ARAB REPUBLIC OF EGYPT

Ministry of Electricity and Renewable Energy (MoERE)

The Egyptian Electricity Holding Company (EEHC)

Power Sector Cooperation Planning Survey in Arab Republic of Egypt

Final Report

October 2018

Japan International Cooperation Agency (JICA)

Tokyo Electric Power Services Co., Ltd. (TEPSCO)

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Abbreviation table

Abbreviation	Unabbreviated expression
AFD	Agence Francaise de Development
AfDB	African Development Bank
BMS	Building Management System
BOO	Built-Operation-Own
BOOT	Built-Operation-Own-Transfer
C/C	Combined Cycle
CAA	Competent Administrative Authority
CAPMAS	Central Agency for Public Mobilization and Statistics
CREMP	Combined Renewable Energy Master Plan
CSP	Concentrating Solar Power
DMS	Distribution Management System
DPF	Development Policy Financing
EBRD	European Bank for Reconstruction and Development
EEAA	Egyptian Environmental Affairs Agency
EEDC	Egypt Economic Development Conference
EEHC	Egyptian Electricity Holding Company
EETC	Egyptian Electricity Transmission Company
EgyptERA	Egyptian Electric Utility and Consumer Protection Regulatory Agency
EIA	Environmental Impact Assessment
EIB	European Investment Bank
EU	European Union
FIT	Feed in Tariff
GAFRD	General Authority for Fish Resources Development
GEFF	Green Economy Financing Facility
GT	Gas Turbine
HPPEA	Hydro Power Plants Executive Authority
IMF	International Monetary Fund
IPP	Independent Power Producer

Abbreviation	Unabbreviated expression
ISES2035	Integrated sustainable energy strategy to 2035
ISES2035Scenario4b	Scenario 4b adopted in Integrated Sustainable Energy Strategy to 2035
JICA	Japan International Cooperation Agency
KfW	KfW Bankengruppe
KPIs	Key Performance Indicators
LED	Light Emitting Diode
LOLP	Loss of Load Probability
LV	Low Voltage
MoERE	Ministry of Electricity and Renewable Energy
MoP	Ministry of Petroleum and Mineral Wealth
MoPMAR	Ministry of Planning, Monitoring and Administrative Reform Cairo
MoSfEA	Ministry of State for Environmental Affairs
MV	Middle Voltage
NECC	National Electricity Control Center
NEEDS	Egypt National Environmental, Economic and Development Study
NREA	New and Renewable Energy Authority
NSEC	National Strategy for Environmental Communication
PPA	Power Purchase Agreement
PPS	Power Producer and Supplier
PV	Photo Voltaic
RMU	Ring Main Unit
SAIDI	System Average Interruption Duration Index
SAIFI	System Average Interruption Frequency Index
SCADA	Supervisory Control And Data Acquisition
SCE	Supreme Council of Energy
SDS2030	Sustainable Development Strategy: Egypt's vision
ST	Steam Turbine
SVC	Static Var Compensator
SVR	Step Voltage Regulator

Abbreviation	Unabbreviated expression
TSO	Transmission System Operator
WB	World Bank

Chapter 1 Introduction

1－1 Background

In Egypt, power demand is steadily increasing by 6% along with economic growth. Frequent occurrence of power outages has been a major social issue due to various causes such as shortage of generation and difficulties in accommodation.

The capacity of thermal power generation facilities, which account for approximately 90% of the power generation facilities in Egypt, have been increased through a so-called fast track plan, which includes installation of many gas units. However, generation capacity should be increased from the mid and long-term perspective to meet the national energy strategy. Furthermore, domestic oil and natural gas, which used to be the main energy sources for thermal power generation, have gradually become short for stable supply due to the increased demand. Although discovery of new gas fields are expected, it is not be clear how far they would contribute to solving the difficulty in securing the resource issues. Therefore, security of energy resources and diversification through electricity generation with various resources should be pursued.

Regarding the transmission and distribution facilities, transmission and distribution loss has gradually increased to 11%, which shows the necessity of reinforcement of the facilities and improvement in the operation, such as the system voltage along with the upgrading of the metering system for the reduction in non-technical loss.

After the inauguration of President El-Sisi in 2014 in Egypt, the economic recovery plan was developed and the Egypt Economic Development Conference (EEDC) was held in March, 2015, at which Egypt's economic reforms were officially showcased to both the country and other nations. At that conference, the massive strengthening plan of Egypt's power generation capacity of 54 GW by the year 2022 was revealed.

In addition, Master Plan (Integrated Sustainable Energy Strategy to 2035) supported by the EU and Combined Renewable Energy Master Plan for Egypt (CREMP) were formalized, and it is believed that these will establish the direction of energy sector development in Egypt.

In these circumstances, bulk amounts of new thermal and renewable energy plants are to be developed in parallel while the electricity demand will increase steadily, even if assuming more energy efficiency improvement and conservation.

Considering these prospects, the electricity system in Egypt will enter into a new era with broad development.

On the other hand, concrete information such as the background data and the realization process has not been fully acquired. Also, the fund issue for required investment is not well revealed. In the area of transmission and distribution system, it is the issues on how the new generation should be connected to the system with the proper reinforcement plans while renovating the existing system along with the reinforcement of international interconnection. Although information regarding these issues should be well coordinated, they might not be realized presently.

This study, in the light of the aforementioned background, is to be comprehensively implemented and will prioritize the fields in need of assistance within the electric power sector.

1－2　Purpose

This work clarifies issues to be addressed by the government in the short term (~ 2020) and the medium to long term (~ 2035) by comprehensively collecting and analyzing the information on the electric power sector in Egypt. Finally, in each identified field, the appropriate supporting projects by Japan’s Official Development Assistance (ODA) should be proposed while reflecting on the commitments of other donors.

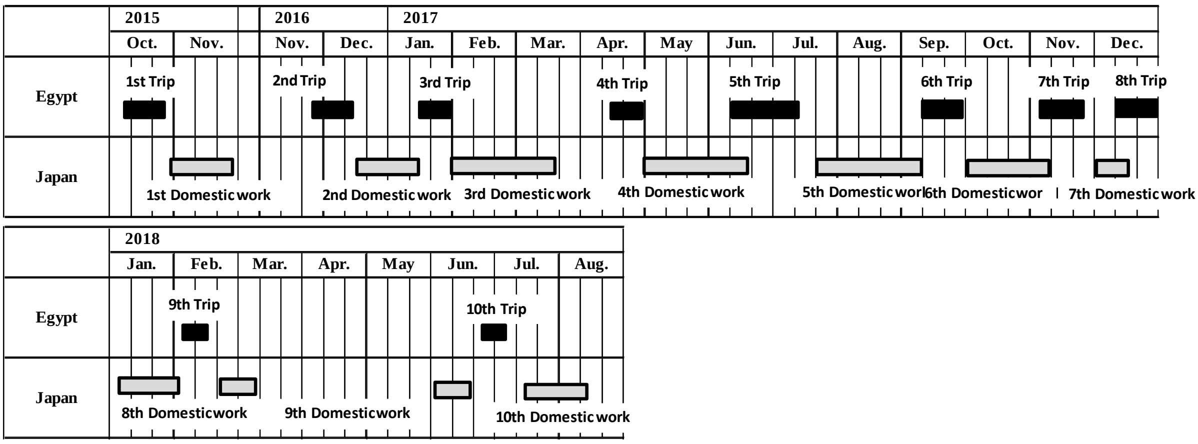
1－3　Survey Team

	Name	Position
1	Tsutomu Watanabe	Team Leader/Power polic1/Transmission Line
	Shigeru Komatsuzaki	Leader
	Makoto Kamibayashi	Power Development Plan/Demand Forecast
	Hiroaki Yoshizawa	Transmission 1
	Ikuya Iwase	Transmission 2
2	Sari Ishizuka	Deputy-Leader/Power Development Plan
2	Kouichi Hoshi	Deputy-Leader/Power Development Plan
	Yutaka Kubota	Coal fired Thermal Power Plant
3	Tetsuro Sasayama	Thermal Power Plant
4	Hidekazu Takase	System Planning
5	Yasuhiro Ishikura	Substation/Power policy2
6	Kenjiro Mori	Distribution Line
	Kouichi Hoshi	Distribution Line
7	Hirokazu Tsujita	Energy Utilization Efficiency/ New and renewable energy
8	Ryosuke Oguri	Energy Conservation
9	Akiko Urago	Environmental & Social Consideration
10	Shigeru Suzuki	Economic & Financial Analysis

➢ The members were reconsidered with the contract change in November 2016. (The gray part represents former member.)

1－4　Work Schedule

This work schedule is as follows;



✧ Team leader, Mr.Tsutomu Watanabe stayed for 90 days in the 2nd trip, from November 26, 2016 until the end of February 2017

✧ Deputy-Leader, Mr. Sari Ishizuka stayed for approximately 1 month in March 2017 because of the Supplementary Survey

Chapter 2 Status-quo and prospects of the power sector

2－1 Formation of policies and plans in the sector and related assistance policies in key donor agencies

2－1－1 Formation of policies in the power sector in the Egyptian government and their implementation

(1) Key policies and plans

Here, main policies and plans are briefly introduced to explain the relations among them.

At first, the introduction target of renewable energy is to be referred because the target has been maintained for a long time until now as the main policy in Egypt. Then, the policy of Sustainable Development Strategy Vision 2030, called SDS2030, is to be touched upon because the policy became the fundamental policy after the establishment of the Sisi government.

Next, Energizing Egypt, called Energy White Paper, which was approved along with SDS2030 and the following policies at present, will be described.

Since these policies and plans are closely correlated with each other, the relation and evolvement among them will be mainly focused on in this section.

1) Renewable energy introduction target

In February 2008, the Supreme Council of Energy (SCE) set a target to supply generated electric energy by renewable energy power to 20% by 2020 in order to improve security of energy supply and reduce CO2 emissions in the power sector. This target is supposed that hydroelectric power supply accounting for 11% at present will be 6% in 2020, and renewable energy power sources other than hydropower will be 14% by 2020. At that time, the capacity of the renewable energy power supply and the ratio of the generated power amount assumed are as follows.

Table2-1-1-1 Renewable energy power supply introduction target until 2020 (set in 2008)

	Wind	Hydro	PV	RE Total
Equipment capacity (RE Proportion)	7,200MW (64%)	2,800MW (25%)	1,320MW (12%)	11,320MW (100%)
Power generation ratio (RE Proportion)	12% (60%)	6% (30%)	2% (10%)	20% (100%)

*The ratio is calculated by the survey team

Source; Current and expected contribution of RES-E in NA countries (NREA)

The target year of 2020 with 20% of generated electricity by renewable energy power supply was postponed by 2 years to 2022. Still, the target of 20% is basically maintained presently. This shows that diversification of energy sources and reducing the dependence on fossil fuels continues to be the main policy in the Egyptian energy field.

2) Renewable energy introduction target

At the SCE in February 2010, a new energy strategy (Strategy of the Energy Sector until 2030 in Egypt) was approved to reinforce the capability of risk management to cope with the energy sector serious impacts such as the world simultaneous recession brought about by the Lehman shock in 2008 as well as the stagnation of oil prices. It was pointed out that diversification of energy sources should be the government's most important task. Specifically, it was raised to start development of nuclear power and renewable energy as soon as possible.

In response to this, in cooperation with AFD and EIB in cooperation with the NIF (Neighborhood Investment Facility) scheme, the EU, under the leadership of the German Reconstruction Finance Corporation (KfW Bankengruppe: KfW), supported to develop the Combined Renewable Energy Master Plan for Egypt: CREMP). This CREMP study was conducted by European consultants Lahmeyer International and Fraunhofer in 2011-2012.

CREMP consists of the following three elements.[1]

- ✓ Framework of wind power and solar energy development
- ✓ Feasibility study of large concentrated solar power (CSP) facility in Kom Ombo
- ✓ Preparation of similar framework study TOR for other renewable energy

In addition, the contents of the study are divided into the following eight tasks.

Table2-1-1-2 Contents of the study in CREMP

Task	Contents
Task 1	Economic potential for wind and solar energy in Egypt and key challenges
Task 2	Integration of wind and solar energy in the electricity power supply
Task 3	Technology policy and promotion of national manufacturing
Task 4	Institutional support structure for wind and solar energy
Task 5	Financing the framework for wind and solar energy in Egypt
Task 6	Wind and solar (CSP & PV) Sector Framework and Road Map for Implementation
Task 7	Terms of Reference for Other Renewable Energies
Task 8	Feasibility study for a large scale CSP project in Kom Ombo, Egypt

Source; CREMP

[1] Combined Renewable Energy Master Plan for EGYPT "Introduction"

In CREMP, not only development of renewable energy itself but also study on the influences to electric grid system and the investigation of necessity on electric power storage, etc., are included comprehensively with the contents relating to the development of renewable energy generation. Specifically, in the mid-2020s, development of renewable energy more than 20 GW: consist of West Nile 13 GW, Central Egypt 8 GW, and Sinai area 1 GW along with the expansion of transmission system, frequency maintenance measures, and economically encouraging measures such as FIT, etc. were studied. These results are not necessarily consistent with the latest situation, including the development volume (described later). However, it is very useful as the first step for further investigation.

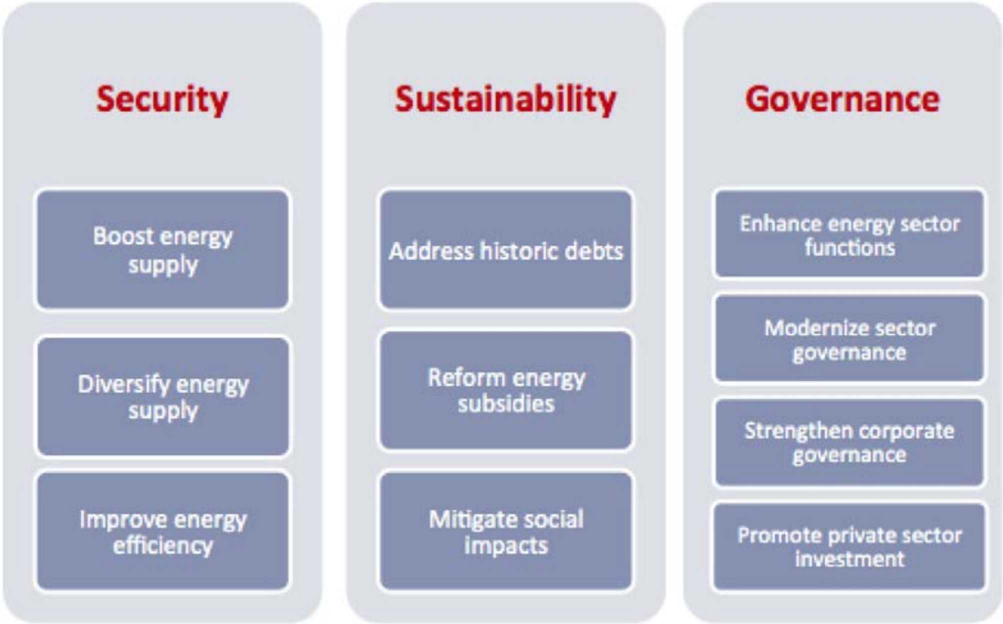
3) Sustainable development strategy 2030

The long-term development vision in Egypt was announced at the Egypt Economic Development Conference held in March 2015, which is the Sustainable Development Strategy 2030 (Egypt's Vision 2030: SDS 2030). This strategy was announced as the development vision of the Sisi government after the inauguration of President Sisi in June 2014. The subsequent generation development has been promoted based on this strategy, which also became the starting point for bringing about the subsequent power sector policies and donor commitments. Therefore, this strategy is positioned as the strategy with highest importance until now. Incidentally, EEDC was the international conference where about 2,000 people from 112 countries and major donors participated, and new financing frameworks were decided (for example many MOUs were signed). Therefore, the conference was a highly evaluated opportunity for the Egyptian government.

4) Energy White Paper (energizing Egypt)

Also published at the EEDC in March 2015, when SDS 2030 was announced, is Energizing Egypt, called Energy White Paper. In 2015, Integrated Sustainable Energy strategy to 2035 (ISES2035) was under study with the support of the EU as well as the medium-term action plans supporting the implementation of the strategy. Still, the Energy White Paper was announced to focus on and complement ISES 2035 and set the coordinated movement for the medium-term action plans, focusing on the nearby period of 2015 - 2019.

In the Energy White Paper, the energy sector is composed of three pillars of security, sustainability and governance, and each pillar has multiple action areas, a total of 10 action areas were set as follows.



Source; Energizing Egypt

Figure2-1-1-2 Three pillars of energy field and ten action areas

In each action area, the related multiple policy measures, key elements, timing and ministries in charge were set up.

The policy measures of each pillar, related contents and its status at present are presented in 2-1-4 in this report.

Naturally, the contents are basically matched with the ISES2035.

These contents were announced by the Minister with Ministry of Electricity and Renewable Energy entitled as Addressing Egypt's Electricity Vision at EEDC, and measures such as reinforcing 54 GW power generation facilities by 2022 were expressed.

(2) Establishment of Integrated Sustainable Energy Strategy 2035

In October 2016, Energy Strategy for Integrated and Sustainable Development to the Year 2035(hereafter called as ISES2035 in this report) was formalized in SCE which shall direct the energy policy in Egypt from fairly long perspectives. The strategy includes comprehensively primary energy, electric power and other cross sectional areas and should be perceived as the epoch-making strategy in Egypt. In ISES2035, several scenarios are presented and studied such as the scenario prioritizing the renewable energy introduction and conventional thermal generation introduction. Among them, scenario-4b was judged as most suitable from the view point of economy, energy diversification and other elements. It was then decided to promote the related policies following the scenario-4b. The transition regarding the share of the electricity generation energy is presented in Figure 2-1-1-3, which shows the basic characteristics of power in the future.

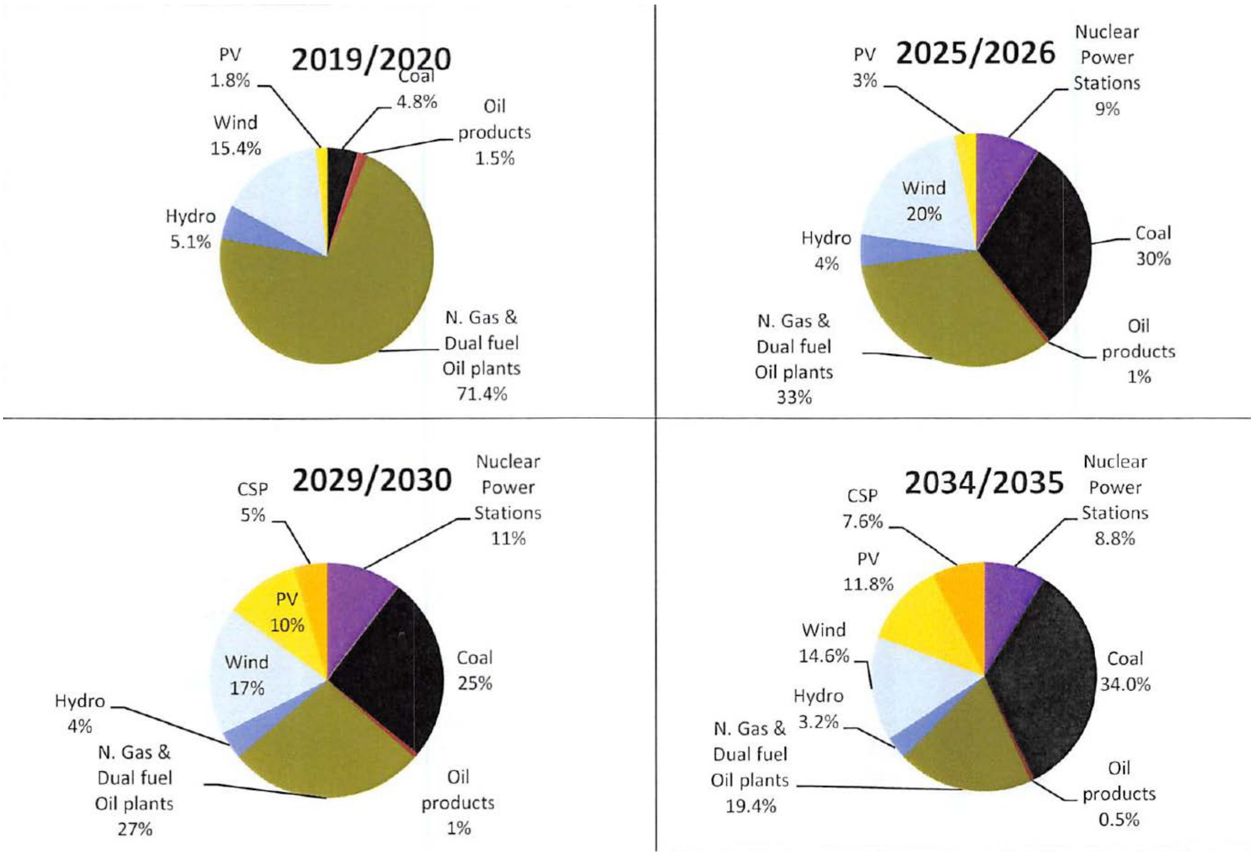


Figure2-1-1-3 Transition regarding the energy shares of the generation in Scenario-4b

In the power sector, the strategy includes the existing target of 54GW generation development for securing the supply side adequacy, along with the target of 20 % electricity energy supply by Renewable Energy (RE) in 2022, as is stated in 2-1-1(1)1). It also formulized the introduction of coal power generation in early 2020s and nuclear power in the 2020s, aiming for energy resource diversification with a good economy. Incidentally, the generation capacity reinforcement should be reexamined especially regarding RE by re-estimating the favorable conditions for RE in Egypt.

(3) Overall status-quo on the implementation of actions to realize ISES2035

As mentioned above, ISES2035 was originally studied, supported by the EU and named Technical Assistance to Support the Reform of the Energy Sector in Egypt (TARES). Based on the TARES, ISES2035 was formed. Originally, in TARES, there are several scenarios and ISES2035 also succeeded the scenarios. Therefore, ISES2035 have several options (=scenarios) in its nature to be flexible for the future. On the other hand, in SCE, Scenario-4b was judged as the most suitable option for the moment and the energy sector should move forward with Scenario-4b as the main strategy. Reflecting on this background, the team surveyed mainly the efforts in the power sector to realize scenario-4b. Scenario-4b should be called ISES2035 Scenario4b hereafter to separate it from other strategy scenarios. In the strategy, the concerned issues are categorized and various solutions or options are also presented to achieve the targets. Regarding the actions required until the year 2022, since the existing plans have been incorporated in the strategy as mentioned above, the team tried to confirm that the plans for the implementation have been studied and formalized with conformity to ISES2035 Scenario4b.

For example, Conventional generation with mainly thermal power reinforcement plan to achieve 54GW in 2022 as well as RE reinforcement plan to achieve 20% of electricity by 2022 have been promoted energetically while securing finances and adjusting the related system such as FIT system. In addition, hikes of the electricity tariff have been, and will be conducted to reflect the actual cost incurred from generation to distribution, which will be finished around early 2020s.

