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Electric Energy Sector in Egypt: A Review

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Abstract

This review presents an appraisal of electric energy options in Egypt. An appraisal review of different electric energies is presented. Some comparisons between different electric energy sources are listed. The study shows that electric energy produced from Renewable Energy in Egypt are very poor compared with other energy sources. The utilization of the renewable energies can also be a good opportunity to fight the desertification and dryness in Egypt which is about 60% of Egypt territory. The rapid growth of energy production and consumption is strongly affecting and being affected by the Egyptian economy in many aspects. It is evident that energy will continue to play an important role in the development of Egypt's economy in coming years. Where total installed electricity generating capacity had reached around 22025 MW with a generating capacity reached 22605 MW at the end of 2007. Hydropower and coal has no significant potential increase. During the period 1981/82- 2004/05 electricity generation has increased by 500% from nearly 22 TWh for the year 1981/82 to 108.4 TWh in the year 2004/05 at an average annual growth rate of 6.9%. Consequently, oil and gas consumed by the electricity sector has jumped during the same period from around 3.7 MTOE to nearly 21 MTOE. The planned installed capacity for the year 2011/12 is 28813 MW and the required fuel (oil and gas) for the electricity sector is estimated to reach about 29 MTOE by the same year.

The renewable energy strategy targets to supply 3% of the electricity production from renewable resources by the year 2010. Electrical Coverage Electrical energy has been provided for around 99.3 % of Egypt's population, representing a positive sign for the welfare of the Egyptian citizen due to electricity relation to all development components in all walks of life.

1. Introduction

Egypt is a country in North-Eastern Africa, with the Sinai Peninsula forming a land bridge to Western Asia. Covering an area of about 1,010,000 square kilometers (390,000 sq mi), Egypt borders the Mediterranean Sea to the north, the Gaza Strip and Palestinian to the northeast, the Red Sea to the east, Sudan to the south and Libya to the west. Egypt is one of the most populous countries in Africa and the Middle East. The great majority of its estimated 75.4 million live near the banks of the Nile River [1]. About half of Egypt's residents live in urban areas, with the majority spread across the densely-populated centres of greater Cairo, Alexandria and other major cities in the Nile Delta. Egypt has used electricity for lightning purposes since the beginning of the 20th century. Egypt started generating electricity from hydraulic sources where Aswan Reservoir Station was established in 1960 at a capacity of 340 MW and High Dam Station in 1968 with a capacity of 2100 MW [2]. Egypt depends on various energy sources such as electricity, petroleum and natural gas, in addition to the new and renewable energy represented in the solar and wind energy. In the same direction, Egypt had adopted plans to establish electronuclear stations that produce electricity through nuclear means. These sources of energy contributed in making a great industrial up raise and in lighting a great part of the Egyptian rural area during this period.

Electric energy generation, transmission and distribution in Egypt are under the umbrella of the Ministry of Electricity and Energy. The Electric Energy sector in Egypt operated by seven executing authorities, namely, Egyptian Electricity Holding Company (EEHC), Rural Electrification Authority (REA), Hydro Power Plants Authority (HPPA), Atomic Energy Authority, Nuclear Power Plants Authority, Nuclear Materials Authority and New and Renewable Energy Authority (NREA). The 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]. Total implemented investments in the electric energy sector reached about LE 6.9 billion (Egyptian Pound) in FY 2006/2007, of which nearly LE 4.8 billion (Egyptian Pound) were carried out by the Egyptian Holding Company for Electricity and Production and the distribution and transmission electricity companies. As a result, maximum load increased by 6.9% to reach 18.5 thousand MW in FY 2006/2007, compared to 17.3 thousand MW in FY 2005/2006. The total installed electricity generating capacity in 2005/2006 reached 20.31 GW with a total generated electric energy of 107.5 TWh (Terra Watt hour) out of which 87.8 % (94.4 TWh) are generated from thermal power plants, 11.7 % (12.6 TWh) from hydropower plants, and 0.5 % (0.5 TWh)

from wind energy farms. Meanwhile , The lengths of electricity lines increased to reach 391,000 km in 2005/06 [4,5]. In the field of International Connections, Work has been completed on the interconnection of Egypt's electric transmission grid with other countries in the region. The Five-Country interconnection of Egypt's system with those of Jordan, Syria, and Turkey was completed by 2002. Egypt also activated a link to Libya's electric grid in December 1999 [6].

2. Background of Energy and Development

The rapid growth of energy production and consumption is strongly affecting and being affected by the Egyptian economy in many aspects. It is evident that energy will continue to play an important role in the development of Egypt's economy in coming years. Where total installed electricity generating capacity had reached around 22025 MW with a generating capacity reached 22605 MW at the end of 2007 [4]. Egypt plans to expand electricity capacity to 32,000 megawatts (MW) over the next five years. Egypt announced that the additional capacity will come principally from 11 new thermal plants and expansions: Kureimat 2 and 3, Talkha, Tabbin, Nuberiya 3, Cairo West, Sidi Krier, el-Atf, Abu Qir, Ain Sokhna and Sharm el-Sheikh. In 2005, nearly 75 percent of Egypt's electric generating capacity was powered by natural gas, some 14 percent by petroleum products, and the remaining 12 percent by hydroelectric, mostly from the Aswan High Dam according to the IEA. Growing electricity demand in the late 1990s spurred industry restructuring and plans for limited privatization of the electric power sector, although this process has yet to result in significant independent power projects. Egypt's power sector is currently comprised of seven regional state-owned power production and distribution companies that are held by the Egyptian Electricity Authority (EEA). In July 2000, the EEA was converted into a holding company, though still owned by the state [6].

Egypt has several privately-owned power plants currently under construction which are financed under Build, Own, Operate, and Transfer (BOOT) financing schemes. The first BOOT project was a gas-fired steam power plant with two 325 MW generating units, located at Sidi Kerir on the Gulf of Suez. The plant cost $450 million, and began commercial operation in late 2001. U.S.-based InterGen (a joint venture of Bechtel Enterprises and Shell Generating Ltd.), along with local partners Kato Investment and First Arabian Development and Investment, have the 20-year BOOT contract for Sidi Kerir. The second BOOT power project award went to Electricite de France, for two natural gas-fired plants located near the cities of Suez and Port Said. The two plants, which came online in 2003, have a total capacity of 1,366 MW. In February 2006, the World Bank agreed to fund a 700-MW plant expected to cost roughly $260 million which will contain two 350-MW steam turbines. In April 2007, Egypt’s Orascom Construction Industries was awarded a contract to build a 700-MW power station al-Tebbin power plant outside Cairo slated for completion by 2012. In July 2007, General Electric and its Italian partner

Techint Cimi Montubi were selected to build two gas turbine generators at the new 750-MW al-Kureimat III combined cycle power plant south of Cairo [3,4].

