The Arab Republic of Egypt
Ministry of Electricity and Energy
Egyptian Electricity Holding Company

PREPARATORY SURVEY REPORT ON IMPROVEMENT IN ENERGY EFFICIENCY OF POWER SUPPLY IN THE ARAB REPUBLIC OF EGYPT

FINAL REPORT

March 2010

JAPAN INTERNATIONAL COOPERATION AGENCY

TOKYO ELECTRIC POWER SERVICES CO., LTD.(TEPSCO)

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PREFACE

In response to the request from the Government of The Arab Republic of Egypt, the Government of Japan decided to conduct the "Preparatory Survey on Improvement in Energy Efficiency of Power Supply in The Arab Republic of Egypt", and entrusted it to the Japan International Cooperation Agency (JICA) conducted.

JICA selected and dispatched a Study team headed by Mr. Atsushi Fujisawa of Tokyo Electric Power Services Co., LTD. (TEPSCO) to Egypt for three times from July 2009 to December 2009.

The Study Team held discussions with the officials concerned of the Government of Egypt, Ministry of Electricity and Energy and Egyptian Electricity Holding Company, and conducted field surveys. After the team returned to Japan, further studies were made. Then, the Study Team prepared this final report.

I hope that this report will contribute to development in The Arab Republic of Egypt, and to the enhancement of friendly relationship between our two countries.

Finally, I wish to express my sincere appreciation to the officials concerned of the Government of The Arab Republic of Egypt for their close cooperation extended to the teams.

March 2010

Nobuhiro IKURO
Chief Representative
Japan International Cooperation Agency
Egypt Office

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Abbreviations and Acronyms

Organization

AEDC	Alexandria Electricity Distribution Company
AFD	Agence Française de Développement
AfDB	African Development Bank
EDC	Electricity Distribution Company
EEA	Egyptian Electric Authority
EEHC	Egyptian Electricity Holding Company
EETC	Egyptian Electricity Transmission Company
EEPC	Egyptian Electricity Production Company
EEUCPRA	Egyptian Electric Utility and Consumer Protection Agency
EPC	Electricity Production Company
EPS	Electrical Power System Engineering Co.
GtZ	Deutsche Gesellschaft fur Technische Zusammenarbeit
JICA	Japan International Cooperation Agency
KfW	Kreditanstalt für Wiederaufbau, meaning Reconstruction Credit Institute .
MOEE	Ministry of Electricity and Energy
NCEDC	North Cairo Electricity Distribution Company
NDEDC	North Delta Electricity Distribution Company
NREA	New and Renewable Energy authority
ODA	Official Development Assistance
TEPCO	Tokyo Electricity Power Company
USAID	U.S. Agency for International Development

Others

AC	Air Condition
ACC	Advanced Combined Cycle
AMR	Automated Meter Reader
AWHM	Advanced Watt Hour Meter
BOD	Board of Directors
BOOT	Built-Operation-Own-Transfer
BUSD	Billion United States dollar
C cycle	Combined Cycle
COP	Co-efficiency of Performance
DAS	Distribution Automation System
DC	Distribution Center
DCC	Distribution Control Center
DMS	Distribution Management System
DSM	Demand Side Management
DT	Distribution Transformer
EE	Energy Efficiency
EGP	Egyptian Pound

EIA	Environmental Impact Assessment
FCB	Feeder Circuit Breaker
FEP	Front End Processor
FY	Fiscal Year
GDP	Gross Domestic Product
GHG	Green House Gas
GR	Growth Rate
GT	Gas Turbine
H.P.	Home Page
HCR	Heat Conversion Rate
IGCC	Integrated Coal Gasification Combined Cycle
IPP	Independent Power producers
IRR	Internal Rate of Return
JPY	Japanese Yen
LBS	Load Break Switch
LED	Light Emitting Diode
LOLE	Loss and Load Expectation
LV	Low Voltage
MAAC	More Advanced Combined Cycle
MEGP	Million Egyptian Pound
M-RTU	Master Remote Terminal Unit
MUS$	Million United States dollar
NOx	Nitrogen Oxide
O&M	Operation and Maintenance
OH	Over Head
PM	Prepaid Meter
PPA	Power Purchase Agreement
PQ	Pre-Qualification
RE	Renewable Energy
RMU	Ring Main Unit
RTU	Remote Terminal Units
SAIDI	System Average Interruption Duration Index
SAIFI	System Average Interruption Frequency Index
SCADA	Supervisory Control and Data Acquisition
SEA	Strategic Environmental Assessment
ST	Steam Turbine
SVR	Step Voltage Regulator
TOU	Time of Use
UG	Underground
WHM	Watt Hour Meter
XLPE	Cross Linked Polyethylene

Chapter 1
Introduction

Chapter 1 Introduction

Section 1 Background

(1) In recently, electricity demand in Egypt has rapidly increased 7.1 % per year on average since 1996. During the last Fiscal Year 2007/2008, it was a challenge for Egypt to meet the high growth rate of electricity demand; the peak demand reached 19,738 MW and energy generated 125 TWh.

(2) The government of Egypt plans completion of 8,547 MW of new power development in the 6th Five-Year Plan (2007/8 to 2011/12) in order to increase 9.1% of power generation per year.

(3) Currently Egypt is one of 11 countries which mean the most growth of emission of greenhouse gases (GHG), so that the emission in 2017 will be reached to over 3 times as compared with 2006.

(4) Within the framework of the Energy Strategy of Egypt, the strategy of the power sector has focused on the diversification of the use of fuel resources, promoting the use of renewable energy and conventional energy resources. Moreover, the energy efficiency and conservation has been strongly requested as well.

(5) The government of Egypt has planned National Sustainable Development Strategy and has considered establishment of Energy Efficiency Agency and enactment of Energy Conservation regulation, so that the related low and organization has been constructing.

Therefore, it is considered that JICA study should be conducted to formulate the Japanese ODA loan Projects under Cool Earth Partnership Initiative for improvement of energy efficiency in Egyptian Power Sector including Power plant, transmission, Distribution and Demand Management.

Section 2 Objective of the Study

The objective of the Study is to propose and formulate the candidate projects regarding improvement of energy efficiency of Egypt to be supported by Japanese ODA loan, based upon the review of the needs of improvement in energy efficiency in Egypt.
The candidate projects expected to be formulated through the study are included in the following field in power sector.

1) Power generation
2) Transmission
3) Distribution
4) Demand side management

Section 3 Terms of Reference

(1) To study the current effort to improvement in energy efficiency of power sector in Egypt.
- To study progress and current situation of improvement in energy efficiency of power sector in Egypt
- To study outline of energy consumption condition in Egypt
- To study policy and activity regarding improvement in energy efficiency in Egypt
- To study energy efficiency projects supported by other donors

(2) To study potential of improvement in energy efficiency of power sector in Egypt and propose the candidates of Japanese ODA loan project.
- To figure out the potential of improvement in energy efficiency of power generation, transmission, distribution and demand side management and to point out the problems and countermeasures
- To propose "Long List" of energy efficiency projects regarding power generation, transmission, distribution and demand side management
- To propose the candidate (Model) projects of Japanese ODA loan

(3) To formulate model project of Japanese ODA loan in the area of power distribution.
- To study the outline and activities of power distribution company such as Alexandria. North Delta and Cairo North distribution company
- To study the current condition and plans to improve the energy efficiency in the distribution companies
- To propose the project scope (e.g. system configuration, project size, implementation schedule, packaging, appropriate tariff, capacity development)
- To calculate the project cost
- To calculate economic viability (e.g. IRR)
- To confirm the problems of environmental consideration for the power distribution project
- To check the problems to formulate the project of Japanese ODA loan

(4) To hold a workshop in Egypt for the purpose of sharing recognition and opinion of Egyptian stakeholders to the above.

Section 4 Study Member

(1) Study Team Members

The study team consisted of 9 specialists as indicated below:

Name	Specialty	Assignment
Mr. Atsushi FUJISAWA	Team Leader and Transmission/Distribution expert	Outline of Study Implementation Program Distribution project Effect by the project
Mr. Hiroyuki SHINOHARA	Power planning and Generation Expert	Power planning analysis Estimation power generation
Mr. Kenichi KUWAHARA	Distribution Expert	Energy efficiency analysis in Distribution network and project
Mr. Keita AKAKURA	Demand Side Management Expert	Energy efficiency Analysis in Demand Side
Mr. Hirokazu TUJITA	Transmission and Substation Expert	Energy efficiency Analysis in transmission and substation
Ms. Akiko URAGO	Environmental & Social Consideration Expert	Environmental and social impacts
Mr. Misaki KITTAKA	Power system Expert	Power network system Analysis
Mr. Kazunori TAKASAWA	Economy and Management Expert	Economic Analysis
Mr. Toshio AKI	Distribution Expert	Distribution network Analysis

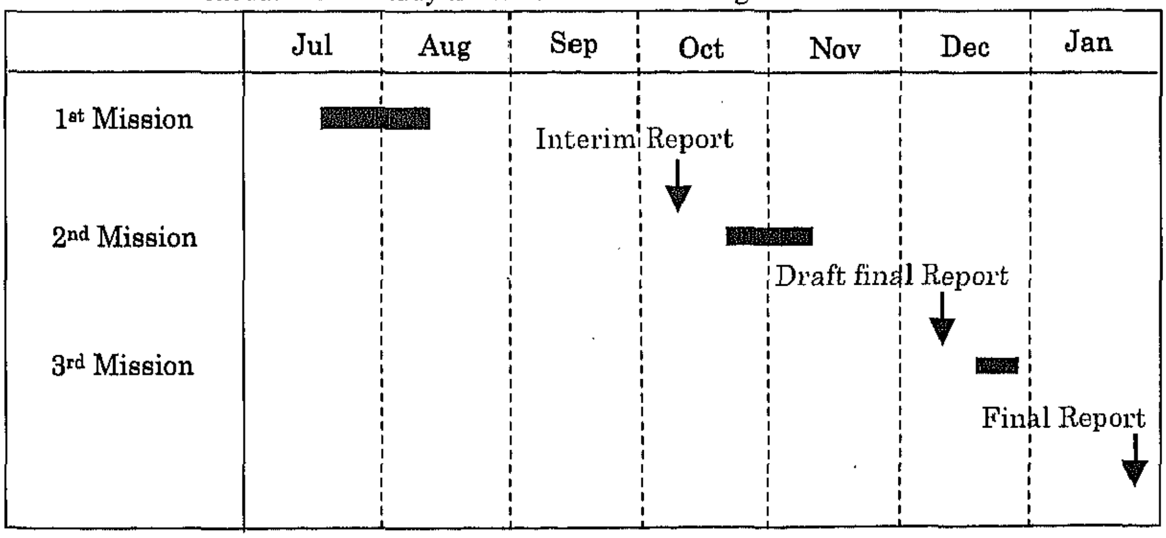
(2) Local Consultant

The following local consultants have been hired to support the study Team. The name of local consultant and its functions in this study are as follows:

✓ EPS (Electrical Power System Engineering Co.): Power sector, Transmission, Distribution and Demand side issues
  - Chairman: Eng. Hosni El-kholy
  - Team Leader: Wahead S.A. Fattah El-Hageen

Section 5 Study Schedule

The schedule of the study is shown in the following table.



Chapter 2

Current effort to improvement in energy efficiency of power sector in Egypt

Chapter 2 Current effort to improvement in energy efficiency of power sector in Egypt

Section1 Current Status of Power Sector in Egypt

Clause1 Structure of Power Sector

(1) History of Power Sector in Egypt

In Egypt some private companies had supplied electricity during the period 1893-1961 when it was the earliest day of power sector. In 1962, however, these electric power companies were nationalized. In 1976 Egyptian Electricity Authority (EEA) was established based on Law No.12 and also gave exclusive concessions in the power generation, transmission and distribution sector.

In 1983 the distribution activities ware separated from EEA and gathered into a new authority called the Public Sector Authority for Electric Power Distribution, under direct jurisdiction of the Ministry of Electricity & Energy (MOEE). In 1991, under Law No. 203, the electricity distribution companies (EDC's) were transferred from MOEE to the "Holding Company for Construction and Electric Power Distribution" under jurisdiction of the Ministry of Public Enterprises Sector, a new Ministry created to prepare for the public sector companies to be privatized.

In June 1996, Law No. 12 was modified again by Law No.100 for permitting private sectors to build, own, operate and transfer (herein after referred to as "BOOT") electric power generating plants. This law established BOOT framework that private generation companies could sell the electricity generated by their own power plant during 20 years and would transfer their estate to EEA after 20 year operation period. This meant that condition for privatization of power generation sector had been prepared.

In 1998 Law No. 18 (another modification for Law No. 12) was issued to transfer the distribution companies to EEA again. Under this law, seven geographic generation zones of EEA were merged with the eight distribution companies in order to create seven vertically integrated companies responsible for generation and distribution. On the other hand, transmission, dispatching, power & transmission development planning and purchase of electricity produced by the BOOT projects were still took responsibility for by EEA.

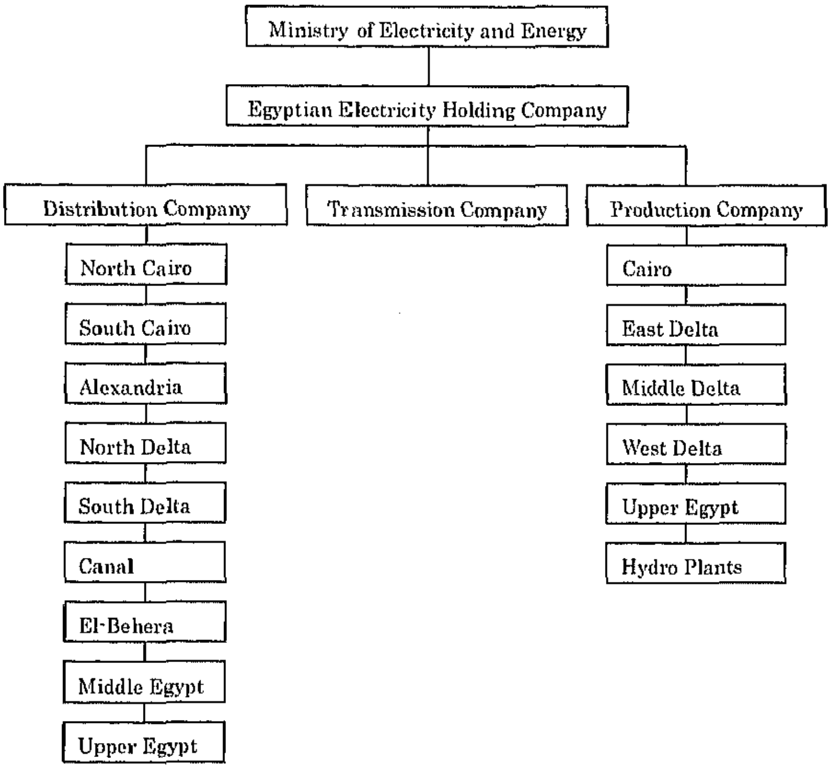
In July 2000 Law No. 164 (a latest modification for Law No. 12) was enacted to change EEA into an Egyptian joint stock company under a name of "Egyptian Electricity Holding Company" or EEHC.

In July 2001 EEHC started restructuring their affiliated companies with unbundling of generation, transmission and distribution activities, and forming thirteen companies (consisting of five generation, one transmission and seven distribution companies). These restructuring efforts aimed at preparation for privatization of state owned companies. MOEE and EEHC might prepare an initial public offering of affiliated companies' stock (except a transmission company) up to 49% at the time.

In July 2002 Delta Company for electricity distribution was split into two distribution companies, North Delta Company and South Delta Company. In November 2004 Cairo Distribution Company was also split into two distribution companies, Cairo North Company and Cairo South Company. Hence now EEHC has nine distribution companies.

Fig. 2-1-1-1 shows the organizational structure of EEHC as of 2009. It consists of six generation, one transmission and nine distribution companies.

Otherwise Egypt has many other electric companies including BOOT generation companies. However amount of electricity with which these companies deal, except BOOT generation companies is very small.