Regarding the introduction of a competitive market in the sector, neutralization of the power transmission sector by transforming EETC into TSO, which should be the core part of the liberalization in the electricity market, has been studied to realize the scheme in 2018.

The study will be formalized on the structure of the organization and the concrete conditions for its operation. The studies are proceeding in parallel with EETC and EgyptERA. EgyptERA is studying the issues from the point of regulation of TSO and coordination work has been promoted by EgyptERA and EETC.

Concerning the energy efficiency area, Leadership by MoERE along with the organizational promotion in EEHC group, supported by concerned donors is bringing about concrete improvement.

(4) The stance for the estimation on the status quo in the power sector by the survey team

Considering the overall situation, along with the establishment of ISES2035 Scenario4b, which would be the core strategy in the power sector, it is judged that the concerned parties are moving forward to realize the targets. Hereafter, the actions regarding realization of ISES2035 Scenario4B should be estimated by the survey team how well the actions are matched with the strategy concerning the main subjects.

2－1－2 Relationship between ISES2035Scenario4b and the various plans concerning development in the power sector, and the propriety of methods used in determining the plans

(1) Electric power development plan in Egypt, the methods used in determining the plan and related data

1) Electric power development plan at present (Interview in Dec. 2017)

EEHC provided the thermal power capacity reinforcement plan of both at the construction stage and planning stage in Egypt. The table below shows the plan.

In addition, information on the plan for 2022/2023 and beyond had not yet been declared in February 2017. Therefore, the plan for 2022/2023 and beyond is not included in the Final Report

After February 2017, regarding the demand estimation, the review on the decrease in demand growth rate is in progress. However, the generation plan shown here will be almost intact and the abolition schemes for the decrepit thermal facilities should be incorporated, according to EEHC.

Table 2-1-2-1 Generating capacity increasing plan

	2016/17	2017/18	2018/19	2019/20	2020/21	2021/22	TOTAL [MW]
COAL	0	0	0	0	0	0	0
Steam Turbine	0	1,300	650	1,300	0	0	3,250
Conversion (GT ➡ CC)	750	590	0	500	0	0	1,840
Combined Cycle	9,600	4,800	0	0	0	0	14,400
TOTAL [MW]	10,350	6,690	650	1,800	0	0	19,490

Source; results of the study team investigation

According to ISES2035 Scenario4b, capacity of Natural Gas & Dual fuel oil plants is estimated to increase from 33.0GW in the fiscal year 2014/15 to 55.9GW in the fiscal year 2019/20 by 22.9GW, and capacity of Coal power plants is estimated to increase from 0GW in the fiscal year of 2014/15 to 1.6GW in the fiscal year of 2019/20. Therefore, capacity of thermal power plant in total (Natural Gas & Dual fuel oil plant + Coal power plant) is estimated to increase by 24.5GW from the fiscal year of 2014/15 to the fiscal year of 2019/20 as shown in the table below.

Table 2-1-2-2 Generating capacity increasing plan (Based on ISES2035 Scenario4b)

Installed Capacity (GW)	2009/10	2014/15	2019/20	2025/26	2029/30	2034/35
	2009	2014	2019	2025	2029	2034
Nuclear Power Stations	0	0	0	3.6	4.8	4.8
Coal	0	0	1.6	12.0	13.6	23.2
Oil products	1.4	1.3	0.9	1.0	1.3	1.3
N.Gas & Dual fuel Oil plant	20.4	33.0	55.9	54.9	55.0	54.8
Hydro	2.8	2.8	2.8	2.9	2.9	2.9
Wind	0.5	0.5	13.3	20.5	20.6	20.6
PV	0	0	3.0	5.9	22.9	31.0
CSP	0	0.1	0.1	0.1	4.1	8.1
Total(GW)	25.1	37.7	77.6	100.9	125.2	146.7

Based on the Table 2-1-2-1, the generating capacity is scheduled to increase by 19.4GW in the period from the year 2016/17 to 2021/22. Considering 4.8GW generating capacity installed by 2016 as the Fast Track Plan and others, the total increased generating capacity up to the year 2021/22 amounts to 24.2GW. Incidentally, introduction of coal fired thermal power plants have been postponed for a year and excluded from Table 2-1-2-1 (2016/17 - 2021/22). Taking these factors into consideration, the current generating capacity plan (Table 2-1-2-1) is judged to be consistent with ISES2035 Scenario4b (Table 2-1-2-2). EEHC itself is quite confident of the consistency between its current plan and ISES2035 Scenario4b.

Incidentally, the capacity reinforcement plan to 2022 is scheduled to be almost completed by around the year of 2020.

2) Electric power demand forecast method

It was confirmed that the electric power demand forecast used in ISES2035 Scenario4b was provided by the demand estimation section of EEHC. Therefore, the survey team verified the outline of the forecast method and estimated the contents.

a) Method of Yearly electrical energy demand (kWh) forecast

Electrical energy demand is estimated using the econometric method called by E-VIES. At first, coefficients on GDP, population, electrical charge level is found in inductive manner, based on the past data, for each field such as industry, agriculture, households, commercial use, government, and public service. Yearly electrical energy demand (kWh) for each field is estimated based on its coefficient.

Ei: Estimated total yearly electrical demand in the year of "i"

$$E_i(\text{kWh}) = \sum\{aj \times GDPj + bj \times \text{population} + \frac{cj}{(Electrical\ charge)\text{j}}$$

In terms of the above equation, “GDPj” is acquired from Ministry of planning, “population” is from the Central Agency for Public Mobilization and Statistics (CAPMAS), and “(electrical Charge)j” is from EEHC. Also, aj, bj, and cj are found in an inductive manner, based on past data.

Total electrical demand at the generators’ end (Gross generating kWh) is calculated considering the losses in distribution – transmission, in-house consumption in power stations, and net energy exchange with the interconnected countries. Losses in distribution – transmission includes non-technical losses and the effects of power factor improvement as well as the expansion of power system. In-house consumption of power stations is acquired from the power production companies. Losses in distribution – transmission and internal consumption of power stations amount up to 14.5% of the Gross generating kWh recently.

b) Method of Peak load (kW) forecast

Measuring instruments with communications functions installed at 3,000 representative customers measure the demand every 15minutes. Measured values are accumulated and used to estimate load rates as well as peak load curve. The effects of DSM and energy efficiency improvement are taken into consideration in the process of estimation.

Peak load (kW) is calculated based on the equation below.

Load rate = Yearly electrical energy demand (kWh) / (peak load (kW) x 8,760)

c) Time span of the forecast, review period for the results, forecast at present

Electrical demand forecast is estimated in the short term (up to 3 years), medium term (up to 5 years), and long term (10years). If estimated peak load diverges from actual measurement value more than +/-3%, the peak load should be reviewed. The review every year is not conducted because frequent reviews are undesirable in maintaining a stable forecast.

Currently, a 5.5% demand increase per year is applied as the most likely case, and this figure basically matches with ISES2035 Scenario4b, whose average electric demand increase rate in the period from 2009/10 to 2034/35 is 4.61%/year, including improvement in energy efficiency in future.

3) Decision on the required generating capacity reinforcement to meet demand

Regarding the method for deciding the required generation capacity reinforcement, it confirmed that the method used in EEHC matched with ISES 2035Scenario4b. Therefore, the survey team confirmed the outline of the method and estimated.

Generating capacity to be installed is determined considering a 25% margin to the estimated peak load. This margin includes maintenance shut-down of generating facilities, facility deterioration, and gas turbines/combined cycle plants output decline caused by high temperatures in summer. Availability capacity, which is calculated as the result of excluding these factors from the margin, is 5%. Gas turbine output decline is set to be 8%, and that of combined cycle plants steam turbine portion is 3%. These declines are calculated based on the actual output decline in the period of June, July, and August.

Loss of load probability (LOLP) is set to be 8 hours/year.

The methods applied for the demand forecast and the generation reinforcement are appropriate because the methods and the ways of the study are matched with the one used abroad, including Japan.

(2) Statas quo of the development plan of RE and related information

1) Latest development plan on RE and Coordination between ISES2035 Scenario4b

As stated in 2-1-1(1)1), the capacity of the RE including existing hydro power should supply 20 % of the electricity energy in 2022. In 2035, according to ISES2035 Scenario4b, more than 30 % of the electricity energy should be supplied by RE with further development after 2022 to realize the most economical performance in total energy consumption.

NREA is now studying a concrete plan for 2022 in cooperation with EgyptERA and taking on some projects.

Development of the capacity of RE would be around solar 3GW and wind 7GW, with the total of 10GW including existing solar 0.05GW and wind 0.75GW. This RE reinforcement, along with the existing hydro power of 2.8GW, will supply 20% of electricity energy in the Egyptian electricity system in 2022.

Incidentally, the reinforcement capacity of RE is relatively small compared with the estimated capacity in ISES2035 Scenario4b. It should reflect on the fact that the development of solar and wind at the initial stage will concentrate on the sites with favorable conditions for solar and wind. The more favorable the conditions, the more energy will be derived with smaller capacity. Therefore, it should be reasonable to reexamine the required capacity for fulfilling the energy requirement of 20%, referring to the progress in the survey on the concrete conditions of the expected sites.

Segmentation of the RE capacity development by developers is as follow;

✓ At present:

Solar: 0.05GW (such as Independent system operation)

Wind: 0.75GW →developed and operated by NREA

✓ In year 2022 (more than 8GW will be developed in addition to the existing ones based on the information provided by NREA and EgyptERA)

Solar: FIT: 1.56GW BOO: 0.4GW NREA: 0.08GW

Wind: FIT: 2GW BOO: 1GW NREA: about 2GW

According to the derived information, many projects are in the process of development. Incidentally, in 2-6-4 in this Report, the concrete projects are presented.

Considering the status quo of the situations, it would be rather achievable to develop 9GW combined with the solar and the wind plants in 2022. Therefore, ISES2035 Scenario4b and the latest development plan confirmed by the survey team are judged to be well coordinated based on the assumption that the average availability of RE, including hydro, is about 47% at that time.

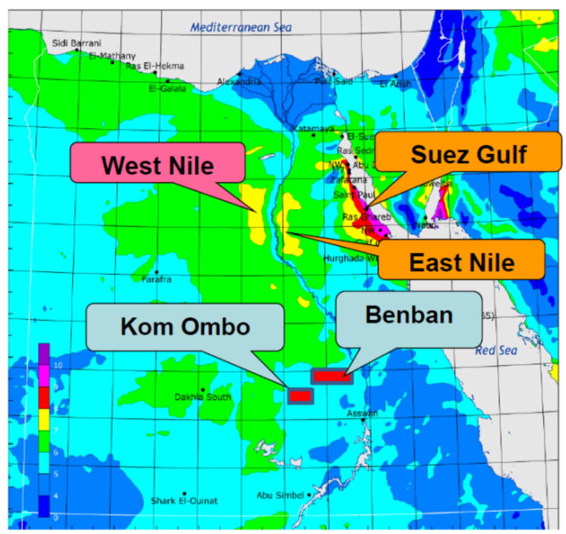
After 2022, it is confirmed that there is still no concrete RE development plan. However, since there are potential new sites of up to more than several tens of GW as shown below, thanks to the very favorable conditions in Egypt, it would be surely expected for developing the RE in due time and fulfilling the target of 2035 in ISES2035 Scenario4b.

Incidentally, since the introduction of large capacity with RE that will bring about the issues of electricity system operation such as system frequency fluctuations, some countermeasures to cope with the issues might be required, which is to be estimated in 2-6-5.

Areas

Zone		Areas (km^2)	Capacity MW
Suez Gulf (wind)		1220	3550
East Nile	wind	841	5800
	Solar	1290	34900
West Nile	wind	3636	25350
	Solar	606	17400
Benban (Solar)		37	1800
Kom Ombo (Solar)		7	260

Yellow shaded cells represent the available areas



Source: NREA

Figure2-1-2-1 Potential development of renewable energy

(3) Status-quo of the Transmission reinforcement plan in Egypt and related information

According to ISES2035 Scenario4b, the transmission network development plan is out of scope. Therefore, the survey team confirmed the transmission reinforcement plan and related principles and methods for the reinforcement and estimated the appropriateness of the plan which should be coped with the generation development targets in ISES2035 Scenario4b.

1) Principles and methods of the transmission network development

The transmission network development principles and methods including transmission network operation method are tabulated in Egyptian Electric Power Transmission Code which is supervised by the EETC. The transmission network development should be conducted, complying with the contents presented as follows.

a) Rated frequency

The nominal fundamental frequency is 50Hz. Control of the System Frequency is the responsibility of the Transmission System Operator. The Transmission System Operator maintains the fundamental Frequency within the limits of 49.95Hz and 50.05Hz during normal conditions.

b) Rated voltage

The rated voltage of the transmission network system in Egypt is used as follows;

500kV, 400kV, 220kV, 132kV, 66kV, 33kV, 11kV

c) Voltage regulation

The Transmission System Operator plans, designs and operates the Transmission network system so that, under normal operating conditions, the voltage at all Connection Points (Substation bus-bar, Transmission sending point, Transmission receiving point, Power generate station bus-bar) lies between 95% and 105% of the normal value.

d) Transmission network system planning criteria

The 500kV and 400kV Transmission network system is planned so that no single contingency (at 500kV or 400kV) results in unacceptable frequency, voltage or large scale demand disconnection; the n-1 criterion.

The 220kV, 132kV and 66kV Transmission network system is planned sot that no any two contingencies (at 220kV, 132kV or 66kV) results in unacceptable frequency, voltage or large scale demand disconnection; the n-2 criterion.

e) Fault current upper limit value

The fault current upper limit value is regulated as follow;

Table 2-1-2-3 Fault current upper limit value

Nominal Voltage at Point of Connection	Design Fault Levels kAmpere	Fault Duration Seconds
500 kV	40	One
220 kV	40 / 50	One
66 kV	31.5	One
33 kV	31.5	Three

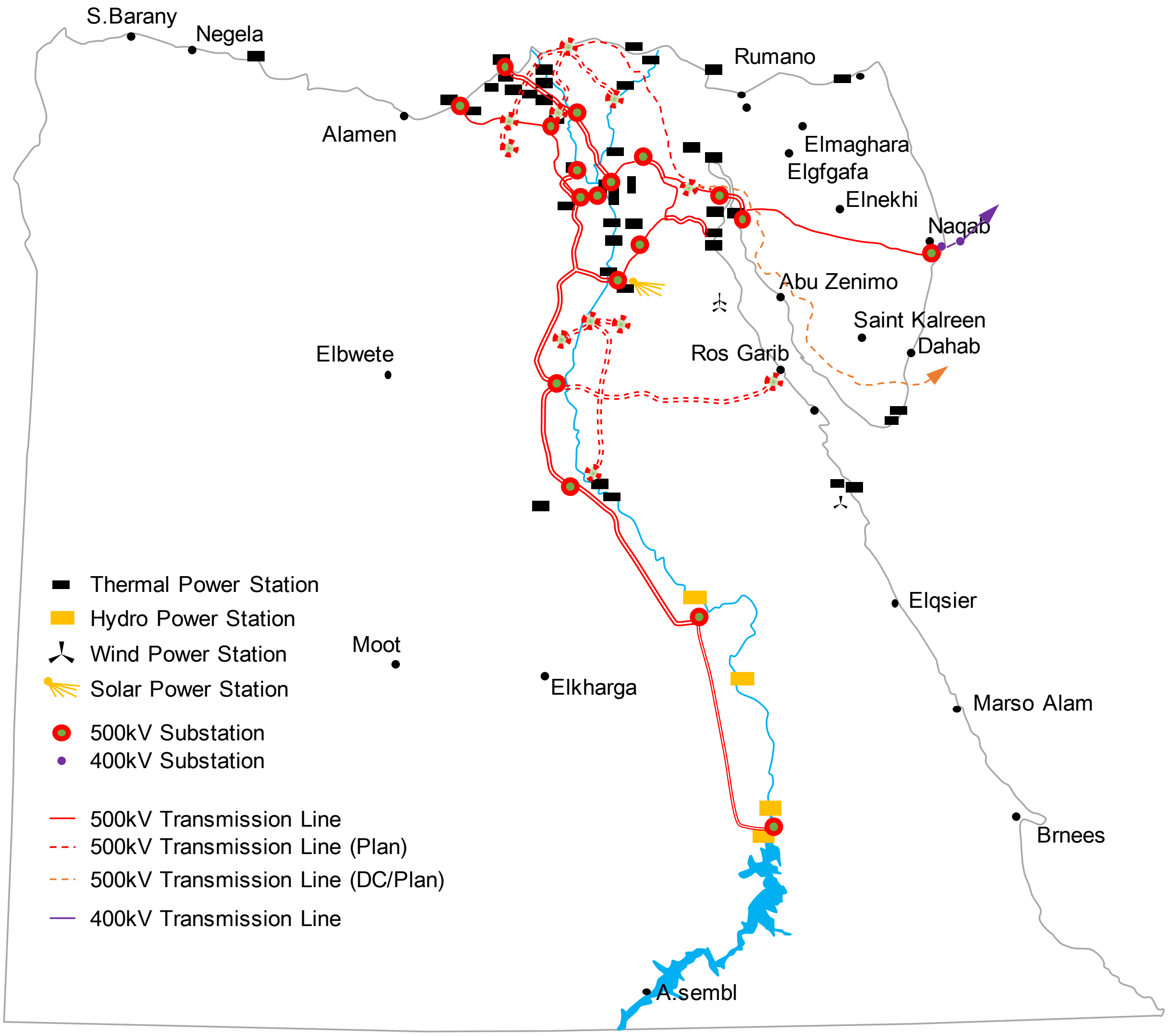
Source: Egyptian Electric Power Transmission Code

2) Transmission network at present and the direction for the future

To understand the network at present and the direction for the future, before visiting Egypt, the survey team studied the current 500kV transmission network system and the future 500kV transmission network based on the Annual report 2014/2015 by EEHC. The study result is shown in Figure 2-1-2-2.

The large hydro power plant Aswan is located in the upper Nile. The population is concentrated in the Cairo and consumes large electricity energy. Therefore, the current 500kV transmission lines were installed between the southern area and the central area. Incidentally, international connection with Jordan is with 400 kV.

The number of 500kV substation is 18 substations as of 2016 and the EETC is planning to build 10 more substations. One of the new substations is an AC/DC converter station for the international interlinking line with Saudi Arabia. Therefore the new 500kV transmission line will be in place. Another international interconnection is with Libya (220kV). There will be large capacity of new thermal generation development now and future. Large scale reinforcement of 500kV system should be inevitable.

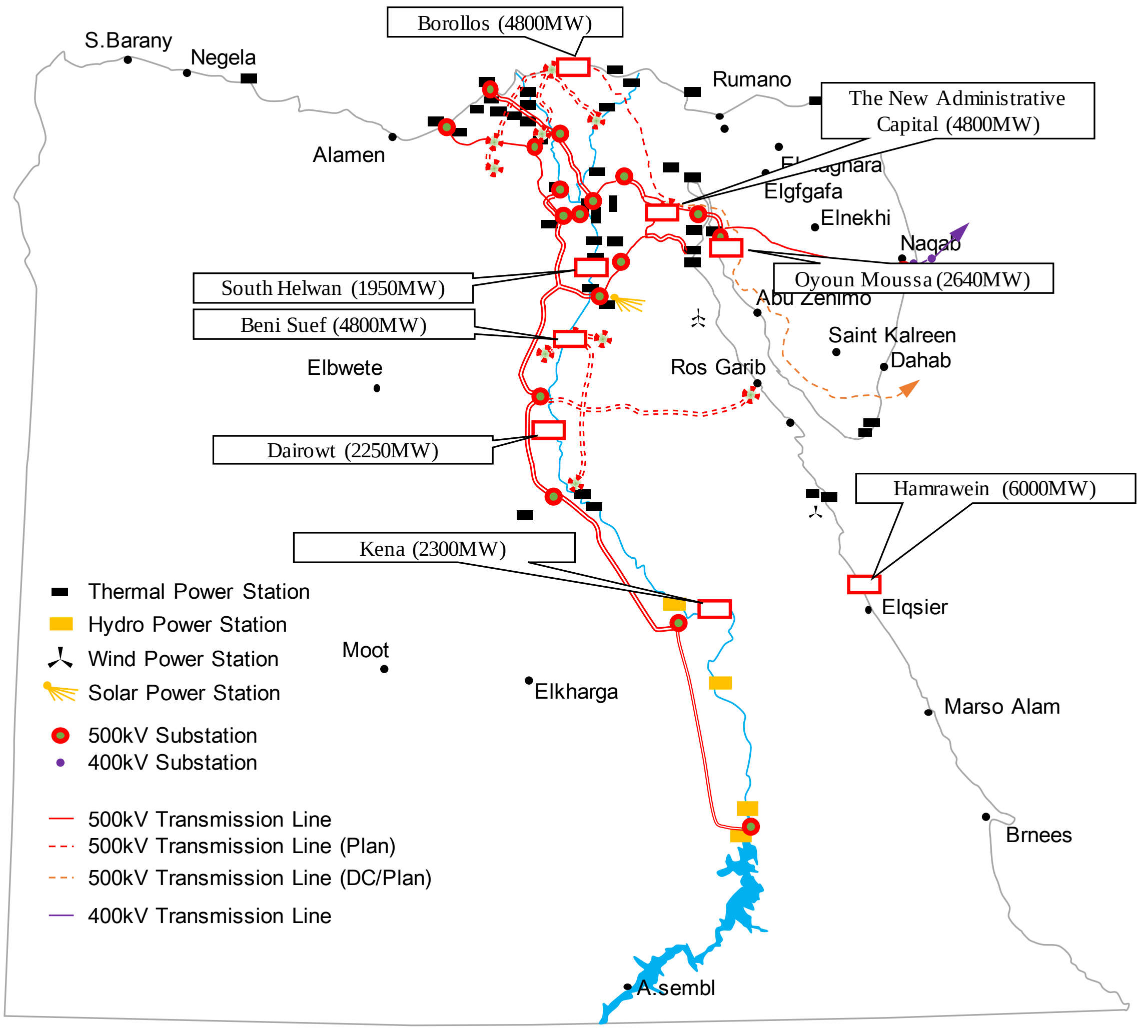


Source: Egyptian Electricity Holding Company / Annual Report 2014/2015

Figure 2-1-2-2 500kV existing transmission line network and planed transmission line network as of 2016

3) Future national grid

Based on the national power generation plan, the point of power generation sites are shown on the 500 kV transmission system diagram in Figure 2-1-2-3. 500 kV transmission line reinforcements in the near future are also included in the diagram, which shows that the new power plants are relatively near the existing power transmission network. On the other hand, further transmission system development is presented in the 2025 transmission system master plan (Draft) including Hamrauin coal power station (6,000 MW)



Source: made by Survey team

Figure 2-1-2-3 500kV transmission line network with planed power generation plants

4) 2025 transmission and substation draft plan (2025 Master Plan(draft))

The transmission system in 2025 was studied from 2015 with the support of Siemens, and the final report is in the process of approval. During the study, EETC has received instructions from MoERE. Therefore, the plan is regarded mostly as the National plan for the transmission and substation development in Egypt.