In pursuance of its reform agenda, the Egyptian government has set an ambitious renewable energy program to generate 500 MW of solar energy, 600 MW of wind power, and 600 MW of hydroelectric power by 2017. Egypt is building a new hybrid power plant – the Integrated Solar Combined Cycle power plant - at Kureimat as a BOOT project, which will have 30 MW of solar capacity out of a total planned capacity of 150 MW. The World Bank will provide a $327.57 million financing package from its Global Environmental Facility which will offset the cost difference between the solar capacity and thermal capacity. Egypt has also built a wind farm at Zafarana that has been operational since 2004 at an output capacity of 80 MW that is expected to increase to 160 MW during 2008 [7]. A Netherlands-funded project is also building 60 MW worth of wind power units in the Suez Canal area. Egypt is also working with Nuclear power. It has a 22-MW nuclear research reactor at Inshas in the Nile Delta, built by INVAP S.A. of Argentina, which began operation in 1997. In March 2008 Egypt also signed an agreement with Russia to assistant in building Egypt's first 1,000-MW nuclear plant at al-Dabaa.

Egypt's power network is now interconnected to the east with Jordan and Syria and to the west with Libya that will be expanded shortly to the Maghreb countries (Tunisia, Algeria, Morocco) and then to Europe through the Spain-Morocco interconnection [6].

3. Brief review of energies technologies

Renewable energy sources made their first real entry onto the international energy scene in the 1970s when the two worldwide oil crises occurred. The importance of renewable energy particularly in recent years, with the pursuit of a sustainable global pattern of energy supply and use, it has been widely acknowledged that renewable energy sources must be a key role. Renewable energy has the potential to respond to global sustainability and environmental, safety, social and economic goals in the Sahel desert countries. Renewable energy resources including biomass, geothermal energy, hydropower, ocean energy; solar energy, wind energy, and hydrogen have several important characteristics like site specify, variable availability, diffuse energy flow, and low or no fuel cost [7]. Egypt as many Africans countries depends a great deal on renewable energy sources mainly in making a great industrial up raise, in lighting and others. Egypt depends currently to a great extent on fossil fuel, oil and natural gas, to meet the increasing demand on primary energy, where fossil fuel satisfied about 94% of primary demand in 2004/2005 including 50.4% as oil share and 43.6% as natural gas share. The rest is mainly met through hydropower at 4.75%, coal at 1.05%, and RE at 0.2% for the same year. The primary energy demand has grown at an average annual rate of 4.64% during the last 25 years 1981/1982 – 2004/2005 [8].

3.1 Hydropower Generation

Hydro power is considered as one of the cheapest and cleanest sources of power generation. Egypt started generating electricity from hydraulic sources where Aswan Reservoir was established in 1960, the High Dam in 1968, and the Esna Barrage Hydropower Station in 1999 as shown in Table 1, with installed capacity of 592 MW, 2100 MW, and 91 MW respectively. Total installed capacities are 2783 MW. There are 109 MW hydropower projects at Nagah Hamady and Assiut Barrages. Small capacities as shown in Table 2 of another 86.5 MW in total are also available at main canals and branches of the river. These capacities which sum up to a grand total of 2978.5 MW represent most of the available potential. Fig. 1 shows Panoramic overview on existing hydropower installations while Fig. 2 shows the percentage of Nile power [3,4,6].

3.2 Wind and Solar Energy

In the early 1980's the government of Egypt recognized the fact that the traditional energy resources would be inadequate to meet future needs. Consequently 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 was established in 1986 to be a focal point for renewable energy activities in Egypt. RE has only a modest share in primary energy production of 0.18% in the year 2004/05. New and renewable energy resources in Egypt include solar, wind and biomass. These resources are generally not yet exploited on commercial scale except for wind energy. For RE future production, it is estimated to meet 3% of electricity demand by the year 2010, which is valued at about 0.95 MTOE. While it should meet 7% of electricity demand by the year 2021/22 amounting to 2.9 MTOE [10]. Wind and solar resources can be summarized as follows:

3.2.1 Wind Energy

Wind energy is one of the big success stories in our effort to develop sustainable energy options. World installed power capacity reached 24471 Mwe in early 2002, and enjoys a 38.2 per cent annual growth In sites with strong winds, the cost of generated electricity varies between US$ 0.04 to US$ per kWh, and is expected to fall to US$ 0.027 to US$ 0.032 per kWh by 2020. The average size of wind turbines 25 years ago was less than 50 kW, whereas the largest is now approaching 5MW with rotor diameters of 125m, the average turbine size is currently 1.6– 2MW [9]. In addition to the energy and environmental benefits, the wind energy commercialization is providing economic and industrial benefits and nowadays the capacity factor of wind electricity is between 20% and 30% [10].

In Egypt wind energy represents a favorable source for producing energy through the areas of Suez Gulf, Red Sea coast between Ra's Ghareb and Safaga and east of Owainat as shown in Fig. 3 [11]. These areas consider one of the best sites in

the world due to high and stable wind speeds. Wind speeds are ranging between 8.5 –10.8 m/s with average yearly capacity factors ranging from 38% up to 60% or more than 5000 equivalent hours. Other locations in the Eastern and Western Desert of Egypt as well as Sinai Peninsula having considerable wind potential, even though less than that of Gulf of Suez, with wind speeds between 6 – 7.5 m/s, in addition to some locations around the Nile Valley near Beni Sweif and Minia Governorates and El-Kharga Wasis in New Valley Governorate with speed 7 – 8 m/s. The overall wind potential in such areas could reach 60000 MW installed capacity .