Sources: EEHC Annual Report 2007/2008

Fig. 2-1-1-1 EEHC Organizational Structure (as of 2009)

Table 2-1-1-1 Private Electricity Utility in Egypt (as of 2008)

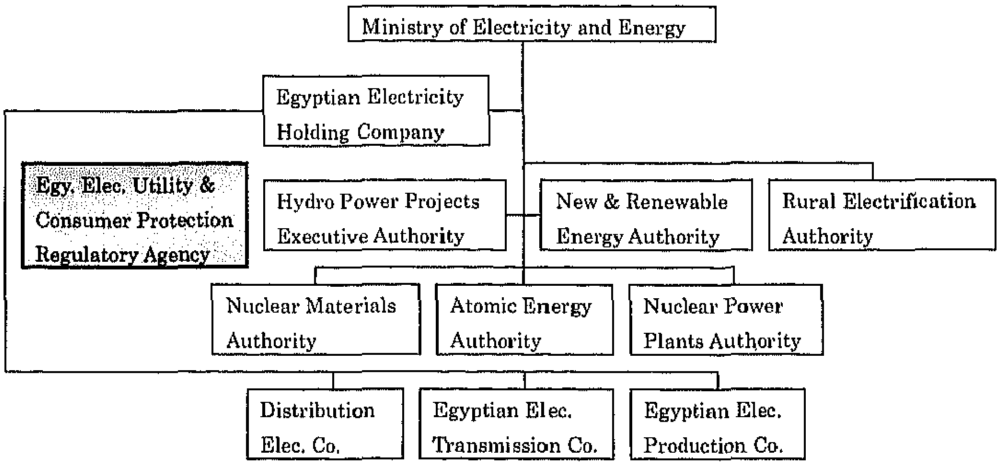
Service Type	**Company Name**
Generation	Port Said East Power Company(BOOT)
	Suez Gulf Power Company(BOOT)
	Sidi Krir Generating Company(BOOT)
Distribution	The Egyptian Chinese Joint Venture Company for Investment
	Delta Company For constructions and reconstruction
	Engineering group For electric energy
Generation & Distribution	Global Energy Company
	Alexandria Carbon Black co. SAE
	Om El Goreifat
	National Elecricity Technology Company(Kahraba)
	Mirage Company
	Sendian Company For Paper Industry
	Consukorra Company for commercial proxies and technical consultations
	Power House Company
	Generget Company For renewable energy

Sources: EEUCPRA H.P.

(2) Regulatory Organization in Power Sector

Fig. 2-1-1-2 shows a government organization in Egyptian power sector.

MOEE had been responsible for regulation of power sectors in Egypt for long time. Now Egyptian Electric Utility and Consumer Protection Regulatory Agency (herein after refer to "EEUCPRA") replaced the ministry. EEUCPRA was established based on presidential decree no.326 in 1997 and reorganized by presidential decree no.339 in 2000. Since the establishment almost coincided with participation of private companies in generation sector in 1996 and unbundling of EEA in 2000, EEUCPRA must intend to enhance privatization and liberalization of the power sector in Egypt.



Sources: MOEE H.P.

Fig.2-1-1-2 Government Organization related to Power Sector

According to EEUCPRA H.P., the objectives are as follows;

- ✓ to regulate, supervise, and control all matters related to electric power activities of generation, transmission, distribution and consumption, in a way that ensures availability and continuity of supply so as to satisfy consideration of environmental protection, interests of the electric power consumers as well as interest of producers, transmitters and distributors.
- ✓ to make condition for lawful competition in the field of electricity generation, transmission, and distribution, and avoid any monopolization within the Electric Utilities.

In order to accomplish the objectives, the agency implements following activities; to grant licenses related to construction, management, operation, and maintenance necessary for carrying out electric power production, transmission, and distribution activities, to define rules for withdrawing previously granted licenses, to define procedures for bringing complaints against such decisions, to settle any dispute among parties involved in power sector activities.

EEUCPRA comprises Board of Directors (BOD) chaired by the Minister of Electricity and Energy, Managing Directors supporting BOD, two main central departments and eight general departments. BOD consists of ten members. Three of those members represent for the electric utilities which means EEHC, three others experienced personal engaged with Neither public authorities, organizations, public sector companies nor public business sector companies; and the other four represents for the consumers.

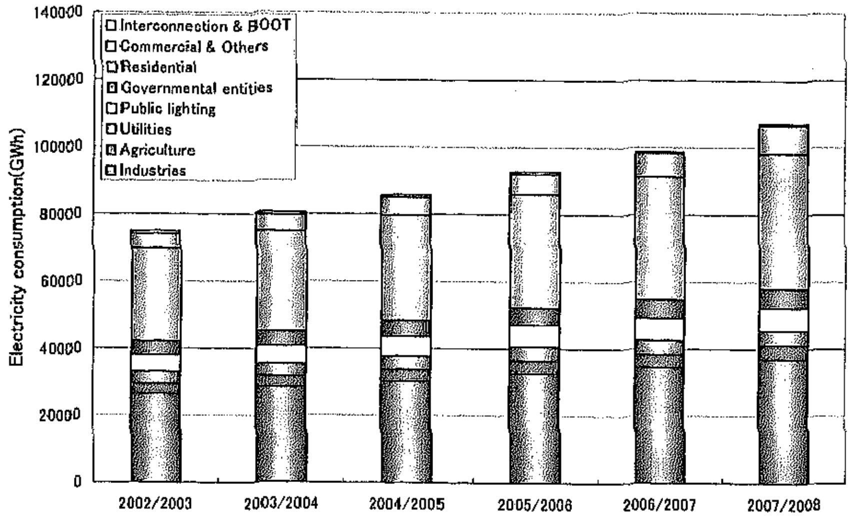
Taking into account that BOD includes member belonging to EEHC, it's supposed the agency might not be an independent regulatory body, as generally said in other countries and could be affected by decision of EEHC.

Clause2 Power Supply & Demand

(1) Current Situation of Power Supply & Demand in Egypt

1) Electricity Consumption

Fig. 2-1-2-1 shows yearly records of electricity consumption in Egypt. According to this, the consumption has reached 107,226GWh in fiscal year (FY) 2007/08. The growth rate during the period 2002/03-2007/08 is 7.4%. Particularly residential and industrial sector consume much energy by sector. The growth rates of both represent 8-10% during recent 3 years and show remarkable increment of electricity consumption.



Electricity Consumption	unit	2002/2003	2003/2004	2004/2005	2005/2006	2006/2007	2007/2008
Industries	GWh	26,525	28,386	30,284	32,701	34,569	37,045
Agriculture		2,991	3,280	3,460	3,719	3,789	4,209
Utilities		3,565	3,719	4,011	4,206	4,228	4,380
Public lighting		5,026	5,302	5,919	6,489	6,653	6,759
Governmental entities		4,040	4,331	4,710	5,054	5,562	5,891
Residential		27,717	29,823	31,311	33,900	36,596	40,271
Commercial & Others		4,256	4,801	5,393	6,016	7,046	8,240
Total		74,120	79,642	85,088	92,085	98,443	106,595

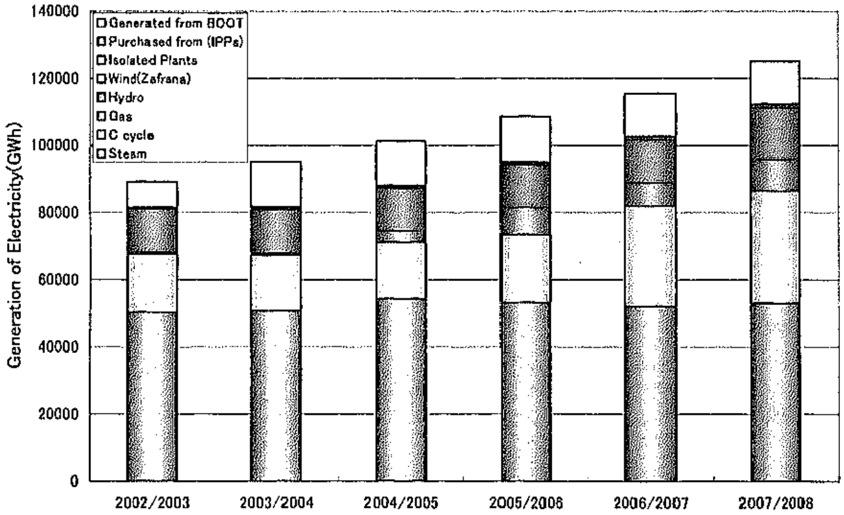
Sources: EEHC Annual Report

Fig. 2-1-2-1 Yearly Electricity Consumption

2) Generated Electricity

In order to meet their remarkable growth of electricity consumption, Egyptian power sector has been making efforts to increase generated electricity. As shown in Fig. 2-1-2-2 the generated electricity including that by IPP has reached 125,129GWH and Egypt has succeeded in increasing the energy at annual rate of 7% during the resent 5 year period FY 2002/03-2007/08.

Steam turbine (ST) plants which use natural gas & heavy or light oil generate the most electricity in amount. In addition BOOT plants are also same type. Hence, amount of electricity generated by ST plants accounts for 53% in FY2007/08. Since recently Egypt has promoted to introduce combined cycles(C cycle), electricity by them becomes accounting for 27% of total. These means that electricity generated by plant utilizing natural gas account for about 80% and natural gas is core energy in this country. Remaining electricity is generated by hydropower, wind power and gas turbine (GT) as peaking power. Particularly electricity by hydro power accounts for about 12% and has not been a main power source anymore, compared with that in old days.



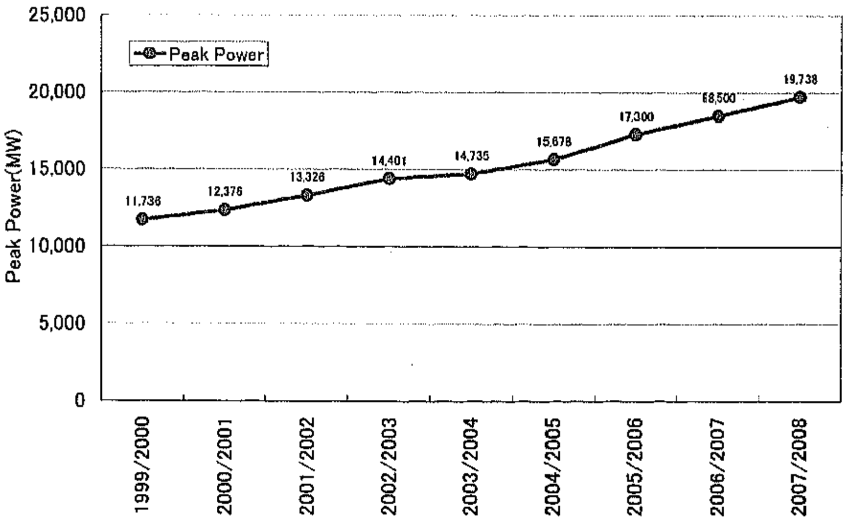
Type	unit	2002/2003	2003/2004	2004/2005	2005/2006	2006/2007	2007/2008
Steam	GWh	50,278	50,781	54,300	53,285	52,082	53,076
Gas		670	564	3,360	8,044	6,888	9,361
C cycle		17,256	16,603	16,900	20,236	29,892	33,345
Thermal total		68,204	67,948	74,560	81,565	88,862	95,782
Hydro		12,859	13,019	12,644	12,644	12,925	15,510
Wind(Zafrana)		204	368	523	552	616	831
Renewable total		13,063	13,387	13,167	13,196	13,541	16,341
Grid total		81,267	81,335	87,727	94,761	102,403	112,123
Isolated Plants		239	270	303	322	347	350
Purchased from (IPPs)		77	77	69	36	32	14
Generated from BOOT		7,607	13,501	13,200	13,571	12,625	12,642
Grand total		89,190	95,183	101,299	108,690	115,407	125,129

Sources: EEHC Annual Report

Fig. 2-1-2-2 Yearly Generated Electricity

3) Peak Power Demand

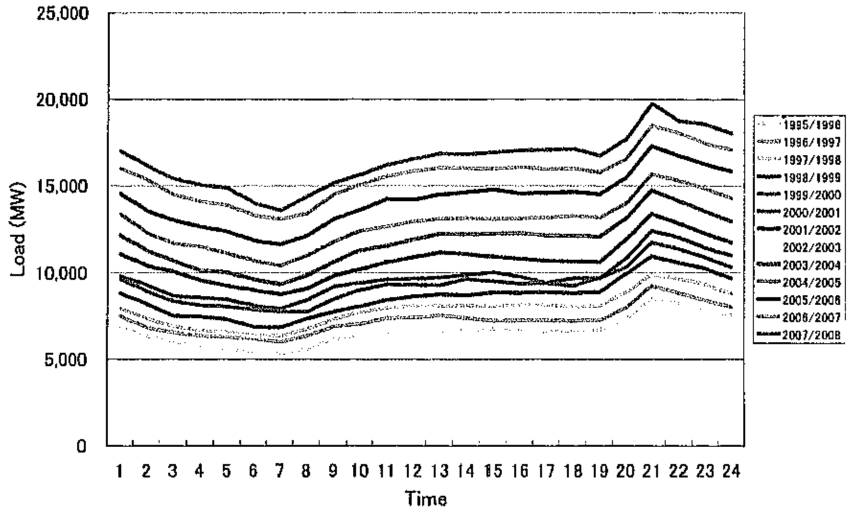
19,738MW of maximum peak power was recorded on June 30, 2008. Fig. 2-1-2-3 represents peak power recorded during the period FY1999/00-2007/08. Peak power has been increasing since FY1999/00 and the growth rate during the period reaches 6.7%.



Sources: EEHC Annual Report

Fig. 2-1-2-3 Peak Power Demand

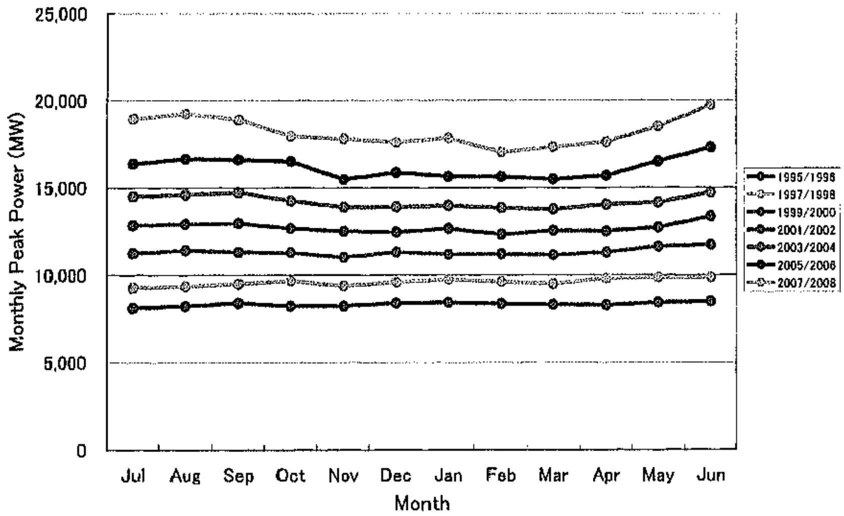
Fig. 2-1-2-4 shows daily load curves on the day when peak power occurred and it indicates that in Egypt power demand peaks at around 21:00. This implies that the power demand may be not only air conditioners but also for lighting & water heater.



Sources: Data by EEHC

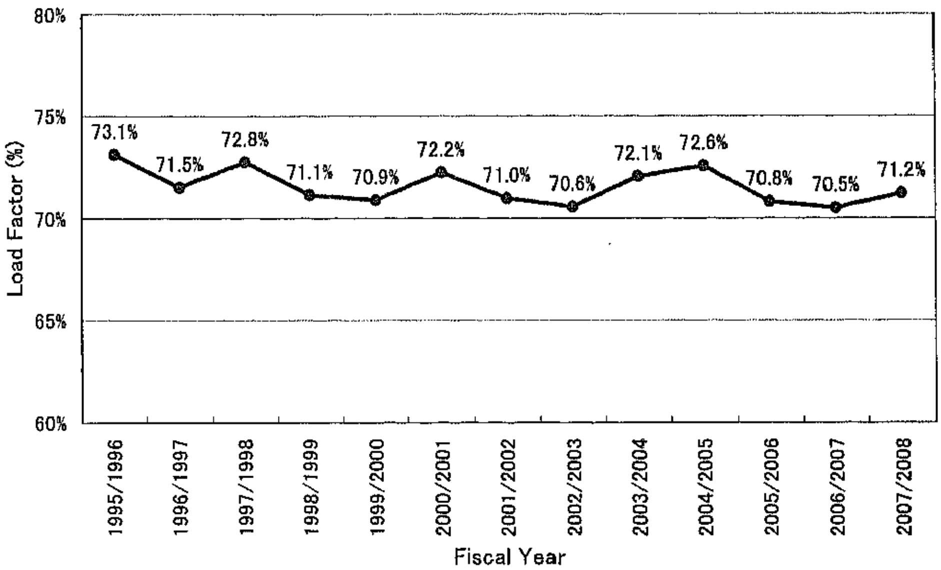
Fig. 2-1-2-4 Daily Load Curve on the day when peak demand occurred

Fig. 2-1-2-5 shows a trend of monthly peak power demand. Although in FY1995/96 there was not much fluctuation among months, in FY2005/06 there happened approximately 2,000MW gap between November and June. On the other hand yearly load factors (as seen in Fig. 2-1-2-6) doesn't illustrate a significant difference among years. So it's envisaged that in Egypt fluctuation of electricity consumption may be not large and not growing. Moreover the load factors are kept at more than 70% and it's at higher level compared with other countries.



Sources: Data by EEHC

Fig. 2-1-2-5 Monthly.Peak Power Demand



Sources: Data by EEHC

Fig. 2-1-2-6 Yearly System Load Factor

4) Power Supply Capacity

Power plants belonging Electricity Production Companies (EPC) are listed up in Table2-1-2-1, and Table2-1-2-2 shows BOOT power plants. General features of Egyptian power generation capacities are as follows;

- Total power generation capacity (installed capacity) : 22,583MW
- ST plant: 19 plants, 9,598MW in installed cap. (Accounting for 42.5%)
- C Cycle: 10 plants, 6,449MW in installed cap. (Accounting for 28.6%)
- Hydropower: 5 plants, 2,842MW in installed cap. (Accounting for 12.6%)
- Wind power: 1 plants, 305MW in installed cap. (Accounting for 1.4%)
- BOOT plants: 3 plants, 2,047MW in installed cap. (Accounting for 9.1%)

Particularly it should be noted that power generation capacity by natural gas & oil fired ST dominates in the total capacity and no coal-fired thermal plant is installed.