The conceptual diagram in 2025 is shown in Figure 2-1-2-4 and the basic characteristics are summarized as follows.

In the southern Egypt area, a 500kV ladder type configuration system will be formed to cope with the large capacity generation development in Hamrawein, RE development along the Nile River west and east sides along with the new international interconnection with Sudan, as well as other generation plant development, the power will be transmitted through the 500kV ladder system. The ladder system with the loop operation principle will have the flexibility to cope with the power flow change caused by such as RE. Incidentally, the loop operation system in the bulk transmission system has been applied with the same idea in Japan. Therefore, it seems to be rational with the principle of the loop transmission system development in Egypt.

In the northern part of Egypt, a 500kV meshed type configuration system will be in place to cope with the need of the supply to the increasing demand, introduction of new thermal generation and requirement of power corridor functions for international interconnection as well as RE development. The meshed system naturally has more flexibility for power flow change than the loop system. In case the transmission length should be relatively long such, as several hundred km, introduction of higher voltage such as 800 kV might become an option other than the meshed system. However, it would be rational to adopt the meshed system after considering all of the aspects in the future. In the meshed system, the fault current should increase in general. In the case of Egypt, EETC is considering upgrading of the fault current breaking capacity along with the opening operation of several transmission line circuit breakers or the abolishment of the lines to cope with the issue (Regarding the fault current increase measures, see 2-4-1-6).

In and around the Cairo area, the enhanced 500kV system with a double ring system will be stepped down to 220kV and the 220kV underground cable system will be formed as the metropolitan bulk supply system.

According to the experience in Japan regarding the bulk power supply system for metropolitan area, the reinforcement of the high voltage overhead transmission line system would become more difficult as the supply measure because of the difficulty in acquiring its right of way and insulation distance. Therefore, the reinforcement of the main supply system has been and will be more dependent on an underground high voltage cable system.

In years to come, EETC is planning to proceed with power supply reinforcement for the Cairo Metropolitan Area with 220 kV underground cable systems according to the 2025 Master Plan. On the other hand, the basic guidelines for long-term supply to the metropolitan should be established according to the Japanese experience, which is not sufficiently set in EETC. Therefore, it is desirable to set the guidelines and create the supply vision from long-term stable supply perspective, which should include the basic idea of the 2025 Master Plan and should be effective for a longer period. Anyway, according to 2025 Master Plan, it seems appropriate to reinforce the 220 kV underground system in and around the Cairo area and secure the main supply functions for the densely populated area, and the securing of a stable power supply which should be the top priority metropolitan city because the stable supply in Cairo area should surely contribute to the development of Egypt itself.

In the planned underground system as presented in the 2025 Master Plan, high reliability will be realized with a 200kV line loose or tight loop operation.

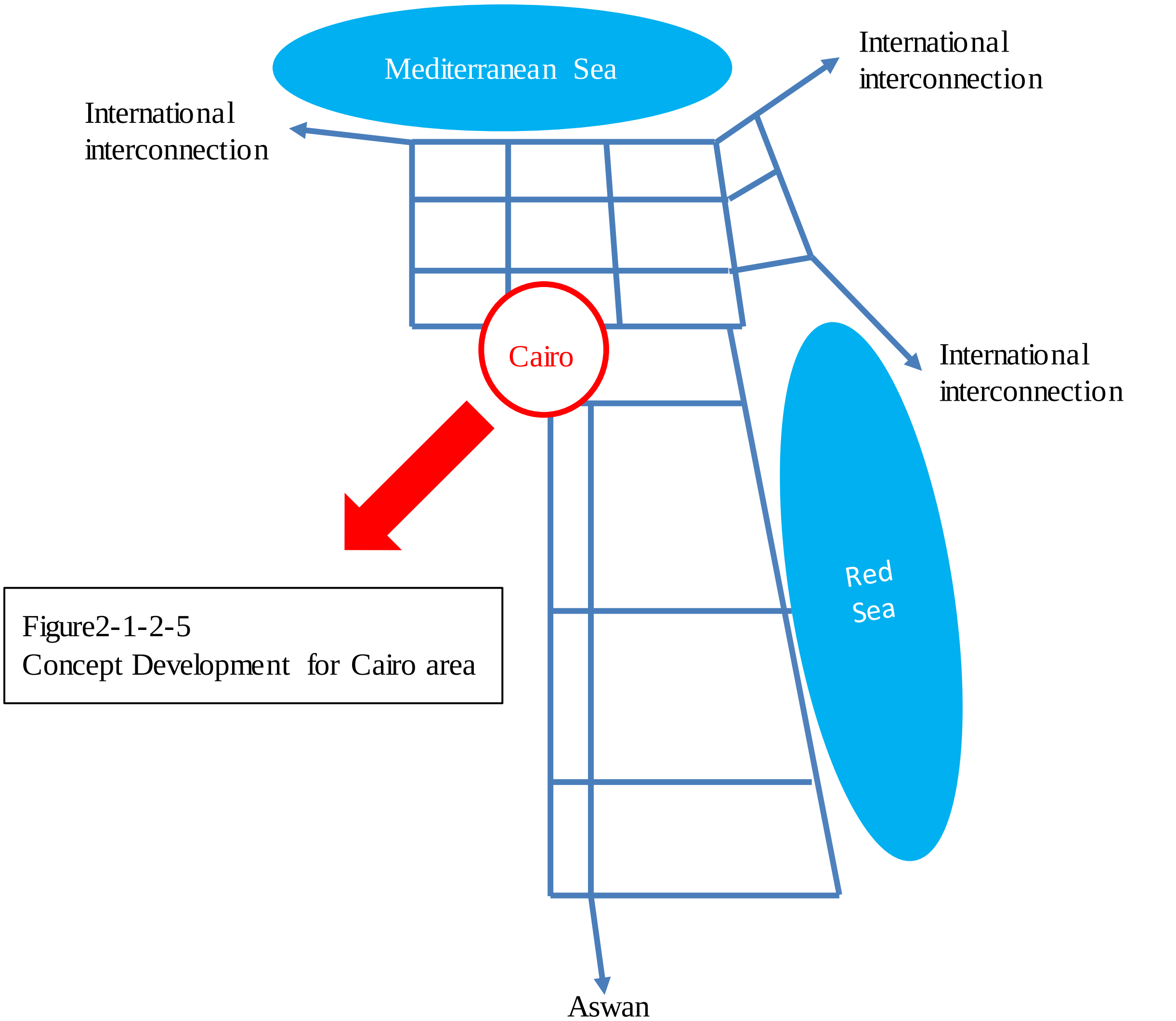
Incidentally, loop operation, especially in the underground cable system, would bring about loop flow because of low impedance of the cable, which would require special attention and some measures in some cases from the experiences in Japan where the radial operation has been common practice. In some cases, some specifications for the cable facilities or power flow control systems might be required to cope with the loop operation without open operation of the circuit-breakers.

Incidentally, loop operation, especially in the underground cable system, would bring about an increase in fault current as is suggested in the 2025 Master Plan because of low impedance of the cables, which would require the special attention and some measures from the experiences in Japan, where the radial operation has been common practice.

In the 2025 Master Plan, it is recommended to adopt a partial abolishment of the 220 kV system and circuit breaker opening operation.

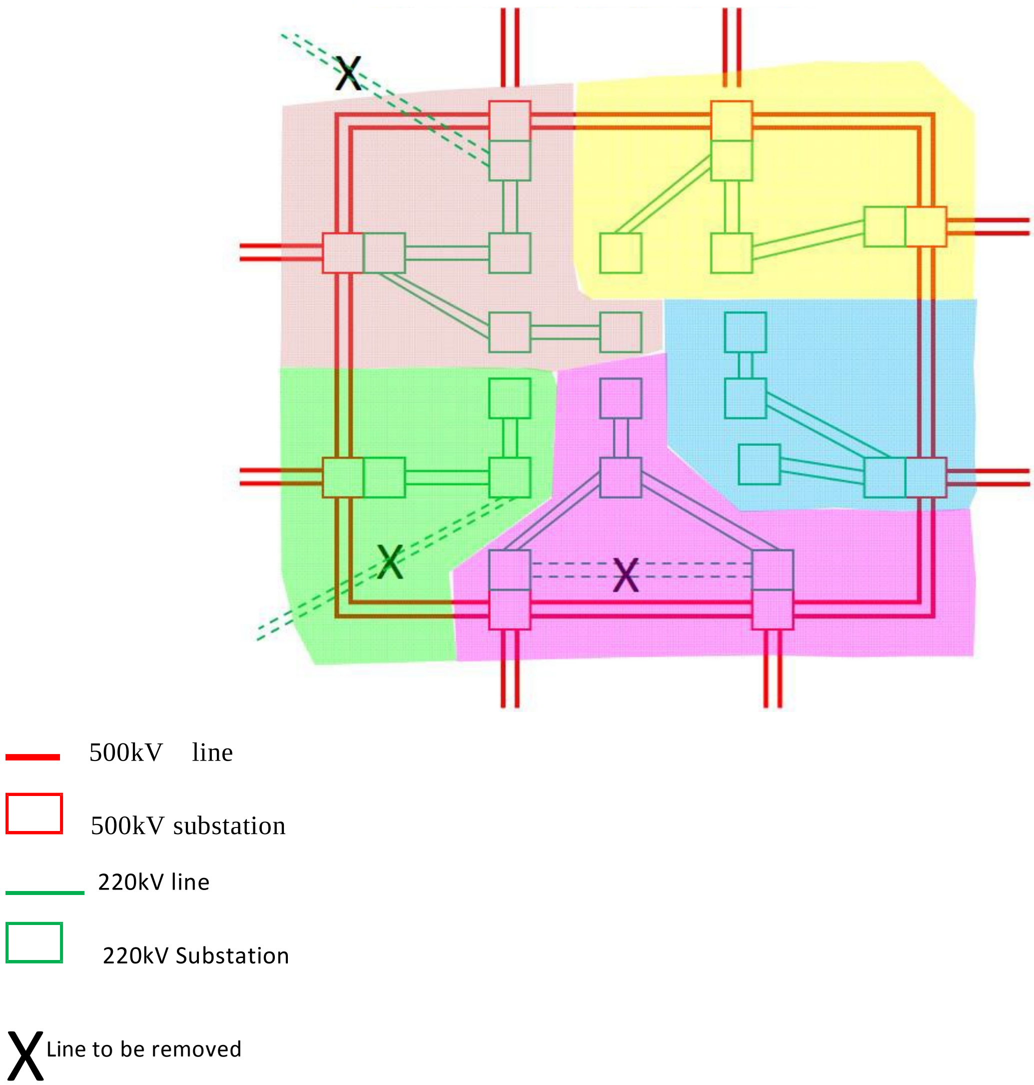
Based on this glimpse of the survey, the bulk transmission system reinforcement into the year 2025 seems to basically meet the requirements assumed in the ISES2035 Scenario4b.

Since the plan includes the bold development in the transmission system, it should be important to realize the plan with a comprehensive viewpoint, encompassing securing a stable system operation and securing the required funds, which might require some adjustment in the Plan in the future.



Source; made by Survey team and offered document by EETC

Figure2-1-2-4 Schematic View of Main system in 2025



Source; EETC

Figure2-1-2-5 Concept Development for the Cairo area

(4) Current status of the distribution plan and the method of planning and related information

Since the plan for the network is out of the scope of ISES2035, the team conducted the survey on EEHC administration of nine distribution companies and each distribution company to verify that their plans are made out properly and matched with ISES2035 Scenario4b.

Since it was revealed that EEHC administration gives a rather free hand to the distribution companies, the team focused on the survey mainly to each distribution company. At first, the survey team selected two distribution companies, North Cairo Distribution Company where the underground cable system is the main supply system, and North Delta Distribution Company where the overhead line system is the main supply system. Information of other companies will be also analyzed because EEHC administration conducted a questionnaire survey with the distribution companies and the related data was provided.

Here, the results of the survey are shown mainly regarding the distribution plan at North Cairo Distribution Company.

1) Increase in load

In the last fiscal year (2015/2016), the increase rate is about 10%. There are differences between sectors (14 sectors), 4 - 20%/year. Based on the past five or six year's data, the demand growth is forecasted.

2) Maximum current value (demand) in the last fiscal year

The maximum demand in the last fiscal year was 3641 MW in the evening in August 2015. The minimum demand was 2728 MW in the morning in February.

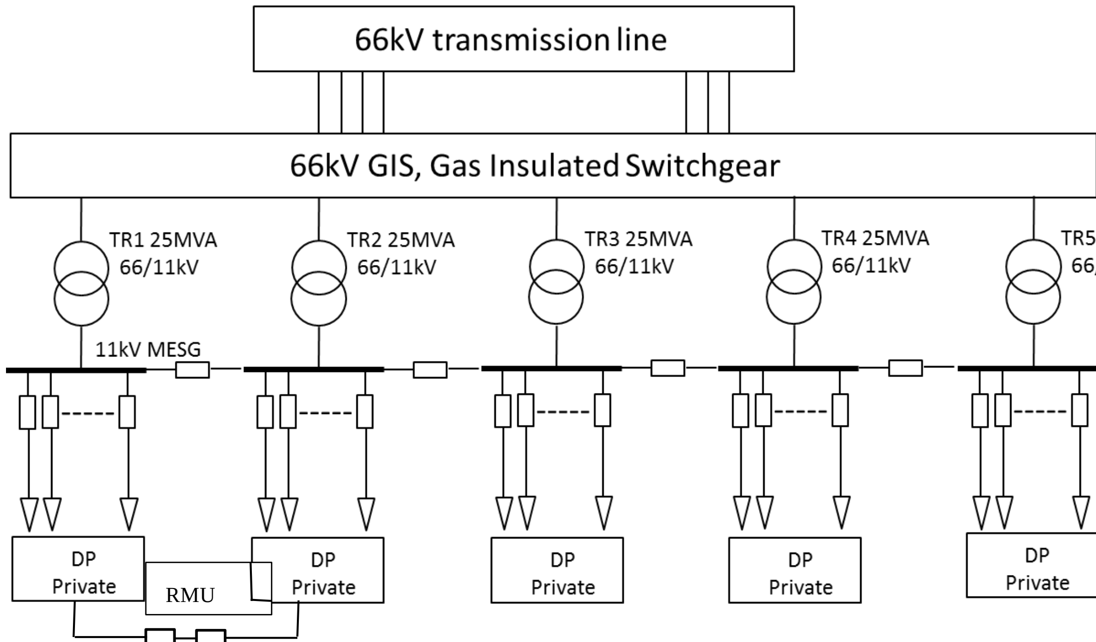
3) How to determine the distribution plan

The distribution system plan is made, considering the increase in maximum demand, and minimum demand is not considered. The voltage drop is also not considered for the study of the plan.

The maximum currents in the distribution substations are referred to and large development projects in the area are also included in the plan. The initial tentative plans are worked out in each area within the allocated budget. After that, considering the measures for such as rapid demand growth in the newly development area, the plan with the budget will be adjusted. EEHC administration should participate in the process of the adjustment among the distribution companies. In case of the North Cairo Company, new development in the North Cairo area should bring about a 30~40% demand increase which should require the reinforcement of many new distribution lines. For the budget of the distribution companies, EEHC administration office should always confirm all the plans of the distribution companies for the long-term, short-term and emergency and instruct correction if required.

4) Basic principle of the Planning on distribution system and status-quo of the plan

Configuration of the distribution system is an open loop system with two RMU. Configuration at the distribution substation is shown in Figure 2-1-2-5.



Source; Interview survey with North Cairo Distribution Company

Figure 2-1-2-6 Basic distribution system configuration

The trend of the budget for the distribution system plan in North Cairo Distribution Company is shown in Table 2-1-2-4.

Table 2-1-2-4 Trends of the budget in North Cairo Distribution Company

year	Investment (Pound)
2014/2015	220,066,000
2015/2016	204,982,000
2016/2017	250,200,000
2017/2018	1,428,320,000
2018/2019	1,918,660,000

Source; Interview survey with North Cairo Distribution Company

- ✓ Values after 2016/2017 are planned.
- ✓ After the fiscal year of 2017/2018, the budgets will increase considerably.
- ✓ Regarding the distribution system plan, a two-year plan is worked out every year. The plan includes improvements, replacements and reinforcements. Although a long-term plan is not made out; the demand forecast for the coming 10 years is to be submitted to EEHC administration.

5) Projects in progress

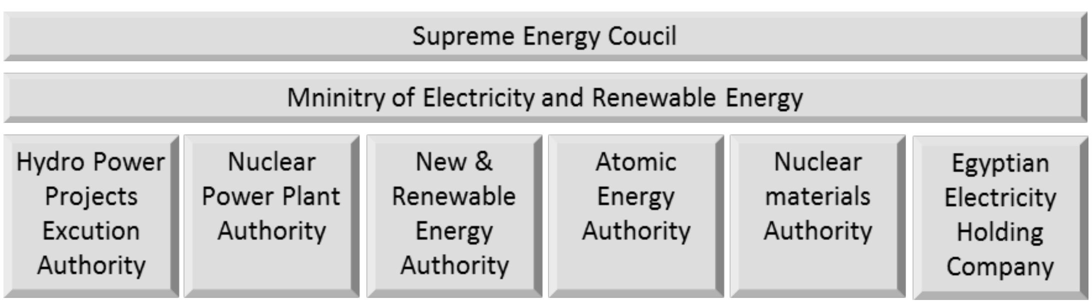
- ✓ There is a project to install 53,000 smart meters in the area of Nasr City and Abour. Incidentally, Northern Cairo Distribution Company has a total of 4 million subscribers. This project is to be conducted with its own budget and now is at the stage of preparing the specifications.
- ✓ Installation of DMS (Distribution Managing System) is planned in all distribution management sectors. Seven units in total will be installed and one of them will be installed by the JICA Project.
- ✓ The existing DMS is the one installed in Shobra. GPRS[2] is applied as a communication system. Currently the system in the Helmaya district including the smart meter installation is under way as a JICA project.

2－1－3 Situation surrounding the power sector, electric power implementation system, related economic and financial analysis

1) Outline of the power sector

a) Composition of the power sector

Figure 2-1-3-1 indicates the governmental organizations in the power sector. The Supreme Energy Council (SEC) is a political council guiding and overseeing the energy sector in Egypt. Substantially, the MoERE supervise the power sector and there are six organizations below the ministry.

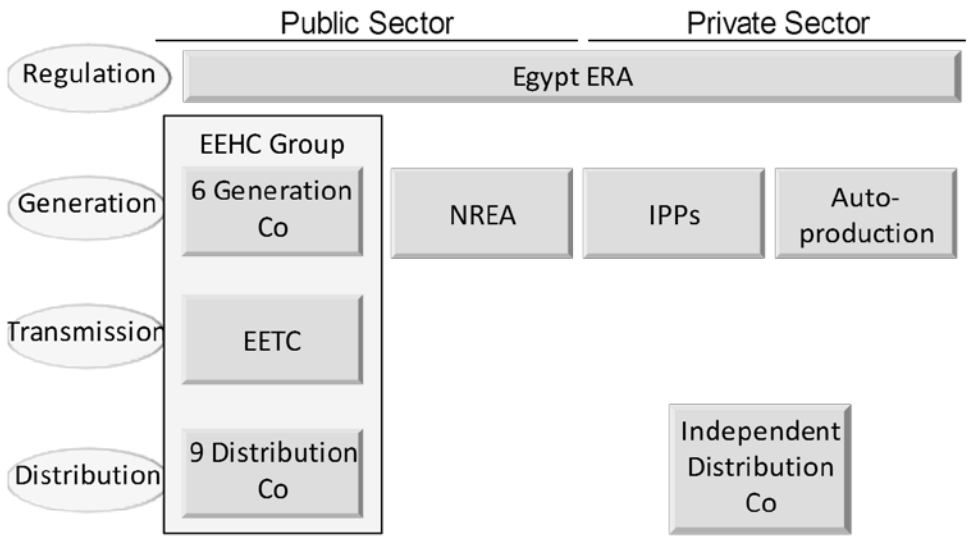


Source: NREA annual report

Figure 2-1-3-1 Governmental organization rerating to power sector

EEHC (Egyptian Electricity Holding Company) & NREA (New & Renewable Energy Authority) are involved in power generation and transactions among these organizations. EEHC group consists of six generation companies, one transmission company and nine distribution companies. Share of EEHC group are 91% in generation, 100% in transmission and almost 100% in distribution. NREA is specialized in renewable energy and the share in generation is around 1%.

[2] General Packet Radio Service



Source: Prepared by study team based on provided data

Figure 2-1-3-2 present organizations related to power transaction

There are public institutions and private organizations regarding power transaction. Public institutions are composed of EEHC group, NREA and regulation agency of Egypt ERA. Private organizations are composed of IPPs and auto-producers. IPPs mean the power plants developed by private entities using the scheme of BOO or BOOT. Auto-producers mean that EETC contracts with some large companies who hold large capacity of auto-production generation with regard to the capacity of the excessive energy trade. Such contracted entities are indicated as auto-producers (Incidentally, those are depicted as IPP in the EEHC annual report). There are several independent private distribution companies in some regions, but according to EEHC they could be neglected because the scale is very small.

The main actor in the power sector is EEHC group at present. It is noticed that the government is encouraging in developing private power plants in generation. Although BOOT power stations are only 3 (Suez Gulf, PortSaid, Sidi Krir3, 4) at present, number will increase in the future including RE stations.