The first commercial wind farm in Egypt at Hurghada (5 MW) was established and interconnected with the local grid in 1993, generating about 9 GWh/year. The farm includes 42 WT of different types and sizes. Large Scale National Grid Connected Projects at Zafarana on the Red Sea Coast Zafarana site, which has been selected to host the 1st large wind park [7,9,10]. The site has been specified as one of the best all over the world, with excellent wind characteristics (stable profile, relatively small variations). In 2005/06, 71 turbine stations at a capacity of 60 MW were established and the sixth phase of electricity generating station from wind energy at a capacity of 85 MW was completed [9]. The seventh and eighth phase at capacities of 120 MW and 80 MW respectively are under construction, in addition to establishing new wind stations at a capacity of 420 MW. The capacity till 2010 will reach 850 MW and represent 3% of demand on electric energy in that year. The short term plan as shown in Fig. 4 targets 850 MW by year 2010 or about 3% of electricity demand; while the long term target is to reach 3000 MW by 2021/2022 or about 7% of electric demand all on the Gulf of Suez, saving about 3 MTOE annually. Table 3 shows the short term plan. The Long-Term Plan for Wind Energy has been announced by the Supreme Council of Energy as a comprehensive plan to increase share of wind energy to reach 20% of the total electric energy demand in by year 2020. According to the new plan and within a few years, Egypt will be considered among the leading countries in the world in terms of wind installed capacity.

3.2.2 Solar Energy

In 2001, the annual world production of photovoltaic panels reached over 390.0 MWp, with a growth rate of 38.0 per cent between 1995 and The current cost of generating electricity using PV panels is US$ 0.20 to US$ 0.60 per It is expected that the PV market will reach 1710.0 MWp by 2010.

Egypt lies among the Sun Belt countries with annual global solar insolation as shown in Fig. 5 ranging from 1750 to 2680 kWh/m^2/year with relatively steady daily profile and small variations making it very favorable for utilization. Such conditions of favorite solar resource utilization are supported by other conditions of sunshine duration ranging from 9 – 11 hours with few cloudy days over the year or range between 2300 to 4000 hours/year [12].

A lighting project for 5 villages in remote areas is under construction by using solar energy. In addition, the procedures of implementing the first thermal solar station with a capacity of 150 MW in al-Kuraimat at a total cost of US Dollar 147 million are under construction. The project consists of a combined cycle island and the solar island consisting of solar collectors to produce the required heat energy from sun to generate steam that will be integrated with the steam generated from the Combined Cycle before introducing it to the Steam Turbine to generate electricity. The project is co financed by the Global Environment Facility and the Japan International Cooperation Agency [7]. The project is expected to be operated by mid of year 2010 with an expected yearly energy of 852 GWh. This project considers the first station in the Middle East and ranks fourth internationally. This station depends on using the natural gas at night as a fuel to continue operating the station all the day. The cost of solar thermal generated electricity currently is US$ 0.08 to US$ per kWh, depending on plant type and the level of solar irradiation on site. The cost is expected to drop by half to US$ 0.04 to US$ 0.06 per kWh by 2010.

3.3 Nuclear Energy

Egypt is considered one of the first countries that used peaceful nuclear energy in the region where there were many attempts to establish the Nuclear Energy Institution in 1957. The first nuclear reactor in Egypt was operated in 1960 in Anshas for the purpose of making nuclear research and producing radioactive isotopes as well as the search for petroleum in wells.

As of 2006, Egypt started establishing stations for generating electricity from nuclear power, especially that it has previous models in this vein, such as the Liquid and Radioactive Waste Treatment Station in 1994; the Nuclear Fuel Plant; the Environmental Bank in 2000 and the Radioactive Isotopes Laboratory in 2001; in addition to various nuclear technology vital projects.

In October 2007, President Hosni Mubarak took the decision to launch a program to build a number of nuclear plants to generate electricity. By virtue of such decision, peaceful use of nuclear energy has become a part and a parcel of the national strategy of energy. President Mubarak as well declared that the implementation of the initial steps to establish the first nuclear plant will be launched by the hands of Egyptian experts in this field, and in cooperation with all international partners together with the International Atomic Energy Agency.

3.4 Gas Turbine and Combined-Cycle Power Plants in Egypt [3,4,14]

With electricity demand growing 5%-7% annually, Egypt is building several power plants and is considering limited privatization of the electric power sector to attract new investment. So, 27 thermal plants were established during the past

two decades. An expansion in using natural gases in electricity generating stations was completed. The natural gas rate used for the stations joined to the natural gas grid reached 85.2 percent while it reached 80 percent of the consumed total fuel. Egypt currently has installed generating capacity of 16 gigawatts (GW). Egypt plans to expand electricity capacity to 32,000 MW over the next five years. The following are the survey of Gas Turbine and Combined-Cycle Power Plants in Egypt

3.4.1 Ayoun Moussa Units 1&2 Power Plant

Ayoun Moussa Power Station as shown in Fig. 6 is located on the West shore of Sinai Peninsula, approximately 30 km from Suez City.

3.4.2 Sidi Krir Units I&II Power Plant

Sidi Krir 1 & 2 Power Station is located on the Mediterranean Sea Coast, approximately 29 km West of Alexandria City as shown in Fig. 7.

The Ayoun Moussa and Sidi Krir I,II Power Plant consists of the following major components:

- Two units 320 MW each indoor condensing steam turbine generator units.
- Two outdoor, dual fuel fired (natural gas and heavy oil), pressurized furnace system generators.
- All necessary auxiliary and balance of plant equipment.
- A GIS 220 kV indoor switchyard, 220 kV transmission 500 kV lines.
- A residential colony.

The major building modules include a turbine generator with turbine cycle equipment, steam generator, control complex, water treatment, a 220 kV switchyard an administration building, a warehouse and a maintenance shop facility.

3.4.3 Sidi Krir Units 3&4 Power Station

Sidi Krir 3&4 Power Station is the first BOOT project in Egypt. The plant as shown in Fig. 8 is located on the Mediterranean Sea Coast, approximately 29 km West of Alexandria City next to the Sidi Krir 1&2 plant. The station consists of the following major components:

- Two 341.25 MW each, indoor condensing steam turbine generator units.
- Two outdoor, dual fuel fired (natural gas and heavy oil), pressurized furnace systems generators.
- All necessary auxiliary and balance of plant equipment.

The Power Block Island for the two generating units includes steam generator structures of outdoor type construction and a fully enclosed turbine generator structure. A single stack is designed to serve the two units and is located North of the Power Block Island.

3.4.4 Sidi Krir Combined Cycle Power Plant (750 MW)

Sidi Krir Combined Cycle Power Plant as shown in Fig. 9 is located on the Mediterranean Sea Coast, approximately 29 km West of Alexandria. Water for the Power Plant cooling demand will be obtained from the Mediterranean Sea and discharged to the Mediterranean Sea.

3.4.5 Cairo North I Combined Cycle

Cairo North I Combined Cycle as shown in Fig. 10. The power plant cooling water is withdrawn from El Ismailia Canal.

3.4.6 Cairo North II Combined Cycle Power Plant (750 MW)

Cairo North II Combined Cycle as shown in Fig. 11. The power plant cooling water is withdrawn from El Ismailia Canal.

