicle to develop Energy Sector’s professional capabilities. They have also proved that energy policies have long term implications on the performance of the Egyptian economy. Furthermore, these studies have identified a set of energy-related problems which adversely effects most of the other economic sectors.

One of the most alarming energy issues in Egypt has been the poor level of energy efficiency in the main consuming sectors that leads to a demand growth which surpasses the economic

and population growth rates. Such escalating demand has been always met with the typical supply-oriented approach. This accelerates the depletion of indigenous oil reserves, erodes export revenues, threatens the environment, and exhausts most of the capital needed for investments which makes it difficult for Egypt to meet its future energy needs. Instead, a well balanced supply/demand strategies have been formulated, and the policies of the energy sector has been developed to adopt the energy efficiency as one of the strategies to enhance economic efficiency, and save the environment.

There are recent market drivers for energy efficiency in Egypt; accelerating privatization of industrial state-owned enterprises has led to more rational in energy use and more awareness of competition. Growing domestic and international competition is creating pressure to improve products quality, and reduce operating costs. Availability of technologies would play a significant role in driving energy efficiency market for products and services. Due to removal of historical energy subsidies within the ongoing economic reform program, the slow down of energy demand growth has been obvious over the last few years. Economic pricing of energy products has emphasized the importance of energy conservation to different energy consumers. Last but not least, the enforcement of the environmental Law No. 4 for the year 1994 which calls for high levels of air and water quality would also create an increasing demand for efficient and clean technologies.

There has been a number of energy conservation activities undertaken by many Egyptian institutions. These activities have clarified to major energy users the extent of their wastage of energy and the potential of energy savings that can be achieved through investing in energy efficiency. Most of these efforts have focused on the industrial sector.

Industrial energy audits showed an average potential energy saving of about 25% of which nearly 10% could be achieved by good maintenance and housekeeping. Energy audits covering metallurgy, food, cement, chemical and petroleum industries were conducted by the Organization for Energy Planning (OEP). These audits served as a basis for a USAID funded project namely Energy Conservation and Environmental Protection (ECEP) project. ECEP is implemented jointly by three Egyptian agencies: the Development Research and Technological Planning Center (DRTPC) of Cairo University, the Tebbine Institute for Metallurgical Studies (TIMS), and the Federation of Egyptian Industries (FEI). It aimed at demonstrating seven energy conservation technologies, these were: 1) cogeneration, 2) power factor improvement, 3) combustion control, 4) energy management systems, 5) high efficiency lighting, 6) waste heat recovery, and 7) process control.

5.5 Enhancing renewable Energy Utilization

Renewable energy strategy was developed and incorporated as integral element of national energy planning since 1985. The strategy targeted 5% saving of the projected 2005/2006 primary energy consumption by renewable energy (presently, the strategy targets 3% of renewable energy share to the electricity demand by the year 2012). These are primarily solar, wind and biomass. In 1986, the New and Renewable Energy Authority “NREA” was established to provide the institutional framework for implementation of the strategy and act as a focal point for expanding efforts to develop and introduce renewable energy technologies to Egypt. Since then, NREA has been successful in assessing renewable energy resources. Solar and wind Atlases were developed and several studies on biomass resources in rural and urban areas have been undertaken. Studies show that solar radiation is highly available in all the Egyptian territories. The average annual direct radiation varies

between 1970-2600 kWh/m^2/year. In addition, Egypt enjoys tremendous wind resources in the Gulf of Suez where the annual average wind speed reaches 10 m/s.

Several solar technology options were assessed and field demonstrated and found to have a promising market potential. These include solar thermal low temperature technologies, Photovoltaic applications, and solar thermal electricity generation. It was found recently that the Integrated Solar Combined Cycle Systems "ISCCS" using parabolic trough with a conventional gas turbine combined cycle could be one of the most appropriate systems for Egypt. NREA has already finalized the pre-feasibility studies for the first "ISCCS" with a capacity of 150 MWe. The plant is expected to start operation in 2009. In addition, Egypt has already crossed the phase of demonstration and pilot projects of large scale wind farms. Currently, a 225 MWe grid connected wind farm at Zaafarana, the Red Sea is operating successfully. A wind energy technology center was established to provide technical support to wind energy manufacturers and developers. The center contained a full scale testing and certification facilities that could serv local as well as regional programs. The installed capacity of at Zaafarana wind farm is planned to reach 850 MWe by the year 2010. Recently, NREA has developed a long term vision for the priority applications of renewable energy technologies through the year 2017. This long term vision envisages about 10% of the total industrial process heat by solar thermal technologies, nearly 9TWeh/year of solar electricity generation, and 2000 MWe of installed capacity from wind. As a result about 9% of the total electricity demand is projected to be provided through the year 2017 by renewables based on private sector participation. Consequently about 12 Mt of CO2 would be reduced annually.