Overviews of the main organizations in the power sector are as described follows;

✓ Supreme Energy Council (SEC)

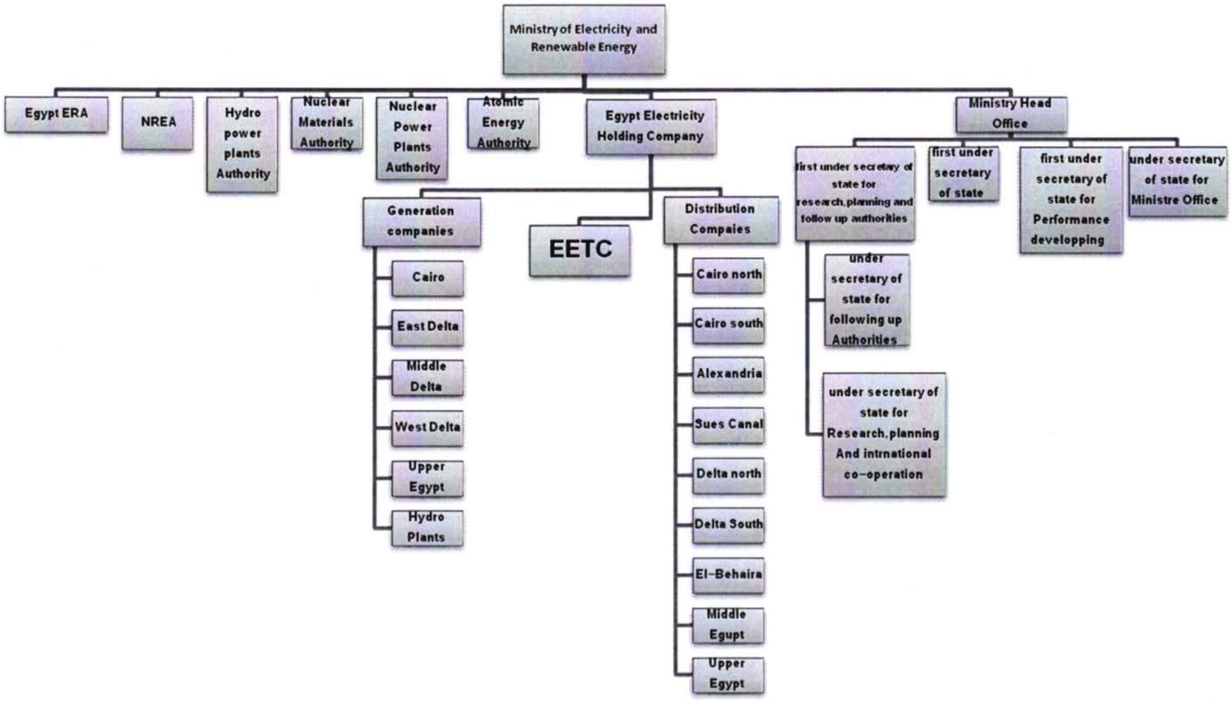
The Supreme Energy Council (SEC) in Egypt is the highest forum for energy policy in the country and is in charge of developing and monitoring the energy policy dynamically and strategies for Egypt through a Ministerial Committee, guiding and overseeing the energy sector in Egypt established in 1979 under Prime Ministerial decree No.1093, and reformed in 2006 with decree No. 1395. It comprises of 11 Ministries: Defense, Finance, Petroleum, Electricity Economic Development, Environment, Investment, Housing, Trade & Industry, Transport, and Foreign Affairs and are headed by the Prime Minister of Egypt[3].

✓ MoERE[4]

Ministry of Electricity and Renewable Energy (MoERE) supervises and guides the power sector and was established in 1964 under the name of Ministry of Electricity and Energy (MOEE). Then many decrees were issued by the state to regulate and specify its activities. The last decree was in 1974 and stated that the goal of the ministry is to provide the electricity to all consumers all over the country. And in order to fulfill that obligation, the ministry has to:-

- Settle a general plan & energy generation, transmission and distribution using the high-tech and latest scientific development and supervise the execution of such plan and follow-up the different activities concerning the electrical network.
- Suggest electric energy prices for all different voltage levels and different usages.
- Supervise the study and execution of essential electrical projects.
- Publish the statistics and data relating to electric energy production & consumption.
- Provide technical consultancies and services in the electric fields to Arab countries and all others.

[3] Development in Egyptian Energy Efficiency Policy Project Technical Director Dr. Ibrahim Yasssin Mahmoud
[4] Approximately 40 regular employees



Source: Prepared by survey team based on provided data

Figure 2-1-3-3 MoERE group

✓ EgyptERA(Egyptian Electricity Utility & Consumer Protection Regulatory Agency)

EgyptERA was formed in 1997 (Presidential Decree No 326), and reformed in 2000 (Presidential Decree No 339). The mandate of the regulatory agency is to regulate, supervise, and control all matters related to electric power activities, whether in generation, transmission, distribution, or consumption, in a way that ensures availability and continuity of supply so as to satisfy the demand for the various aspects of usage at the most equitable prices, taking into consideration environmental protection, the interests of electric power consumers as well as the interest of the production, transmission, and distribution .The agency also aims at preparing for lawful competition in the field of electricity generation, transmission, and distribution, and avoiding any monopolization within the Electric Utility. Since the agency started in 2000, it licensed all government owned utilities, the three BOOT projects and over 22 ISP. The agency follows the performance of these utilities through a bench marking scheme for both their financial and technical performance[5].

- Egypt ERA's Vision: Upgrading the electricity sector and it's services in accordance with international standards, this help in the existence of a competitive electricity market, achieving the best price with the highest level of

[5] Paving the way for MSP Activity 1.1.1: Benchmarking of existing practice against, -Country Report Egypt-MVVdecon/ENEA/RTE-I/Sonelgaz/Terna and can

service, attaining regional cooperation through the compatibility with other countries, establish the principles of nondiscrimination, emphasis on free competition taken under by predictable decisions, work on consumer protection through the transparency of performance, and ensure a balanced relationship between suppliers and consumers. It also encourages investment in the electricity sector through provision of infrastructure investment on economic fundamentals and stimulates investing in renewable energies.

- EgyptERA's mission: Follow up and monitor all the activities of electrical energy production, transmission and distribution, in order to ensure the availability and continuity in meeting the requirements of different usage at a reasonable price and preserve the environment. This could be achieved by setting rules and regulations for the electrical energy providers and consumers in order to achieve the transparency of performance and prevent monopolistic competition.
- Egypt ERA's Objectives: The Agency aims organizing, follow up and monitor all the activities of electrical energy production, transmission, distribution and consumption, ensuring the availability and continuity to meet the requirements of different usage at a reasonable price and preserve the environment, considering the interest of the producer, transporter, distributer and the consumer of electricity, adapting fair competition in the activities of electrical energy production, transmission and distribution[6].

✓ Egypt Electricity Holding Co. (EEHC)

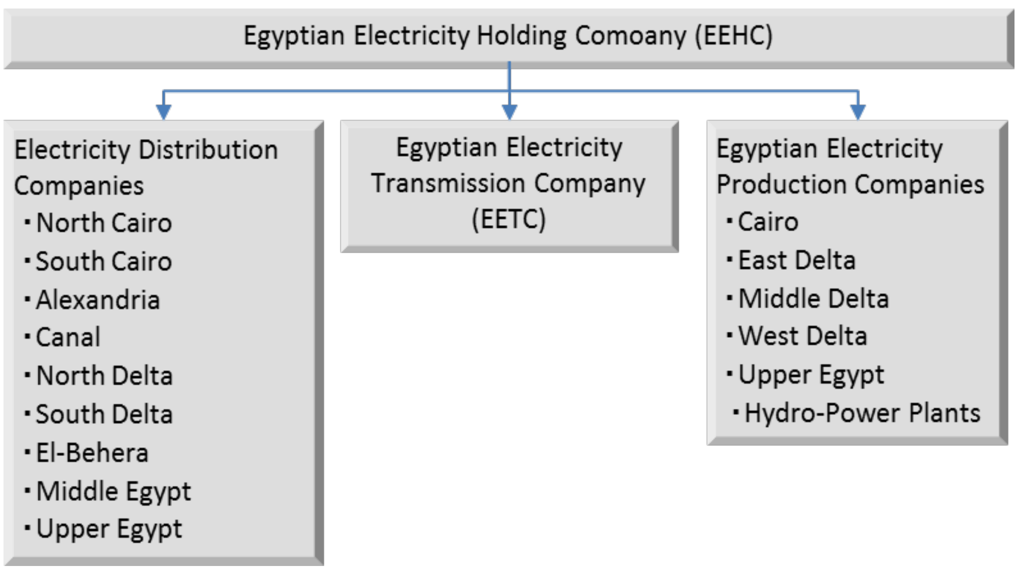
Egypt Electricity Holding Co. (EEHC) was formed by transforming the former Egyptian Electricity Authority (EEA) under law 164/2000. EEHC inherited the role of EEA and other earlier entities responsible for the electricity sector in Egypt. EEHC carries on a dominant active role in the planning as well as overlooking the execution and operation of the government owned electric utilities (affiliated companies - six generation, one transmission and nine distributions).

Aims of the company which is stated on the homepage are as follows;

- Various efforts to save electricity and realize high efficiency and appropriate price for all uses.
- Planning, researching and designing in the field of the company and its subsidiaries' capabilities.
- Implementation of a project to produce electricity from a thermal power plant.
- Implementation of electricity rationalization program for homes and street lamps.

[6] Home page of Egypt ERA

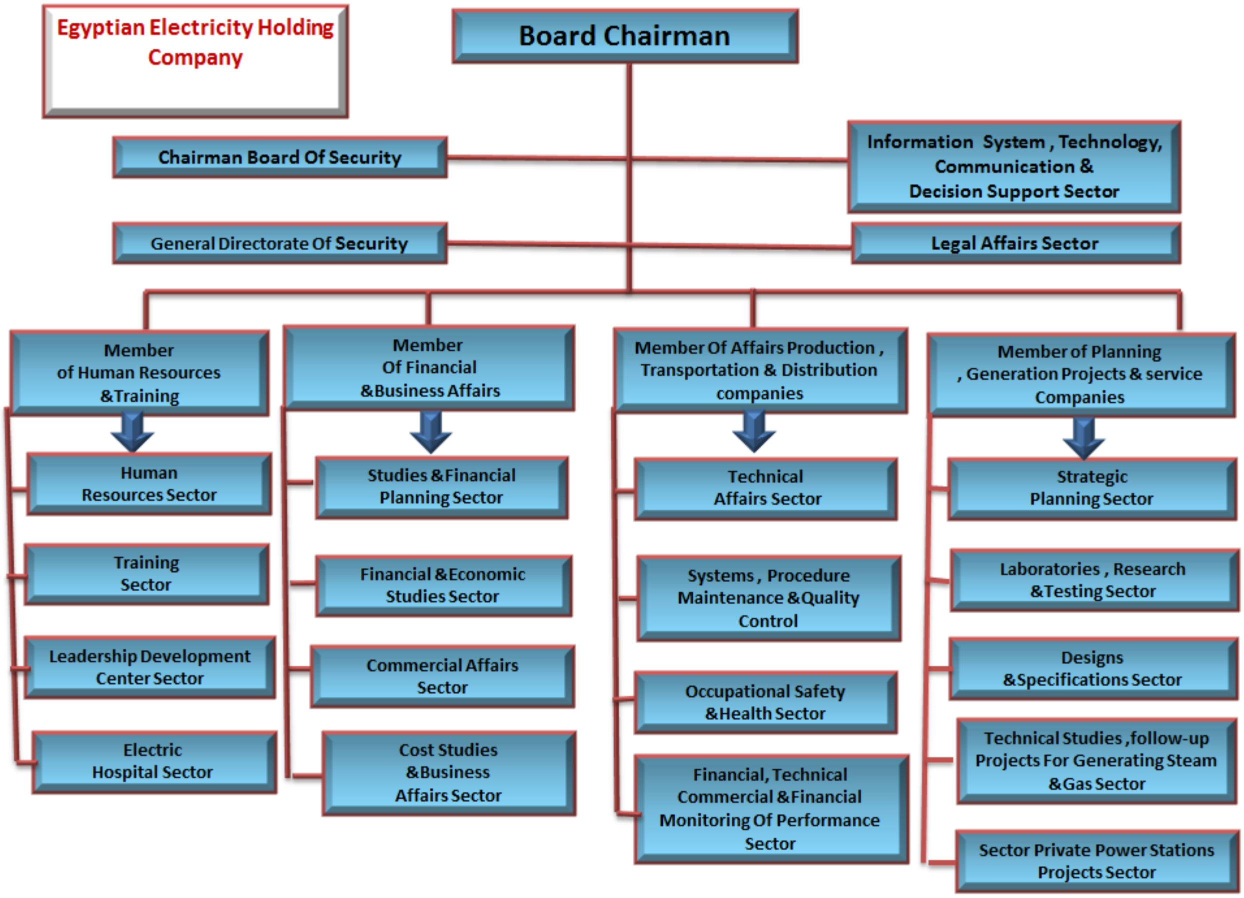
- Implementation of relocation of electric power project.
- Controlling bureau supervising the production, transmission and distribution of electric energy.
- Purchase electricity produced from the power plant and sell it through the network.
- Proper management, operation and maintenance of transmission and distribution networks, appropriate electric power sales in the country, development of an optimum network
- Appropriate management of load movement across the nationwide network.
- Implementation of electricity international connection projects and electric mutual exchange, sale and purchase with other countries according to the needs of the domestic network.
- The company will also work with Arab / African companies and institutions to establish joint ventures in the field of engineering consultants such as Egypt / Libya and Syria / Egypt, if necessary.
- Appropriate care and conduct electrical equipment research and testing



Source: Prepared by study team based on provided data

Figure 2-1-3-4 EEHC group

EEHC group consists of six generation companies, one transmission company and nine distribution companies under the holding company. Generation and distribution companies are basically divided into regions. Only Hydro-power Plants Company is separated by the type of generation. Names and locations of each company are described above.



Source: EEHC Web Site

Figure 2-1-3-5 EEHC group

Number of personnel in EEHC is 17,486 and the numbers in each organization are as shown in Table 2-1-3-1

Table 2-1-3-1 Number of personnel in EEHC group

EEHC	
EEHC headquarter Employees	2175
Electricity Hospital	743
Total	2918

- The total number of employees in The affliated companies:

Production Companies		Distribution Companies	
Cairo	5621	North Cairo	13104
East Delta	7288	South Cairo	17778
Middle Delta	6729	Alexandria	12855
West Delta	8389	Canal	16413
Upper Egypt	3508	North Delta	8758
Hydro power plants	3471	South Delta	10233
Total	35006	El-Behera	8464
		Middle Egypt	9563
		Upper Egypt	7849
Egyptian Electricity Transmission Company	31935	Total	105017

Total No. of Employees of EEHC and Its Affiliated Companies	174876

Source: EEHC Annual Report 2014/2015

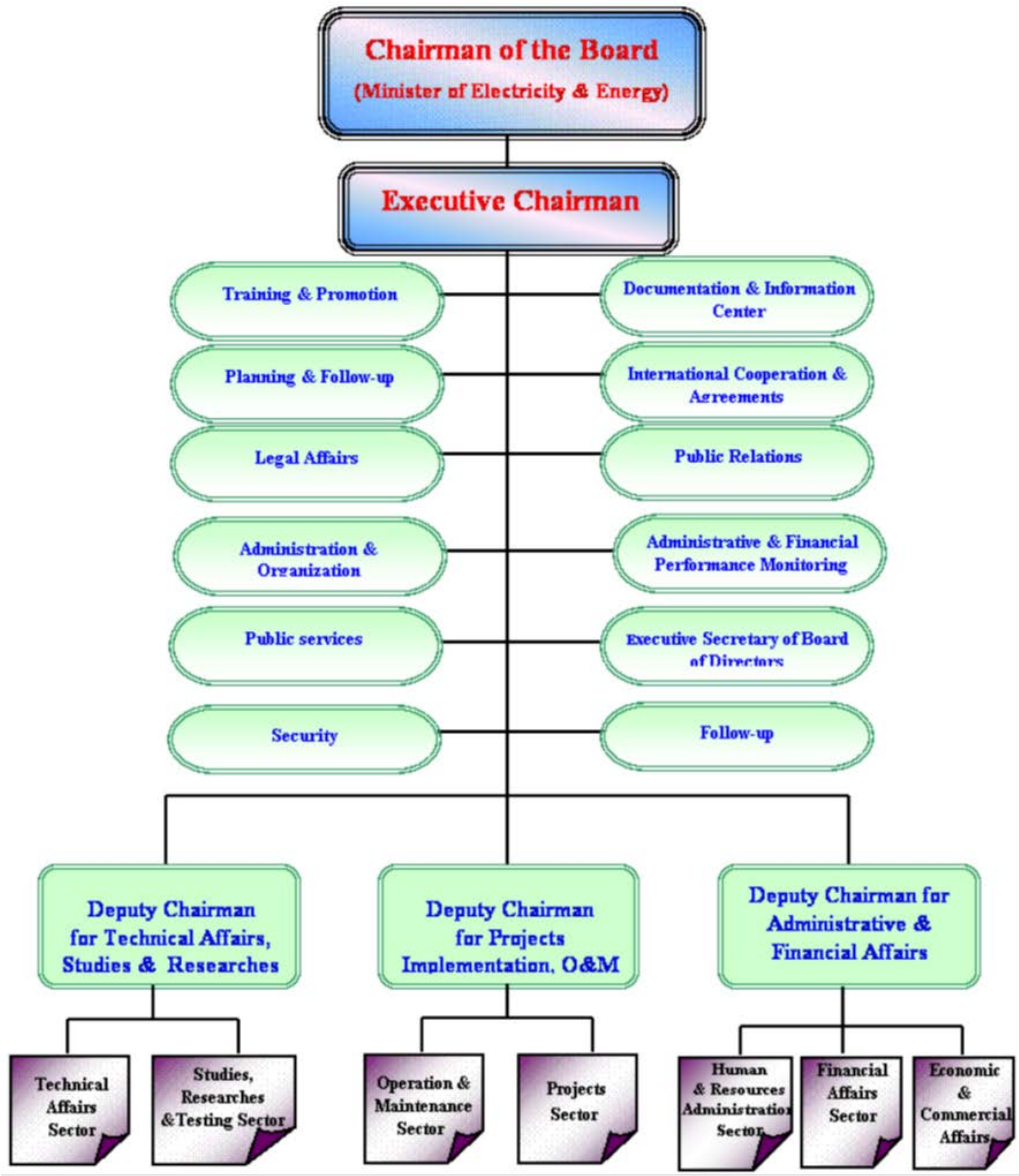
✓ New and Renewable Energy Authority (NREA)

The New and Renewable Energy Authority (NREA) was established in 1986. Since then, it has been working to disseminate the utilization of renewable energy in different fields, performing efficiency tests, and conserving energy.

NREA is entrusted to plan and implement renewable energy programs in coordination with other concerned national and international institutions within the framework of its mandate which includes:-

- Renewable energy resource assessment.
- Research, development, demonstration, testing and evaluation of the different RE technology focusing on solar, wind and biomass.
- Implementation of renewable energy projects.
- Proposing the Egyptian standard specifications for renewable energy equipment & systems, and conducting tests to evaluate their performance, under prevailing Egyptian conditions, hence issuing respective licensing certificates to that effect.
- Rendering of consultancy services in the field of renewable energy.
- Technology transfer and development of local manufacturing of Renewable Energy equipment.
- Education, training and information dissemination.

The structure of NRA is shown in Figure 2-1-3-6 and the number of the personnel was 1,159 in 2015/2016.



Source: NREA Web Site

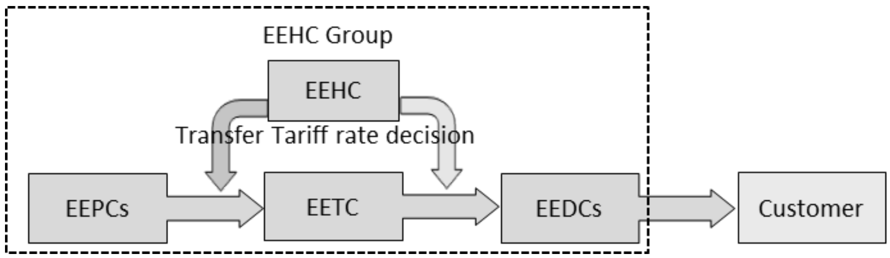
Figure 2-1-3-6 Structure of NREA

b) Present power market (regulated market)

✓ Power Pool

Currently the EEHC group is responsible for the majority of electricity transactions in the country. Except for imports and exports, power trading are mainly between the EEHC Group and outside of EEHC group which consist of transactions with IPP, surplus power of large-scale private power generation, and purchase of electricity from renewable energy generation by NREA. In terms of the shares, IPP is about 8%; NREA is about 1% while the surplus electricity purchase of the self-generated electricity is quantitatively small.

From the above mentioned, it can be said that the majority of the electricity transactions from generation to distribution are conducted within the EEHC group.



Source: Prepared by study team based on the provided data

Figure 2-1-3-7 Power Pool System Structure

Each company of the EEHC Group is an independent company, but since EEHC owns 100% of the shares in each company in the group, the setup is almost as if it is actually one company. Power trading among group companies is designed with a special system called Power Pool. The purpose of Power Pool is to make the profit level of the EEHC group companies more uniform, the outline of this system is as shown in Figure 2-1-3-7.

EEHC systematically determines the sales prices from each power generation company to EETC and the selling prices from EETC to each distribution company so that the financial contents of each company are leveled. The point of this system is the role of EETC. Since electricity transmission is monopolized by EETC, and from the viewpoint of power generation, electricity is sent through the EETC transmission system, and almost all of the power is sold to EETC. Likewise, from the viewpoint of distribution, electricity is sent from the transmission system and the only power supplier is EETC. Therefore, EEHC can manage the financial contents of each company by controlling the transaction price between EETC and each company using this system.

This price is formally a selling price between the company and EETC, but the actual situation is close to the internal price in the manufacturing company.

✓ Decision method on the prices

At first, the transaction prices between the six production companies and EETC, as well as between EETC and the nine EDCs are tentatively decided based on the previous year’s prices and the prospect of the coming year. These rates are provided to each company before the start of the fiscal year. The tentative price for each generation company basically covers the generation cost (fixed cost and variable cost). Because the type of generator (steam, gas, CC), capacity and fuel are different with each generation company, the cost of generation is different and a tentative price is set, reflecting the difference in generation cost of each company. The tentative price from EETC to each distribution company is determined according to average unit sales to the customers of each distribution company. Although the sales price list applied in Egypt is common, the average sales price per unit (kWh) will change depending on the type (difference in the ratio of Residential and Commercial) and the difference in consumer energy consumption.

The tentative prices are used for transactions between the companies and EETC within the fiscal year. After the year end, EEHC's board of directors decides and finalizes the transaction prices for the fiscal year. Transactions during the period are retroactively revised and the transactions are finalized by the officially decided prices, As a result, the transaction prices are adjusted so that each company can enjoy similar profits.

✓ Offset regarding transaction with the Government and its affiliates

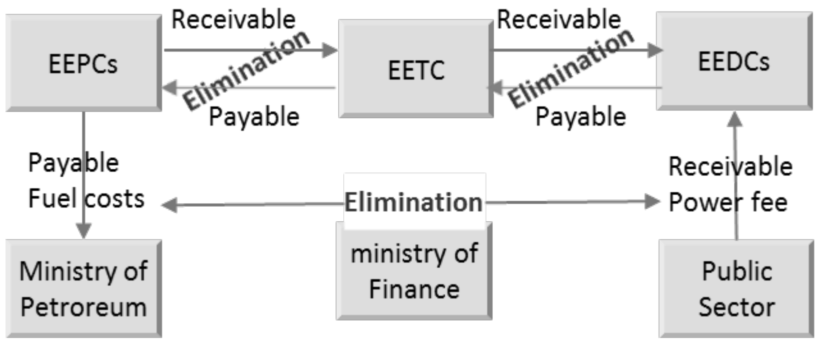
Important transactions of EEHC group with the Government and public sector are as follows.

- Power production companies purchase petroleum and other energy resources from the Ministry of Petroleum and other governmental bodies.
- Distribution companies sell electricity to each governmental body and public sector organization.