3.4.7 Talkha Combined Cycle Power Plant

New Talkha 750 MW Combined Cycle Plant as shown in Fig. 12 located within the boundaries of the existing Talkha Power Generation Compound. The plant is located in Talkha City. Dakahlia Govern ate, on the west Bank of the River Nile, Damietta Branch, Egypt. The Power Plant cooling water is withdrawn from Damietta Branch of the Nile River.

3.4.8 Nubaria I&II Combined Cycle Power Plant (1500 MW)

Nubaria Combined Cycle Plant as shown in Fig. 13 consists of two slides along modules delivering 1500 MW (nominal) 750 MW each. A phased construction plan is adopted between the two modules. Each module includes two 250 MW (nominal, ISO) combustion turbine generators (CTGs), each feeding exhaust gases to its respective heat recovery steam generator (HRSG) with no supplementary firing. Power is generated at manufacturer's standard voltage in the CTGs and the STG, stepped-up through main transformers, and fed to the EEHC national grid via a 500 KV and a 220 KV, conventional switchyard. Water for the Power Plant cooling demand is obtained from Nubaria's Canal. The project includes all site development, housing colony and administrative facilities.

3.4.9 Nubaria III Combined Cycle Power Plant (750 MW)

Nubaria III Combined Cycle plant as shown in Fig. 14 consists of one module 750 MW (nominal). The module includes two 250 MW (nominal, ISO) combustion turbine generators (CTGs), each feeding exhaust gases to its respective unfired HRSG with no supplementary firing. Water for the power plant cooling demand will be obtained from Rayah El Nasery.

3.4.10 El-Kureimat II Combined Cycle Power Plant (750 MW)

El-Kureimat 750 MW Combined Cycle Project as shown in Fig. 15 is located within the boundaries of the existing 2600 MW thermal power plant site. The power plant cooling water is withdrawn from the Nile River.

3.4.11 El-Kureimat III Combined Cycle Power Plant (750 MW)

El-Kureimat III Combined Cycle Power Plant as shown in Fig. 16. Water for The Power Plant cooling demand will be obtained from the Nile River.

3.4.12 El-Tebbin Thermal Power Plant 2x350 MW

The facility is designed to include a 2x350 MW Thermal Power Plant for interconnection to the National Unified Power System (NUPS) through the new GIS 220 KV switchyard facility. The power block comprises two identical rankine cycle turbine natural gas, residual (mazout) oil, or a combination of both. The Two-unit station arrangement shall include an enclosed turbine building, an open boiler building, a common control room and all associated structures and facilities. The facility will include water treatment plant that will provide make-up water to the cycle. A new 220 KV GIS switchyard will be constructed to deliver the generated power to the national grid. Fig. 17 shows El-Tebbin Thermal Power Plant.

3.4.13 EL Atf Combined Cycle Power Plant (750 MW)

Water for the power plant cooling demand will be obtained from the Nile River (Rosetta Branch) and discharged to the Marquase Canal. Fig. 18 shows EL Atf Combined Cycle Power Plant

3.4.14 Cairo West Thermal Power Plant 2x350 MW

The facility is designed to include a 2x350 MW Thermal Power Plant as shown in Fig. 19 for interconnection to the National Unified Power System (NUPS) through an extension of the existing GIS 500 KV Switchyard facility. The power block comprises two identical ranking cycle turbine generator units, each with a nominal rated capacity of 350 MW using natural gas, residual (mazout) oil, or a combination of both. The two-unit station arrangement including an enclosed Turbine building, an open boiler building, a common control room, and all associated structures and facilities.

3.4.15 New Abu Qir Thermal Power Plant 2x650 MW

The Abu Qir Site is located on the Mediterranean Sea Coast approximately 25 km East the Alexandria city. The plant includes a 2x650 MW Thermal Power Plant for interconnection to the National Unified Power System (NUPS) through the new 500 KV GIS Switchyard facility.

All station mentioned above are designed to include a power block consisting of two 250 MW (nominal, ISO combustion turbine generators (CTGs), each feeding exhaust gases to its respective heat recovery steam generator (HRSG). Steam from the two HRSGs is fed to one 250 MW (nominal), reheater, condensing STG. The net output from each plant is 750 MW.

This output is achieved by burning natural gas in the combustion turbines with no supplementary firing in the HRSGs. Nitrogen oxides emitted are controlled by dry low nitrogen oxides combustors. An inlet air filtration system is included to supply suitable filtered combustion air to the CTGs. The steam exhausted through the steam turbine is dumped into a once - through cooling, single-pass and divided water box condenser. Power will be generated at manufacturer's standard voltage in the CTGs and the STG, stepped up through main transformers, and fed to the EEHC National grid via a 220kV and 500kV, gas insulated switchgear m, GIS switchyard.

4. Electricity Market

The present electricity market in Egypt is composed of two submarkets:

1. The unified power system of Egypt in which EETC acts as a single buyer of bulk power, purchasing electricity from the generating companies through Power Purchase Agreements (PPAs) and selling it to the distribution companies and UHV and HV customers. The vision of the Egyptian Regulatory Agency is to gradually transform the market structure from a single buyer – based structure to a free market based on bilateral contracts or similar. In addition to the generation companies owned by EEHC, the power sector includes few Independent Power Producers (IPPs) selling electricity to EETC through long term PPAs.

The Egyptian Electric Utility as shown in Table 4 divided into government owned companies under the Egyptian Electricity Holding Company and Private Sector Companies whether it was a BOOT projects or independent companies.

EEHC was established by law in 2000 as a joint stock company that, up to now, is fully owned the state. EEHC replaced the previous state – owned, vertically integrated power utility; Egyptian Electricity Authority. Besides its responsibility for the planning of the whole electricity sector, EEHC along with its affiliate companies is responsible for generation, transmission and distribution as follows:

a) Six generation companies, four responsible for thermal power generation plants, one hydro power plant and New and Renewable Energy Authority (NREA). In addition to three private sectors.

b) The Egyptian Electricity Transmission Company (EETC), solely responsible for ultra high and high voltage (UHV & HV) transmission system. EETC controls and manages Egyptian power system through the national dispatching center as well as the regional control centers. EETC also performs electricity sales at extra high and high voltages and manages export – import of electricity through network interconnections with neighboring countries.

c) Eight Regional Distribution Companies responsible for medium and low voltage distribution and corresponding electricity sales for different end-users.

2. Isolated limited sub-market comprising mostly tourist villages and resorts at the Red Sea and the Sinai Peninsula that are mainly served by IPPs.