Table 2-1-2-1 General Feature of EPC's Power Plant

Company	Station	Type	No. of Units	Cap.(MW)	Commissioning Date	Efficiency(%)
Cairo	Shoubra	ST	4x315	1260	84-85-1988	37.7
	Cairo West	ST	4x87.5	350	66-1979	32.6
	Cairo West Ext.	ST	2x330	660	1995	39
	Cairo South 1	CC	3x110+4x60	570	57-65-1989	38.8
	Cairo South II	CC	1x165	165	1995	47
	Cairo North	CC	4x250+2x250	1500	05-2008	47.3
	Wadi Hof	G	3x33.3	100	1985	20.7
East Delta	Damietta	CC	6x132+3x136	1200	89-1993	45.9
	Ataka	ST	2x150+2x300	900	85-86-1987	37
	Abu Sultan	ST	4x150	600	83-84-1986	33.2
	Shabab	G	3x33.5	100	1982	23.8
	Port Said	G	2x23.96+1x24.6	73	77-1984	23.4
	Arish	ST	2x33	66	2000	37
	Oyoun Mousa	ST	2x320	640	2000	40.9
	Sharm El-Sheikh	G	2x23.7+4x24.27+4x5.8+2x5	178		-
	Hurghada	G	3x23.5+3x24.3	143		-
	Zafarana(Wind)		100x0.6+127x0.66+190x0.85	305	00-03-04-06-07-2008	-
Middle Delta	Talkha	CC	8x24.72+2x45.95	290	79-80-1989	36.5
	Talkha210	ST	2x210	420	93-1995	35.7
	Talkha750	CC	2x250+1x250	750	06-2008	36.3
	Nubaria	CC	4x250+2x250	1500	05-2006	53.4
	Mahmoudia	CC	8x25+2x58.7	316	83-1995	40.8
	Maumoucia	ST	1x50+1x25	75	81-1982	22.8
West Delta	Kafr El-Dawar	ST	4x110	440	80-84-1986	31.8
	Damanhour Ext.	ST	1x300	300	1991	37.9
	Damanhour(Old)	ST	3x65	195	68-1969	31.8
	Damanhour	CC	4x24.62+1x58	156.5	85-1995	40.7
	El-Seiuf	G	6x33.3	200	81-82-83-1984	28.6
	El-Seiuf	ST	2x26.6+2x30	113	61-1969	18.8
	Kamouz	G	1x11.37+1x11.68	23.1	1980	22.5
	Abu Kir	ST	4x150+1x311	911	83-84-1991	37.9,39.7
	Abu Kir	G	1x24.27	24.3	1983	
	Sidi Krir 1,2	ST	2x320	640	99-2000	42
	Matrouh	ST	2x30	60	1990	28.6
Upper Egypt	Walidia	ST	2x312	624	92-1997	36.8
	Kuriemat 1	ST	2x627	1254	98-1999	41.7
	Kuriemat 2	CC	2x250+1x250	500	2007	37.5
	Assiut	ST	3x30	90	66-1967	29.4
Hydro Plants	High Dam		12x175	2100	1967	90.1
	Aswan Dam I		7x46	322	1960	83.5
	Aswan Dam II		4x67.5	270	85-1986	90.1
	Esna		6x14.28	86	1993	83.5
	New Naga Hamadi		4x16	64	2008	

Sources: EEHC Annual Report

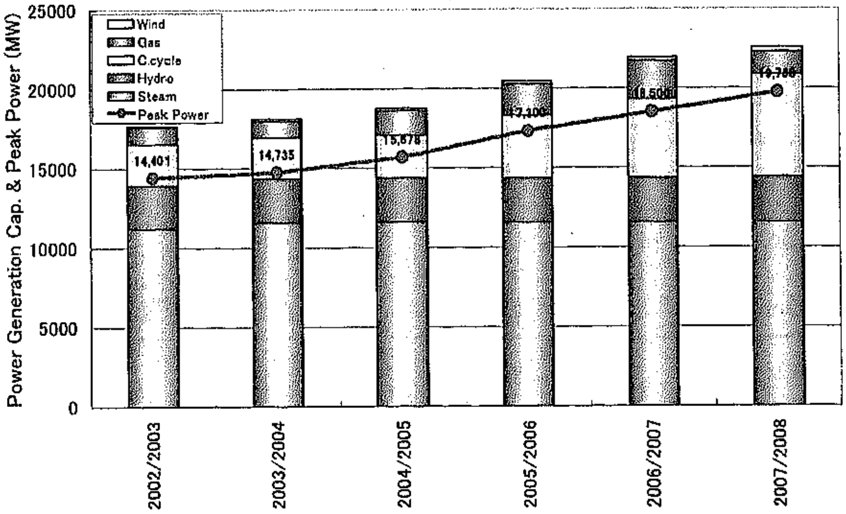
Table 2-1-2-2 General Feature of BOOT Power Plant

Company	Station	Type	No. of Units	Ins. Cap.(MW)	Commissioning Date
East Delta	Suez Gulf	ST	2x341.25	682.5	2002
	Port Said East	ST	2x341.25	682.5	2003
West Delta	Sidi Krir 3,4	ST	2x341.25	682.5	2002

Sources: EEHC Annual Report
Note: CC(Combined Cycle), G(Gas turbine), ST(Steam Turbine)

Fig. 2-1-2-7 shows generation capacities by plant type. Followings are notified hereby.

- Generation capacity by ST is almost constant and proportion of it has been decreasing year by year.
- On the contrary C Cycle development has been promoted since FY2005/06 and the proportion of the capacity has been increasing.
- Little hydropower has been developed and, however, its role has become minor compared with it in old days.
- Wind power has been introducing since 2000.



Unit : MW

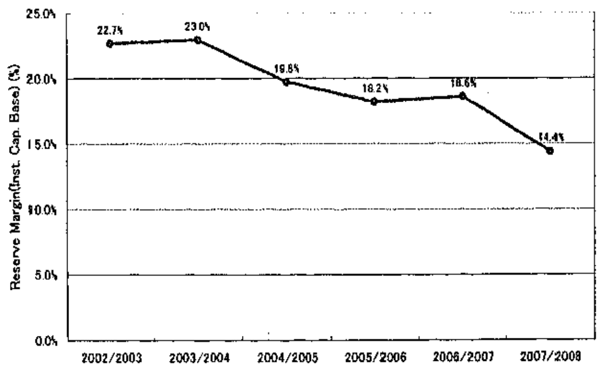
Type	2002/2003	2003/2004	2004/2005	2005/2006	2006/2007	2007/2008
Wind	63	140	140	183	225	305
Gas	1,055	1,019	1,537	1,966	2,416	1,416
C.cycle	2,605	2,605	2,699	3,949	4,949	6,449
Hydro	2,745	2,745	2,783	2,783	2,783	2,842
Steam	11,203	11,610	11,616	11,571	11,571	11,571
Total	17,671	18,119	18,775	20,452	21,944	22,583
Peak Power	14,401	14,735	15,678	17,300	18,500	19,738

Sources: EEHC Annual Report

Fig. 2-1-2-7 Generation Capacity by Energy Source

5) Reserve Margin Rate (based on Installed capacity)[1]

Fig. 2-1-2-8 shows yearly reserve margin rate based on installed capacity in Egypt. The rate has been decreasing and in FY2007/2008 it's become less than 15% in the end. Egyptian criterion of loss of load expectation (LOLE) is 8 hour/year and the required reserve margin rate corresponded with this is about 18-20%. Hence balance between power demand and supply may have been in very severe situation currently.



Sources: EEHC Annual Report

Fig. 2-1-2-8 Reserve Margin (Installed Capacity Base)

1 Reserve Margin Rate(Installed Capacity Base) : RMR = (Total installed cap.-Peak power)/Peak power - 1

(2) Forecasts of Electricity Consumption & Peak Power Demand

Table2-1-2-3 shows forecast of electricity consumption and peak power demand during the period FY2007/08-2012/13. Egypt prospects their peak power will grow up to 26,753MW in FY2012. As shown in Table 2-1-2-4 Egyptian criterion of LOLE is 8 hour/year and the required reserve margin rate corresponded to the LOLE is about 18-20%. Taking into account 18% of reserve margin rate, 4,815MW of reserve margin will be required in FY2012/13. And Egypt will need 31,568MW of total generation capacity at that time, as seen in Table2-1-2-3.

Table 2-1-2-3 Demand Forecast of Electricity Consumption & Peak Power for Future 5years

Year	Peak Load (MW)	GR (%)	Energy Consumption (GWh)	GR (%)	Require Cap. Based on reserve margin rate18%
2007/2008	19,738.0	6.7	107,189.1	8.5	23,290.8
2008/2009	20,999.6	6.4	114,211.8	6.6	24,779.5
2009/2010	22,329.8	6.3	121,628.8	6.5	26,349.2
2010/2011	23,729.0	6.3	129,443.9	6.4	28,000.2
2011/2012	25,199.8	6.2	137,673.3	6.4	29,735.8
2012/2013	26,752.7	6.2	146,326.0	6.3	31,568.2

Table 2-1-2-4 LOLE Criteria & Reserve Margin Target

Reserve Margin (%)	18-20
Loss of Load Expectation (Hour / Year)	8

(3) Power Development Planning

EEHC annual report says that in ordered to meet the demand prospected in the previous section, they has plan to develop 8,547MW of additional & indicative plants including 7,550MW of C Cycle during the period FY2007/08-2011/12.

Egypt government also published the same plan in the 6th Five Year Plan as shown Table2-1-2-5 concretely.

Table 2-1-2-5 PDP in 6th Five Year Plan

Project Name	Type	2007/08	2008/09	2009/10	2010/11	2011/12
Zaafrana-Gabal EL Zeit	Wind	150	125	130	160	200
Naga Hamady	Hydro	64				
North Cairo(2)	C cycle	250				
Talkha	C cycle	250				
Korymat(2)	C cycle	250				
Korymat(3)	C cycle		500	250		
Nobaria	C cycle		500	250		
Tebin	Steam			700		
Korymat	Solar/Gaseous		150			
Expansion of west Cairo	Steam				700	
Al-Arf	C cycle		500	250		
Small water units	Hydro			13	5	
Sidi Krer	C cycle		500	250		
Abu Keir	Steam				650	650
Oyoun Mosa	Steam					350
Sharm El-Shelkh	C cycle					750
Total annual added cap.		964	2275	1843	1515	1950

Sources: The 6th Five Year Plan

Fig. 2-1-2-9 shows a power balance based on the demand forecast and the power development planning.

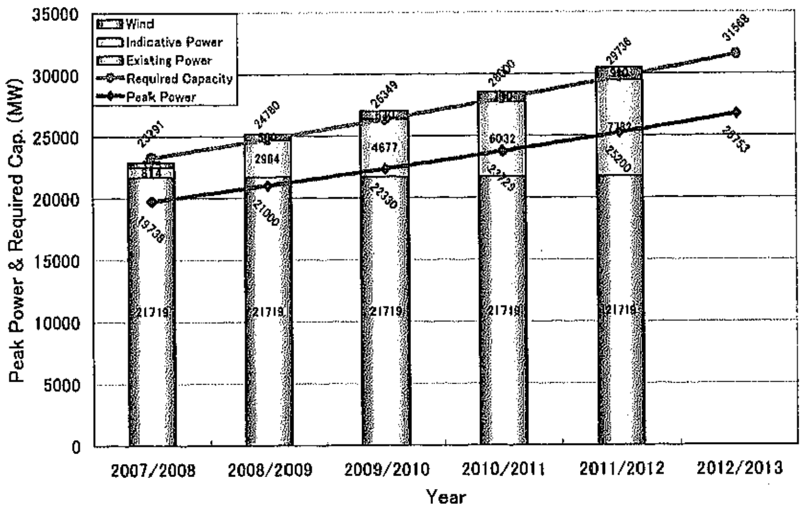


Fig. 2-1-2-9 Power Balance based on Demand Forecast & PDP

Clause3 National Sustainable Development Strategy

The main elements of the Egyptian Ministry of Electricity and Energy sustainable development strategy are as follows:

- ✓ To implement measures to encourage energy efficiency and use of renewable energy.
- ✓ To diversify energy sources to reduce Egypt's reliance on gas for power generation.
- ✓ To develop nuclear option to ensure future energy supplies at reasonable cost in comparison with alternative sources of energy.
- ✓ To accelerate installation of wind turbines to cope with the Supreme Council for Energy long-term plan to meet 20% of electricity demand by renewable energy.
- ✓ To upgrade the interconnection network with neighboring countries to maximize the efficient use of regional resources.

Clause4 The 6th Five Year Plan and Progress on the Plan

Egypt government has "Five Year Plan" including measures to stimulate investment, plans to expand public infrastructures and so on, in order to accomplish tangible socio-economic development. At present Egypt is in term of "The 6th Five Year Plan (2007/08-2011/12)". Targets of the plan are as follows;

- ✓ To enhance economic reform to foster development
- ✓ To promote private sector participation in economic activity through allowing the private sector to carry on two-third of total investment
- ✓ To create employment through the stimulation of private investments

(1) The Five Year Plan in Power & Energy Sector

1) Develop Planning Policy in Power & Energy Sector

Develop planning policies in power & energy sector are as follows;

- To provide electric power for all industrial, agricultural, tourism and services projects at proper time to avoid delay in projects' execution
- To optimize the use of all energy sources, especially renewable friendly-environment sources
- To consolidate electricity networks in rural areas to enhance further development
- To expand joint projects with African countries to strengthen regional cooperation

(2) Target in Power Sector

Targets of the plan in their power sector are as follows;

- ✓ To add generation capacity of 8,547MW of which 964MW is planed during the Plan's first year
- ✓ To expand the use of renewable generation sources to reach 12% of total additional capacities to diversify energy sources and gradually substitute renewable friendly-environment for traditional sources based on heat generation
- ✓ To add transformation stations with total capacities of 16,950MVA
- ✓ To extend air networks and ground cables for total length of 52,330km
- ✓ To increase average per-capita consumption of energy by an annual rate of 7%

(3) Development Plan

Followings represent development plan in each sector in detail.

1) Generation Sector (see Table2-1-2-5)

- Thermal Power: The plan includes implementation of thermal power plans that are expected to increase capacities of 7,550MW with 750MW in the first year. About 4,500MW will be generated through C Cycle and the rest additional capacities will be supplied by ST. EHCC and EEPC are assigned to implement the entire power plant projects.
- Wind Power: In the plan, there are a number of projects to generate electricity from renewable sources. It's targeted to add electric power of about 765MW through wind power, to reach a total wind generation capacity of 1,050MW by the end to the plan.
- Hydropower: It's expected to add capacities of 82MW, of which 64MW will be added within the first year 2007/08.
- Solar Heat Generation: The plan includes adding 150MW of solar heat energy in Korymat area.

2) Transmission & Distribution

EEHC is assigned to establish necessary network to transfer produced energy from power plants with total capacity of 16,950MVA and expanding aerial networks and ground cable of total length of 52,330km which includes Aswan/Shalatin line (345km) and Sidi Barrani/El Sallum line (80km).

3) Rural Electrification

- To implement 13 transformation stations with total capacity of 650MVA
- To extend 460km aerial lines
- To replace and renew electrical networks for 615 previously lightened village
- To lighten 1,880 household units and 105 inland desert villages
- To supply electricity to 1 million feddans of reclaimed lands belonging to companies and individuals

(4) Progress on the 6th Five Year Plan

Table2-1-4-1 and 2-1-4-2 shows progress on the 6th Five Year Plan in the first year, FY2007/08.

Regarding power generation sector, implementation of hydropower and thermal power development is almost on schedule. On the other hand, only 80MW of wind power was developed compared with 150MW planed originally.

Regarding transmission and distribution, about 5,500MVA of transformer and 12,000km of transmission lines have already been expanded.

Table 2-1-4-1 Progressing Situation of PDP

Project Name	Type	Status	2007/08	2008/09
Zaafrana-Gabal EL Zeit	Wind	Plan	150	125
		Commissioning	80	
Naga Hamady	Hydro	Plan	64	
		Commissioning	64	
North Cairo(2)	C cycle	Plan	250	
		Commissioning	250	
Talkha	C cycle	Plan	250	
		Commissioning	250	
Korymat(2)	C cycle	Plan	250	
		Commissioning		250

Sources: EEHC Annual Report

Table 2-1-4-2 Progressing Situation of Expansion of Transmission & Distribution Sys.

	Transformar Capacity(MVA)	Transmission Lines(km)
The 6th Five Year Plan	16,950	52,330
Expantion in FY'2007/08	5,568	11,821

Sources: EEHC Annual Report

Clause5 Current Status of Power Sector Reform

It should be noticed that turning points of power sector reform in Egypt are enactment of Law No.100 in 1996 and Law No.164.

The Former was to allow not only domestic but also international private investor to participate in Egyptian power generation sector such as BOOT power plant sector. The latter was for unbundling EEA into EEHC and affiliate companies consisting of generation, transmission, distribution companies and preparing for condition of privatization of the companies.