5.6 Energy Pricing Reform

Domestic energy prices have been characterized by a great deal of rigidity for a long period of time. The under pricing of energy products has promoted unwise consumer behaviors, and non-optimal investment strategies. For decades, the Egyptian economy has suffered from severely subsidized energy prices used to be as low as 5% of their opportunity costs. Furthermore, low energy prices have contributed to inefficient use of energy in different consuming sectors. This led to a high rate of growth in demand. Also, the artificially low domestic prices of energy have impaired the economic viability of most of the efficiency projects. Within the ongoing economic reform program, the government decided to escalate the energy prices gradually to their economic levels. A program was established to increase prices and it is revised annually taking into consideration the economic and social impact resulting from price increases of energy, in order to ensure the viability of the program. By 1986/87 the government started some steps to correct the costly subsidization by increasing the energy prices gradually, but since 1995 no more price increases have been imposed due to social and political reasons. However, the expected effect of the pricing policy on slowing down the growth in demand has been obvious in the last few years. Energy intensity has also been improved by an average of 6% annually during the 1990`s. Table 1 presents information on energy prices development during the period 1981/82-2004/2005.

Table 1 - Energy Prices Development, 1981/82 –2004/2005

(Unit : LE/Ton)

Year	LPG	Gasoline[1]	Kerosene[2]	Gas Oil[3, 4]	Fuel Oil	Diesel	Natural Gas [5,6,7,8]	Electricity Average System Price (Pt/kWh)
81/82	52	182	37.8	36	7.5	30.42	9	N/A[10]
82/83	52	210	37.8	36	7.5	30.42	9	N/A
83/84	52	210	37.8	36	7.5	30.42	9	N/A
84/85	52	211	37.8	36	7.5	30.42	9	N/A
85/86	52	284	37.8	36	7.5	30.42	9	N/A
86/87	52	355	37.8	36	7.5	30.42	9	N/A
87/88	52	357	63	60	28	52.65	34	N/A
88/89	52	499	63	60	28	52.65	34	N/A
89/90	52	502	88.2	84	35	76	43	N/A
90/91	120	786	126	120	50	105.3	61	N/A
91/92	200	1013	252	240	80	210.6	75	8.68
92/93	200	1301	378	360	100	315.9	99	11.16
93/94	200	1305	504	480	130	421.2	149	12.22
94/95	200	1305	504	480	130	421.2	152	12.59
95/96	200	1305	504	480	130	480	156	12.57
96/97	200	1305	504	480	130	480	156	12.60
97/98	200	1305	504	480	182	480	156	12.84
98/99	200	1305	504	480	182	480	156	12.83
99/00	200	1305	504	480	182	480	179	12.72
00/01	200	1305	504	480	182	480	179	12.73
01/02	200	1305	504	480	182	480	179	12.78
02/03	200	1305	504	480	182	480	179	12.92
03/04	200	1305	504	480	250	480	244	13.03
04/05	200	1305	504	720	300	720	275	14.15
05/06	200	1836	964	900	500	900	345	14.92

Source: Egyptian General Petroleum Corporation (EGPC), 30 January 2007.
(Source for Electricity prices is the Egyptian Electricity Holding Company (EEHC), 1 February 2007)

Notes:

(1) 1 Tonne Gasoline = 1360 liters
(2) 1 Tonne Kerosene = 1285 liters
(3) 1 Tonne Gas Oil = 1200 liters
(4) 2004/2005: Gas Oil price = LE 0.6 / liter.
(5) 2003/2004: Tonne of Natural Gas = 1312 m^3
(Natural Gas price = LE 0.186/m^3)
(6) 2004/2005: Tonne of Natural Gas = 1349 m^3
(Natural Gas price= LE 0.22/m^3)
(7) 2005/2006: Tonne of Natural Gas = 1360 m^3
(Natural Gas price= US$ 1.25/Btu)
(8) Price of Natural Gas for domestic use = LE 0.141/m^3
(9) Exchange Rate : US$ 1 = LE 5.71
(10) N/A : Not Available

5.7 Power Sector Restructuring

Starting in1994, the Ministry of Electricity and Energy embarked on a vast program for restructuring the financial and legal framework of the national electric utility of Egypt, EEHC as well as the distribution companies.