5. Egyptian Electricity Network

The number of villages and hamlets connected to the electricity network increased from 38.8 thousand villages and hamlets in FY 2005/2006, to reach 39.1 thousand in FY 2006/2007. Consumed Energy Quantity of consumed electric power in 2005/06 reached about 92.9 billion kWh. The lengths of electricity lines increased to reach 391,000 km in 2005/2006 [3,4]. On the year 1984/85 lengths of transmission lines at different levels were 1576 km for 500 KV, 3638 km for 220 KV, 2224 km for 132 KV, and finally 3838 km for 66 KV. By the year 1994/95 these lengths increased to 1736 km, 7279 km, 2536 km, and 7942 km consequently, then for the year 2004/05 the lengths of the transmission lines have become 2262 km, 13920 km, 2467 km, and 16248 km respectively. Figure 20 shows Egypt's unified power network with its backbone ring having 220 KV transmission lines and transformers sub-stations. The developments in the electricity utility network Lengths for V.H.V , H.V and Medium Voltages During the period (1999/2000- 2006/2007) is shown in Table 5 and Fig. 20 [15].

6. Evaluation of Electricity Sector

6.1 Evaluation and Structure of the Energy

Total implemented investments in the electricity sector of 2005/06 reached about LE 5.813 billion (Egyptian Pound) to provide electric energy for about 99 percent of population. The amount of electric generation capacity by the end of 2005/2006 reached 21.944 GW with a total generated electric energy of 108.690 TWh out of which 87.529 % (95.136 TWh) are generated from thermal power plants, 11.63 % (12.644 TWh) from hydropower plants, and 0.507 % (0.552 TWh) from wind energy farms. This is done through adding 12 new thermal plants and expansions: Kureimat 2 and 3, Talkha, Tabbin, Nuberiya 3, Cairo West, Sidi Krier, el-Atf, Abu Qir, Ain Sokhna and Sharm el-Sheikh. In addition to 25 MW in al-Z'afarana wind station, plus lifting a unit of about 50 MW from al-Mahmoudeya electricity generating station. Table 6-a and 6-b show energy generated and purchased in GWh for the year (06-07 and 05-06) [3,4,6,14].

6.2 Evaluation of electricity demand

Electricity expansion is another factor causing growth of primary energy consumption. As mentioned before, the limited share of RE and hydropower puts the whole burden on thermal power stations mainly using natural gas. Based on data presented on Table 7, the analysis of the historical electric power consumption of the different classes of customers during the period 1981/82 to 2005/06 indicates that the industrial sector consumption share of the total consumption has decreased

from 55.4% in fiscal year 1981/82 to 35.52% in fiscal year 2005/06, also the agricultural sector consumption share has decreased from 5.1% in fiscal year 1981/82 to 4.03% in fiscal year 2005/06. While the residential sector consumption share has increased from 22.7% in fiscal year 1981/82 to 36.8% in fiscal year 2005/06. For other consumption sectors (commercial, government, public utilities, sales for resellers, street lighting) their consumption share has increased from 16.8% in fiscal year 1981/82 to 23.7% in fiscal year 2005/06. Major load centers all over the country are served through transmission lines and cables having other voltage levels ranging from 132 to 11 KV.

Table 8 also shows the forecast for peak load, electricity generation, sales, and sectors demand for the period 2006/07 to 2021/22. The estimated Peak load, the total generation, and the total sales for the year 2021/22 will reach 43020 MW, 273.1 TWh, and 241.8 TWh respectively, compared to 18500 MW, 115.58 TWh, and 98.832 TWh respectively for the year 2006/2007 [6,15].

7. International Connections

The electric network interconnection with Libya started functioning since May 1998 and with Jordan since October 1998. The interconnection with Syria through Jordan has been operational since March 2000. Table 9 shows Electricity Exports and Imports to Neighboring Countries from years 1998 to 2006, Egypt is a net exporter of electricity to its neighbors (Libya, Jordan and Syria) [1].

Electricity sector succeeded to link the unified electric grid in Egypt with Arab and African Countries' grids and hence with European Countries. The most important Egyptian electric linkage projects are the seventh linkage project including Egypt, Jordan, Iraq, Lebanon, Libya, Syria and Turkey. In 2005/06 the exchange of security reserves between Egypt and linkage countries (Jordan, Libya and Syria reached about 766 million kWh at a total value of US Dollar 57.5 million). A study to raise the linkage voltage from 220 kV to 400/500 kV was concluded between Egypt, Libya, Tunsia, Algeria and Morocco in the framework of technical cooperation between Egypt and Arab Moroccan Countries to increase the transferred energy among these countries. A consultant contract was signed to study the Egyptian/Saudi electrical linkage and participate in the attempts of operating the Libyan/Tunisian linkage line to complete the linkage circle between Arab Morocaan Countries and Europe in addition to electrical linkage programmes with Sudan, Ethiopia and Nile Basin Countries.

8. Electricity sector strategy and policies

EEHC set a five years plan (2007/2008-2011/2012) to meet the expected average annual growth of demand of 6. 8%. This entails adding a generation capacity of 775 MW with maximizing the use of Combined Cycle to reach 4.1% of the total installed capacity in 2011/2012. In the meantime EEHC and its affiliated companies continuously develop, improve and

modernize the services to its customers (the number of customers increased from 4.5 million in early eighties to 22.6 million in FY2006/2007) to speed and facilitate the processes of the required services. EEHC gives great importance that the affiliated companies achieve the targeted technical, operational, procedural and financial indicators which were set with reference to international standards. In order the companies achieve the targeted performance indicators, they set up all necessary mechanisms and provide all technical and human resources capabilities necessary for the continuous development of generation, transmission and distribution techniques. In order to maximize the local contribution in different planned electricity projects, EEHC cooperates and coordinate with all local Egyptian firms and entities. EEHC aims to create a wider market for its services in the Arab and African countries through the establishment of joint consulting companies or marketing the Egyptian experience in the field of electricity -as an example of such cooperation - the electrical interconnection projects and the establishment of the joint consulting companies with Syria and Libya. In order to acquire, benefit and transfer latest and diversified international experience to its dear customers, EEHC cooperates with international companies and firms and participate in international conferences, workshops and seminars. Acknowledging the importance of data documentation, Egyptian Electricity Holding Company issues this annual report to document its activities and achievements over the Fiscal Year 2006/2007 to be as a reference to those who are interested in the field of electrical energy. The main strategic goals of the electricity sector are supplying electricity according to international standards, and meeting demand in all consuming sectors, with due consideration for environmental concerns.