Sidi Krir power plant was developed by InterGen. Suez Gulf plant and Port Said plant were developed by EdF. These plants ware implemented as a BOOT scheme with 20 years of contract period. The PPA contract conditions were as follows;

- ✓ 20 years, US dollar denominated power purchase agreement exclusively between IPP and EEHC
- ✓ Take-or-pay provisions for capacity factor of 65% for Sidi Krir, 70% for Port Said and Suez
- ✓ To make monthly capacity payments & energy payments
- ✓ Sovereign guarantees signed between the Egyptian Central Bank and IPP to cover EEHC payments including termination payment

Since these conditions were very attractive for private investor, there were many companies which intended to take part in bids for the IPP scheme at the first stage. After implements of the three plants, however, Egypt suffered from devaluation caused by currency liberalization of Egyptian pond in early 2003 and increment of payment for the BOOT because PPA was contracted based on US dollar. EEHC and Egypt government reviewed the situation and revised contract conditions for new participants. Because these are restricted one, little investors have participated in power sector newly since then.

Regarding privatization of EEHC, MOEE and EEHC have been preparing an initial public offering of affiliated companies' stock (except a transmission company) up to 49%. However it has not been implemented yet as of 2009.

Section 2 Energy Efficiency in Egypt

Clause1 Primary Energy Consumption

Table2-2-1-1 shows primary energy balance in Egypt in 2006 and Fig. 2-2-1-1 indicates trend of yearly total primary energy supply. Hereby total primary energy supply has been increasing year by year and reached 62,501ktoe (ton of oil equivalent) in 2006. Particularly natural gas supply has been growing since 2000 dramatically.

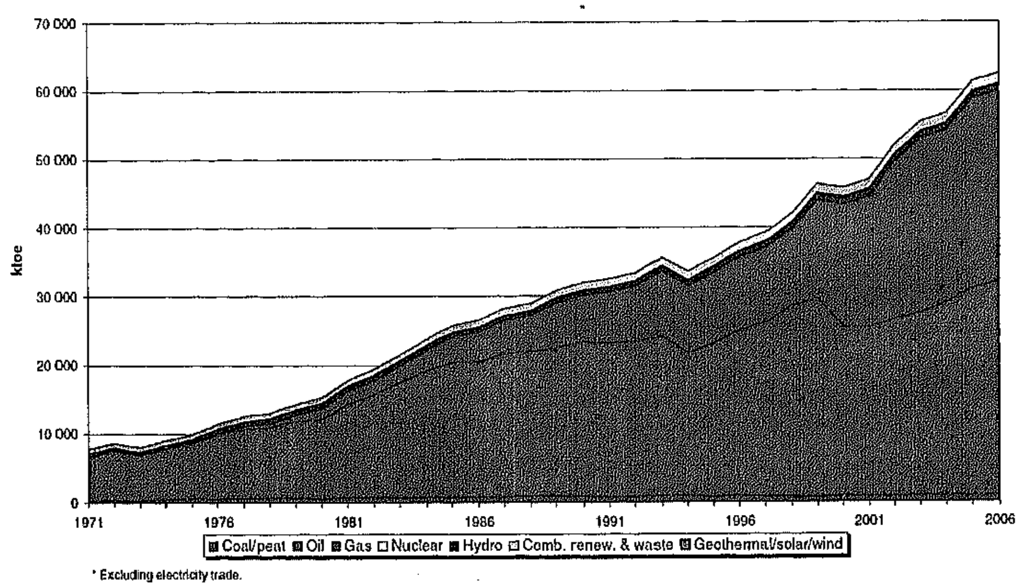
Final energy consumption by each sector in 2006 can be seen in Fig. 2-2-1-2. Energy consumed by the industrial sector is the most in the countries and account for 34% followed by the transport sector accounting for 27% and residential sector accounting for 20%.

Table 2-2-1-1 Energy Balance Sheet of Egypt (in2006)

uni : ktoe

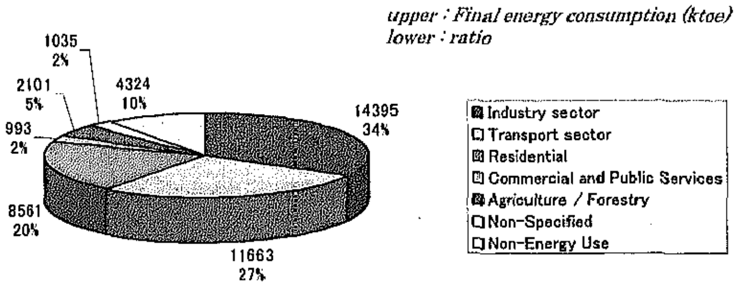
SUPPLY and CONSUMPTION	Coal and Peat	Crude Oil	Petroleum Products	Gas	Hydro	Geothermal, Solar, etc.	Combustible Renewables and Waste	Electricity	Total
Production	15	33571	0	41602	1112	53	1477	0	77830
Imports	1,227	2433	3670	0	0	0		18	7349
Exports	-372	-2908	-4538	-13828	0	0	-22	-48	-21715
International Marine Bunkers**	0	0	-1055	0	0	0	0	0	-1055
Stock Changes	0	0	93	0	0	0	0	0	93
Total Primary Energy Supply	**871**	**33096**	**-1830**	**27774**	**1112**	**53**	**1456**	**-30**	**62501**
Transfers	0	-1192	1325	0	0	0	0	0	133
Statistical Differences	57	0	-37	0	0	0	0	0	19
Electricity Plants	0	0	-4185	-17464	-1112	-53	0	9925	-12889
Gas Works	-20	0	0	8	0	0	0	0	-11
Petroleum Refineries	0	-31905	31386	0	0	0	0	0	-518
Coal Transformation	-497	0	0	0	0	0	0	0	-497
Own Use	0	0	-1155	-3082	0	0	0	-347	-4584
Distribution Losses	0	0	0	0	0	0	0	-1082	-1082
Total Final Consumption	**411**	**0**	**25503**	**7235**	**0**	**0**	**1456**	**8466**	**43072**
Industry sector	**411**	**0**	**6361**	**3908**	**0**	**0**	**743**	**2973**	**14395**
Transport sector	**0**	**0**	**11381**	**282**	**0**	**0**	**0**	**0**	**11663**
Other sectors	**0**	**0**	**5926**	**558**	**0**	**0**	**713**	**5493**	**12690**
Residential	0	0	4143	558	0	0	713	3147	8561
Commercial and Public Services	0	0	0	0	0	0	0	993	993
Agriculture / Forestry	0	0	1783	0	0	0	0	318	2101
Non-Specified	0	0	0	0	0	0	0	1035	1035
Non-Energy Use	**0**	**0**	**1836**	**2488**	**0**	**0**	**0**	**0**	**4324**

Sources: IEA HP



Sources: IEA HP

Fig. 2-2-1-1 Primary Energy Supply in Egypt

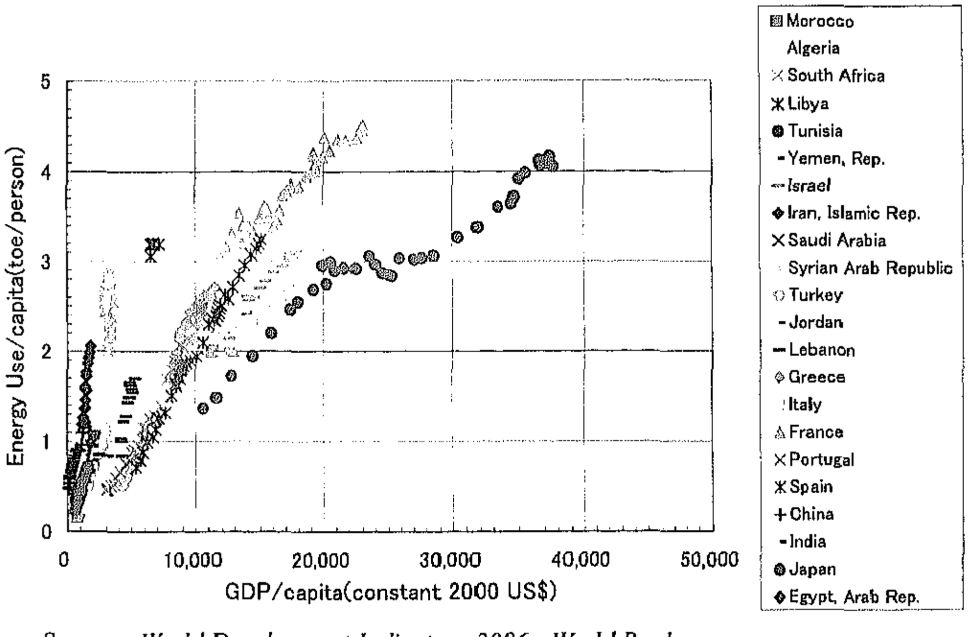


Sources: IEA HP

Fig. 2-2-1-2 Final Energy Consumption (in 2006)

Fig.2-2-1-3 shows a correlation between energy use per capita and GDP per capita. This illustrates the energy use per capita hasn't reached one (1) toe in 2003 and it's less than a quarter (1/4) of that in developed countries such as France or Japan. On the contrary it's envisaged that the energy use in Egypt could grow at significantly high rate as its economy is emerging in near future.

Energy Elasticity which indicates situation of energy saving (it's related with incline of line in the figure below) is 1.05 in Egypt. It's higher compared with 0.89 in Japan. The lower Energy Elasticity is the more efficiently the country uses energy. On this view point, Egypt may have some potential to save energy and will be required to do so in the future.



Sources: World Development Indicators 2006 ; World Bank

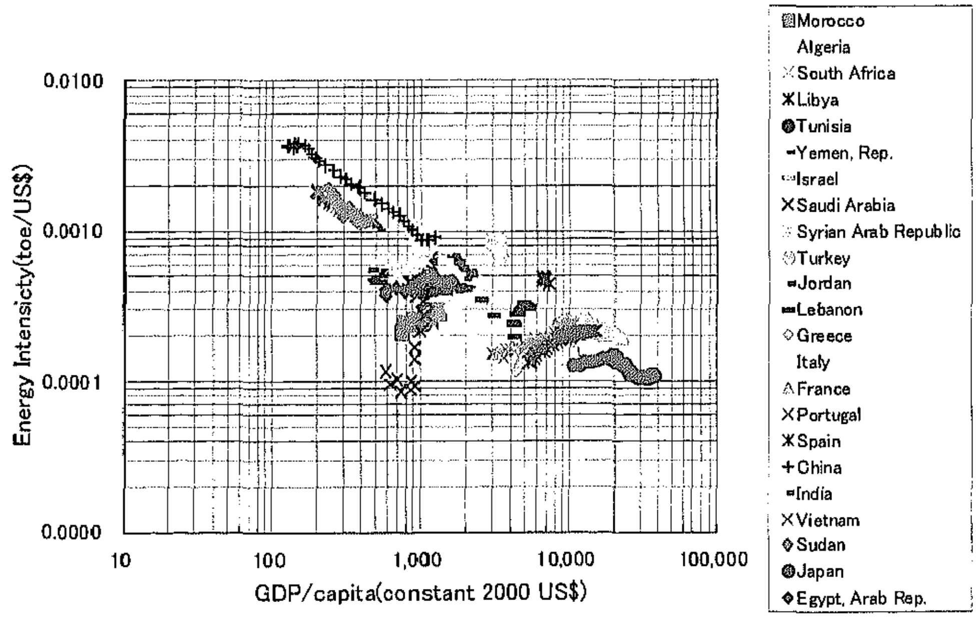
Fig.2-2-1-3 Correlation between GDP & Energy Use

Fig.2-2-1-4 represents Energy Intensity which indicates a amount of energy consumed to produce a USD of GDP and it means a measure of the energy efficiency of a nation's economy.

In this graph, the bottom-righter hand data locates in, the more developed country it means that of. Those of emerging countries located in the center of the chart. The reasons why the data of developed country is shifting into bottom-right hand side are as follows; (1) as the economy is highly emerging, the industrial structure is transforming to finance

& service sector dominance (which consume less energy) from heavy industry sector dominance (which consume huge energy), and (2) in developed country energy saving measures have been so progressing that energy saving commodity and industrial facilities have been diffused widely.

The Energy Intensity of Egypt is approximate 4.6×10^{-4}toe/US$ in 2003 and four (4) times more than 1.1×10^{-4}toe/US$ in Japan. On this view point, Egypt is expected to be shifting to energy saving society based on promotion of changing their industrial structure and energy consuming society.



Sources: World Development Indicators 2006 ; World Bank

Fig.2-2-1-4 Correlation between GDP & Energy Intensity

Clause2 Plan and activity of Egypt regarding improvement of energy efficiency in Power Sector

Energy efficiency measures which EEHC is taking are basically same as what Egypt government is implementing.

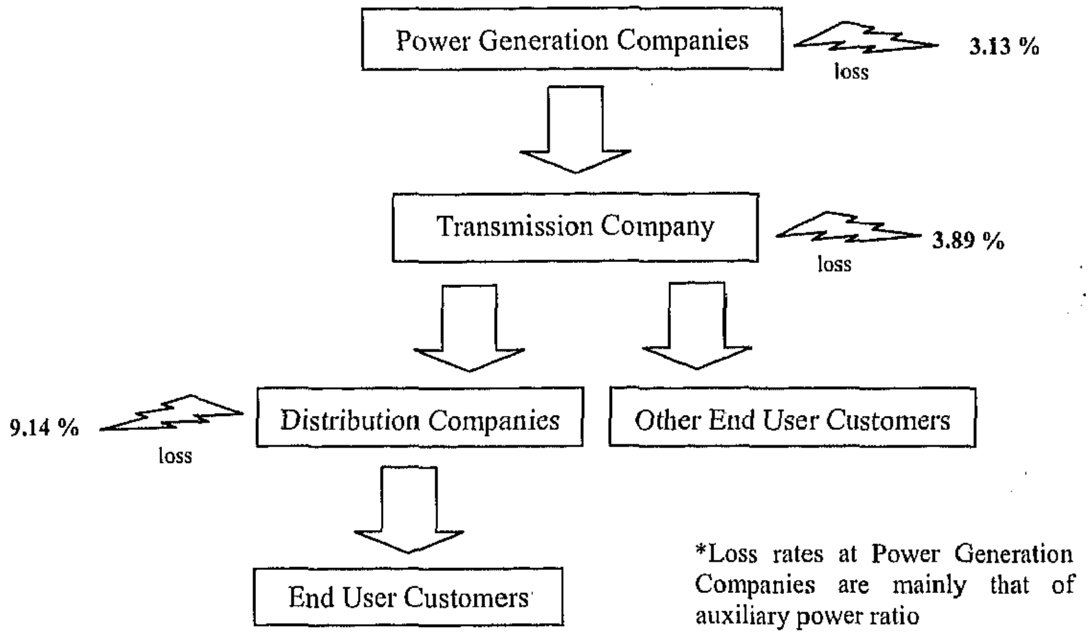
They have three main points. The first one is promotion of developing renewable energy including significant wind power, hydro power and solar power. The second one is to utilize natural gas effectively by maximizing use of C Cycle. The last one is to diffuse compact fluorescent light bulbs (CFLB) and to replace incandescent lights for road lighting with fluorescent lights actively.

In respect to CFLB, EEHC's subsidies corresponded with a half value of purchasing cost for CFLB are promoting to be installed in residential and commercial sector. As result approximately five(5) millions of CFLBs have been introduced until now. In regard with fluorescent lights for read lighting six(6) millions of the lights have been installed so far.

The 7th five year plan, the next plan, is now been examining and did not finalized yet. According to EEHC it's envisage that the plan would comprise not only the three main points of the 6th five year plan but also promotion of nuclear, bench mark activity of energy intensities, construction of framework for introducing energy efficiency buildings and installation of LED road lighting.

Clause3 Loss in Electric Power System

In the year of 2007/2008, 4,663GWh of energy loss has been observed in Transmission Company as shown in Fig. 2-2-3-1.
This is nearly half of the loss that has been observed from distribution of energy to end user customers.



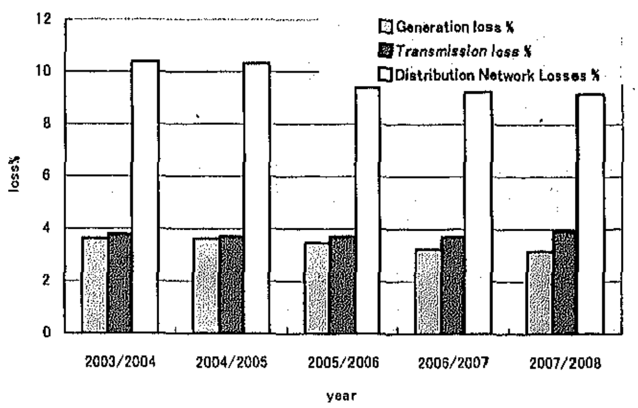
Data source: EEHC / prepared by the Team

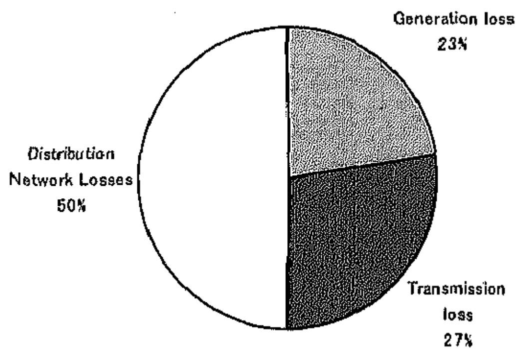
Fig. 2-2-3-1 Electric Power Energy Flow (DATA 2007/2008)

Loss data in electric power system is shown in Table 2-2-3-1. The data shows that the loss in transmission line is not larger than that of the distribution network. Moreover, the loss is about half of distribution network's.