Collection of receivables from the government and public sector were a big issue for the distribution companies. There were many cases where no organization paid debts. On the other hand, as the EEHC group, each power company purchased fuel from the Ministry of Oil, but did not pay its obligated fee. Also, each distribution company had sold electricity to each public agency, but collection of debts was stalled.

The Ministry of Finance, introduced an "elimination" system to solve this issue. Account receivables to the government and public sector are eliminated with accounts payable to the government and public sector with the assistance of the Ministry of Finance. In other words, account receivables of distribution companies to each governmental bodies and public bodies are eliminated with account payable of production companies to the Ministry of Petroleum and other governmental bodies. Adjustment of debts and credits among governmental bodies and public bodies are cleared through the allocation of budget.

This offset can be described as follows;



Source: Prepared by the study team based on provided data

Fig. 2-1-3-8 Offset of receivables and debts

Procedures of elimination are as follows;

- Each distribution company issues an invoice of power charges for one month to each governmental body and public body every month.
- If some governmental bodies and public bodies could not pay before due date, a member of each distribution company visits those bodies with certification which states that a certain body could not make payment of a certain electricity fee for a certain month.
- A member of the distribution company asks the body to sign the certification of overdue receivables.
- Distribution company submits certification of overdue receivables to the Ministry of Finance.
- Ministry of Finance eliminates receivables of distribution company by some payables of the power production companies.

In the above procedure, new receivables can be offset, but receivables that have remained in the past cannot be offset. They deal separately with regard to the aged receivables.

✓ Transaction system features

This transaction system was considered as tentative when EEHC group was formed in 2000. The government transformed the public corporation into a company on the assumption of future privatization and liberalization. All members of EEHC group were supposed to become independent both in name and reality, and power sales rates (internal transaction price) become market-based. However, no major points of this system have been reformed during these 16 years though direction of the reform has been decided and several discussions have been made.

In this system, EEHC can control profit of subsidiaries by manipulating transaction prices, and EEHC can strengthen management and supervision to each subsidiary. In addition, as long as the transaction and finance of subsidiaries are guaranteed by the parent company, the EEHC Group will practically become a single company.

One of the important issues on this "Power Pool" transaction system is that the system could hide inefficient operation of group companies. Since a certain level of profit is guaranteed in this system, the management of each company can achieve a certain level of positive results. Under such circumstances, the possibility should remain that the management may ignore inefficient operations and inefficient organization, and that inefficiency may continue as are. There might be an idea to introduce the concept of standard prices as is applied in the internal management by the manufacturing industry

c) Consumer tariffs and subsidies

The revision of the electricity consumer tariff is issued as a Ministry Decree in Egypt. The draft revision is prepared by EEHC based on the profit and loss forecast for the next fiscal year and submitted to MoERE for approval. After the ratification by EgyptERA, the revision is finally approved by the prime minister. As electricity is one of the essential commodities, the government was cautious about raising the tariff. The response to the revision by the government has been changed in the El-Sisi administration, faced with the tightening of the fiscal budget situation.

The electricity tariff in Egypt has been constant without any increase for 10 years from 1994 to 2003, after which slight increases have been applied followed by an increase in the tariff of the industrial sector. The constantly applied tariff over a long period resulted in a deficit in the cash flow of electricity companies and an increase in subsidies by the government for residential customers. Faced with this situation, the power sector prepared a study and submitted to the Cabinet for electricity tariff reform and adjustment based on these circumstances[7].

The Prime Minister issued the decree 1257 for the year 2014 dated 17 July 2014, to gradually increase the electricity tariff over five years, but could be reconsidered by the Cabinet in the case of a change in the assumption and basis used during the study preparation. Prices have been revised for four consecutive years to date in 2014, 2015 2016, 2017and 2018. However, some categories are not being revised due to instructions from the president.

The goal is to increase the tariff continuously for five consecutive years, to match the cost with the selling price. However, since it is inevitable to raise the price considerably if it reflects both the recent fall of the Egyptian pound and the abolition of subsidies to energy, it can be considered that the achievement period will be delayed by 1 to 2 years. Even if the tariff reflects the cost, subsidies by the government will be allocated to the tariff for the poorest residences and irrigation (Article 41 of the Electricity Law), and

[7] EEHC annual report 2014/2015

cheaper charges will be maintained. Incidentally, the industrial tariff has already become the level reflecting the cost[8].

Consumer electricity tariffs in the past five years are as follows.

[8] Interview with Egypt ERA

Table 2-1-3-2 Transition of Consumer Tariffs 2010/11~2013/2014

Purpose of use	2008/10/1-2012/12/31	2013/1/1-2014/6/30
	Pt/kWh	Pt/kWh
UHV (220-132 KV)		
Kima	4.7	4.7
Metro- Ramsis	6.8	7.9
Somed (Arabian Company fo	27.3	31.6
Other Consumers	12.9	15.0
HV (66 KV)		
Metro - Toura	11.3	13.1
Other subscribers	15.7	18.2
MV (22-11 KV) & LV (380 V)		
More than 500 KW		
Demand charge (Le/kW/M)	9.5	10.0
Energy rate (Pt/kWh)	21.4	25.0
Up to 500 KW		
Agriculture (Pt/kWh)	11.2	11.2
Irrigation (Le/fedan/year)	135.2	135.2
Other purpose (Pt/kWh)	25.0	29.0
Domestic (kWh/Month)		
0-50	5.0	5.0
51-200	11.0	12.0
201-350	16.0	19.0
351-650	24.0	29.0
651-1000	39.0	53.0
More than 1000	48.0	67.0
Commercial (kWh/Month)		
0-100	24.0	27.0
101-250	36.0	41.0
251-600	46.0	53.0
601-1000	58.0	67.0
More than 1000	60.0	72.0
Public lighting	41.2	47.5

Purpose of use	2010/7/1-2011/12/31		2012/1/1-2014/6/31	
	Outside rash hours	In rash hours	Outside rash hours	In rash hours
	Pt/kWh	Pt/kWh	Pt/kWh	Pt/kWh
UHV (220-132 KV)				
Intensive industries	21.7	32.6	27.7	41.5
Glass, ceramic, porcelain	15.9		25.2	
Other consumers	15.4		15.4	
HV (66 KV)				
Intensive industries	26.3	39.5	30.0	45.0
Glass, ceramic, porcelain	19.2		28.6	
Other consumers	18.6		18.6	
MV (22-11 KV) Demand charge Le/kW/Month				
Intensive industries	35.8	53.8	35.8	53.7
Glass, ceramic, porcelain	26.3		32.7	
Other consumers	25.5		25.5	

Source: EEHC Annual Report 2011/2012- 2013/2014

Table 2-1-3-3 Transition of the Consumer Tariff 2014/2015~

Purpose of use	1/7/2014-30/6/2015				1/7/2015-30/6/2016					1/7/2016-				
	Capacity charge	Average energy price	Outside rash hours	In rash hours	Capacity charge	Average energy price	Outside rash hours	In rash hours	Customer service charge	Capacity charge	Average energy price	Outside rash hours	In rash hours	Customer service charge
	LE/kW mo	Pt/kWh	Pt/kWh	Pt/kWh	LE/kW m	Pt/kWh	Pt/kWh	Pt/kWh	Le/cust/M	LE/kW/M	Pt/kWh	Pt/kWh	Pt/kWh	Le/cust/M
UHV (220-132 KV)														
Kima			4.7				4.7		25			9.4		30
Cairo Metro(Subway)			14.5				18.0					30.0		
Heavy industries	10.0	39.6	34.1	51.1	15.0	39.6	36.6	54.8		25.0	46.5	42.9	64.4	
Other subscribers	10.0	-	22.6		15.0	26.9	24.8	37.2		25.0	41.9	38.7	58.1	
HV (66 KV)														
Cairo Metro(Subway)			16.3				20.5		25			32.0		30
Heavy industries	20.0	38.8	35.8	53.7	26.0	41.4	37.9	56.9		35.0	49.0	45.2	67.8	
Other subscribers	20.0	-	27.5		26.0	29.1	26.9	40.3		35.0	44.6	41.1	61.7	
MV (22-11 KV)														
Intensive industries	30.0	41.5	38.3	57.5	30.0	43.5	40.2	60.2	25	45.0	52.0	48.0	72.0	30
Glass, ceramic, porceli	30.0		41.5											
Other consumers	30.0		36.5											
LV (380 V)														
Irrigation	-	-	17.0		-	-	22.0		3	-	-	27.1		4
Other subscribers	-	-	36.6		-	-	46.0		7	-	-	64.4		8
Public lighting	-	-	56.6		-	-	58.0			-	-	75.0		
Domestic usages Consumption (kWh/Month)														
0-50	7.5				7.5				1	11.0				1
51-100	14.5				14.5				1.5	19.0				2
101-200	16.0				16.0				3	21.5				6
201-350	24.0				30.5				6	42.0				8
351-650	34.0				40.5				8	55.0				8
651-1000	60.0				71.0				20	95.0				20
More than 1000	74.0				84.0				20	95.0				20
Zero read	-				-				6	-				6
Commercial shops Consumption (kWh/Month)														
0-100	30.0				32.0				3	35.0				5
101-250	44.0				50.0				10	69.0				15
251-600	59.0													
601-1000	78.0				61.0				10	96.0				25
More than 1000	83.0				86.0				20	96.0				25
Zero read	-				-				6	-				6

Source: EEHC Annual Report 2013/2014 – 2014/2015

The electricity tariff system is divided into two categories, the tariff for the consumers in the low voltage distribution network and the one for large customers (mainly large factories) in the ultra-high or high voltage transmission grid. Both consist of separated tariff systems

The tariff structure has been changed over the past five years. For UHV, HV & MV customers, industrial tariff lists have been issued separately, and the related Decrees have also differed. Due to the reform of the tariff system in 2014, two lists are summarized in a single tariff list and Capacity Charge was introduced. In 2015, Customer Service Charge was also introduced. As a result of these tariff revisions, the average selling price per kWh has changed as follows.

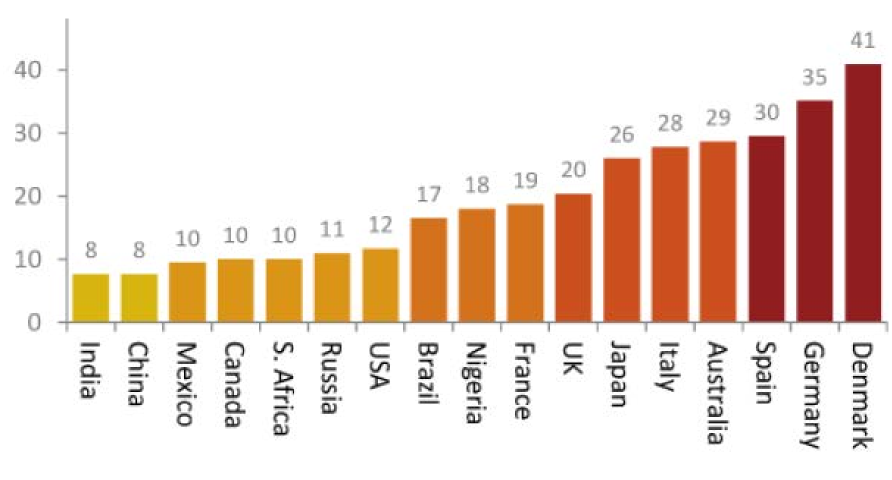
Table 2-1-3-4 Consumer average selling prices

	2011/2012	2012/2013	2013/2014	2014/2015
Total Revenue (LE Mil)	27,886	31,457	33,303	46,056
Total Energy Sold (GWh)	135,838	140,918	143,585	146,645
Unit Price (LE/kWh)	0.205	0.223	0.232	0.314

Source: EEHC Annual Report

d) Comparison of the power price among the countries

Reflecting that 0.509 LE / kWh is converted to 2.7 USC / kWh at the exchange rate in December 2016 after the decline in the exchange rate. The consumer price rate is lower than even the rate of the cheapest countries like India and China as shown in Figure 2-1-3-9. It should be noted that the impact of the fall in the exchange rate greatly affected the cheap dollar value of the price. Consumers may be dissatisfied or repulsed because the tariff will be greatly raised compared with the present. However, the power tariff should be raised considering the level of international power prices.



Source: Master Plan Update Project, 2012 - 2027 EDM.E.P April 2014

Figure 2-1-3-9 Power price of other countries (USC/kWh) (USC: US cents)

e) Comparison of the financial aspects with the companies in other countries

Many of the electricity corporations are statutory companies and these companies have characters which are different from usual corporations. Therefore, it is useful to compare with other public electricity companies.

Table 2-1-3-5 Comparison with electricity companies in other countries

■ **Profitability ratios**	PT PLN	TNB	TANESCO	BPDB	EEHC
ROA	1.3%	5.2%	-5.4%	-13.6%	-0.5%
ROE	1.8%	12.8%	-17.5%	73.0%	-12.6%
Operating profit rate	-13.3%	19.6%	-15.5%	-24.9%	7.0%
Current profit rate	-1.4%	16.2%	-21.8%	-34.6%	-0.3%
Liquidity ratio					
Current ratio	68%	121%	48%	120%	51.6%
Acid-test ratio	37%	113%	37%	92%	23.1%
Fixed assets ratio	135%	207%	268%	-304%	1787.4%
Ratio of fixed assets to long-term capital	103%	97%	130%	89%	158.3%
Equity ratio	69%	41%	31%	-19%	4.0%
Activity ratio					
Assets turnover	18%	38%	34%	40%	30.4%
Average collection period[	33days	71days	106days	185days	100days
Cash flow analysis					
Profitability					
Operating cash flow margin	16.2%	25.9%	-5.0%	-21.3%	13.0%
Liquidity					
Operating cash flow to current debt	30.1%	73.4%	-4.6%	-23.6%	7.2%
Cash flow ratio	16.8%	46.3%	-9.2%	-30.9%	9.5%
Investment					
Investment ratio	86%	597%	-448%	-61%	184.8%
Investment cash flow	-109%	-112%	602%	84%	-210.5%

Source: Annual reports of each company

PT PLN: PT Perusahaan Listrik Negara, Indonesia[9]

TNB: Tenaga National Malaysia[10]

TANESCO: Tanzania Electric Supply Company, Tanzania[11]

BPDB: Bangladesh Power Development Board, Bangladesh[12]

[9] PT PLN is a public corporation 100% owned by the Indonesian government. PT PLN including its subsidiaries dominates generation, transmission and distribution in the country.

[10] TNB is a former electric authority and privatized in 1990, in charge of generation, transmission and distribution on the Malay Peninsula. In terms of generation, it is permitted for private companies to construct power plants.

[11] Tanzania Electric Supply Company is a 100% government owned company which is in charge of national power generation, transmission and distribution except for small volume private generation. In 2016, the government announced they will sell 49% of stock.

[12] BPDB consistently developed and operated power from generation to distribution but after 1996 the government has promoted a spin off and government corporation.

The selected four entities are all government-owned electricity corporations or former government-owned electricity corporations in developing countries or governmental bodies.

The company's financial situation differs from company to company. TNB is superior to almost all indicators and was chosen as a successful example of privatization. EEHC's financial situation is somewhat similar to that of TANESCO. What differs from TANESCO is that EEHC's fixed assets ratio and equity ratio are low and it is clear that EEHC has excessively small capital compared with other companies[13]. Results of cash flow analysis for TANESCO are poor because cash flow from operation activities is negative.

Compared with PT PLN&TNB, results of EEHC are worse in almost all categories; EEHC's profitability is in the red and PT PLN & TNB are profitable. It is often the case that power companies cannot control their profitability because electricity prices are decided outside of electricity companies and EEHC is no exception. However, profitability differs from country to country and some companies managed to record a surplus.

In terms of liquidity ratio, as for fixed assets ratio & ratio of fixed assets to long-term capital, the lower the better. As for other indicators, the higher is the better. Results of EEHC are notable in fixed assets ratio and equity ratio which capital amounts directly affect.

In terms of turnover, lower is better. EEHC's results are roughly average among those five companies. Turnover ratio and turnover periods are affected by sales conditions and in the case of EEHC, the condition is monthly closing and monthly payment. Therefore, a turnover period of 30 days is ideal.

As for cash flow analysis, higher is better, except for investment analysis. EEHC's position is in the middle of the five companies and it can be said to be average.

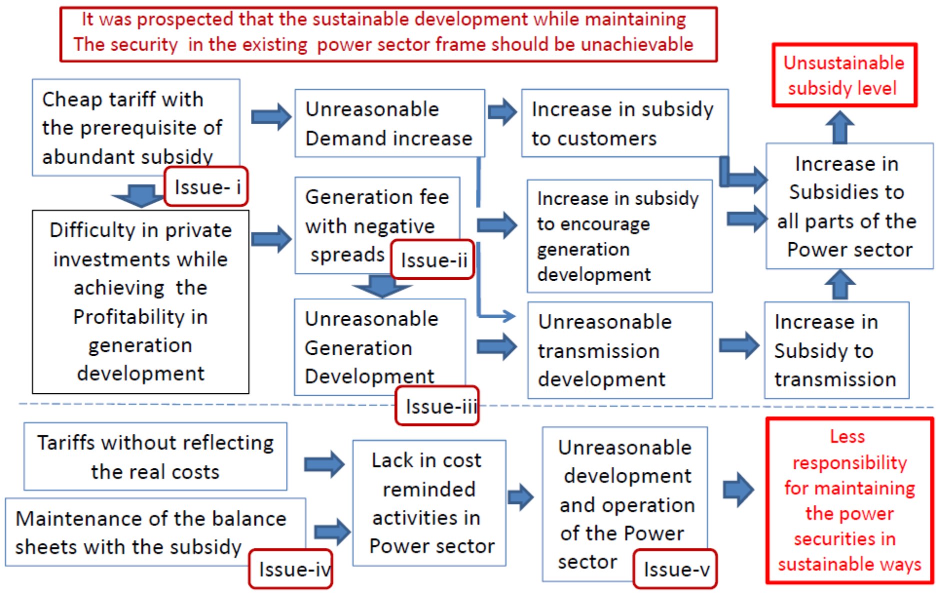
2－1－4 Status quo of Reform in the Power Sector and expected issues

In Egypt, the direction of Reform of the Power Sector has been recognized as a big issue since the beginning of the 2000s. As mentioned above, one of the main motivations is that although the power sector is heavily dependent on government subsidies, it is expected that the subsidy system will be faced with deadlock, reflecting on the continuous demand growth in a sustainable manner.

To reform such a subsidy premise structure, the basic concept of such, as establishing a self-sustaining electric power sector with the power market where private capital actively could be invested even without government involvement, realization of a supply system that will induce consumers to purchase electricity at rational prices in a competitive environment. In proceeding with these basic concepts, concrete measures were set up such as EEHC group unbundling. The national goals and the related measures to be realized in the Egyptian power sector are depicted

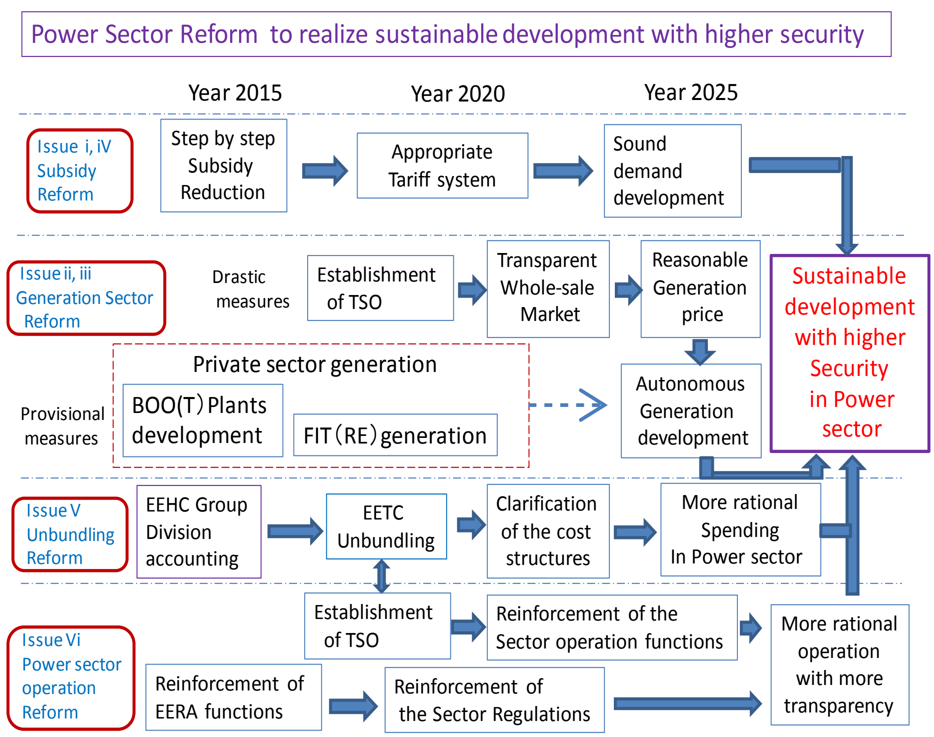
[13] Capital ratio of BPDB is negative because of excess of debt. It does not mean that capital amounts are small.

below. The step by step approach will be expected to implement the Reform under the given conditions to ensure energy supply security and power sector sustainability and so on, assuming good coordination among the concerned parties consisting of public and private sectors.



Source: Prepared by study team

Fig. 2-1-4-1 Issues of Egyptian Power Sector



Source: Prepared by study team

Fig. 2-1-4-2 Steps of Reform in the Power Sector

(1) Action plans regarding the power sector in Energy White Paper

In the Energy White Paper, three pillars were set for the energy strategy in Egypt as shown in Table 2-1-4-1, which is coincided with the contents of ISES2035. Based on the pillars, concrete action plans are formulated.

Table 2-1-4-1 Pillars for the Energy Strategy

Pillars	Explanation
Security	A diversified energy supply that can reliably meet the energy demands of a growing economy, and takes full advantage of domestic energy resources
Sustainability	An energy sector that is both financially and socially sustainable: (i) financially self-sustaining with clear incentives for private investment; and (ii) preserves affordability for households and competitiveness for business
Governance	Roles of all public and private actors clearly defined and mutually complementary, and all institutions held accountable for performance

Source: Addressing Egypt's Electricity Vision, Minister of Electricity & Renewable Energy: Dr. Mohamed Shaker El-Markabi, 13 - 15 March 2015

Here, the action plans are tabulated in each pillar, where the rows with blue characters are not directly related with the power sector.

1) Energy Security

The action plans in energy security regarding the power sector are basically related to the promotion of power supply development. Therefore, most of the action plans are not directly referred to the Reform.

Incidentally, the latest situations in the plans are presented, namely, the development of thermal power is in 2-1-2, 2-2-3, the development of RE is in 2-1-1, 2-1-6 and energy efficiency improvement is in 2-1-1, 2-8.

Regarding these action plans, international donors are involved in some areas.

The situations identified by the survey team are as follows,

Supply capability increase in thermal power has been supported by WB, AfDB while KfW in the commercial sector financed Siemens Megaprojects.

Incidentally, the supports in this area would be reduced because enough supply capacity would be added in the electricity system in near future.