The sector’s policies' objectives include but are not limited to:

1. Maximizing the utilization of hydropower resources through electrification of suitable barrages on the Nile River and its branches.
2. Maximizing the use of natural gas in thermal power plants.
3. Promotion of new and renewable energy to increase its share in the power generation mix.
4. Interconnecting the Egyptian electricity grid with neighboring countries both east and west.
5. Improving efficiency of energy generation, transmission, distribution, and use.
6. Adopting measures to enhance environmental protection.

Egypt has permitted private sector investors to share in large electricity generation power plants, where three BOOT power plants were built until 2003. Private investments in small power plants are also practiced in the country [16].

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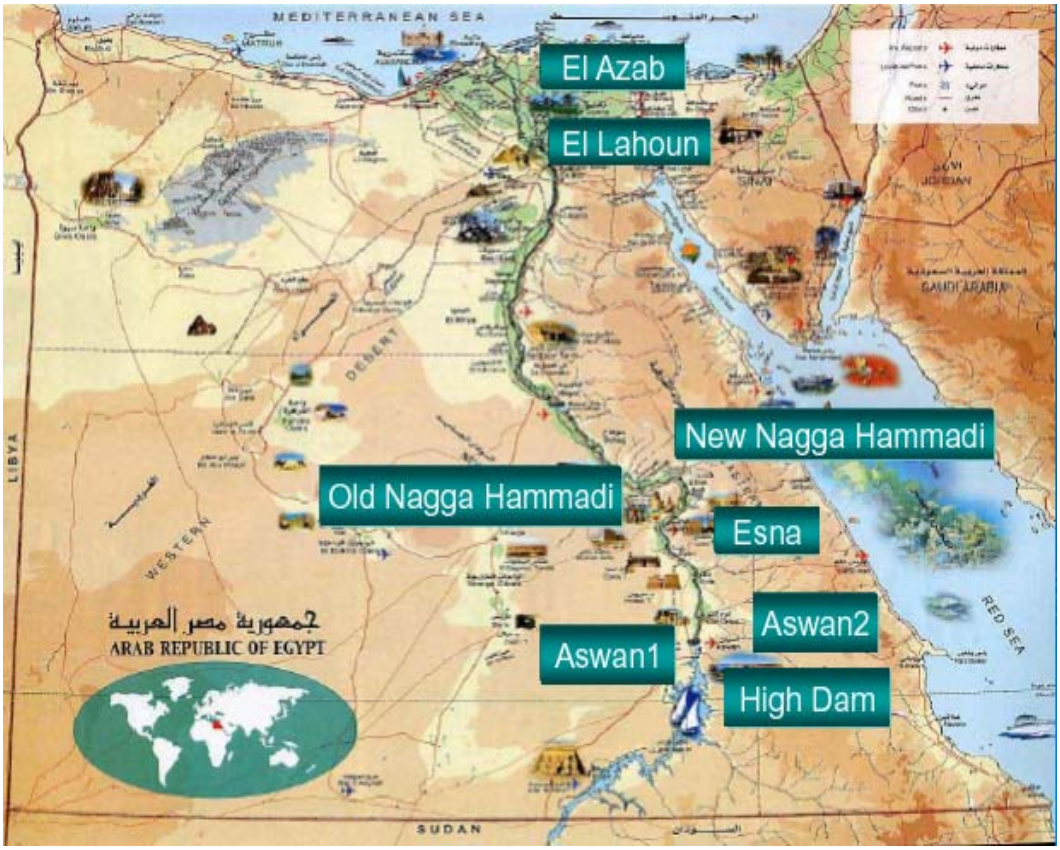

Fig. 1 shows Panoramic overview on existing hydropower installations [1]

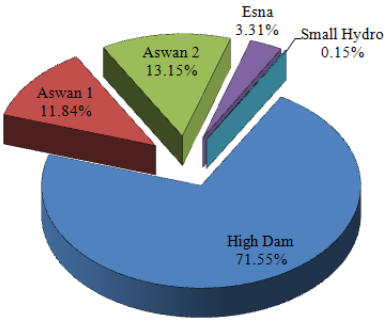

Fig 2 Percentage of Nile Power

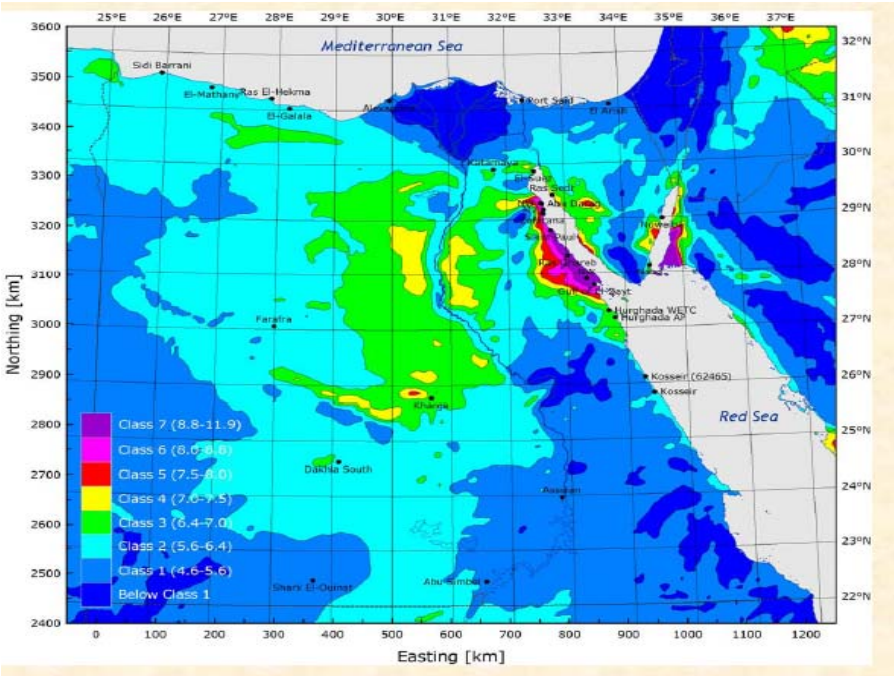

Fig. 3 Potential of Wind Energy in Egypt [11]