Table 2-2-3-1 Loss in Electric Power System

Year	2003/2004	2004/2005	2005/2006	2006/2007	2007/2008
Generation loss %	3.63	3.64	3.43	3.25	3.13
Transmission loss %	3.78	3.72	3.73	3.71	3.89
Distribution Network Losses %	10.38	10.28	9.38	9.24	9.14





Data source: EEHC / prepared by the Team

Section3 Plan and activity of other donors regarding energy efficiency

At the current, WB, AfDB, USAID, KfW, GTZ, UNDP, AFD, GEF maintain their local office in Egypt (of course including JICA) and make activities as a donors. The team has been studying on their cooperation activities on energy saving projects in Egyptian power sector based on some interview surveys, desk research through some publication, HP and so on.

【Interview survey】
WB Cairo Office, AfDB Cairo Office, KfW Cairo Office, UNDP Cairo Office & EEIGGR Office

【Desk research】
WB, AfDB, KfW, USAID, GTZ, AFD, GEF

The achievement of interview survey can be summarized in the table below.

Table 2-3-1-1 Interview Survey on Activities for Energy Efficiency

	World Bank	**African Development Bank**	**KfW**
Responder	Dr. Mohab Halloud	Dr.Khaled EL-ASKARI	Mr. Andreas Holtkotte, Ms. Sherine ElGhatit
On-going projects regarding energy efficiency	Non	**<El Kureimat C Cycle Power Plant Project>** **Type :** C Cycle **Installed capacity :** 3x250MW **Total project cost :** 340 million USD	**<Rehabilitation of Thermal Power Plant>** **Feature :** In a case of electricity generation sector of Egypt, KfW is financing to improve the efficiency level of power station. **Total project costs :** N/A
Plan of energy efficiency projects	Making consultant EEHC about implementation of fact finding study on energy efficiency and North Cairo Electricity Distribution Company about diffusing compact fluorescent light bulb. (however not having obtained the EEHC's reaction yet)	Non	KfW is focusing in DSM including prevalence of Energy efficiency light and consulting manufacturer for energy saving.
Other activities in power sector	**<Ain Sokhna Power Project>** **Type :** Steam Turbine **Installed capacity :** 2x650MW **Total project cost :** 2,189.8 million USD **<El-Tebbin Power Project>** **Type :** Steam Turbine **Installed capacity :** 700MW **Total project cost :** 449.6 million USD	**<Ain Sokhna Power Project>** **Type :** Steam Turbine **Installed capacity :** 2x650MW **Total project cost :** 2,004 million USD **<Abu Qir Power Project>** **Type :** Steam Turbine **Installed capacity :** 2x650MW **Total project cost :** 1,419 million USD	**<New Naga Hammadi Power Project>** **Type :** Conventional Hydropower **Installed capacity :** 64MW

	UNDP
Responder	Dr. Mohamed Bayoumi Dr. Ibrahim Yassin Mahmoud (EEIGGR Director)
On-going projects regarding energy efficiency	**<Energy Efficiency Improvement & Greenhouse Gas Reduction(EEIGGR)>** **EEIGGR Feature:** EEIGGR consists of three components. The objectives of the components are as follows; ○ Component 1: Loss Reduction, Load Shifting and Load Management in the UPS ○ Component 2 : Energy Efficiency Market Support ○ Component 3 : Cogeneration **【Component 1】** The activities of Component 1 comprise followings. ● To Reduce Transmission Losses ● To Set Priorities for Dynamic Response of Generating Unit

	● Network Analysis & Control Strategies ● Load Shifting through (TOU) Tariff The activities have already been completed. **Project costs :** 5.9MUSD(GEF:4.1MUSD, Egypt gov. : 1MUSD, UNDP : 0.8MUSD) **[Component 2]** The activities of Component 2 comprise followings. ● Energy Efficiency Industry Support by ESCO ● Energy Standard & Labeling ● Energy Codes for New Buildings ● Energy Efficiency Center Component 2 is now at stage of approving procedure. **Prospected project costs :** 0.8MUSD **[Component 3]** The activities of Component 2 comprise followings. ● Legal Framework for Cogeneration ● Agriculture Waste
Plan of energy efficiency projects	Non
Other activities in power sector	Non

Table 2-3-1-2 Desk Research on Activities for Energy Efficiency

USAID	Improving hydropower efficiency based on rehabilitation of existing plants (Aswan High Dam)
GTZ	Training on EEHC operators for operating thermal power plants efficiently
GEF (Global Environment Facility)	Supporting NGO to diffuse energy efficiency appliances to residents by Small Grant Program (SPG)

Based on the survey and research, it's envisaged that other donors would not deal with energy saving projects in Egyptian distribution sectors which JICA focus on yet.

Chapter 3

Potential of improvement and Candidates of project in energy efficiency of power sector in Egypt

Chapter 3 Potential of improvement and Candidates of project in energy efficiency of power sector in Egypt

Section 1 Potential of Energy Efficiency

Clause1 Potential of Energy Efficiency Improvement in Power Generation

(1) Optimal Generation Mixture (Best Mix)

First in this section, a study on power generation mixture which utilizes energy and fuel most efficiently shall be implemented. Generally if such a study is done, it should be analyzed based on searching the optimal generation mixture which consumes the least energy with some operation simulation tools such as WASP-IV (Wien Automatic System Planning; IAEA) or PDPAT-II (Power Development Planning Assist Tool; Tokyo Electric Power Company). However implementation of such a study needs detail information of all power plants and much time, and this study does not afford to do it. Hereby the team decided to select "Screening Curve Method" (refer to appendix 3.3-1 which represents the methodology in detail) which is a simple and easy way to analyze the optimal mixture.

This method is based on combination of a linear analysis of generation costs by plant type and a duration curve of power demand. And it's used for optimization of power development planning basically. Fortunately since Egyptian power sector is utilizing almost uni-fuel-type (i.e. natural gas); the optimal power development combination is almost same meaning as the optimal generation mixture.

Fig.3-1-1-1 shows a screening curve in Egypt. Upper chart indicates annual generation costs, and until 2% of capacity factor, it can be economical and efficient to generate by GT. Between 2% and approximate 30% of capacity factor it may be efficient to generate by conventional ST and over 30% C Cycle should generate.

When an analyzing which demand range each power type should meet by reflecting each capacity factor to the lower chart, which is a power demand duration curve, it can be noticed that GT should generate to meet power demand between 18,500MW and 17,000MW of which amount is 1,500MW accounting for 9% of peak power. Table3-1-1-1 was obtained by analysis for conventional ST and C Cycle in a similar way. Moreover Table 3-1-1-2 shows the optimal mixture considering nuclear power plants and pumped storage power plants or PSPP in addition for a reference.

Table3-1-1-1 indicates proportions of current power system and that in the end of the 6th Five Years Plan. It shows both of ST portions are larger and both of C Cycle portion are smaller compared with the optimal mixture. Meanwhile Egypt government and EEHC declared to promote to develop C Cycle, it's expected to prompt it furthermore merely on energy saving, based on the result.

Through the analysis, the promotion of C Cycle can be selected as an option of energy saving projects.

The 6th Five Year Plan still has many conventional ST projects. Hence, only in the view of energy efficiency, not only existing old ST plants but also these future ST projects should be replaced with C Cycle projects.

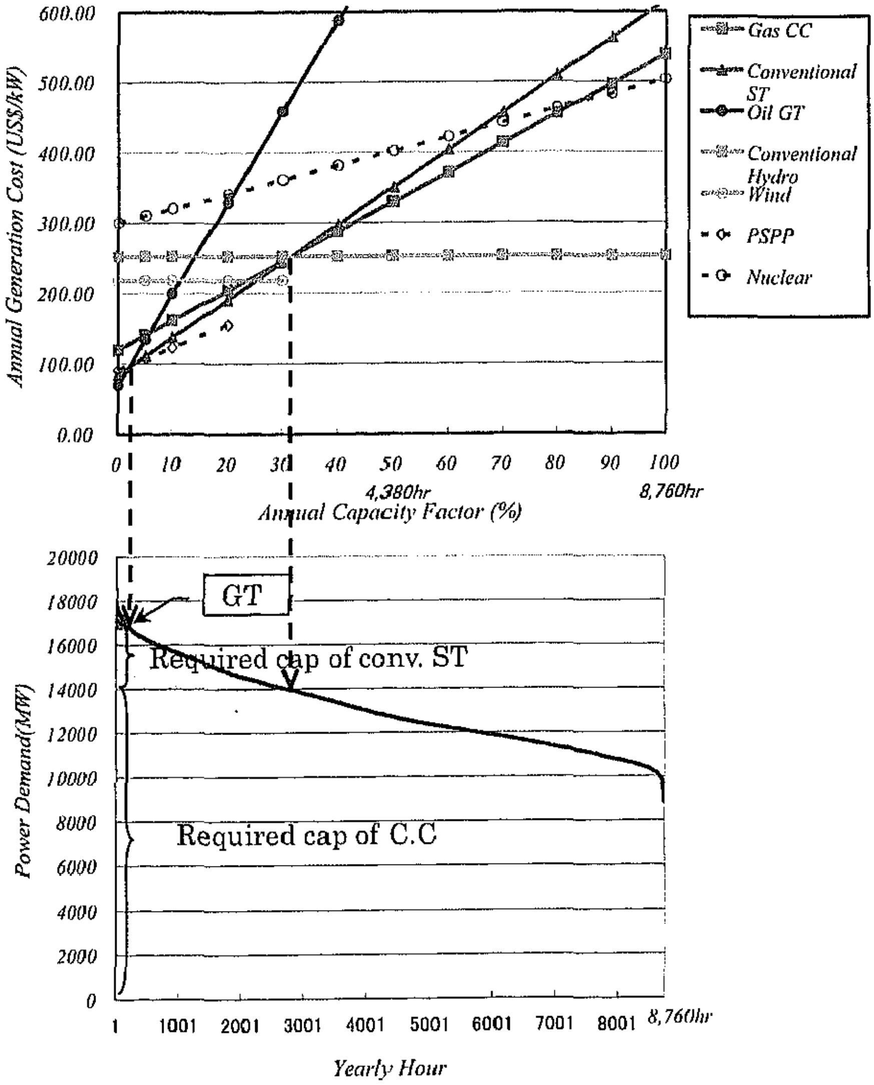


Fig. 3-1-1-1 Screening Curve

Table 3-1-1-1 Optimal Generation Mix (Best Mix)

Power plant type		Opt. Mix. Ratio	Existing Ratio	Plan in 2013
Peak power plant	GT	5-10%	6%	5%
Middle power plant	Conventional ST	15-25%	51%	50%
Base power plant	Conbined Cycle (or Hydro, Wind)	65-80%	43%	46%

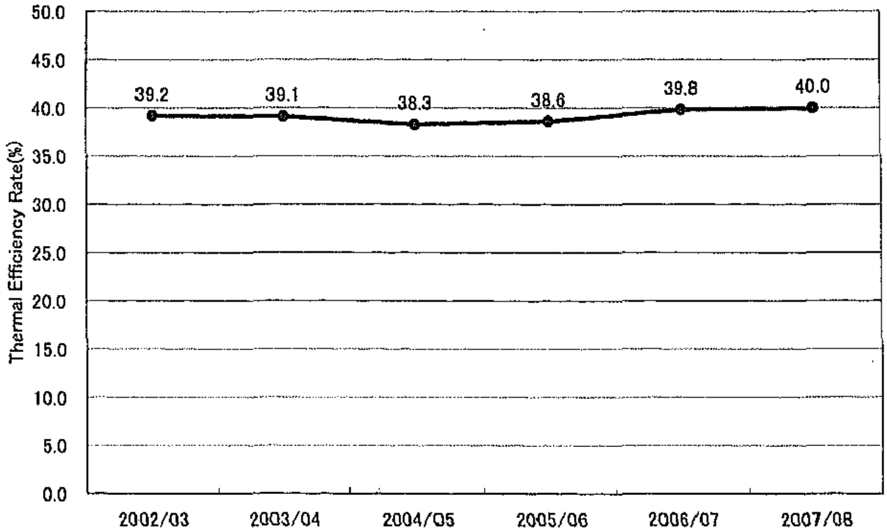
Table 3-1-1-2 <Reference> Opt. Generation Mix including PSPP & Nuclear

Power plant type		Opt. Mix. Ratio
Peak power plant	PSPP(or GT)	10-20%
Peak-middle power plant	Conventional ST	5-10%
Middle power plant	Conbined Cycle	10-20%
Base power plant	Nuclear (or Hydro, Wind)	50-70%

(2) Thermal Efficiency Rate in Egypt

Thermal efficiency in Egypt should be examined in this section in order to find which energy efficiency project is feasible and how efficient the project is.

Fig. 3-1-1-2 indicates comprehensive thermal efficiency rates year by year. The thermal efficiency rates have been almost constant and about 40%. Compared with those of other countries (see Table3-1-1-3), Egyptian efficiency rate is at a high level in the world because most of the power plant are run by firing natural gas.



Sources: EEHC Annual Report

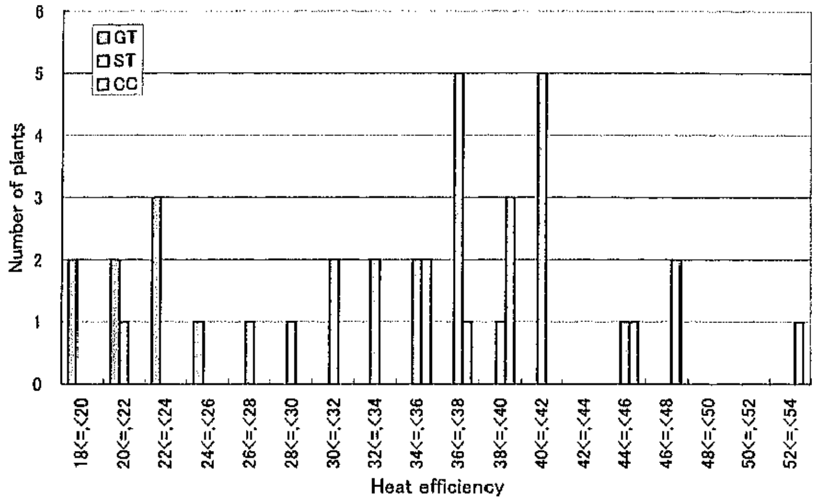
Fig. 3-1-1-2 Yearly Thermal Efficiency in Egypt

Table 3-1-1-3 Comparison among Countries

Country	Thermal Efficiency	Sources
Egypt	40.0 %	EEHC annual report 2007/08
South Africa	34.6 %	Eskom annual report 2008
Iran	39.1%	IEA E/B sheet
Japan TEPSCO	42.0 %	TEPCO Illustrated 2008

On the other hand Fig. 3-1-1-3 shows histogram of thermal efficiency plant by plant. Followings are notified hereby.

- ✓ Efficiency rates of GT are distributed between 18% and 26% and there are 2 plants which have low efficiency of less than 20%.
- ✓ Efficiency rates of ST are distributed between 20% and 46% and there are 3 plants which have extremely low efficiency of less than 30%.
- ✓ Efficiency rates of C Cycle are distributed between 34% and 54% and there are 2 plants which have low efficiency of less than 36%. However one of these has not been completed and under testing operation. This can conclude that there is one inefficient C Cycle.
- ✓ Egyptian comprehensive thermal efficiency is not low. However, they have some extremely inefficient plants. Consequently these plants should be overhauled or retrofit based on additional inspections.
- ✓ They have many ST which is lower efficient than C Cycle. So more efforts are required for EEHC to maximize the use of C Cycle up to the optimal generation mixture as mentioned in the previous section.



Sources: EEHC Annual Report

Fig. 3-1-1-3 Histogram of Thermal Efficiency

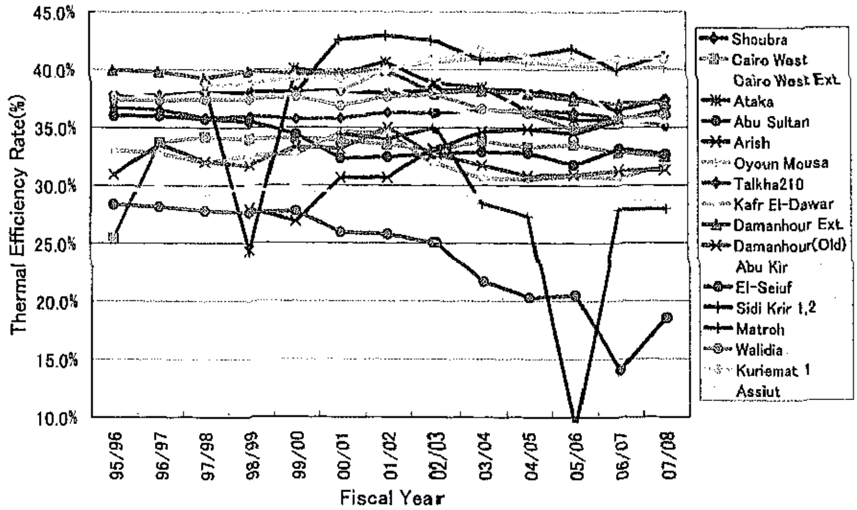
Furthermore in order to analyze the thermal efficiency in more detail, the team reviewed yearly records by plant as shown in Fig.3-1-1-4 and 5. These figures show that the thermal efficiencies of EL-Suez station (ST commissioned in 1984), Matroh station (ST commissioned in 1990) and Damanhour station (C Cycle commissioned in 1995) are becoming worse in these five years.