Because of this, and like utilities throughout the world, EEHC is undergoing a process of change brought about by several factors, including: the structural adjustment program of the Government of Egypt (GOE) that is committed to a more market-based economy, the massive capital needs of the power sector, and the movement towards commercialization and private sector participation in the development of the electric power sector.

In April 1995, a Business Plan was established to empower the entire EEHC organization so that operating efficiency and customer service are improved, and activities are focused on profitability and sustained long-term growth in an increasingly competitive energy environment.

This Business Plan for bringing EEHC a new mission to be the leader in providing electrical energy to customers according to international standards, to operate on a competitive economic basis, and to support the welfare of Egypt was a compulsory introduction for EEHC to adopt the new policy aiming at giving private investment opportunities, whether Egyptian, foreign or mixed, in building and operating projects for electric power production. The new policy is applied within the formula of BOOT (Build – Own – Operate &Transfer) scheme.

This institutional change represents the necessary framework for promoting energy efficiency, avoiding market distortions and ensuring that markets function as effectively as possible to obtain balanced measures to cope with the various priority issues in the power sector.

5.8 Regional Interconnection

Trading in energy across borders, particularly in electricity, should be considered as a contributor to sustainable development plus its economical merits. Such trading on equitable and just basis would add to the political stability of the interconnected parties.

That is why electrical interconnection among Egypt and neighboring countries ranked a high priority in strategic goals.

Egypt being a North African, Middle Eastern and Mediterranean country, is anticipated to play a prominent role in enhancing cooperation in the electrical energy field through electrical interconnections, benefiting from its unique strategic geographical position.

In fact, through Egypt, it would be possible to interconnect Africa to Asia across Sinai and then to Europe. This can be achieved through the electrical interconnection projects, which are either constructed, under execution or agreed upon between Egypt and neighboring countries.

The prospects for these present or future interconnections are to be as follows:

- Egypt / Jordan / Syria / Lebanon / Iraq / Turkey , to Europe
  - Egypt / Jordan: fully operational since 1998.

- Jordan / Syria: fully operational since 2001.
- Syria / Lebanon: supposed to be operational end 2007.
- Syria/Turkey: in operation by isolated method since 2006 – waiting for the approval of UCTE.
- Turkey / Iraq: in operation for 154 kV – planned 400 kV interconnection is proposed to be constructed in 2008.
- Syria / Iraq: 400 kV link is being implemented by Syrian side and proposed to be fully constructed by the year 2008.

- Egypt / Jordan / Saudi Arabia / Gulf Cooperative Council (GCC), (Arab Mashreq).
- Egypt / Libya / Tunisia / Algeria / Morocco (Arab Maghreb) to Spain to Europe (only commissioning of Libya / Tunisia link is proposed to be implemented by the end of 2007 to allow full operation of the north Africa interconnection).
- Nile Basin / Egypt to Europe (studies are underway).

These intensive plans for regional and inter-continental interconnections call for international standardization and liberally oriented energy market for energy exchange or energy trading across borders, which will result in a significant environmental improvement.

6. GHGs REDUCTION AND ASSOCIATED ENVIRONMENTAL BENEFITS IN THE POWER SECTOR

For environmental benefits, on the first priority, all power plants built during the last decade were dual firing to enabling entire substitute of heavy fuel oil by natural gas as much as it be adequate and available throughout gas networks.

However, the utilization of natural gas in a combined cycle mode raises the priority of this application to the first category based on higher efficiency utilization.

Natural gas utilization, during last two decades, played a prominent role in curbing air pollutants as well as GHG emissions of power generating processes in the NUPS of Egypt.

For instance, the Sulfur Dioxide (SO_2), Nitrogen Oxide (NO_x) and Total Suspended Particulates (TSP) emission reduction was over 2,000,000, 1,250,000 and 150,000 tons respectively in the year 2005/2006 and the Carbon Dioxide (CO_2) emission reduction was about 20 million tons in the same year.