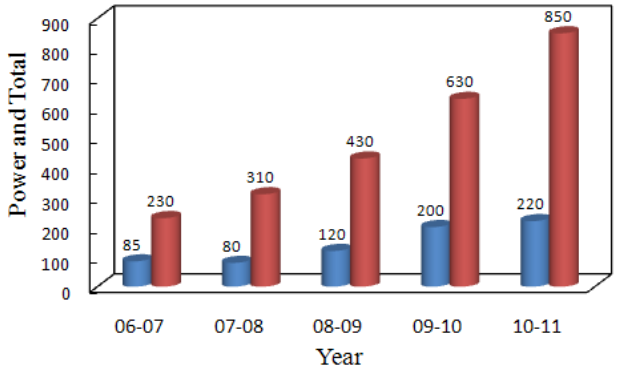

Fig. 4 Short term plan for RE up to 2011

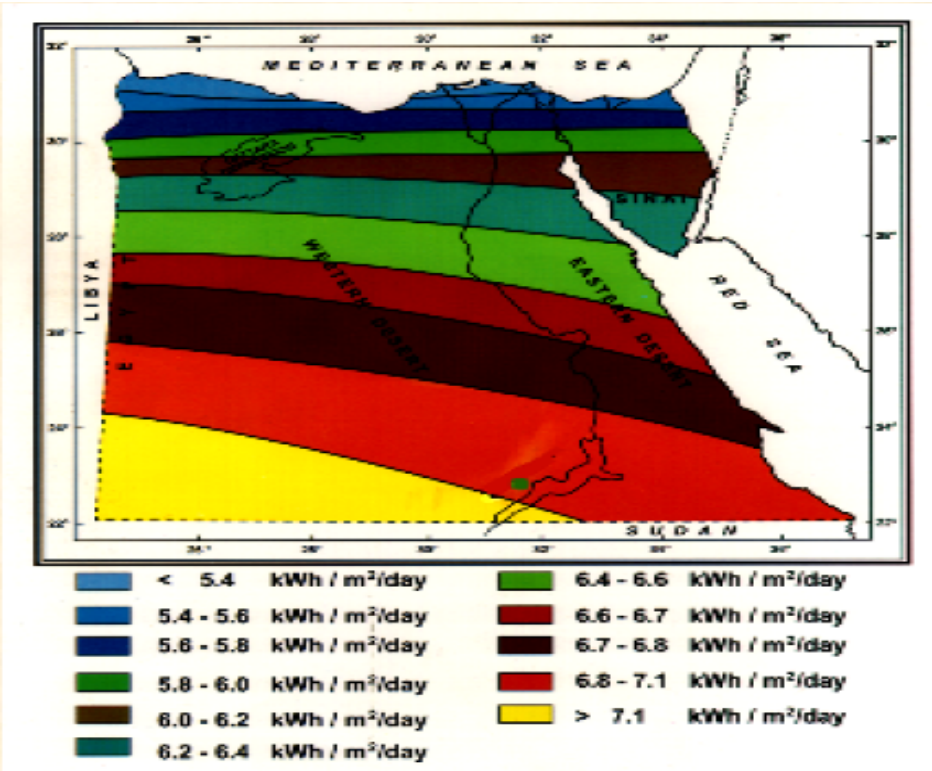

Fig. 5 Global Solar Energy in Egypt [13]

Fig. 6 Ayoun Moussa Power Plant [14].

Fig. 7 Sidi Krir I,II Power Plant [14].

Fig. 8 Sidi Krir III,IV Power Plant [14].

Fig. 9 Sidi Krir Combined Cycle Power Plant [14].

Fig. 10 Cairo North I Combined Cycle Project [14].

Fig. 11 Cairo North II Combined Cycle Power Plant [14].

Fig. 12 Talkha Combined Cycle Power Plant [14].

Fig. 13 Nubaria I&II Combined Cycle Power Plant [14].

Fig. 14 Nubaria III Combined Cycle Power Plant [14].

Fig. 15 El-Kureimat II Combined Cycle Power Plant [14]

Fig.16 El-Kureimat III Combined Cycle Power Plant [14].

Fig. 17 El-Tebbin Thermal Power Plant [14].

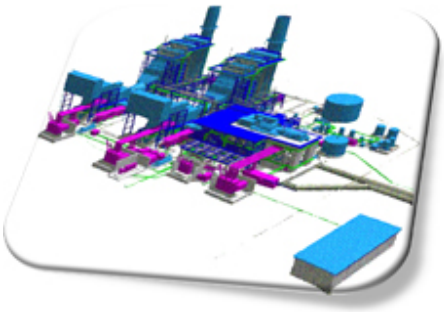

Fig. 18 EL Atf Combined Cycle Power Plant [14].

Fig. 19 Cairo West Thermal Power Plant [14].

Figure 20 Egypt map with a representation of the unified power system [6].

Table 1 Hydro Power Generation

Site	Head , m	Flow m^3/sec	Power, MW	Completed	No. of Units	Annual Generation GWh
Aswan I	20	1340	280 (322)	1960	7*46	1497
Aswan II	20	1200	270	1985	4 *67.5	1663
High Dam	70	4152	2100	1967	12*175	9049
Esna	5.7	1800	90	1994	6 *14.28	419
Naga Hammadi	7.97	320	64	1997	4*16	15
Small Hydro						19

Table 2 Potential sites for small/mini hydropower installations in Egypt

Site	Head , m	Flow m^3/sec	Power, MW
Assuit Barrage	3.5	1200	32.00
Damietta	4.00	350	13.00
Zefta	5.00	150	5.00
El Mokhtalat	20.75	5	1.00
Tawfiki Rayah	1.86	134	2.45
Assuit Regulator	1.33	229	3.00
Abbasi Rayah	1.48	127	1.85
Ibrahimia Canal in Take	1.38	114	1.55
Beheri Rayah	1.2	188	2.2
Menoufi Rayah	1.00	173	1.80
Sharkawia Canal	0.82	232	1.85
Bahr Yousef Canal	0.86	120	1.00

Table 3 Renewable energy expansion Plan Up to Year 2010/2011

Year	Installed Capacity, MW	Total Power, MW	Generated Power, GWh
06-07	85	230	635
07-08	80	310	1080
08-09	120	430	1500
09-10	200	630	2300
10-11	220	850	3000