Capacity increase in RE has been and will be supported by the related donors.

In this area, KfW supported for making out CREMP, which has become the RE development policy in Egypt.

Loss reduction in the electricity network including non-technical loss has been supported by organizations such as JICA with the installation of a smart meter system in the distribution sector.

Energy efficiency improvement has been supported by such organizations as UNDP with the replacement of the existing lighting system with LED etc. In addition, DPF by

WB and AfDB has encouraged acceleration of the activities regarding the energy efficiency unit in MoERE (established in 2014).

Table 2-1-4-2 Action plans for Energy Security

Action area	No	Measures	Key Elements	3/2015	3/2016	2016-19	Lead Institutions
Boost Energy Supply	1a	Accelerate existing gas field developments	Sign agreements for acceleration of gas fields	■			EGAS
	1b	Encourage new oil & gas exploration development	Sign 56 new concessions for exploration	■			EGPC & EGAS
			Review joint venture model (PSA and prices)	■			EGPC & EGAS
			Award concessions for unconventional oil & gas	■			EGPC & EGAS
	1c	Expand and upgrade fuel infrastructure	Award contracts for investment in refineries	■	■	■	EGPC
			Award contracts for transportation infrastructure upgrades		■	■	EGPC & GASCO
			Award contracts for Investment in hydrocarbon product handling facilities		■	■	EGPC
	1d	Secure New LNG Import Contracts	Sign agreements for port, FSRU, pipeline and LNG shipments	■			EGAS
	1e	Expand Power Generation & Transmission Capacity	Award contracts for upgrade transmission and distribution networks	■	■		EETC/DISCOS
			Award contracts for new generation capacity by 2022 (54 GW)	■	■	■	EEHC/EETC
Diversify Energy Supply	2a	Diversify Energy MIX	Sign agreements to diversify import & local sources of oil & gas	■			EGPC & EGAS
			Award contracts for 12.5 GW of coal-fired power generation		■	■	EEHC
			Award contracts for 4GW of nuclear power generation			■	EEHC & NUC
			Award contracts to expand renewable energy capacity to 20% by 2022		■	■	EETC/NREA
	2b	Strengthen Regional Energy Trade	3GW interconnector with Saudi Arabia		■		EETC
			Award contract to upgrade pipelines & LNG terminals for regional re-export			■	EGAS & GASCO
Improve Energy Efficiency	3a	Improve Supply side Efficiency	Award contracts for improvement of efficiency of refineries	■	■	■	EGPC
			Award contracts for conversion of open cycle gas plant to combined cycle	■	■	■	EEHC
			Adopt measures to reduce T&D losses from 12% to 8%		■	■	EETC & DISCOS
			Create specific branch of utility dedicated to promote energy efficiency		■	■	EEHC & EGPC

Action area	No	Measures	Key Elements	3/2015	3/2016	2016-19	Lead Institutions
Improve Energy Efficiency	3b	Improve Demand side Efficiency	Publish a 5 year energy efficiency plan with targets		■	■	CAB, SEC
			Adopt efficiency programs for energy intensive industry	■		■	SEC (MoI, MoP, MoERE)
			Enforce appliance efficiency standards and building codes		■	■	MoI, MoH
			Introduce appropriate incentives for energy efficiency finannce		■	■	CAB
			Conduct awareness raising campaign	■	■	■	CAB, EEHC, EGPC
			Phase out incandescent bulbs and rollout 10+50 million LED lamps	■	■	■	DISCOS
			Approve a plan to rollout smart meters within 5 years		■	■	DISCOS

Source: Energizing Egypt

f) Financial Sustainability

Regarding the action plans in Financial Sustainability, maintenance of financial balance in the power sector, which is identical with EEHC financial balance, becomes the main targets. (4b)

From the Reform point of view, achieving the balance in five years, which means the total abolishment of subsidies to the customers in five years, is one of the influential action plans.

International donors, WB and AfDB have promoted this action by setting the target in Development Policy Financing. (DPF: See 2-1-5)

Table 2-1-4-3 Action plans for Financial Sustainability

Action area		Measures	Key Elements	3/2015	3/2016	2016-19	Lead Institutions
Address Historic Debts	4a	Restore financial balance of EGPC	Agree repayment schedule with IOCs	■	■	■	EGPC
			Prepare 5year plan to clean-up historic arrears			■	MoF & EGPC
	4b	Restore Financial Balance of EEHC	Restructure EETC debt to NIB		■	■	EEHC/EETC & NIB
			Develop plan to raise revenue collection		■		EEHC
			Establish ceiling on contingent liabilities		■		MoF & MoERE
			Prepare 5 year plan to clean up historic arrears			■	MoF & EEHC
Reform Energy Subsidies	5a	Adjust Energy Prices	Implement annual price increments for electricity and fuel up to cost recovery	■	■	■	MoP/MoERE & CAB
	5b	Improve Subsidy Administration	Rollout petroleum smartcard and associated database	■	■	■	MoP
			Compensate EGPC on time and in full for subsidized fuel price paid by EHCC		■		MoF
			Introduce mechanism to monitor fiscal reallocation of energy subsidy savings		■		MoF
Mitigate Social Impact	6a	Increase access to natural gas	Secure finance for 2.4 mmn. household gas connections	■			EGAS
	6b	Increase Social Spendings	Partially allocate savings from energy subsidy reforms to social sectors	■	■		MoF
			Improve coverage, targeting and benefits of Social Solidarity Pension	■	■		MoSS

Source; Energizing Egypt

g) Governance

Concerning the action plans regarding power sector, establishment of the energy strategy (ISES2035) (7b), Setting up of the market and its operator for HV customers (8b), Enhancement of EgyptERA tariff design powers (8b), Easing the constraints on access to the land and finance and introduction of FIT for RE (8b) should be deeply related with the Reform.

These issues will be estimated in the latter half of this chapter.

Regarding the activities by the international donors in this field, EU has conspicuously contributed to establishment of the energy strategy (ISES2035)

Table 2-1-4-4 Action plans for Governance

Action area		Measures	Key Elements	3/2015	3/2016	2016-19	Lead Institutions
Enhance Energy Section Functions	7a	Enhance Energy Planning	Create Energy Planning Entity (EPE)	■			SEC, MoP, MoERE
			Operationalize energy information system		■	■	SEC, MoP, MoERE
	7b	Adopt Integrated Susutainable Energy Strategy 2035	Energy strategy under preparation with EU support is adopted			■	SEC/ CAB, MoP, MoERE
	7c	Enhance Energy Efficiency	Transform Energy Efficiency unit into a fully fledged entity			■	SEC
Modernize Sector Governance	8a	Modernize Gas Sector Governance	Adopt new legal and reguratory frame work		■	■	MoP
			Establish independent gas regulator		■	■	MoP
			Create independent Gasco with third party access to gas transportation network		■	■	MoP
	8b	Modernize Electricity Sector Governance	Develop a transition plan to a competitive wholesale market for HV customers		■	■	MoERE & ERA
			Separate EETC into an Independent TSO providing third party access to grid		■	■	MoERE & ERA
			Create Market Operator for transactions settlement		■	■	MoERE & ERA
			Enhance EGYPTERA tariff design powers		■	■	MoERE & ERA
			Introduce Feed In Tariff regulations	■			MoERE & ERA
			Address constraints on access to land and finance for renewable energy projects		■		MoERE
Strengthen Corporate Governance	9a	Enhance Corporatization of SOEs	Introduce International Financial Reporting Systems and business plans for EEHC and their subsidiaries			■	MoP & MoERE
			Develop and Implement institutional and financial strengthening plan for SOEs			■	MoP & MoERE
Promote Private Investment	10 a	Design Transparent Process for Selecting IPPs	Select least cost projects for private investment	■			EEHC/EETC
			Introduce standardized tendering process	■			EEHC/EETC
			Select developers on a competitive basis	■	■		EEHC/EETC
			Benchmark any directly negotiated projects	■	■		EEHC/EETC
			Develop model contracts for IPPs	■	■		EEHC/EETC
			Create a single agency focal point for IPPs		■		EEHC/EETC
			Facilitate third party guarantees		■	■	MoF

Source; Energizing Egypt

(2) Reform articles stipulated in New Electricity Law (87/2015)

The above energy strategy and action plan includes not only strategies of the electric power sector, but also sectors other than power sector. Below we describe the part of "Modernize Sector Governance" which is not mentioned in other parts of the report. This policy is being implemented by enactment of the New Electricity Law and the Renewable Energy Act.

- ✓ Free (competitive) market

The new electricity law 87/2015 was enacted in 2015 and a new competitive market for HV customers was to be established adding to the regulated market for lower voltage customers. The objective is to "establish a fully competitive electricity market, where electricity generation, transmission and distribution activities are fully unbundled". The proposed market will adopt bilateral contracts with a balancing and settlement mechanism. Efficiency increase and service enhancement are sought by virtue of introducing competition, freedom of electricity supplier choice, and third party access. Gradual enhancement of procedures and functions should be realized for promoting competition within the electricity market in a way that creates a fair and attractive investment environment for new comers in electricity generation and trading.

In the new Electricity Law, Eligible Customers have a choice of Electricity Supply. Eligible Customers can freely negotiate prices directly with Generators operating in the competitive Electricity Market, or with Suppliers, which are expected to be established in order to serve Eligible Customers. Balancing Service to the competitive Electricity Market shall be provided by the TSO and financially settled by the Market Operator (TSO/MO), established in the TSO. Initially the threshold for achieving Eligible Customer status would be set at a level, namely all EHV and HV customers that opens a meaningful portion 16% of the Electricity Market to competition, according to 2010/11 statistics[14].

- ✓ Clarification of the function of EgyptERA

In the new Electricity Law, the function of EgyptERA is minutely stipulated, especially for achieving the core role in the Reform.

EgyptERA is restructured to be an independent institutional champion responsible for supervising, developing and coordinating between electricity producers, transmitters, distributors and end users. It has become the electricity regulator in terms of licensing, designing and approving tariffs, providing a separate dispute resolution mechanism, and developing a competitive market design and structure. It is also responsible for ensuring a reliable long term supply of electricity with reasonable prices and preserved environment.[15].

An investor wishing to produce, distribute or sell electricity must obtain a license from EgyptERA, and must establish a Special Purpose Vehicle. A temporary permit will be obtained in order to undertake the preliminary work and studies needed to inaugurate the

[14] Overview of the Electricity Sector in Egypt, Milan 22-23 October - 2nd, Capacity building reporting methodologies: how to collect data and monitor regulated entities, Salma Hussien Osman, Egypt ERA

[15] Electricity in Egypt Policy and Regulatory Reform,Dr. Fatma Salah,Partner Ibrachy & Dermarkar Law Firm, November 2015, Ibrachy & Dermarkar Law Firm

project. The license will be issued for a maximum period of 25 years. It may be renewed for a similar period or part thereof. EgyptERA shall annually examine the continued fulfillment of the license's requirements and issue a certificate confirming the validity of the license. It is not allowed to assign the license or the permit to a third party, unless written approval is obtained from EgyptERA to this effect[16].16 private power generation companies are licensed at present[17].

Agency authorized below functions[18].

The agency shall approve all market documents

- Transmission rules (grid code)
- Market rules (commercial code)
- Annual adequacy report

Monitoring the implementation of:

- Demand Side Management programs
- Energy Efficiency programs
- Renewable Energy programs
- Customer awareness

✓ Function of Electricity Distribution

Private electricity distributors are allowed to develop and implement electricity distribution projects on medium and low voltage (MV & LV), and to operate and maintain the distribution network in the licensed geographical area. They are allowed to sell MV & LV electricity to unqualified users in consideration for a tariff to be approved by EgyptERA. 23 private distribution companies are licensed at present.

Regarding the structure of the power supply shall be reexamined within 8 years (2023), including EEHC and production companies according to the New Electricity Law Article 63.

(3) Renewable Energy Law (No. 203 of 2014)

As shown in the action plans in Energy White Paper, introduction of RE with large scale should bring about the grave influence on the power sector, which would affect in the Reform.

In order to encourage the private sector to produce electricity from renewable energy sources, Egypt has issued the new Renewable Energy Law (No. 203 of 2014). Renewable Energy Law adopted four development schemes for the private development of renewable energy projects[19].

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[16] Electricity and Renewable Energy Regulations in Egypt, Dr. Fatma Salah, Partner, Riad & Riad Law Firm, July 2016
[17] Overview of the Electricity Sector in Egypt, Milan 22-23 October - 2nd, Capacity building reporting methodologies: how to collect data and monitor regulated entities, Salma Hussien Osman, Egypt ERA
[18] Regulatory Framework to Develop RES Projects in Egypt Hatem Waheed Managing Director Egypt ERA
[19] Electricity and Renewable Energy Regulations in Egypt, Dr. Fatma Salah, Partner, Riad & Riad Law Firm, July 2016

- ✓ Government project

  Under this scheme, the New and Renewable Energy Authority ("NREA") shall issue tenders to private-sector companies to install renewable energy power stations via EPC contracts. Such stations shall be operated by NREA. Produced electricity shall be sold to EETC at a price to be suggested by ERA and approved by the Cabinet.

- ✓ IPP

  The second scheme allows EETC to issue tenders to private-sector companies to build, own, and operate and transfer (BOOT) renewable energy power stations and sell the generated electricity to EETC at the terms and prices agreed between EETC and the investor.

- ✓ FIT

  Private sector investors are allowed to build, own and operate renewable energy power stations and sell the generated electricity to EETC or to licensed distribution companies via PPA in accordance with the pre-announced FIT.

- ✓ Commercial Project

  Under this scheme renewable energy independent power producers ("IPP") are allowed to conclude bilateral purchase agreements with eligible consumers. EETC and distribution companies are mandated to allow investors to sell electricity directly to consumers using their grids subject to a grid access fee (wheeling charge) via network connection contracts.

(4) Further Incentives for promoting the Reforms[20]

In the reformed system, competitive market with abundant private investment should be essential.

- ✓ Extra Non-Tax Incentives

  On 12 March, 2015, the Presidential Decree 17/2015 was issued to introduce substantial amendments to the Egyptian Investment Law no. 8/1997. The amendments generally aim at attracting new investments to Egypt through offering further incentives and guarantees, removing obstacles, and streamlining the procedure. Incentives include, for example, trimming sales tax to 5% from as high as 10%, and setting customs duties on equipment used for production at 2%.

Further non-tax incentives are offered to specific sectors including electricity projects:

[20] Electricity and Renewable Energy Regulations in Egypt, Dr. Fatma Salah, Partner, Riad & Riad Law Firm, July 2016

- Refunding the expenses paid to extend infrastructure facilities to the project's land. Such refund will be after the commencement of the project.
- Subsidizing the technical training programs of the employees as well as social insurance subscriptions.
- Allocating the land owned by the government free of charge or at discounted prices.

✓ Subsidies Policy Reform

As shown in the action plans, realization of financial balance in the power sector is an essential target. The Egyptian government accordingly announced a gradual increase of the electricity tariff over the coming five years with an aim to fully remove electricity subsidies by 2019. The Egyptian Prime Minister issued implementing decrees with the increased electricity tariff for the years 2014 till 2018.

✓ Sovereign Guarantee of Off-taker payments

The Egyptian government represented by the Ministry of Finance (MoF) is authorized by virtue of Law 14/2013 to guarantee all financial obligations of the Egyptian Electricity Holding Company and its affiliated companies under all projects they implement in partnership with the private sector. This means that the MoF will guarantee the obligations of EETC as the government off-taker under the power purchase agreements (PPA) concluded with electricity producers.

(5) Present situations regarding the Reform in the power sector

In Egypt, the Reform is proceeding with the policies, action plans and related laws as shown in (1) ~ (4). Here, several essential subjects are picked up and estimated for assessing the present situation.

1) Abolishment of subsidies on the electricity tariff

i. MoERE issued a ministerial order No 436 (2016) and raises the prices of electricity

ii. The Supreme Energy Council (Supreme Energy Council) decided to compensate for the difference between the actual energy cost and the assumed cost within the set budget.

These measures were implemented in line with plans to reduce the overall level of subsidies starting in 2015 to 0.5% of GDP by 2019.

The subsidy for the whole energy has declined from 6.6% in FY 2014 to 3.1% in 2016, of which 1.1% is electricity, 2% is fuel, 44% of the contribution to the decline is an electricity price raise, 56% was due to sharp decline in oil price.

MoERE implemented an average electricity tariff rate raise of 33% in 2017 (July 1, 2016), due to a decline in exchange rates, an increase in power consumption, and an increase in amortization burden accompanying the establishment of power generation facilities. As a result, a 107% raise exceeding the total price increase of 77% that was anticipated in the five years of 2014 - 2019 has already been implemented.

In raising the tariff, consideration is also given to energy conservation by drastically raising the rate of industrial consumers consuming more than 1,000 kWh (per month).

Regarding (ii), even if the planned value does not match the actual fuel price trend, all the difference would not be subsidized and by setting a ceiling and some difference should be passed on to the customers, which will be implemented from FY 2018.

Regarding the abolishment of the subsidies on the electricity tariff, the hike of the tariff has been annually conducted since 2015. The Egyptian government stated that the power sector should achieve a 70% cost recovery by increasing the tariff until 2018 (in 2015: 50%) according to the DPF appraisal by WB. Therefore, the action plan regarding the subsidies is expected to be continued in future. On the other hand, the rest of the 30% cost recovery should be achieved in the very near future according to the action plan and it would not be practical to take more years to reach the target because electricity is a necessary common commodity and the influence on society with a rapid hike of the tariff should be taken into account.

h) Improvement in Governance: Establishment of the market, TSO, Enhancement of EgyptERA function

MoERE issued Decree 230 in 2016 notifying the executive regulation of the new Electricity Law which stipulates the governance structure in the power sector, including measures to improve energy efficiency, which is coordinated with the Energy White Paper.

In a liberalized market, eligible customers should use the transmission system with transparent rules and a regulated fee along with emergency treatment contract between the transmission operator and power producer for securing the power supply to the eligible customers. All of these things should be dealt by TSO with transparency and neutrality to promote competition in the power sector. Therefore, establishment of the TSO and realization of its proper operation would be the core subjects in the Reform for the moment and establishments of the market.

Both EgyptERA and EETC are collaborated with international consultants who are well versed with the issues and they are collaborating in the related issues.

According to the consultants, they will finish the studies and finalize the frame work in the autumn of 2017 and prepare for the establishment of TSO in 2018.

In addition, it is expected that the Market Operator (MO) dealing with the power of the eligible consumer sector and Wholesale Public Trader (WPT) dealing with electricity of the regulated customer sector is to be established in the future. However, the concrete functions and establishment times of these two systems are currently under discussion among the concerned parties.

Still, the following item should be included to finalize the framework of TSO from the experience in Japan where a similar structure has been established and is in operation.

- ✓ Clear separation of finance and accounting between EEHC and EETC, which should be the pre-conditions for the transparent transmission tariff such as,
  - ➢ The separation of the assets owned or used in common
  - ➢ Draw up of Balance Sheet and Profit and Loss Statement with transparency and neutrality
- ✓ Transaction rules between generation and TSO with preferably market structures, which should guarantee the equality between the existing electricity transactions and new competitor transactions, which might include,
  - ➢ Transaction in Day-ahead market (unit time (in Japan 30 minutes) should be set)
  - ➢ Transaction in Real-time market
  - ➢ Transaction in Ancillary market
  - ➢ Other transactions other than mentioned above

The rules should be stipulated, assuming that the parties other than EEHC group will participate. The rules should also include electricity transaction rules and price settlement rules.

- ✓ Setting of the transaction system for recording sales deals among the concerned parties
  - ➢ Between generations
  - ➢ Between sales side which would be dependent on the market system
- ✓ Setting the rules for formation of the transmission tariff including such as combination of kW and kWh charges
- ✓ Sharing rules for subsidies if any by government among EETC and other EEHC groups

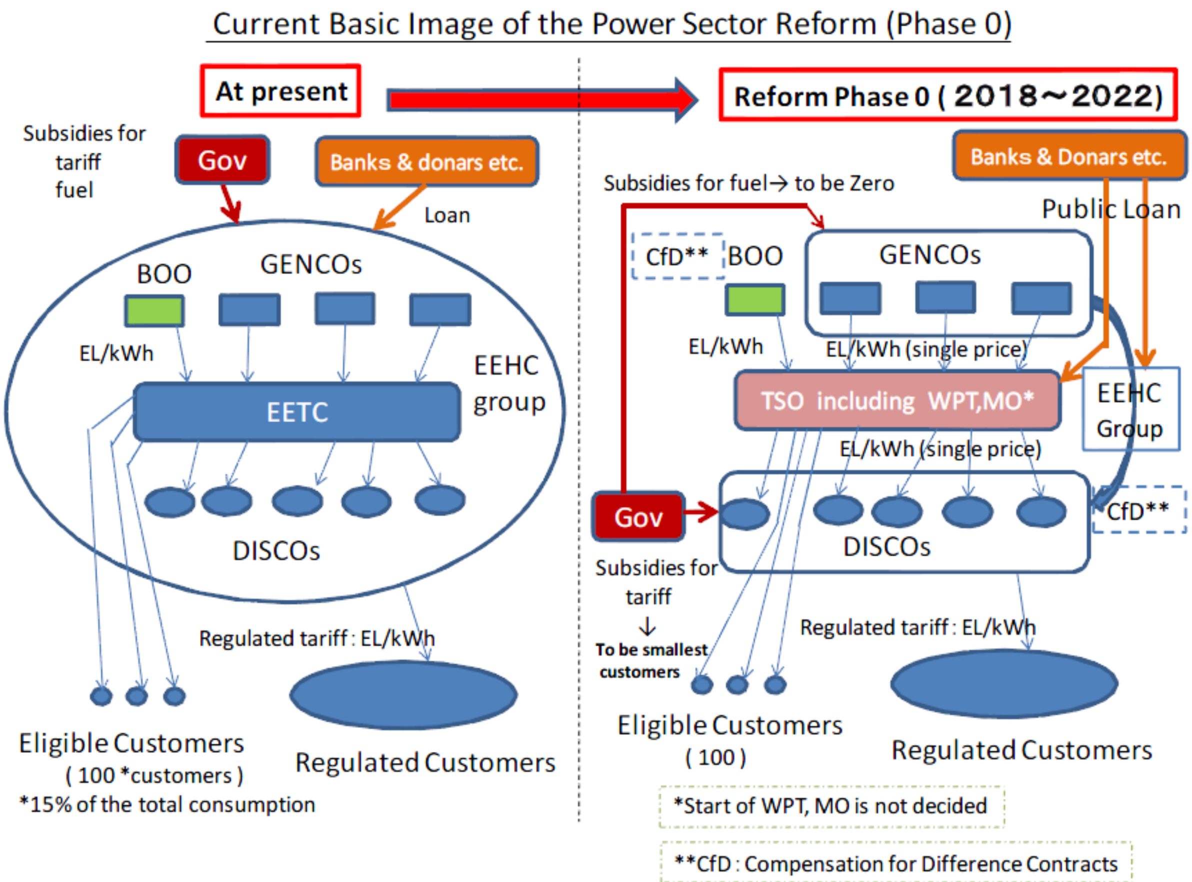
TSO could start the operation without setting all the items shown above if the concerned parties should agree. However, all the items should be finalized gradually in due time for gaining international recognition as a liberalization system.