When an index of decrement of thermal efficiency is defined as a formula below, it can classify power plants with inefficiency as shown in Table3-1-1-4.

Decrement of efficiency = Highest record of thermal efficiency – Efficiency in 2007/08

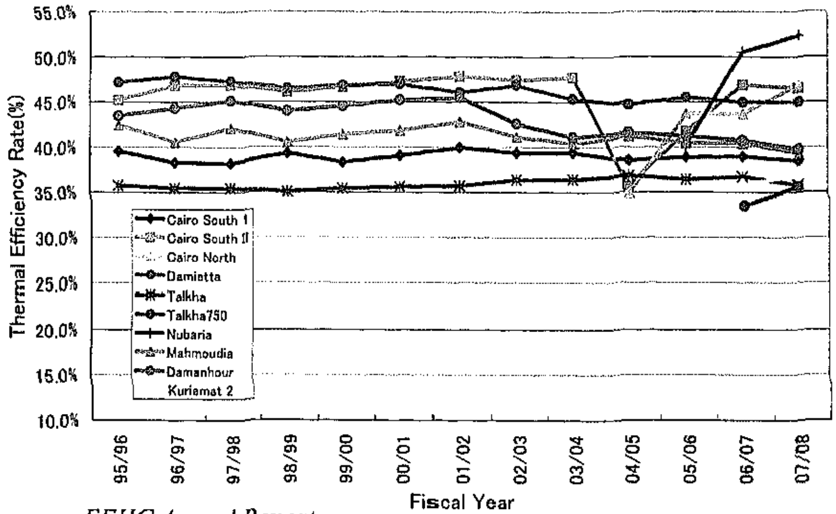
The plants indicated in the table are expected to be replaced or rehabilitated. Particularly Matroh station have been generating at more than 50% of capacity factor though generally inefficient plants should be operated at low capacity factor. Hence it should be notified that the power station wastes precious fuel.

On the other hand, C Cycle plants in the table such as Damahour, Demiette and Mahmoudia have been run at high efficiency level. However the thermal efficiencies have been decreasing since 2000. Taking into consideration of this situation, these plants are also needed something like overhauls. Since their capacity factors have been kept at high levels, it should also be noticed that these plants wastes natural gas.



Sources: EEHC Annual Report

Fig.3-1-1-4 Yearly Record of Thermal Efficiency by ST Plant



Sources: EEHC Annual Report

Fig.3-1-1-5 Yearly Record of Thermal Efficiency by CC Plant

Table3-1-1-4 Power plants of which thermal efficiency have decreased

Decrement of Effi.	Combined Cycle Plant	Conventional ST plant
2%=<	Demietta,Mahmoudia	Ataka,Abu Sultan,Kafr El-Dawar, Damanhour Ext,Damanhou(old),Abu Kir
5%=<	Damanhour	El-Seiuf,Matroh

(3) Potential of Energy Efficiency in Power Generation

Taking into account these situations, following potential of energy efficiency can be selected.

- ✓ For inefficient plants of GT, ST and C Cycle, retrofitting project can be adopted.
- ✓ For existing ST, (depending on conditions) repowering project that will make existing plant combined with new GT can be adopted
- ✓ For planed ST, promoting project to develop advanced C Cycle (ACC) can be adopted. (For existing ST, replacing can be one option.)

Clause2 Potential of Energy Efficiency Improvement in Transmission

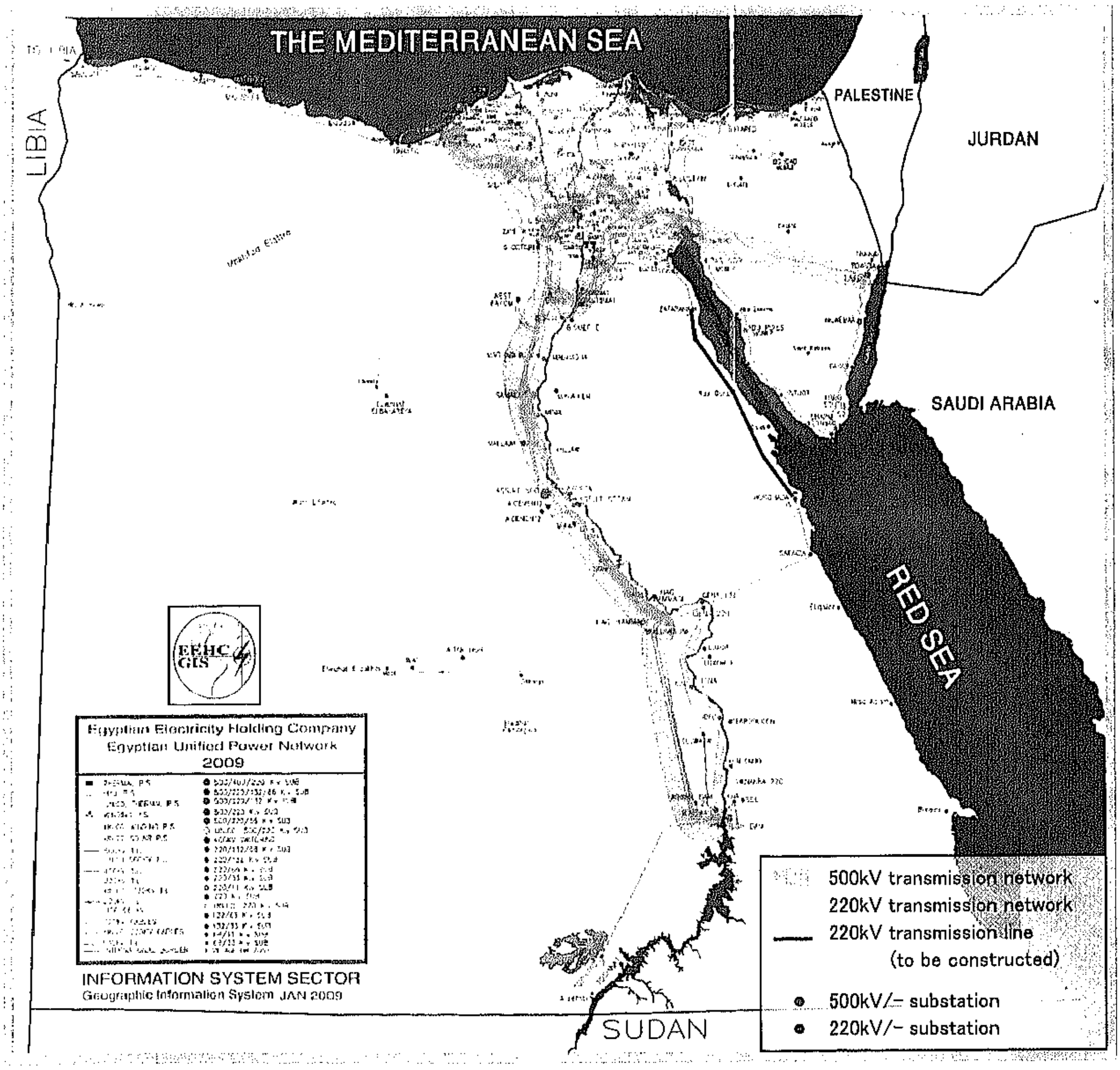
(1) Current overview of power transmission system

Maximum voltage level is 500kV, while the voltage of trunk (backbone) power system is 220kV, 140kV and that of local to be 66kV.

The transmission line network is built along the coast line of Mediterranean Sea and along the Nile River.

Basically, the transmission line is built in 2 circuits and in parallel.

Also, there are 2 routes of transmission lines in the same section (zone), like in Cairo zone for 500kV/220kVs and along the Nile River for 500kVs as shown in Fig. 3-1-2-1.



Data source: Annual Report of EEHC / prepared by the Team

Fig. 3-1-2-1 Power System

List of Transmission Lines and Substations for each voltage level (500/220/132/66/33kV) are shown below in Table 3-1-2-1 and Table 3-1-2-2, respectively.

Table 3-1-2-1 Transmission Lines (Lines & Cables) (km)

Zone	500kV	400kV	220kV	132kV	66kV	33kV	Total
Cairo	212		991		2679		3882
Canal	409	33	4771		3212		8425
Delta			1546		3238		4784
Alexandria & West Delta	217		3373		3577		7167
Middle Egypt	885		2096	1097	2246	1168	7492
Upper Egypt	756		2135	1332	2034	1545	7802
Total	2479	33	14912	2429	16986	2713	39552

Data source: Annual Report of EEHC

Table 3-1-2-2 Total Transformer Capacities (MVA)

Zone	500kV	220kV	132kV	66kV	33kV	Total
Cairo	1500	8690		12368		22558
Canal	1750	6335		5673		13758
Delta		3425		5306		8731
Alexandria & West Delta		5085		6397		11482
Middle Egypt	2910	2450	861	2712	816	9749
Upper Egypt	1605	2865	2566	2767	953	10756
Total	7765	28850	3427	35223	1769	77034

Data source: Annual Report of EEHC

(2) Energy Efficiency in Transmission Line

Table 3-1-2-3 below, shows generated power energy for each zones and Table 3-1-2-4 shows the available energy for consumption at Distribution Companies.

Available power energy for Distribution Companies includes the power energy bought from Transmission Company and that of self generating.

It can roughly be said from Table 3-1-2-3 that the power sources are equally installed and located for each zones although Cairo and Delta zones are in northern part of the country which are the power-consuming area.

Table 3-1-2-3 Generated Power Energy

Zone	Generated Power Energy (GWh)
Cairo	25,679
East Delta	21,498
Middle Delta	18,562
West Delta	16,051
Upper & Hydro	29,502

Data source: EEHC report 2007/2008

Meanwhile, from Table 3-1-2-4, the available power energy of each Distribution Companies, when appointing them approximately to each zone still has trend of even distribution except for Cairo which has more than double of the available power energy compared to other Distribution Companies.

Table 3-1-2-4 Available Power Energy at Distribution Companies

Electric Distribution *Company*	**Available Power Energy *(GWh)***
North Cairo	14,026
South Cairo	17,199
Alexandria	6,805
El-Behera	5,360
North Delta	7,657
South Delta	7,139
Canal	14,301
Middle Egypt	7,370
Upper Egypt	6,375

Data source: EEHC / prepared by the Team

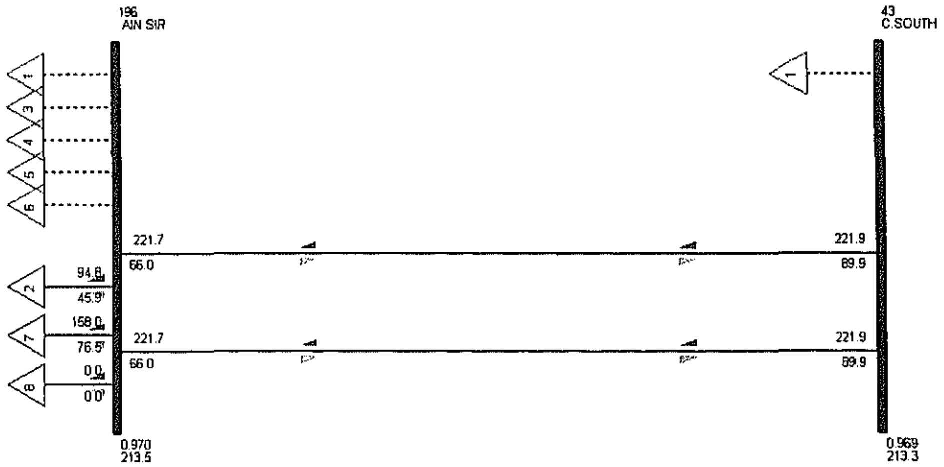
In General terms, when the power supply is evenly distributed through out the land and so as the power demand, there are no high-needs for long transmission lines with large capacity. This is know as, "local production for local consumption".
Here, it is obvious that the power-consuming center is around Cairo and northward area and the existence of the 500kV transmission line fulfills the large consuming region with low transmission loss.
Topologically, the power system in Egypt is in a fine balance.

Most of the 500kV and 220kV transmission lines in Egypt are planned to be doubled of circuit or have another route for load-balanced distribution, so the losses are relatively small, but here, from the study of reducing transmission loss, and with the rapid growth of power supply, some part of the transmission lines are getting tight in its capacity.
One of the general methods to reduce transmission loss is to augment transmission line, which is to increase circuits.
Here to pick up a rather heavy loaded transmission lines of 220kV between Ain El Sira and South Cairo has been examined, as shown in Fig. 3-1-2-2.

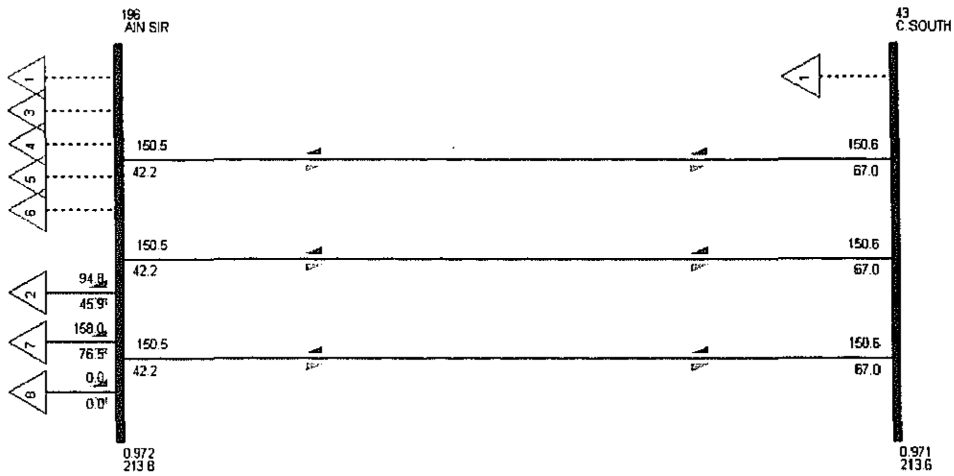
The examination has been done by using PSS/E[1].
First the current transmission loss between the 2 Substations with double circuit *transmission line has been observed. Then, an additional circuit of the same type of the* transmission line was added to see how the transmission loss changes.
The result is shown in Table 3-1-2-5.

When one circuit is added in parallel to the mentioned transmission line, the power flow will be evenly distributed to each of them to reduce its loss to approximately 0.4MW.
This will be 0.138% rate of loss reduction.

[1] Power System Simulator for Engineering: System analysis software developed by Power Technologies Inc. (Currently merged to Siemens).



(2 circuit of Transmission Line between Ain El Sira and South Cairo)



(3 circuit of Transmission Line between Ain El Sira and South Cairo)

Fig. 3-1-2-2 Power Flow between Ain El Sira and South Cairo

Table 3-1-2-5 Comparison of Transmission Loss

zone	loss 2cct (MW)	loss 3cct (MW)
ALEX	23.1	23.1
CANAL	44.4	44.4
UPPER	103.7	103.6
CAIRO	55.6	55.3
DELTA	62.5	62.5
total	**289.3**	**288.9**

The 220kV transmission line between Ain El Sira and South Cairo is approximately 10km. The average construction cost for 220kV transmission line will be 2.4million USD/km. From these studied results, to reduce 0.4MW loss for power transmission, more than 20millionUSD will be needed. This definitely does not have enough advantages to pick up transmission sector as energy efficiency goal at current condition.
Also from the point of view in power factor, the transmission line has about 0.97 – 0.99 and this leaves very little space for improvement, which also leads to the same conclusion.

Table 3-1-2-6 shows some other heavy loaded transmission lines.