Table 4 Electricity Utility in Egypt

<table>
<tr><th colspan="4">Generation</th></tr>
<tr><th colspan="2">Government Owned</th><th colspan="2">The Private Sector</th></tr>
<tr><td>West Delta Generation Company</td><td>East Delta Generation Company</td><td colspan="2">Port Said East Power Company</td></tr>
<tr><td>Cairo Generation Company</td><td>Upper Egypt Generation Company</td><td colspan="2">Suez Gulf Power Company</td></tr>
<tr><td>Hydro Plants Generation Company</td><td>Developing and Utilizing The New and Renewal Energy Authority</td><td colspan="2">Sidi Krir Generating Company</td></tr>
<tr><th colspan="4">Transmission</th></tr>
<tr><td colspan="4">The Egyptian Electricity Transmission Company</td></tr>
<tr><th colspan="4">Distribution</th></tr>
<tr><th colspan="2">Government Owned</th><th colspan="2">The Private Sector</th></tr>
<tr><td>Alexandria Distribution Company</td><td>South Cairo Distribution Company</td><td colspan="2" rowspan="2">The Egyptian Chinese Joint Venture Company for Investment</td></tr>
<tr><td>North Cairo Distribution Company</td><td>Behaira Distribution Company</td></tr>
<tr><td>South Delta Distribution Company</td><td>North Delta Distribution Company</td><td colspan="2">Delta Company For constructions and reconstruction</td></tr>
<tr><td>Upper Egypt Distribution Company</td><td rowspan="2">Middle Egypt Distribution Company</td><td colspan="2" rowspan="2">Engineering group For electric energy</td></tr>
<tr><td>Canal Distribution Company</td></tr>
</table>

Table 5 Network Lengths for V.H.V, H.V and Medium Voltages during the period (99/00- 06/07)

Year	Length, km
99-00	110000
00-01	139000
01-02	148000
02-03	157614
03-04	161125
04-05	169597
05-06	172232
06-07	176869

Table 6-a Energy generated and purchased (GWh) by Technology type

Item	2006/2007	2005/2006	Variance %	Percentage
Steam	52082	53285	2.3	45.1289001
Gas	6888	8044	14.4	5.968431779
Combined Cycle	29892	20236	47.7	25.90133025
Hydro	12925	12644	2.2	11.19947456
Wind	616	552	11.6	0.533762192
Isolated plants	347	322	7.7	0.300674481
Purchased from (IPPs)	32.2	36	10.6	0.027901205
Generated from BOOT	12625	13571	7	10.93952544
Grand total	115407.2	108690	6.2	100

Table 6-b Energy Generated and Purchased (GWh) By Production Company

Company	Power Generated GWh
Cairo Electricity Production Company	25485
East Delta Electricity Production Company	24091
Middle Delta Electricity Production Company	4129
West Delta Electricity Production Company	22561
Upper Egypt Electricity Production Company	12596
Hydro- Power Plants Electricity Pro. Co.	12925
Generated from Boot, Iso. Plants & Purchased	13620
Total	115407

Table 7 Historical Electricity Peak load (MW), generation, Sales and Consumption by Sector (GWh)

Sales by Sector (GWh)	FY 81-82	Av. Annual G.R. 82-87	FY 86-87	Av. Annual G.R. 87-92	FY 91-92	Av. Annual G.R. 92-97	FY 96-97	Av. Annual G.R. 97-02	FY 01-02	Av. Annual G.R. 82-06	FY 05-06
Peak Load, MW	3694	9.45 %	5803	4.45 %	7215	5.06 %	9235	7.61 %	13326	6.64 %	17300
Total Generation	21895	9.96%	35202	5.26%	45481	4.87 %	57675	7.62%	83259	6.89%	108357
Total Sales	17332	10.44%	28471	5.75%	37648	5.47 %	49137	7.08%	69166	7.25%	92055
Total Industry	9603	7.63%	13872	4.33%	17145	4.23%	21092	3.79%	25402	5.24%	32701
Agriculture	882	5.41 %	1148	2.96%	1328	7.87%	1940	7.10%	2733	6.18%	3719
Residential	3938	16.99%	8630	7.60%	1244	6.57%	17108	8.46%	25673	9.37%	33900
Others	2909	10.63%	4821	6.90%	6730	5.98%	8997	11.29%	15358	8.78%	21735
Sector's consumption share to total sales (%)											
Total Industry	55.4		48.7		45.5		42.9		36.7		35.5
Agriculture	5.1		4.0		3.5		3.9		4.0		4.0
Residential	22.7		30..3		33.1		34.8		37.1		36.8
Others	16.8		16.9		17.9		18.3		22.2		23.7

Table 8 Forecast Sales by sectors in GWh, Total electricity generation (GWh), and Peak laod (MW) until 2021/2222

Sectors GWh	06-07	07-08	08-09	09-10	10-11	11-12	12-13	13-14	14-15	15-16	16-17	17-18	18-19	19-20	20-21	21-22
Total Industry	34596	36916	39368	41954	44552	47295	50185	53218	56394	59713	63194	66816	70578	74484	78529	82711
Agriculture	4040	4326	4624	4933	5249	5576	5916	6267	6631	7007	7394	7793	8204	8627	9063	9510
Public Utilities + Ligh Ting	11403	12246	13124	14034	14936	15869	16835	17831	18858	19913	20977	22069	23187	24325	25488	26674
Commercial &others	6542	7152	7792	8462	9095	9759	10452	11175	11929	12715	13527	14371	15247	16154	17094	18066
Residential	36080	38341	40751	43314	46628	50068	53633	57315	61111	65014	69001	73084	77258	81509	85837	90234
Government	5396	5763	6150	6557	7043	7548	8074	8621	9189	9779	10390	11024	11682	12364	13071	13803
Total	98057	104745	111809	119254	127503	136116	145094	154428	164112	174141	184483	195158	206156	217464	229082	240998
Net Sales for Interconnection	775	775	775	775	775	775	775	775	775	775	775	775	775	775	775	775
Total Energy Sales	98832	105520	112584	120029	128278	136891	145869	155203	164887	174916	185258	195933	206931	218239	229857	241773
Total Generated Energy	115581	123065	131214	139591	148538	157750	167496	177539	188087	198960	210317	222018	234189	246720	259708	273068
Peak Load MW	18500	19640	20920	22250	23650	25110	26640	28220	29860	31560	33320	35140	37020	38960	40960	43020

Table 9 Electricity Exports and Imports to Neighboring Countries

Item	Units	1998	1999	2000	2001	2002	2003	2004	2005	2006
Exports	GWh	53.8	140.8	196.9	461.6	489.4	1175.6	1004.4	900.4	747.8
	MTOE	0.012	0.031	0.0430	0.101	0.107	0.2560	0.219	0.196	0.163
Imports	GWh	66.4	157.6	159.8	217.4	210.4	136.9	148.7	167.4	192.6
	MTOE	0.014	0.034	0.035	0.047	0.046	0.030	0.032	0.036	0.042