7. FURTHER MITIGATION OPPORTUNITIES FOR THE POWER SECTOR

7.1 Opportunities for Energy Efficiency and Demand Side Management (DSM)

There is a considerable opportunity to improve the end-use efficiency of energy use in Egypt. As indicated in Table 2. This table summarizes the potential for demand side energy efficiency as a percentage of the energy use from each energy source in each consuming sector. The range in values in Table 4 for each estimate includes a high value which reflects an upper limit to what might be technically and economically viable, as well as a low value which reflects what might be realized from a practical standpoint. This lower value reflects both a lower estimate of technical and economic viability and a adjustment factor to allow for what end users may willing to implement.

In the industrial sector alone, efficiency of oil gas and electric use can be improved up to 30% or more with investments that pay for themselves in 3 years or less. In the residential sector up to 15 % efficiency improvements in energy use could be technically achieved from improved lighting and electric appliance efficiency. There is less specific data available for the relatively small sectors of commercial buildings and agriculture energy use (primarily for irrigation pumping).

If the information in Table 2 is combined with the actual energy consumption values in each of the energy source /end-use sector categories, a better idea of the significance of each area is obtained relative to the overall energy consumption. This information is summarized in Table 3, based on energy data for 1995 and the analysis where sectoral information is not available. Information from Egyptian sources on the potential for renewable to reduce the consumption of traditional energy sources has also been included in Table 3 for illustrative purposes.

Table 2 - Demand – Side Efficiency Improvement Potential
Relative to 1995 Egyptian Energy Use
(As Percentage of Each Sector's Energy Source Uses)

Energy Source	Residential (%)	Commercial (%)	Industrial (%)	Agricultural
Electricity	5 – 15	5 – 15	10-30 Efficiency 10-40 Cogeneration	NA
Petroleum	10-30	NA	20-40	NA
Natural gas	Not Applicable	NA	10-40	NA

NA = Not Available

Table 3 - Estimates of Demand Side Energy Savings Potential
Relative to 1995 Total Egyptian Energy Use[(1)]
(Percent Reduction of Total toe)

Energy Source	SECTOR					Total (%)
	Residential (%)	Commercial (%)	Industrial (%)	Agricultural (%)	Other (%)	
Electricity	0.6 – 1.8	0.1 – 0.3	1.8-5.2(Effic.) 1.8–7.0(Cogen.)	NA–Small	0.15– 0.45	2.7 – 7.8 + 1.8 – 7.0
Petr. Products	1.3 – 3.9	NA – Small	4.3 – 8.6	NA–Small	NA-Small	5.6-12.5+
Natural Gas	NA – Small	NA – Small	0.9 – 3.6	NA–Small	NA-Small	0.9 – 3.6 +
Renewables	1.0		2 – 3			3 – 4
Total	**2.9 – 6.7 +**	**0.1 –0.3 +**	**10.8 – 27.4**	**NA–Small**	**0.15-0.45+**	**14.0–34.9+**

NA = Not Available
1) Excluding energy for transportation use.

The most significant opportunity for energy savings is seen to be in reduced industrial fossil fuel consumption, particularly in petroleum products. This is due not only to the high

efficiency improvement potential in industry, but also because industry is the largest consumer of petroleum products.

Considering electricity use, energy savings potential is also greatest in the industrial sector which uses the greatest proportion of electricity and has very high DSM energy efficiency potential (up to 30 percent of that use).

Potential industrial savings become even large when cogeneration is included. The residential sector offers the second greatest source of electrical energy savings potential (up to 15% efficiency improvement for 33% electricity use) – primarily from lighting and efficient refrigerators.

Although not included specifically in Tables 2 and 3, time of use (TOU) pricing presents another efficiency opportunity. Egypt's evening electric peak suggests, however, that only those commercial and industrial facilities with evening operation could make a beneficial load shift with TOU rates.

7.2 Current Energy Efficiency Activities in Power Sector

7.2.1 Load Management Program

Since mid-nineties, and with support of the World Bank, EEHC started to implement a load management program, through which EEHC has already achieved the following:

- Designing a system for the collection, storage and analysis of data relating to consumption patterns.
- Specifying and supplying necessary hardware and software.
- Establishing load management strategy for cement industry aiming at shifting their loads from the system peak, without affecting cement production, which represents a reduction of about 150 MWe.
- Applying load management strategy for irrigation pumping station.
- Applying load management strategy for other industries (chemical, metallic engineering).

- **Introducing Time Of Use (TOU) Tariff:**

Demand management, as the name implies, involves managing change in the pattern of demand of customers. There are two ways in which a change in customer pattern of demand could be achieved: by direction and by application of incentives.