Based on the experience in Japan, it would take a rather lengthy process because the scheme will affect many aspects in the power sector and EgyptERA will have to be involved in all the phases and find the best solution for Egypt in a coordinated manners among many concerned parties.

Therefore, a survey team will recommend that the study should be conducted, assuming an appropriate timeframe which will be presented in 3-2-5.

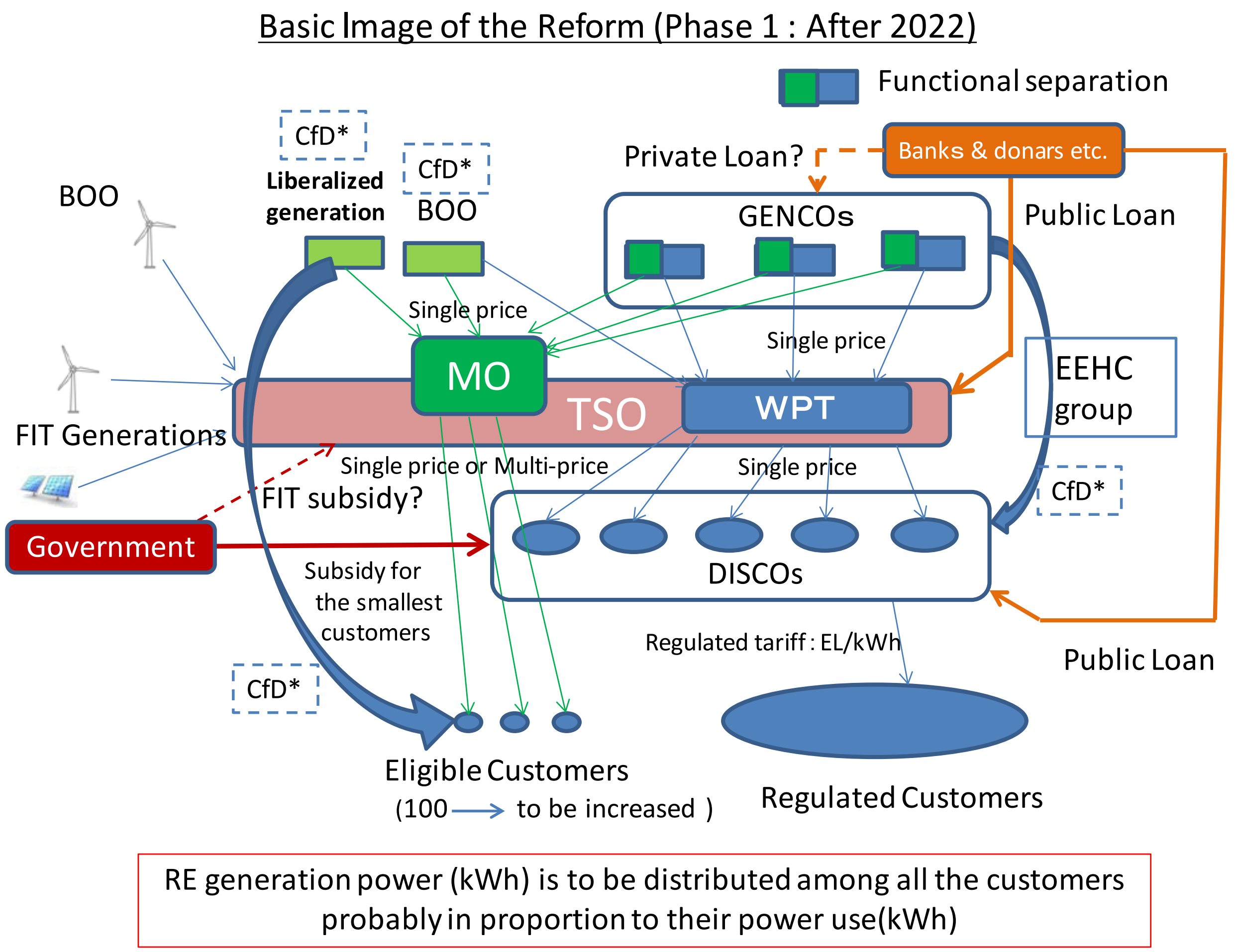
At present, governmental organizations such as MoERE, Egypt-ERA are contemplating the concrete Reform steps based on the process above. The figures shown below, which consist of Phase-zero and Phase-one, are relatively possible scenarios.

However, there are some unsettled factors, for example, the year 2018 and 2022 are not still fixed at the moment.



Source：Made by survey team based on the hearing with concerned organizations

Figure2-1-4-3 Reform steps in the Power Sector（from present situation to Phase 0）



Source: Source : Made by survey team based on the hearing with concerned organizations

Figure2-1-4-4 Reform steps in the Power Sector (Phase 1 (around year 2022 and after)

i) Introduction of RE with private sector investments

In the action plans in Energy White Paper, introduction of RE with private sector investments is formalized as the target including FIT system utilization. As presented in 2-1-2(2), the framework for the introduction of large scale RE is working well at present, which demonstrates that the related action plans are being conducted as assumed. In addition, in September 2016, the FIT system was revised in response to currency fluctuations, taking into consideration that sufficient application was not obtained under the previous system. (Refer to 2-6-1) The International Finance Corp (IFC) and the European Bank for Reconstruction and Development (EBRD) shall finance to this revised FIT against 2000 MW of solar development. The policy was to be continued until October 2017. According to EgyptERA, they plan to continue it thereafter.

Furthermore, promotion of introduction of private investment is being promoted by the BOO scheme, such as the final negotiation process to introduce the power selling price of 0.04 dollars (/ kWh).

As a result of the above, finance closure of 1.5 GW of private investment power generation facilities is expected to be completed by the end of fiscal 2018.

Regarding energy efficiency improvement, a team within MoERE in 2014 was established and a chief investigation officer was nominated in May 2016, and full-fledged activities have started, and are working to establish and implement the National Efficiency Action Plan. The team is also working with the distribution company, EgyptERA in collaboration with railway companies and local governments.

(6) Reform after the action plans

Although the action plans are formalized to realize the Reform and other important targets until around 2020, New Electricity Law stipulates the Reform after that, that is, until 2023, the next Reform should be formalized including production companies, distribution companies and EEHC itself.

Before going to the next stage issue, establishment of TSO and its effects on the competitive market should be well analyzed because, TSO should bring about impartial operation in the electricity system as well as transparency in the process in decisions on the transmission tariff with the regulation of EgyptERA. Although the survey team should admit that many impartial efforts have been made by EEHC on the electricity areas until now, TSO would clearly improve the accountability on the matters in the systematical ways which are recognized as common in the world.

Therefore, after TSO establishment with proper operation, worry against arbitrary influential power by EEHC would be mitigated drastically. Then, in Egypt, the discussion on the next step of reform will begin, affirming the effectiveness of TSO in a “calm” atmosphere.

For instance, since EEHC has greatly contributed to bringing about stable supply for the customers in the power sector, the next structure without EEHC would not be easily formulated. Namely, it would be a very serious matter who would take responsibility of the stable supply instead of EEHC. In developing countries, “market-only” solutions could not be applied uniformly because many original systems regarding liberalization have been developed in the world, reflecting the situation in each country.

In considering the situations in Egypt, special attention should be paid and thorough discussion should be made before reaching a conclusion which might include continuation of EEHC while securing enough time for the transition process to the next step.

2－1－5 Assistance policies and related information in key donors

(1) Overall situation

In Egypt, many donors have been contributing to the power sector, such as World Bank and African Development Bank as multilateral agencies, and KfW and AFD as bilateral agencies. Similar assistance will continue in future.

Regarding the multilateral agencies, World Bank and African Development Bank have promoted DPF (Development Policy Financing) since 2015 to support the Reform in the power sector. Therefore, at first, DPF issue is to be presented and other issues of assistance will be summarized afterwards.

(2) DPF assistance by WB and AfDB

DPF (Project name in WB: Fiscal consolidation, Sustainable Energy, and Competitiveness Programmatic Development Policy Financing) has been conducted based on the agreement between Egyptian government and the donor regarding the policies to be promoted. The fund financed by the donor could be used for any subject in the government budget and the result indicators should be checked to assess the realization levels of the agreed policies. The assessment is to be conducted annually and the following year's financing is to be determined based on the results of the assessment.

The DPF by WB and AfDB started in 2015. Fiscal year 2016/2017 was the second year of the financing and the related assessment process has just ended and the second year DPF started in November 2016.

In the assessment, the stance of the donor WB who is coordinated with AfDB and the stance of Egyptian government are clearly stated regarding promotion of the Reform in the power sector.

Therefore, the contents of the DPF program document are briefly presented as follows to understand the situation in the Reform in Egypt. In conclusion, the contents show that the essential issues from the perspective of donors are matched with the targets or action plans in the WHITE paper and ISES2035.

a) Contribution areas for DPF (3 pillars)

The Reform should be promoted with the three pillars shown below.

Pillar 1 Advancing Fiscal Consolidation

Pillar 2 Ensuring Sustainable Energy Supply

Pillar 3 Enhancing the Business Environment

The Reform in power sector is included in Pillar 2 as one of the essential factors

b) Result indicators in Pillar 2

In each pillar, Result indicators were set and the indicators in pillar 2 where the Reform in the power sector is included are as follows, where the indicators with bold characters are closely related with the power sector.

✓ Reforming energy subsidies:

- 1.5% of GDP in 2018 expected (6.6% in 2014)
- Promotion of cost recovery in electricity tariffs 70% in 2018 expected (50% in 2014)
- Promotion of the reduction in subsidies in the petroleum sector

- ✓ Improving Energy Governance
  - Strengthening energy security 1000MW surplus in 2018 (5540MW deficit in 2015)
  - Establishment of TSO
  - Public disclosure of the electric tariff methodology and others in 2018
  - Public disclosure of gas transmission and others in 2018
  - Publication of related information at WEB in 2018
  - Implementation of modernizing program in the gas and petroleum sector
  - Increase in domestic gas production: 4700MMScf/day expected in 2018 (4020 in 2016)
  - Renewable Energy contract of 1500MW by the private sector by 2018

c) Main points in the assessment in the power sector

- Reduction of subsidies are proceeding step by step
- EgyptERA is gradually strengthening its functions on such as tariff formation
- Establishment of TSO is proceeding with cooperation among concerned parties
- Improvement in energy security has been dramatically achieved
- Introduction of RE is proceeding with efforts of the concerned parties

Based on the assessment, the policies predetermined in DPF are proceeding with the efforts from the Egyptian government. Therefore, DPF in 2017 would be allocated with an amount of 1.5 billion dollars (WB+AfDB total).

DPF would be continued until 2018 assuming that the assessment by the donors would suffice the result indicators.

(3) Assistance other than DPF by international donors

The multilateral agencies are also promoting assistance in almost the same stance as bilateral agencies in areas such as development of RE, transmission and distribution reinforcement projects required for new generation evacuations, and technical assistance for reform in those sectors.

On the other hand, both multilateral and bilateral agencies would leave from the area of conventional generation plant assistance such as thermal generation development. According to World Bank, because this area would be committed more by the private sector, reflecting the facts that the liberalization schemes would progress and private sector should play more important roles.

Basic policies of the main donors are summarized as follows,

1) World Bank (WB)

The policy regarding assistance in the area of utilization of natural gas and development of thermal generation using gas will not be changed in the future.

The policy regarding assistance in the area of power transmission, RE and energy efficiency will be strengthened.

Incidentally, conventional generation development will be supported by IFC (International Finance Corp.) in WB group which should mainly be involved in private sectors.

2) African Development Bank (AfDB)

In the power sector, an energy efficiency improvement plan for the gas combined cycle generation with repowering is now under study. In the area of RE, wind generation development and some solar development in FIT scheme will be supported.

3) Agence Francaise de Development (AFD)

AFD has supported the development of RE along with improvement in the electricity network such as replacement of the control center system and will be committed to the same area. Regarding technical assistance, some projects are now under discussion with the concerned parties such as the estimation method on technological aspects in solar generation development.

4) Kreditanstalt für Wiederaufbau Bankengruppe (KfW)

KfW will support the public sector projects in RE and private sector projects will be supported indirectly by introducing a credit line for the Egyptian local banks that would finance the projects. It is expected that efficiency improvement in industrial customers shall be the next targets of support.

In Table 2-1-5-1, some financing projects are tabulated as a reference.

The table also shows the assistance projects have moved from thermal generation area to RE area.

Table 2-1-5-1 Donor's power sector support in Egypt

Donor	Project	Support summary	Amount (million US$)	Approval date
World Bank	Second Fiscal Consolidation, Sustainable Energy, and Competitiveness Programmatic Development Policy Financing Project	DPF	1,000	2016/12/20
	First Fiscal Consolidation, Sustainable Energy, and Competitiveness Programmatic Development Policy Financing Project	DPF	1,000	2015/9/17
	Helwan South Power Project	Expansion Thermal	585.4	2013/6/27
	Giza North Additional Financing	Expansion Thermal	240	2012/2/14
	Wind Power Development Project	Wind development	70	2010/6/15
	Giza North Power Project	Expansion Thermal	600	2010/6/10
AfDB	First; Economic Governance and Energy Support Program(EGESP)	DPF	358.5	2015/12/15
	Second; Economic Governance and Energy Support Program(EGESP)	DPF	500	2016/12/13
	Damanhour Combined Cycle Power	Expansion Thermal	1,208	2015/9/1
	200 MW Wind Farm Project (Gulf OF Suez)	Wind development	450*	2016/6/1
	Delta Solar Project**	PV development	103*	2016/5/4
	Enara Sunedison Solar**	PV development	130*	2016/5/4
	Neon Solar Project**	PV development	45*	2016/5/4
	Shapoorji Pallonji Solar Project**	PV development	108*	2016/5/4
	Gulf New Energy Egypt Project**	PV development	118*	2016/5/4
	Alcazar Solar Project**	PV development	100*	2016/5/4
	1500MW Power Plant	PV development	250*	2016/3/1
	Improv. Oper. Eff. Exist. Power Plants	Thermal efficiency	UAC 532,500*	2011/5/16
	CTF (Complete Technical Feasibility Study) Project Preparation Grant for 200mw Wind Project in Gulf of Suez	Wind development	0.624*	2011/11/29
	Studying Integration Wind Power	Wind development	UAC 529,000*	2011/5/16
	CTF (Complete Technical Feasibility Study) Preparation Grant for Kom Ombo Concentrated Solar Power Project in Egypt	PV development	0.655*	2011/11/29
	Suez Thermal Power Project	Expansion Thermal	635.8*	2010/12/15
	Ain Sokhuna Thermal Power Generation Project	Expansion Thermal	1,278*	2008/12/22
AFD	New regional control center for the Nile Delta’s electric network	Transmission	61 million Euro	2017/3/2
	Project to reinforce the electric power grid	Transmission	50 million Euro	2016/4/12
KfW	Refurbishment of the generators of the Aswan High Dam	Hydro power	85.65 million Euro	2017
	Zafarana IV Wind Farm	Wind development	77.7 million Euro	2016
	Zafarana I-Ⅲ Wind Farm	Wind development	68 million Euro	2009

*; Display is total amount, and AfDB is partially supported

**; Stage under investigation (Pipeline)

Source Web Site of the organizations

2－2　Supply and demand of electric power

2－2－1　Current status and forecast of primary energy procurement

(1) Current status of primary energy procurement

The table below shows the primary energy balance for 2013/14, which is based on the publication by CAPMAS.

Table 2-2-1-1 Primary energy balance 2013/14

List	Electrical	Hydro	Wind	Solar	Natural Gas	others	Gas/Diesel oil	Kerosene	Jet Fuel	Naphtha	Gasoline	LPG	Crude Oil	Coke Oven	Hard coal
Primary Production		1148	115	3	43639								33535		2
Imports	5				429	64	5993		80		1723	2265	2801		279
Stock exchange														7	
Exports	40				1883	296			498	1391			11940	14	
Bunker									615						
Gross inland	-34	1148	115	3	42185	-232	5938		**-1033**	-1391	1723	2265	24396	-7	281
consumption					24135		122						26008		281
Transformation input					23745		122								
Thermal power Stations															281
Coke-oven Plants															
Gas Works					389								26008		
Refineries															
Transformation	13180					1689	7958	74	1776	1409	4760	651		202	
output	13174														
Public Thermal Power	5														
Station														202	
Independent Thermal Power												21			
Station						1689	7958	74	1776	1396	4760	630			
Coke-oven Plants															
Investment Company															
Refineries															
Exchanges transfer, return	1266	-1148	-115	-3								1735			281
Interproduct transfer	1266	-1148	-115	-3								1735			-281
Consumption Energy branch	473														
Distribution Losses	1631														
Available for final consumption	12292				18051	1457	13774	74	742	18	6483	4651	-1611	195	
Final Energy Consumption	12348				18004		13539	5	685		6342	4677		195	
Final non-energy consumption						1286									
Industry	3210				11543		3315	1				25		195	
Transport	38				416		3941		685		6342				
Household	5329				1448			3				4652			
Agriculture	343						822	1							
Other	3228				4597		5461								
Statistical differences	-56				47	171	235	69	58	18	141	-26	-1611		

Source: CAPMAS 2013/14

In the fiscal year of 2013/14, 43,639 thousand tons equivalent oil (ktoe) of natural gas, 33,535ktoe of crude oil, and a small amount of coal was produced within Egypt.

As for natural gas, 1,883ktoe was exported, while 429ktoe was imported, thus 42,185ktoe in total was domestically consumed. Approximately 56% of the total domestic consumption, 23,745ktoe, was used as fuel for electric power generation, approximately 1% was for refineries, and the rest was for final consumption. Approximately 64% of the final consumption was for industry, and approximately 8%was for households.

As for crude oil, 24,396ktoe in total was domestically consumed, in which, approximately 36%, 11,940ktoe was imported, while 2,801ktoe was exported. All the crude oil was used for refineries, and not used for electrical power generation.

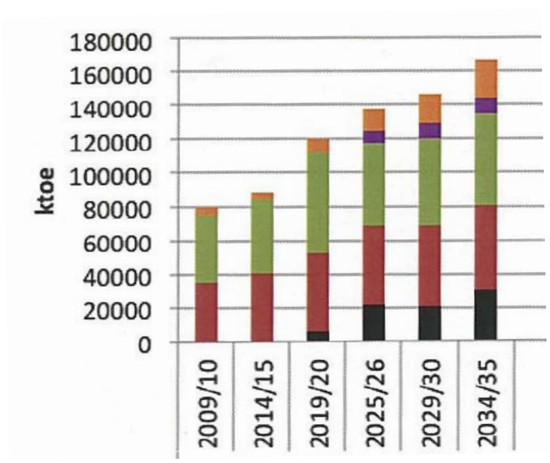
As for coal, 2ktoe was domestically produced, 279ktoe was imported. All coal was used for coke-oven plants.

For electrical energy, 1,148ktoe was generated by hydro power stations, 115ktoe was by wind power, and 3ktoe was solar in Egypt, while 5ktoe was imported and 40ktoe was exported. Electric power generated from thermal power stations, including BOOTs was 13,180ktoe. Excluding the transmission losses etc. from the gross power, 12,348ktoe of electric power in total was finally consumed domestically. Approximately 43% of the final consumed electric power was for households, and approximately 26% was for industry.

Electric power accounts for about 22% of all primary energy consumption.

(2) Forecast of primary energy procurement

Figures below show estimated primary energy supply by fuel, and share of energy commodities in the primary energy supply, taken from ISES2035Scenario4b.



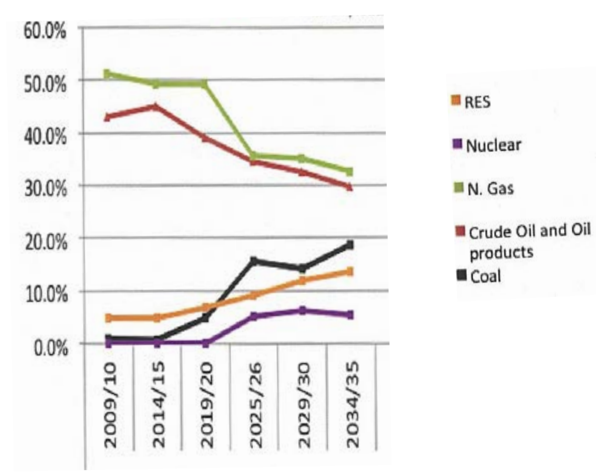


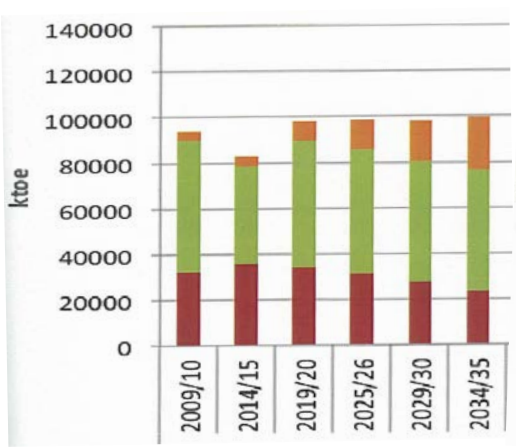
Figure 2-2-1-1 Primary energy supply by fuel

Figure 2-2-1-2 Shares of energy commodities in the primary energy supply

Source: Integrated Sustainable Energy Strategy 2035

Total primary energy supply in the fiscal year of 2034/35 is estimated to be more than 160,000ktoe, which is double of that in 2014/15. At present, approximately half of the total primary energy supply is supplied by natural gas, and more than 40% is by crude oil. In the 2034/35, the rates of natural gas and crude oil are expected to be down to approximately 30%; instead, coal, renewable energy, and nuclear power are expected to account for about 20%, 15%, and 5% of the energy supply respectively. As for natural gas, it is expected that gas shortages could potentially happen in the future notwithstanding new gas fields being discovered. Therefore, although the importance of new gas field development is well recognized, switching from natural gas to other fuel such as coal, renewable energy, and nuclear power will proceed, and surplus gas will be exported.

The next figures show primary production of indigenous energy sources, and imports of energy commodities.