Table 3-1-2-6 Heavy Loaded Transmission Lines

from bus name	to bus name	Circuit	Length	Active power	Reactive power	Apparent power	Loading	P loss	Q loss	ZONE
			km	MW	Mvar	MVA	%	MW	Mvar	
HEL I	C EAST	1	20	270.7	-35.7	273.1	92	0.43	2.82	4 CAIRO
TEB.220	S. TEBIEN	1	6	190.1	34.1	193.2	76	0.56	2.74	4 CAIRO
TEB.220	S. TEBIEN	2	6	190.1	34.1	193.2	76	0.56	2.74	4 CAIRO
N.10.RA	A.SOLT.	1	60	-196	-29.4	198.2	78	4.91	17.96	2 CANAL
N.10.RA	A.SOLT.	2	60	-196	-29.4	198.2	78	4.91	17.96	2 CANAL
BASSOUS2	GN.CN2	1	9.5	-266	-83	278.8	76	1.2	6.12	4 CAIRO
BASSOUS2	GN.CN2	2	9.5	-266	-83	278.8	76	1.2	6.12	4 CAIRO
10 RAM	N.10.RA	1	22.5	-188	-32	190.5	75	0.53	2.7	2 CANAL
10 RAM	N.10.RA	2	22.5	-188	-32	190.5	75	0.53	2.7	2 CANAL

In the future, to respond to the growing demand and for the stabilized power transmission plans for power transmission facility to contribute to energy efficiency has been drawn up. There are mid- and long-term development plans of transmission lines and substations. Table 3-1-2-7 shows Transmission Development Plan up to 2010, Table 3-1-2-8 and Table 3-1-2-9 shows Transmission Development Plan from 2010 up to 2015. Table 3-1-2-10 and Table 3-1-2-11 show Transmission Development Plan from 2015 up to 2025.

Table 3-1-2-7 Transmission Development Plan up to 2010

Transmission Lines		Voltage level (kV)	Length (km)	Decided / planned	No of circuits	Expecting Commissioning Date
R.Sedr	Sharm El Shikh	220	300	Decided	2	2011/2012
Open T.L Atf – K.Shiekh (in/out) to Sidi Salm to become						
Atf	Sidi Salm	220	35	Decided	2	2007/2008
K.Shiekh	Sidi Salm	220	35	Decided	2	
Open T.L Sharm El Sheikh – Nweaba (in/out) to Nabq to become						
Sharm El Sheikh	Nabk	220	12	Decided	2	2009/2010
Nweaba	Nabk	220	145	Decided	2	
Construct						
Sidi Krir	Nobaria	500	130	Decided	1	2007/2008
Cairo East	Kurimat	220	100	Decided	2	
			10	Decided		
Modification of T.L 6 October – Doms to become						
06-Oct	Kurimat	220	45 + 90	Decided	2	2007/2008
Doms	Fayuom West	220	35	Decided	2	
Modification of T.L Aswan.I – Toshky to become						
Toshky	H.Dam	220	277	Decided	2	2007/2008
Aswan.I	H.Dam	220	12	Decided	2	
Modification of T.L Cairo 500 – Cairo South to become						
Cairo South	Haram	220	17	Decided	1	2007/2008
			1.25	Decided	1	
Cairo 500	Haram	220	43	Decided	1	
			1.25	Decided	1	
Cairo South	Giza	220	17	Decided	1	
			6.25	Decided	1	
Cairo 500	Giza	220	47	Decided	1	
			6.25	Decided	1	
Giza	Haram	220	5	Decided	1	
Open T.L Amrikia – Nobaria (in/out) to Iron Sadat to become						
Amrikia	Iron Sadat	220	1	Decided	2	2009/2010
Nobaria	Iron Sadat	220	50	Decided	2	
Construct						
Cairo North	Bahteem 2	220	5	Decided	2	2008/2009
Bahteem 1	Bahteem 2	220	1	Decided	2	
Zaafrana 1	Zaafarna 2	220	12	Decided	2	2008/2009
Mahmoudia	N. Atf PS	220	1	Decided	2	
Open T.L Tanta – Itay (in/out) to K.Zayat to become						
Tanta	K.Zayat	220	30	Decided	2	2008/2009
Itay	K.Zayat	220	30	Decided	2	
Construct						
K.Zayat	N. Atf PS	220	60	Decided	2	2008/2009
Open second circuit of cable Cairo E. – Astad (in/out) to Metro to become						
Cairo E.	Metro	220	13	Decided	2	2008/2009
Astad	Metro	220	5	Decided	2	
Construct						
New Metro	Ain Sira	220	9	Decided	2	2008/2009
S. Tebin	Tebin Power	220	5 cable	Decided	1	2009/2010
Release T.L S.Tebin – W.Houf from W.Houf side and extend it to Tebin Power Plant to become						
W.Houf	Tebin Power Plant	220	7 cable	Decided	2	2009/2010
Open T.L Sakr – Cairo E. (in/out) to Rabaa after modification cable to become						
Sakr	Rabaa	220	10	Decided	2	2009/2010
Cairo East	Rabaa	220	7	Decided	1	
Open Sharkia – Gamalia (in/out) to Abu Keber						
Gamalia	Abu Keber	220	90	Decided	2	2009/2010
Sharkia	Abu Keber	220	40	Decided	2	
Open Ras Gharib – Hurghada (in/out) to Gabal El Ziet						
Ras Gharib	Gabal El Ziet	220	70	Decided	2	2009/2010
Hurghada	Gabal El Ziet	220	90	Decided	2	
Open T.L Sauaz Gulf – North Cairo (in/out) to El Sawedy						
Sauaz Gulf	El Sawedy	220	158	Decided	2	2009/2010
North Cairo	El Sawedy	220	6	Decided	2	

Source: EEHC during 1st & 2nd mission

Table 3-1-2-8 Transmission Development Plan from 2010 up to 2015 (1)

Transmission Lines		Voltage level (kV)	Length (km)	Decided / planned	No of circuits	Expecting Commissioning Date
Open T.L Basteen - Cairo East (in/out) to Mokatem and extend it with length 2*2.5 km						
Cairo East	Mokatem	220	10	Planned	2	2010/2011
Basteen	Mokatem	220	10	Planned	2	
			3.25	Planned	2	
Construct						
Masaeed	El Arish	220	6	Planned	2	2010/2011
Masaeed	Baghdad	220	80	Planned	2	
Construct new T.L from Kafer Zalat to cross the T.L Abo Zabel - Bassous with length 97 km						
Abo Zabel	Kafer Zalat	500	97	Decided	1	2010/2011
Kafer Zalat	Bassous	500	97	Decided	1	
Open T.L Zagazig - Mansoura (in/out) to Met Ghamer and extend it with length 2*15						
Zagazig	Met Ghamer	220	30	Planned	2	2010/2011
Mansoura	Met Ghamer	220	35	Planned	2	
Construct						
Talkha	Met Ghamer	220	60	Planned	2	2010/2011
Open T.L Economy - Tebeen (in/out) to Karbid Kalciom and extend it with length 1*2						
Economy	Karbid Kalciom	220	4	Decided	1	2010/2011
Tebeen	Karbid Kalciom	220	70	Decided	1	
Open T.L Katamia - Economy (in/out) to Karbid Kalciom and extend it with length 1*2						
Katamia	Karbid Kalciom	220	4	Decided	1	2010/2011
Economy	Karbid Kalciom	220	70	Decided	1	
Construct						
Abu Kir 500	Kafer Zalat	500	94	Decided	2	2011/2012
Abu Kir 500	Bader	500	400	Decided	1	
Construct						
10 Ramadan	Bader	220	40	Planned	2	2011/2012
Open T.L Abo Zabel - Helioples (in/out) to Obour and extend it with length 2*2						
Helioples	Obour	220	12	Planned	2	2011/2012
Abo Zabel	Obour	220	30	Planned	2	
Open T.L Abo Zabel - Suez (in/out) to Bader and extend it with length 1*2						
Abo Zabel	Bader	500	80	Planned	1	2011/2012
Suez	Bader	500	45	Planned	1	
Open second C.T Reswa - Domiat (in/out) to Chemical and extend it with length 2*5						
Domiat	P Chemical	220	50	Decided	1	2011/2012
Reswa	P Chemical	220	20	Decided	1	
Open T.L Abo Zabel - Tebeen (in/out) to Bader and extend it with length 1*3						
Tebeen	Bader	500	55	Decided	2	2011/2012
Abo Zabel	Bader	500	45	Decided	2	
Open T.L Omayed - Matrouh (in/out) to Sedy Abd El Rahman and extend it with length 2*5						
Omayed	Sedy Abd El Rahman	220	70	Planned	2	2010/2011
Matrouh	Sedy Abd El Rahman	220	40	Planned	2	
Open T.L Luxor E - Selwa West (in/out) to Esna and extend it with length 2*15						
Selwa West	Esna	220	95	Planned	2	2011/2012
Luxor E	Esna	220	60	Planned	2	
Open 6 October - Korimat (in/out) to New 6 October and extend it with length 2*5						
Korimat	New 6 October	220	120	Planned	2	2011/2012
36805	New 6 October	220	15	Planned	2	
Open T.L Suez Gulf - New Cairo (in/out) to Bader and extend it with length 2*5						
New Cairo	Bader	220	30	Decided	2	2011/2012
Suez Gulf	Bader	220	130	Decided	2	
Open T.L Abu Zabal - Tebeen (in/out) by Bader 500 to El Sokhna and extend it with length 1*85						
Bader 500	El Sokhna	500	78	Planned	1	2012/2013
Tebeen	El Sokhna	500	95	Planned	1	

Source: EEHC during 1st & 2nd mission

Table 3-1-2-9 Transmission Development Plan from 2010 up to 2015 (2)

Transmission Lines		Voltage level (kV)	Length (km)	Decided / planned	No of circuits	Expecting Commissioning Date
Open T.L Katamaia – cement Masria (in/out) to El Sokhna and extend it with length 2*40						
Katamaia	El Sokhna	220	100	Planned	2	2012/2013
cement Masria	El Sokhna	220	40	Planned	2	
Open T.L Qwesena – Kalubia (in/out) to Benha and extend it with length 2*2						
Qwesena	Benha		40	Planned	2	2012/2013
Kalubia	Benha	220	40	Planned	2	
Construct						
Abo Tartor	Balat	220	110	Planned	2	2012/2013
Construct						
Abo Menaga	Cairo West	220	10	Planned	2	2012/2013
Abo Menaga	Basouss	220	5	Planned	2	
Construct						
Katamaia	New Mokatam	220	5	Planned	2	2012/2013
Mokatam (pri)	New Mokatam	220	15	Planned	2	
Open Sec C.T Cairo 500 – Samalut (in/out) to New 6 October 500 and extend it with length 1*10						
Cairo 500	New 6 October	500	25	Planned	1	2012/2013
Samalut	New 6 October	500	185	Planned	1	
Open T.L Sedy Abd El Rahman Matrouh (in/out) to Dabaa and extend it with length 2*10						
Sedy Abd El Rahman	Dabaa	220	90	Planned	2	2013/2014
Matrouh	Dabaa	220	130	Planned	2	
Open T.L Kurimat – Basateen (in/out) to Tora and extend it with length 2*5						
Kurimat	Tora	220	100	Planned	2	2013/2014
Basateen	Tora	220	3.5 cable 10	Planned	2	
Open T.L Somoha – Karmoz (in/out) to Int. Park and extend it with length 2*3						
Somoha	Int. Park	220	6	Planned	2	2012/2013
Karmoz	Int. Park	220	6	Planned	2	
Construct						
Dabaa	Sidi Krir	500	140	Planned	1	2013/2014
Dabaa	Saloum	500	320	Planned	1	
Open T.L Sidi Krir – Dekhila (in/out) to Abo Talat and extend it with length 2*5						
Dekhila	Abo Talat	220	30	Planned	2	2013/2014
Sidi Krir	Abo Talat	220	20	Planned	2	
Construct						
Safaga	El Kosir	220	85	Planned	2	2014/2015
El Kosir	Marsa Elam	220	135	Planned	2	
Marsa Elam	Shlateen	220	130	Planned	2	
W Domiat	Samanoud	220	50	Planned	2	
Samanoud	Tanta	220	30	Planned	2	
Open T.L Abo Kir – Bader (in/out) to W Domiat and extend it with length 1*5						
Abo Kir	W Domiat	500	200	Planned	1	2014/2015
Bader	W Domiat	500	200	Planned	1	
Open T.L Qena – N Hamadi (in/out) to Qena West and extend it with length 2*10						
Qena	Qena West	220	25	Planned	2	2014/2015
N Hamadi	Qena West	220	25	Planned	2	
Open T.L New 6 October – Samalut (in/out) to South Giza and extend it with length 1*5						
New 6 October	South Giza	500	70	Planned	1	2014/2015
Samalut	South Giza	500	140	Planned	1	
Open T.L New Cairo – Sewis boot (in/out) to Eqtsadia 2 and extend it with length 1*5						
New Cairo	Eqtsadia 2	220		Planned	1	2014/2015
Sewis boot	Eqtsadia 2	220		Planned	1	

Source: EEHC during 1st & 2nd mission

Table 3-1-2-10 Transmission Development Plan from 2015 up to 2025 (1)

Transmission Lines		Voltage level (kV)	Length (km)	Decided / planned	No of circuits	Expecting Commissioning Date
Open T.L Sidi Krir - Amiria (in/out) to Max to become						
Sidi Krir	Max	220	25	Planned	2	2019/2020
Amiria	Max	220	10	Planned	2	
Construct						
Dabaa	Sadat	500	250	Planned	1	2019/2020
Gleem	Montazah	220	5	Planned	2	2017/2018
Suif	Montazah	220	5	Planned	2	
Construct						
B Arab Inds	Dabaa	220	120	Planned	2	2017/2018
B Arab G	B Arab	220	30	Planned	2	
B Arab Inds	B Arab G	220	30	Planned	2	
Construct						
Ghazl	Kafer El Dawar	220	35	Planned	2	2016/2017
Damnhour	Matamir	220	80	Planned	2	
Open 2 circuit Basouss - Shobra El Khama (in/out) to N Basouss to become						
Basouss	N Basouss	220	6	Planned	2	2017/2018
Shobra El Khama	N Basouss	220	6	Planned	2	
Construct						
N October	Sadat	500	65	Planned	1	2020/2021
Embaba	Cairo West	220	7	Planned	2	2017/2018
Embaba	Cairo 500	220	5	Planned	2	
Tabben G	Helwan	220	10	Planned	2	2024/2025
Helwan	Korimat	220	100	Planned	2	
Ismailia	Shabab	220	50	Planned	2	2020/2025
P Said East	Shabab	220	100	Planned	2	
Open Oyon Mousa - Kantra (in/out) Indus Canal to become						
Oyon Mousa	Indus Canal	220	80	Planned	2	2019/2020
Construct						
Indus Canal	El Arish	220	70	Planned	2	2019/2020
Indus Canal	Qantra	220	80	Planned	2	
Construct						
N Motamadia	Motamadia	220	0.5	Planned	2	2021/2022
N Motamadia	Cairo W	220	17	Planned	2	
Construct						
Construct El Doki	Giza	220	5	Planned	2	2017/2018
El Doki	Haram	220	10	Planned	2	
Construct						
Manshia Naser	Stade	220	5	Planned	2	2023/2024
Manshia Naser	Mokatam	220	5	Planned	2	
Construct						
Dabaa	Sadat	500	250	Planned	1	2017/2018
Menouf	Shebeen Kom	220	40	Planned	2	2015/2016
Qewsena	Shebeen Kom	220	15	Planned	2	
New Delta	Tanta	220	100	Planned	2	2018/2019
Construct						
New Delta	Domiat	220	40	Planned	2	2018/2019
New Delta	Mahala	220	70	Planned	2	
Wadi Natron	Dabaa	220	150	Planned	2	2019/2020
Wadi Natron	Delta West	220	100	Planned	2	
Wadi Natron	Ezz	220	50	Planned	2	

Source: EEHC during 1st & 2nd mission

Table 3-1-2-11 Transmission Development Plan from 2015 up to 2025 (2)

Transmission Lines		Voltage level (kV)	Length (km)	Decided / planned	No of circuits	Expecting Commissioning Date
Open T.L N.Hamadi – Safaga (in/out) to Qena G to become and add second circuit						
N.Hamadi	Qena G	500	50	Decided	2	2016/2017
Safaga	Qena G	500	250	Decided	1	2016/2017
Open the second circuit T.L Cairo 500 –Samalut (in/out) to South Giza 500 to become						
Cairo 500	South Giza	500	100	Planned	1	2015/2016
Samalut	South Giza	500	130	Planned	1	
Construct						
New 6 October	South Giza	500	130	Planned	1	2015/2016
Safaga	Gabel Zait	500	150	Planned	1	
Construct						
Mokatam	N Fayuom	220	100	Planned	2	2020/2025
Baharia	N Fayuom	220	60	Planned	2	
Baharia	Samalut	220	70	Planned	2	
Open T.L Cairo 220 – Cairo West (in/out) to Abu Rawash to become						
Cairo 220	Abu Rawash	220	7	Planned	2	2015/2016
Cairo West	Abu Rawash	220	14 + 7	Planned	2	
Open T.L Kurimat – 6 October (in/out) to Hwamdia to become						
Kurimat	Hwamdia	220	75	Planned	2	2020/2021
			5			
6oOctober	Hwamdia	220	50		2	
			5			
Open T.L Kurimat – Dmi (in/out) to Zahraa Maadi to become						
Kurimat	Zahraa Maadi	220	90	Planned	2	2018/2019
Dmi	Zahraa Maadi	220	10		2	
Open T.L Menouf – Kalubia (in/out) to Ashmoun to become						
Menouf	Ashmoun	220	30	Planned	2	2017/2018
Kalubia	Ashmoun	220	30		2	
Construct						
Domiat W	Shrbeen	220	30	Planned	2	2019/2020
Samanod	Shrbeen	220	30	Planned	2	
Samanod	Tanta	220	30	Planned	2	
Open T.L Shobra Khima – Cairo North (in/out) to El Mataria to become						
Shobra Khima	El Mataria	220	6	Planned	2	2015/2016
Cairo North	El Mataria	220	2	Planned	2	
Open T.L Abo Zabel 500 – Tebeen 500 (in/out) to N.Helioplies to become						
Zabel 500	N.Helioplies	500	40	Planned	2	2020/2021
Tebeen 500	N.Helioplies	500	90	Planned	2	
Open the second circuit T.L High Dam – N. Hamadi (in/out) to H Dam Switch						
High Dam	H Dam Switch	500	8	Planned	1	2020/2021
N. Hamadi	H Dam Switch	500	236	Planned	1	
Construct						
Oynat East	H-Dam Switch	500	550	Planned	2	2020/2021

Source: EEHC during 1st & 2nd mission

(4) Current Situation of Substation

The Team made research of distribution substations and the summary is as like written below.