Since the direction could only be imposed with the existence of the required level of authority, which is not practically an easy way, the application of incentives seems to be the only way to achieve change in the pattern of customers demand. The most usual form of incentive is by tariff structure.

The application of Time of Use (TOU) tariff is considered one of the indirect load management technologies. This can direct the customers to reduce their loads during system peak hours of high tariff. This, in turn, will lead to avoiding the use of peaking units with high operating cost and saving large investments required to add new generating units.

The implementation of Time of Use tariff could result in reasonably quick response, particularly if the level of incentive and the actions required were selected to be attractive to the customers. In the meantime the EEHC is testing TOU system to demonstrate its application.

- **The Program "Energy and Urban Environment in the Mediterranean Countries":**

This program has been proposed by the Mediterranean Countries in 1993 aiming at regional cooperation between Mediterranean cities in the field of energy conservation and environment protection. Ten Mediterranean cities have been chosen to participate in the program.

The 10 pilot cities included the city of Alexandria which participated in networks number 1 and 2 of 4 thematic networks namely Rational Use of Electricity and Gas, Urban Energy Planning and Geographical Database, Promotion of Public Transport, and Management of Municipal Wastes. The organizations involved in Alexandria project were EEHC, Alexandria EDC, OME and OEP.

- **New Contract System for VHV and HV Users to Apply the Demand Side Management**

The new contract is now based on power factor 0.9 instead of the previous one 0.8. The contract includes both peak demand and access demand penalty clause.

Due to the above mentioned energy conservation and demand management programs, the rate of growth of peak load has been reduced from 12% in 1981/82 to about 6.5% in 2005/2006/2006.

The rate of growth of generated energy has been reduced as well from 10% in 1981/82 to about 6% in 2005/2006/2006.

EEHC developed the most recent revised electricity demand forecast using the different forecasting methodologies and models.

The econometric model forecast shows that the rate of growth in both peak load and energy during the next decade will be about 5.5%, and 5% respectively.

- **Energy Efficiency Improvement and Greenhouse Gas Reduction Project**

The overall objective of this project is to assist Egypt to reduce the long term growth of GHG emissions from electric power generation and from consumption of non-renewable fuel resources.

This objective will be achieved through:

- Supporting efficiency improvement and loss reduction in generation, transmission & distribution of electric power.

- Facilitating adoption and implementation of energy conservation measures in residential, commercial and industrial sectors through initiation of energy audits, promotion financing and standard-setting activities.

- Stimulating and guiding the private sector in the development of a capability for end use energy efficiency service planning, feasibility analysis, conceptual design and project implementation including the manufacture of energy efficient products.

- Assisting in international and regional transfer of technology and experience that could be instrumental in GHG emission reduction.

- Promoting public and private sector investments in energy projects that are beneficial for the global environment.

The project objectives and achievements are classified through the following three main components:

Loss Reduction and Load Management in the Unified Power System

- Calibration of all measuring devices (200 devices).
- Reducing the % losses value from 7% to 3.71%.
- Conducting dynamic response tests for all generating units beyond 125 MWe, total of 37 units.
- Implementing load shifting pilot projects at 2 cement factories and 1 iron & steel company.
- Sensitivity analysis study has been carried out to select the most appropriate scenarios for peak and off peak Time -of- use (TOU) tariff.

Energy Efficiency Market Support

- Conducting 193 audits, and recommendations of 20 audits are implemented resulting in savings of 285 toe and 800 tons of CO_2.

- Replication of CFL leasing program at Cairo and Canal Distribution Companies and diffusion of CFL through exhibitions held in electricity companies, in addition to other governmental buildings.

- Assisting local manufacturers in manufacturing efficient lighting systems encouraged by the increase of the market of CFLs from 200,000 lamps in 1999 to more than 3.3mi!lion in 2005/2006

- Reforming loan guarantee mechanism and signing a contract with a credit guarantee company for small and medium size enterprises to activate the mechanism for implementing energy efficiency projects.

- Implementing number of energy efficiency projects, in addition to exhibitions for the diffusion of energy efficient lighting systems .

- Standards and labels have been developed for refrigerators and air conditioners and washing machines, work is undergoing for heaters, CFLs and electronic ballasts.

- Establishing a reference Energy Efficiency Testing Laboratory located at NREA for refrigerators and washing machines and lighting systems , as for the air conditioners the testing laboratory is under construction.