- ✓ Must be indoor or half-outdoor type.
- ✓ Substations must be manned supervisory control.
- ✓ The standard capacity of the distribution transformers (66kV/11kV) is around 25MVA, and they consist of around 4 banks.
- ✓ Oil-immersed self-cooled or oil-immersed air-cooled transformers are used.
- ✓ Bus bar for 66kV is double bus system, and that of 11kV is single bus system.
- ✓ Voltage and power factor adjustment is manually done by opening and closing of capacitor, and tap changer when necessary. (From supervision of voltage, request from distribution companies, etc.)

The images of the distribution substations are shown in Fig. 3-1-2-3 to Fig. 3-1-2-5.

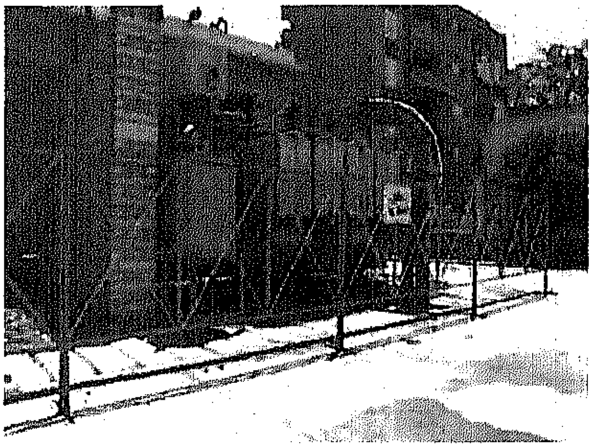


Fig. 3-1-2-3 Main transformer (66kV/11kV)

Fig. 3-1-2-4 Distribution feeder panel (11kV)

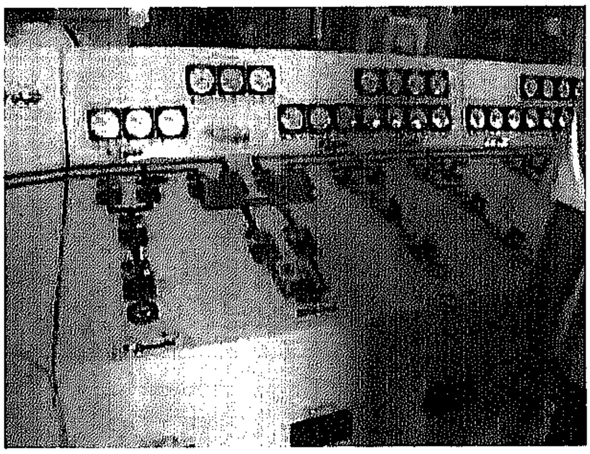


Fig. 3-1-2-5 Control desk

(Voltage is controlled by manually)

The mainstream for Substation is indo-or or half-outdoor type, and that for transformer is oil-immersed self-cooled or oil-immersed air-cooled type. The internal consumption rate (auxiliary power ratio) is relatively low for there are no specific large scale auxiliaries.

Fig. 3-1-2-6 shows a single line diagram of a typical distribution substation from the studied area.

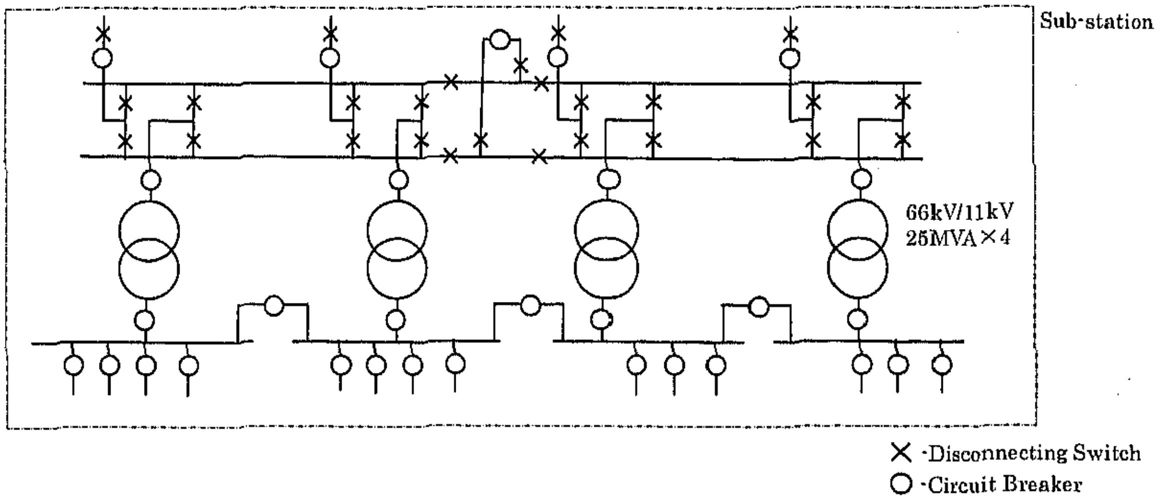


Fig. 3-1-2-6 Single Line Diagram of Typical Distribution Substation

The facts found in this study of distribution substation, is as follows.

- ✓ The transformers are operated basically around 4 placed in parallel with configuration of appropriate load changing through bus bars, are preferable from the point of view of loss reduction.
- ✓ Unit capacity of each transformer is selected to be around 25MVA which is not so large and the rated current in secondary side is suppressed moderately, which is preferable from the point of view of reducing copper loss and cable loss etc.
- ✓ The transformer is equipped with tap changer. Also on the middle voltage side, equipped with phase modifying condenser. In this substation the voltage is monitored in full-time and when necessary to use these equipments. The mentioned way of operation is preferable contributing to reduce power loss.

Table 3-1-2-12 and Table 3-1-2-13 show Substation Development Plan up to 2015.

Substations are fully manned to keep up optimal operation but when in future, for further power saving, installation of automatic power factor regulator (APFR) and automatic voltage controller is desirable, especially in unmanned facilities.

Table 3-1-2-12 Substation Development Plan up to 2015 (1)

Name of Substation	new Substation Upgrade	Voltage Ratio	Existing No. of Units and Installed Capacity	Planned No. of Units and Installed Capacity	Expected Commissioning Date	Location (Zone)	Decided
Borg Arab (ext.)	Upgrade	220/66	2×125	3×125	2007/2008	Alex.	Decided
Sidi Krir	New	500/220	0	1×500	2009/2010	Alex.	Decided
Sidi Krir 500	New	500/220	0	1×500	2007/2008	Alex.	Decided
Sidi Abd El-Rahman	New	220/66	0	2×75	2010/2011	Alex.	Planned
Abu Kir	New	500/220	0	1×500	2011/2012	Alex.	Decided
Borg Arab 2 (Ind)	New	220/66	0	2×125	2017/2018	Alex.	Planned
Int Park	New	220/66	0	3×125	2012/2013	Alex.	Planned
Dabaa	New	500/220	0	1×375	2013/2014	Alex.	Planned
Dabaa	New	220/66	0	2×75	2013/2014	Alex.	Planned
Abo Talat	New	220/66	0	3×125	2013/2014	.Alex	Planned
Bahteem 2	New	220/66	0	3×125	2008/2009	Cairo	Decided
N. Saptia (ext.)	Upgrade	220/66	3×125	4×125	2008/2009	Cairo	Decided
Cairo West (ext.)	Upgrade	220/66	3×125	4×125	2009/2010	Cairo	Decided
Metro	New	220/20	0	5×50	2008/2009	Cairo	Decided
Rabaa	New	220/66	0	3×125	2009/2010	Cairo	Decided
Tebin pwer plant	New	220/66	0	2×125	2009/2010	Cairo	Decided
Mokatem (Pri.)	New	220/66	0	2×125	2010/2011	Cairo	Planned
Ind. 6 October	New	220/66	0	2×125	2010/2011	Cairo	Planned
Abu Zabal	New	500/220	0	1×500	2013/2014	Cairo	Planned
New Cairo (ext.)	Upgrade	220/66	2×125	3×125	2010/2011	Cairo	Decided
Sakr (ext.)	Upgrade	220/66	3×125	4×125	2010/2011	Cairo	Decided
Obour	New	220/66	0	3×125	2010/2011	Cairo	Planned
New 6 October	New	220/66	0	3×125	2011/2012	Cairo	Planned
Bader	New	500/220	0	2×500	2011/2012	Cairo	Decided
Mokatem	New	220/66	0	3×125	2012/2013	Cairo	Planned
Abo Menaga	New	220/66	0	3×125	2012/2013	Cairo	Planned
New 6 October 500	New	500/220	0	1×500	2012/2013	Cairo	Planned
Tora	New	220/66	0	3×125	2013/2014	Cairo	Planned
Giza	New	220/66	0	2×125	2007/2008	Cairo	Decided
Wadi Houf (ext)	Upgrade	220/66	3×125	4×125	2007/2008	Cairo	Decided
Haram	New	220/66	0	3×125	2007/2008	Cairo	Decided
A.sera (ext)	Upgrade	220/66	2×125	3×125	2007/2008	Cairo	Decided
Cairo South (reh.)	Upgrade	220/66	2×75	2×125	2008/2009	Cairo	Decided
N.Cairo 2	New	220/66	0	3×125	2011/2012	Cairo	Planned
N 10 Ramadan (ext.)	Upgrade	220/66	2×125	3×125	2007/2008	Canal	Decided
Ras Gharb (mob.)	New	220/66	0	1×40	2008/2009	Canal	Decided
Zaafran (2)	New	220/22	0	2×150	2008/2009	Canal	Decided
El-Sawidy (pri)	New	220/66	0	2×75	2009/2010	Canal	Decided
Ras Seder	New	220/66	0	2×75	2009/2010	Canal	Decided
Massaeed	New	220/66	0	2×125	2010/2011	Canal	Planned
El-Tour (mob.)	New	220/66	0	1×40	2009/2010	Canal	Decided
Abo Redees (mob)	New	220/66	0	1×40	2007/2008	Canal	Decided
Nabk	New	220/66	0	3×125	2009/2010	Canal	Decided
Abu Keber	New	220/66	0	3×125	2009/2010	Canal	Decided
Gabel El-Zeit	New	220/22	0	2×150	2009/2010	Canal	Decided
P Chemical (pri.)	New	220/66	0	2×125	2010/2011	Canal	Decided
Karbid Kal (pri.)	New	220/66	0	2×125	2010/2011	Canal	Decided
El-Sokhna	New	500/220	0	2×500	2012/2013	Canal	Planned
Economy (2)	New	220/66	0	2×125	2014/2015	Canal	Planned
Economy (reh.)	Upgrade	220/66	2×75	2×125	2013/2014	Canal	Planned
El-Kosir	New	220/66	0	2×75	2014/2015	Canal	Planned
Marsa Alam	New	220/66	0	2×75	2014/2015	Canal	Planned
Zagazig (ext)	Upgrade	220/66	3×125	4×125	2007/2008	Canal	Decided
Manyef (ext)	Upgrade	220/66	2×125	3×125	2007/2008	Canal	Decided
Ghardaga (ext)	Upgrade	220/66	2×125	3×125	2007/2008	Canal	Decided

Source: EEHC during 1st & 2nd mission

Table 3-1-2-13 Substation Development Plan up to 2015 (2)

Name of Substation	new Substation Upgrade	Voltage Ratio	Existing No. of Units and Installed Capacity	Planned No. of Units and Installed Capacity	Expected Commissioning Date	Location (Zone)	Decided
Borg Arab (ext.)	Upgrade	220/66	2×125	3×125	2007/2008	Alex.	Decided
Sidi Krir	New	500/220	0	1×500	2009/2010	Alex.	Decided
Sidi Krir 500	New	500/220	0	1×500	2007/2008	Alex.	Decided
Sidi Abd El-Rahman	New	220/66	0	2×75	2010/2011	Alex.	Planned
Abu Kir	New	500/220	0	1×500	2011/2012	Alex.	Decided
Borg Arab 2 (Ind)	New	220/66	0	2×125	2017/2018	Alex.	Planned
Int Park	New	220/66	0	3×125	2012/2013	Alex.	Planned
Dabaa	New	500/220	0	1×375	2013/2014	Alex.	Planned
Dabaa	New	220/66	0	2×75	2013/2014	Alex.	Planned
Abo Talat	New	220/66	0	3×125	2013/2014	Alex	Planned
Bahteem 2	New	220/66	0	3×125	2008/2009	Cairo	Decided
N. Saptia (ext.)	Upgrade	220/66	3×125	4×125	2008/2009	Cairo	Decided
Cairo West (ext.)	Upgrade	220/66	3×125	4×125	2009/2010	Cairo	Decided
Metro	New	220/20	0	5×50	2008/2009	Cairo	Decided
Rabaa	New	220/66	0	3×125	2009/2010	Cairo	Decided
Tebin pwer plant	New	220/66	0	2×125	2009/2010	Cairo	Decided
Mokatem (Pri.)	New	220/66	0	2×125	2010/2011	Cairo	Planned
Ind. 6 October	New	220/66	0	2×125	2010/2011	Cairo	Planned
Abu Zabal	New	500/220	0	1×500	2013/2014	Cairo	Planned
New Cairo (ext.)	Upgrade	220/66	2×125	3×125	2010/2011	Cairo	Decided
Sakr (ext.)	Upgrade	220/66	3×125	4×125	2010/2011	Cairo	Decided
Obour	New	220/66	0	3×125	2010/2011	Cairo	Planned
New 6 October	New	220/66	0	3×125	2011/2012	Cairo	Planned
Bader	New	500/220	0	2×500	2011/2012	Cairo	Decided
Mokatem	New	220/66	0	3×125	2012/2013	Cairo	Planned
Abo Menaga	New	220/66	0	3×125	2012/2013	Cairo	Planned
New 6 October 500	New	500/220	0	1×500	2012/2013	Cairo	Planned
Tora	New	220/66	0	3×125	2013/2014	Cairo	Planned
Giza	New	220/66	0	2×125	2007/2008	Cairo	Decided
Wadi Houf (ext)	Upgrade	220/66	3×125	4×125	2007/2008	Cairo	Decided
Haram	New	220/66	0	3×125	2007/2008	Cairo	Decided
A.sera (ext)	Upgrade	220/66	2×125	3×125	2007/2008	Cairo	Decided
Cairo South (reh.)	Upgrade	220/66	2×75	2×125	2008/2009	Cairo	Decided
N.Cairo 2	New	220/66	0	3×125	2011/2012	Cairo	Planned
N 10 Ramadan (ext.)	Upgrade	220/66	2×125	3×125	2007/2008	Canal	Decided
Ras Gharb (mob.)	New	220/66	0	1×40	2008/2009	Canal	Decided
Zaafran (2)	New	220/22	0	2×150	2008/2009	Canal	Decided
El-Sawidy (pri)	New	220/66	0	2×75	2009/2010	Canal	Decided
Ras Seder	New	220/66	0	2×75	2009/2010	Canal	Decided
Massaeed	New	220/66	0	2×125	2010/2011	Canal	Planned
El-Tour (mob.)	New	220/66	0	1×40	2009/2010	Canal	Decided
Abo Redees (mob)	New	220/66	0	1×40	2007/2008	Canal	Decided
Nabk	New	220/66	0	3×125	2009/2010	Canal	Decided
Abu Keber	New	220/66	0	3×125	2009/2010	Canal	Decided
Gabel El-Zeit	New	220/22	0	2×150	2009/2010	Canal	Decided
P Chemical (pri.)	New	220/66	0	2×125	2010/2011	Canal	Decided
Karbid Kal (pri.)	New	220/66	0	2×125	2010/2011	Canal	Decided
El-Sokhna	New	500/220	0	2×500	2012/2013	Canal	Planned
Economy (2)	New	220/66	0	2×125	2014/2015	Canal	Planned
Economy (reh.)	Upgrade	220/66	2×75	2×125	2013/2014	Canal	Planned
El-Kosir	New	220/66	0	2×75	2014/2015	Canal	Planned
Marsa Alam	New	220/66	0	2×75	2014/2015	Canal	Planned
Zagazig (ext)	Upgrade	220/66	3×125	4×125	2007/2008	Canal	Decided
Manyel (ext)	Upgrade	220/66	2×125	3×125	2007/2008	Canal	Decided
Ghardaga (ext)	Upgrade	220/66	2×125	3×125	2007/2008	Canal	Decided

Source: EEHC during 1st & 2nd mission