- Completion of the energy efficiency code for new residential buildings and the ministerial decree for its enforcement was issued. Preparing the Arabic version for commercial buildings energy efficiency code in order to issue the Ministerial Decree and starting preparation of the energy efficiency code for new administrative buildings.

- Encouraging participation of more than 10 Non Governmental Organizations (NGOs) in promotion of energy efficiency through the partnership with the GEF Small Grants Program.

- An Energy Efficiency Center has been created within the project premises. A database for large consumers and audit customers has been prepared. Also a project website has been developed and issued.

- A study for energy efficiency in governmental buildings has been implemented and a program has been settled in cooperation with Electricity Distribution Companies for implementation of energy efficiency projects in administrative buildings belonging to these companies.

Co-generated Power

- Establishing the cogeneration small power group within EEHC.
- Developing the technical aspects for safety interconnection to the grid.
- Developing cogeneration tariff structure.
- Developing model for power purchase agreement suitable for small producers.

The full impact of the project is estimated to be achieved by the year 2010 resulting in energy savings about 4.2 Mtoe/year of the total energy consumption and CO2 reduction about 11.73 million tonnes.

The duration of implementation of this project is 4.5 years and the total budget equals US$5.895 financed by the GEF (4.11), UNDP (0.8) and the Government of Egypt (0.985).

8. POTENTIAL MITIGATION POLICIES AND MEASURES

Several studies on the likely effects of climate change on the energy sector in Egypt point out to the possibility of reducing GHG emissions via improving energy efficiency and using cleaner energy sources and technologies. For instance, the SNAP Study, on GHG Mitigation and Adaptation Technology Assessment took a step further to identifying a set of seven energy efficiency technologies that have been used in Egypt. This set included the following technologies:

1. fuel substitution of oil with natural gas in the industrial sector,
2. combined heat and power production, co-generation;

3. combustion control;
4. waste heat recovery;
5. efficient lighting systems;
6. use of renewable energy in electricity production;
7. steam condensate recovery.

This set has been thoroughly evaluated in terms of costs, effectiveness and socio-economic impact. The evaluation of the socio-economic impact of the assessed technologies are represented in Table 4.

The technology assessment was followed by another study "Assessment of Scenario Development for the Energy Sector In Egypt", aimed at estimating the future potential reduction in energy based CO_2 emissions related activities / sources for the next four National Plans till the year 2017.

Based on the baseline scenario for energy and CO2 emissions, the study tried to identify and assess a number of measures/technologies for mitigating CO2 emissions. These selected measures and technologies were classified into three scenarios as follows:

- Fuel Substitution Scenario, FSS
- Use of Renewable Energy in Electricity Production Scenario, RES
- Energy Efficiency Scenario, EES.

Table 4 : Evaluation of Social and Cultural Impacts of Assessed Technologies

No.	Criteria	(1) F.S.O.N.G	(2) C.H.P.	(3) C.C.	(4) W.H.R	(5) E.L.S	(6) U.R.E.E.P	(7) S.C.R
1	Job Opportunities	8	8	9	2	5	10	2
2	Enhancement of Employee's Cleverness	7	7	8	9	5	10	2
3	Compliance with Current Legislation	8	5	7	10	9	10	10
4	Replacement of Local Communities	3	9	9	10	9	10	10
5	Change in Cultural Behavior	2	8	8	5	8	10	10
6	**Improving Management** Commitment to Energy Savings	2	10	10	4	9	10	2
7	Management Acceptance for Energy Saving Incentive	2	6	8	3	8	10	3

Table 4 (Contd.): Evaluation of Social and Cultural Impacts of Assessed Technologies

No.	Criteria	(1) F.S.O.N.G	(2) C.H.P.	(3) C.C.	(4) W.H.R	(5) E.L.S	(6) U.R.E.E.P	(7) S.C.R
8	Labor Reaction Towards Safety and Social Aspects	7	7	8	10	8	10	5
9	Possibility of Using Revenues in Social Services	2	10	10	3	10	10	1
10	Society Acceptance to Invest in the Technology	7	7	7	5	8	8	7
	Total	48	77	85	61	79	98	53

Source: SNAP, Stand Alone Technology Assessment Report, OEP, 1997.

The energy savings for the three scenarios were found to reach about 19.64, 117.4 and 70.68 PJ in 2016/17 respectively. The corresponding CO_2 reduction is expected to reach about 5.863 and 4.28 million tons in 2016/17 respectively.

Expected capital investment needed for each scenario is the summation of the capital investments needed for implementing the selected options within each scenario. The total investments needed for implementing the selected scenario is presented in Table 5. About US$ 3,277 million are needed for the renewable energy scenario which represents about 76% of the total investment of the three scenarios.

Table 5: Total Investments for Assessed Scenarios

Scenario	**Capital Investment (US$ 1000)** ***Scenario***
Fuel Substitution Scenario	96,390
Use of Renewable Energy Scenario	3,277,250
Energy Efficiency Scenario	926,222
Cumulative Scenario	4,299,862

Source: EEHCA; Building Capacity for Egypt to Respond to UNFCCC Communication Obligations, 1998.

The environmental, economic and social impacts of the mitigation options are summarized in Table 6.

Table 6: Summary of Impacts of Mitigation Options

Criteria	1-Fuel Substitution Scenario (FSS)	2-Renewable Energy Scenario (RES)	3- Energy Efficiency Scenario (EES)
GHG Saving			
* CO_2 (Mt)	78	134	72
* CH_4 (tonne)	40	402	215
* N_2O	4.2	5.3	2.8
Life-cycle-cost (US$/t CO2 equiv.)			
* Capital investment (US$/t CO2 equiv.)	1.2	77.3	15.9
* Net cost (US$/t CO2 equiv.)	- 103 to – 14	- 35	- 11
Indirect Impacts			
* Jobs created	Medium	High	High
* reduced imports	High	Low	Low
Equity considerations, impact on:			
* Low-income jobs	Medium	High	Low
* Low-income monthly expenditure	Medium	Low	High
National Environmental Impacts (net change) :			
* Sulfur oxides SOx (Mt)	+6	-74	-42
* Particulates (Mt)	-0.6	-3.6	-2.1
	Uncertain	Positive	Positive
Potential impact of implementation policy	Low	High	Medium
Sustainability of option	Low	High	High
Consistency with national development goals	Medium	High	High
Uncertainty of data			
* Technology performance and test	Low	Low	Low
* Cost of implementation programs	Low	Medium	Low

Source: EEHCA; Building Capacity for Egypt to Respond to UNFCCC Communication Obligations, 1998.

Based on the above mentioned studies in Egypt's National Action Plan, the following mitigation actions were identified:

8.1 Energy Supply Mitigation Actions:

There are four recommended mitigation actions:

- Efficient production and transmission of energy
- Maximizing the use of natural gas,
- In the petroleum industry, using flared gases.
- Promoting renewable energy in electricity generation

8.2 Energy Demand Mitigation Actions in the Power Sector

In the industry sector, energy conservation is recommended in industrial processes with the aim of reducing CO_2 emissions. Measures and policies related to power production under this sector include the following:

- Energy efficiency improvement.
- Database and performance monitoring.
- Promoting fuel switching to natural gas.
- Promoting the use of solar hot water applications.
- Supporting and encouraging energy conservation efforts through free industrial energy auditing, and free consultation services.
- Promoting energy efficiency and environment protection.

In the electrical energy sector, energy conservation is recommended through:

- The use of steam production management techniques, thermal insulation, condensate recovery, waste heat recovery, use of high efficiency motors, and efficient burners;

- The establishment of energy efficiency standards and labelling for all generic and industrial equipment such as motors, pumps, fans, compressors, boilers, heaters, etc. Such standards have to be reflected in local production and import regulations.

Table 7 illustrates climate change priority energy sectors for mitigation measures.

Table 7: Climate Change Priority Energy Sectors for Mitigation Measures

Priority Sector	Measures
Energy : Industry	Waste heat recovery Co-generation Combustion control Switching to natural gas Using condensate recovery systems Efficiency standards
Energy : Commercial/residential	Efficient lighting systems Co-generation Building codes Switching to natural gas Appliance efficiency standards
Energy : Electricity generation	Wind power Switching to natural gas combined cycle system Solar thermal Power purchase agreements
Energy : Transportation	Compressed natural gas Improved public transportation Inner and inter-city electrified metro

Source: EEHCA; Facing Global Challenge: Egypt and Climate Change. Building Capacity to Respond to UNFCCC Communication Obligations. Nov. 1998, (presented to the Ministry of State for Environment affairs).

9. BARRIERS TO IMPROVING ENVIRONMENTAL QUALITY

During a transition period to market economy, when most of the market distortions are not fully reformed and some market drivers are not fully effective, it is normal that the energy efficiency and environmental quality market will be expanded slowly. There is a set of market barriers that inhibit energy efficiency and environmental market growth. These are lack of financing mechanisms for energy efficiency and environmental projects, poor cash flow of public sector industries, the largest energy consumers, lack of government incentives to enhance environmental quality, and lack of application of the concept of life cycle costing. Investments in environmental quality improvement needs to be balanced on top of the country's investments portfolio.

10. IDENTIFICATION OF GAPS AND RECOMMENDED ACTIVITIES

Based on Egypt's previous experience in carrying out a national GHG emissions inventory, and relevant studies such as the study of mitigation options/strategies and abatement costs, priority should be given to improve knowledge in these areas, particularly, where information on GHG additional sources and sinks, abatement technologies and costs is very much needed. In particular, the following information gaps were identified:

1. Possible change in insulation and wind patterns associated with CC.
2. Possible change in hydropower outputs as a result of fluctuations in water resources.
3. The construction of nuclear power plants in Egypt is dependent to a certain degree on whether the huge hydropower project of Democratic Congo would materialize or not. Hence it is important to be kept informed of the development of this project so that a feasibility study on nuclear power could start in time.

Recommendations

- For Egypt, a developing country, the policy that merely regulates or restricts energy consumption may have significant detrimental socio-economic impacts. Hence, only those options and policies that have no adverse impact on economic development can be considered. Improvement in energy efficiency is a good example as it would significantly reduce GHG emissions while benefiting the economy. The previously mentioned set of mitigation measures or actions listed before is recommended, for further in-depth study and investigation of their social implications.

- Demand-side management and integrated resource planning should be the cornerstones of a new energy policy, based on coordinated efforts involving government, industry, the power sector and the other concerned agencies and institutions.

- Energy pricing is an effective tool for the rationalization of energy consumption. Continuous adjustment of energy prices to reflect the real economic cost, scarcity, long-range marginal cost, and environmental damage will contribute to reducing GHG emissions, and at the same time will result in substantial increases in income to the Government from fuel taxation. The funds obtained this way should be reallocated in a rational way to encourage production and utilization of energy efficiency technology and of renewable energy sources.

For example, to render energy conservation and efficiency improvement a viable choice for consumers, the government must promote the development and marketing of energy efficient and renewable energy technologies. This implies that the government will need to enhance national capabilities in the science and technologies of efficient energy supply and use, and in promoting renewable energy sources.

- Public information campaigns in the mass media could demonstrate the importance and the economic and environmental benefits of energy conservation. Supporting the concerned institutions, e.g. OEP, EEHCA and others working in the field is one of the highly recommended actions that enable these institutions to play their role more efficiently.

- The availability of several energy/environment/economic planning models is necessary for performing various activities and tasks within the framework of the national action plan for dealing with climate change, particularly those that deal with energy demand simulation/forecasting, energy demand/supply balances, and the evaluation of the environmental impacts of various energy systems. Furthermore, such models will be particularly helpful in the preparation of the country GHG inventory desegregated by various economic sectors.

- Some macro models may be needed to address the interrelated interactions between the energy sector and the rest of the economy. These models could be used for discussing several important issues, like the effect of adopting certain energy and environmental policies, mitigation, and abatement measures on the whole economy especially for some of the most important dominant factors (e.g. customers welfare, investment, employment, GDP growth rates,... etc.)

Research Needs

Despite the efforts and projects which have taken place in Egypt in the field of Climate Change, there are still a lot of research gaps and needs that ought to be covered in the near future. Climate research needs in the power sector include the following:

- A prominent role was given to renewable energy resources particularly wind energy, where more than 16 TWh need to be produced by the year 2020. This would necessitate a comprehensive pre-feasibility study to investigate whether these ambitious plans were realistic and could be implemented under the industrial capacities in Egypt.

- A feasibility study on nuclear power as a long term energy option for Egypt is needed.

In addition, the following areas of research were identified in the Egyptian Climate Change Action Plan:

- Research projects for energy efficient buildings and buildings that use renewable energy technologies.

- Research on the potential role of the international electricity trades in CO2 reductions.

- Research on electric and solar cars.

- Research and demonstration projects on the production of energy from sewage and solid wastes.

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