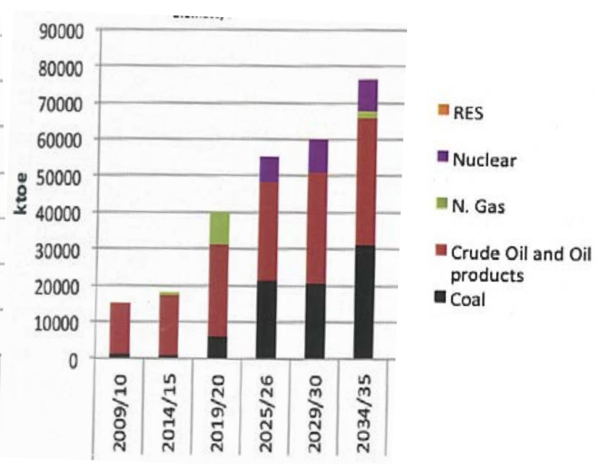


Figure 2-2-1-3
Primary production of indigenous energy sources

Figure 2-2-1-4
Imports of energy commodities

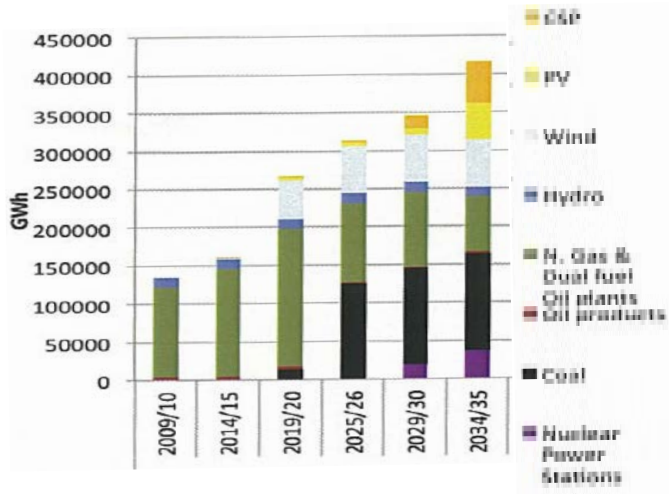
Source: Integrated Sustainable Energy Strategy 2035

Total amount of the primary production is expected to be the same level up to 2034/35 while renewable energy is expected to grow up to about 20% of the total amount of the primary production in the fiscal year of 2034/35. On the other hand, crude oil production is expected to decline.

Total amount of imported primary energy is expected to grow up to 4 times as much as the current total amount. At present, most of the imported energy is from crude oil, oil products, and natural gas. In the fiscal year of 2034/35, coal is expected to amount to about 40% of the total imported energy, and nuclear energy is expected to amount to about 10%.

Namely, ISES2035Scenario4b, which describes the long term energy strategy up to 2035, shows the future diversion of energy sources by introducing renewable energy, coal, and nuclear energy.

The next figures show electricity production by plant type, and fuel input for electricity production by plant type.



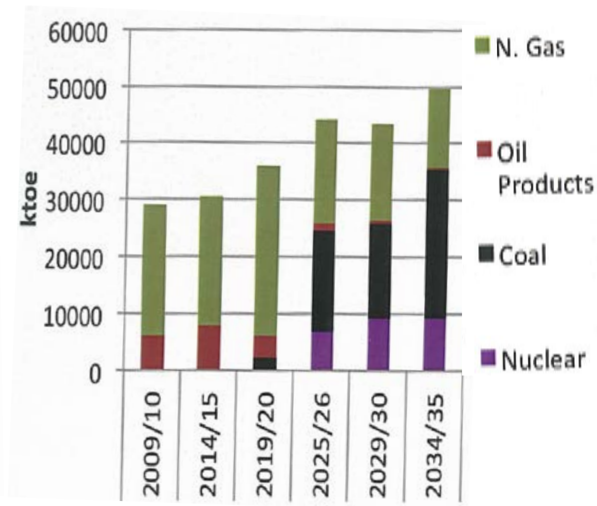


Figure 2-2-1-5
Electricity production by plant type

Figure 2-2-1-6
Fuel input for electricity production by plant type

Source: Integrated Sustainable Energy Strategy 2035

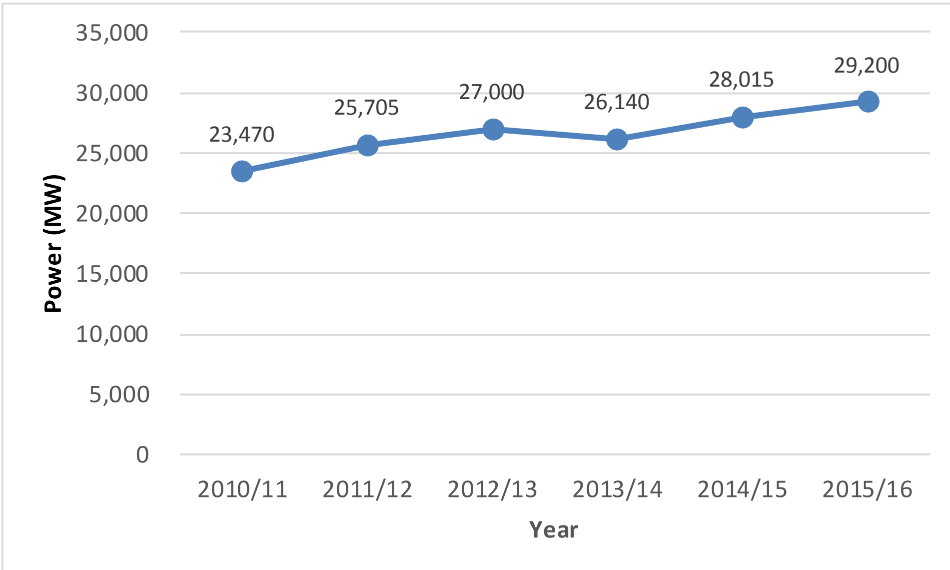
In the fiscal year of 2034/35, total electricity production is expected to grow over twice as much as current electricity production, and future electricity will be supplied by various types of generation. As shown in Figure 2-2-1-4, approximately 30,000ktoe of coal will be imported in the fiscal year of 2034/35, while 25,000ktoe of electricity production in 2034/35 is expected to be generated by coal fired thermal power stations as shown in Figure 2-2-1-6, thus more than 80% of imported coal is expected to be used for electric power generation.

Coal fired thermal power plants in Egypt are scheduled to be developed by both EEHC and BOO schemes as described later. As for the BOO schemes on coal power station, fuel coal shall be secured by BOO private sectors, while coal for EEHC owned power stations will be procured by EEHC.

The coal thermal power station to be owned by EEHC is under tendering stage as of Feb, 2017, and the characteristic of coal to be procured has not been formally decided yet. However, EEHC has already asked availability of coal to major coal suppliers all over the world based on the estimated coal characteristics, and from the results of the research, EEHC seems to have confidence in securing coal by itself. Therefore, Japanese support in securing coal, such as support for establishment of an organization whose purpose is to secure stable coal supply, does not seem to be necessary for EEHC at present. Moreover, the function of the coal center for handling the coal in one place will not be necessarily required because EEHC will have only one coal power station plan for the time being. However, since there has been no coal power station in Egypt and EEHC has no experience in operation of coal power stations, EEHC recognizes the need of technical support in coal handling within the station, as well as in environmental monitoring of the coal power station according to the interview with EEHC.

2−2−2 The current situation and outlook for power demand

The trends in power demand are as shown in Figure 2-2-2-1.

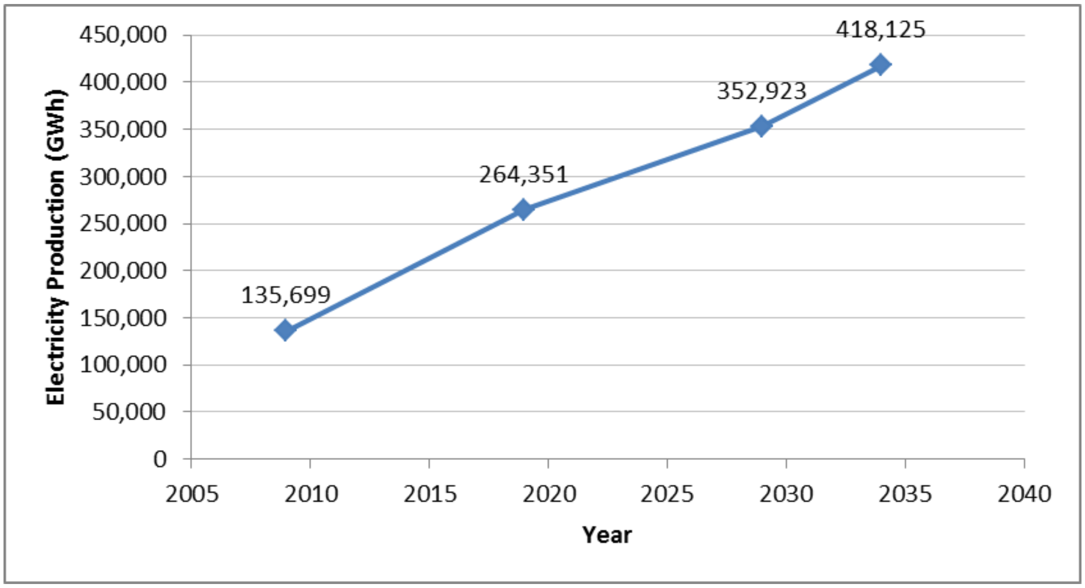


Source: 2014/15 Annual report by EEHC and information on demand in 2015/16 obtained from the national energy control center

Figure 2-2-2-1 Changes in power demand by EEHC

Although the power demand fell slightly in 2013/14, the power demand has been growing year by year. The average of annual growth rate for power demand from 2010 to 2016 was 4.5%. The power demand forecast section in EEHC expects an annual growth rate of 5.5% based on this record of actual annual growth rate and other data. The power demand forecast section informs the power generation companies and transmission planning department with higher and lower increase predictions to this value for the reference.

On the other hand, according to ISES2035, the changes in power demand from 2009 to 2035 as shown in the following figure;



Source: Integrated sustainable energy strategy to 2035

Figure 2-2-2-2 Changes in power demand by ISES2035

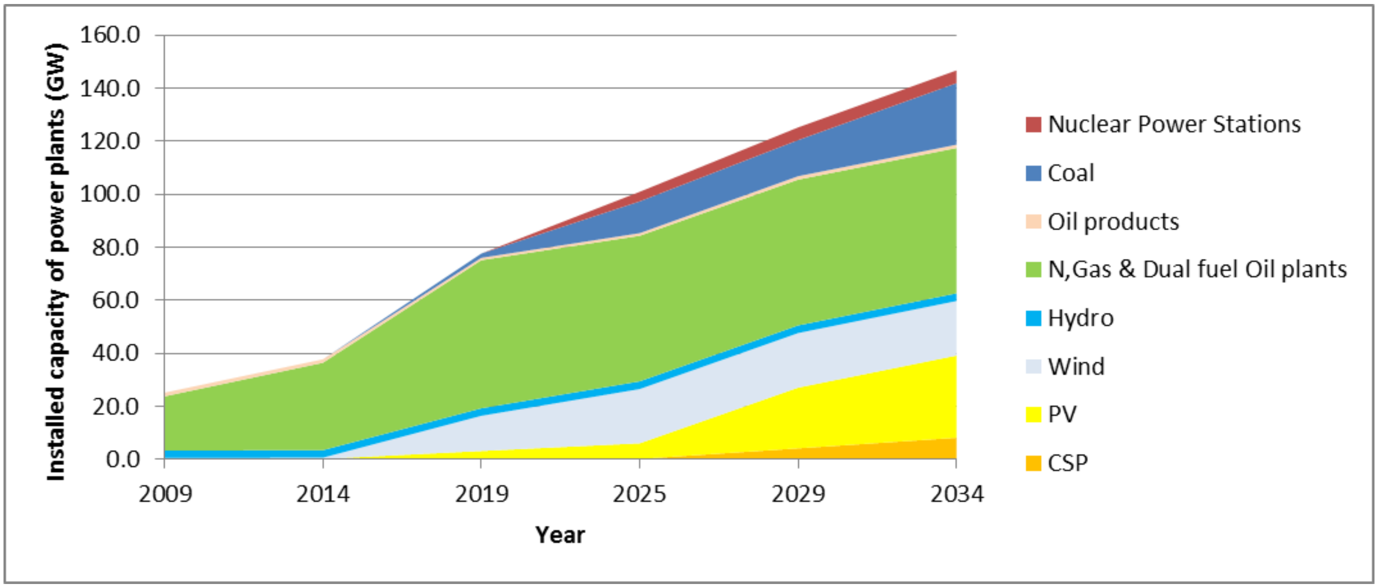
The average of annual growth rate of power demand from 2016 to 2035 is 4.6% which is same as the average of annual growth rate of power demand from 2010 to 2016. Since the power demand forecasted rate by the section was 5.5%, the power demand growth by the TARES rate 4.6% is different by about 1.0%. The difference seems to be that ISES2035 expects the effect of more efficient use of energy.

Although it seems that the power demand growth in recent years is consistent with ISES2035 Scenario4b, in the short-term point of view, the growth rate of power demand from 2015 to 2016 is 4.3% and lower than the scenario. Therefore, the power demand growth might be slowing down and it might be necessary to review the power demand forecast if this trend should continue.

2－2－3 Present situation and future for power plant development and power supply / demand

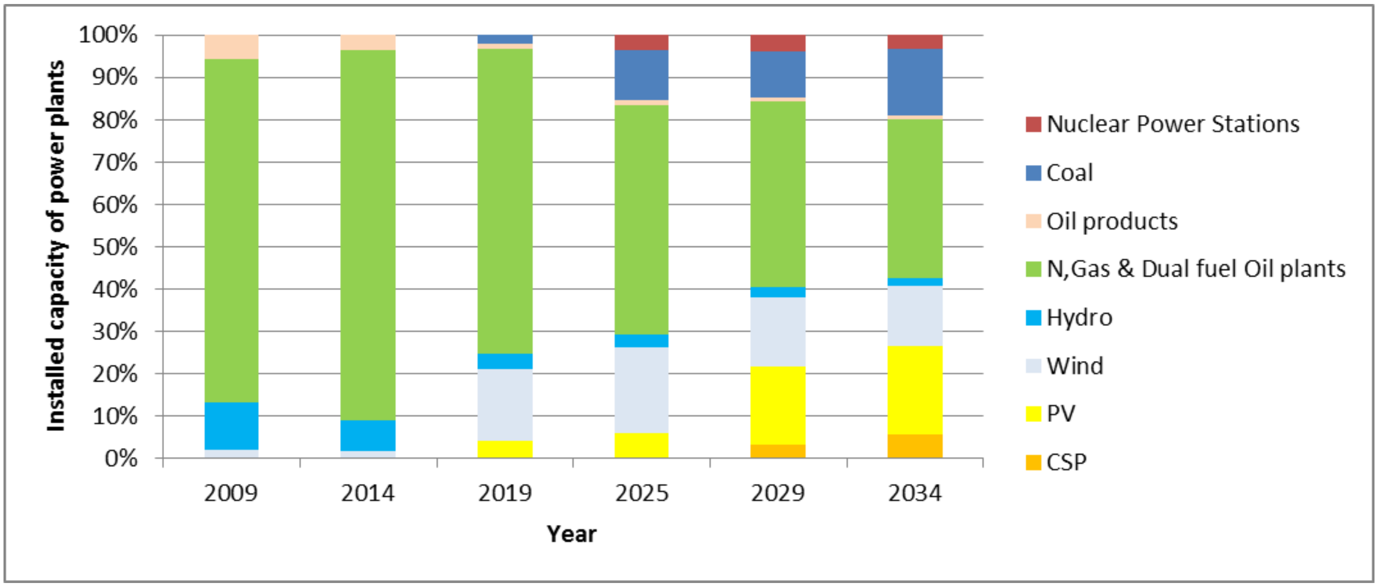
(1) The present situation and future for power plant development and power supply / demand

The change in the capacity of the power plants, share of the capacity with respect to the resource type, electricity production and share by plant type are shown in the following figures respectively.



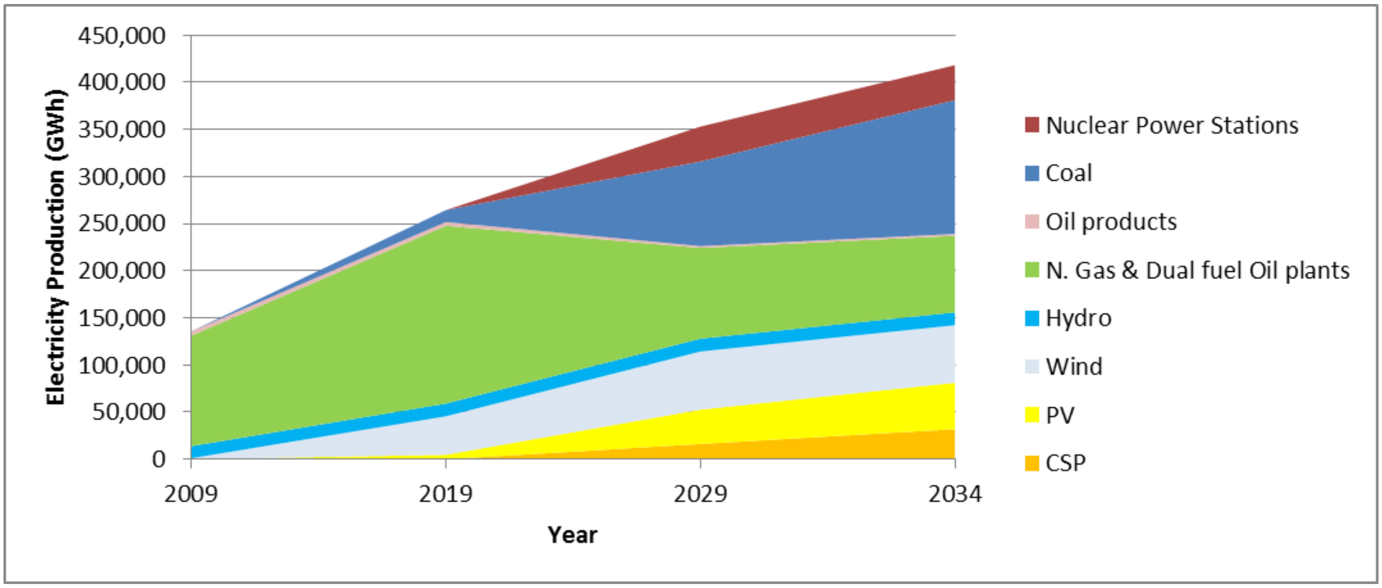
Source: Integrated sustainable energy strategy to 2035

Figure 2-2-3-1 Change in capacity of power plants



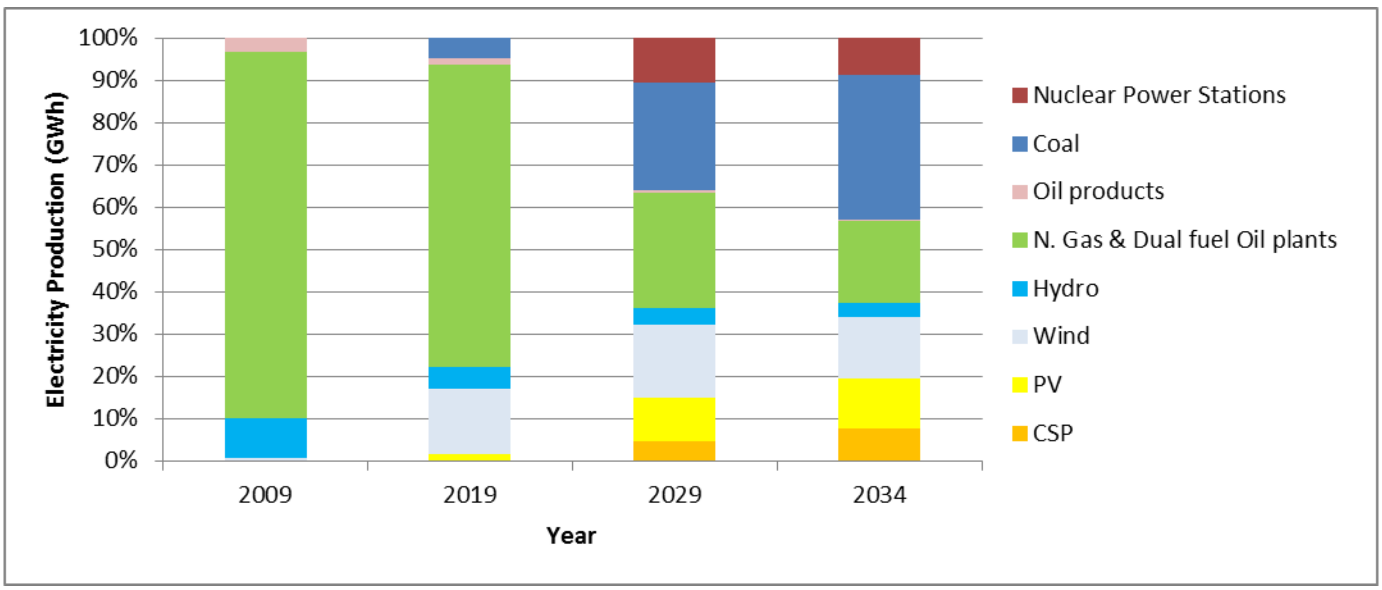
Source: Integrated sustainable energy strategy to 2035

Figure 2-2-3-2 Change in share of the generation capacity with respect to energy resource type



Source: Integrated sustainable energy strategy to 2035

Figure 2-2-3-3 Change in electricity production



Source: Integrated sustainable energy strategy to 2035

Figure 2-2-3-4 Change in share of production with respect to energy resource type

The total capacity of power plants is increased form 25.1GW in 2009 to 147GW in 2034. Incidentally, since in Egypt the conditions of wind power generation and solar generation is favorable compared with those in Europe, the assumed power generation capacity development of RE generation should be reexamined.

Regarding shares of the resource type, since the natural gas and dual fuel oil plant will remain installed until 2019, the share of these types will amount to 80% of the total generation around that time. After that, coal-fired power plants will be installed steadily and the share will amount to 40% of the total generation in 2034. On the other hand, the amount of electricity generated by renewable energy is assumed to account for 30% in 2034. Especially photovoltaic power generation will be increased at a higher rate after 2029.

The production of electric energy is planned to shift from natural gas to coal and renewable energy. In addition, nuclear power will begin operation in the 2020s

Recently, the power demand growth rate is lower than the assumption of the TARES mentioned above. On the other hand, the new power plants will be installed at 19.5GW by 2022 as shown in Table 2-1-2-1. Therefore, the supply and demand balance will be well preserved. Therefore, the energy supply balance would not be a big issue for the time being.

(2) Status of Supply Reliability

- ✓ Power outage due to difficulty in maintaining supply-demand balance

According to NECC, there is no outage due to the failure to maintain a supply-demand balance over the past two years (including rolling blackouts). This is considered to be the result of a rapid increase in the power supply capacity of about 5 GW as FAST-TRACK and others.

Since the new generation additions and generation capacity increase in the existing power plants are to begin operation subsequently, it is judged that the possibility of power failure due to supply / demand balance is not likely to happen for the moment.

- ✓ Power outage due to transmission and distribution system

According to NECC, the operation with the n-1 standard (power failure would not occur even if one of the equipment stops operation unexpectedly) is maintained in the main facilities (220 kV or above) in recent years. Therefore, it is judged that reliability degradation due to the power transmission system has not been experienced recently and will be so in the near future.

On the other hand, regarding the reliability of the distribution system, it is generally assumed that the situation varies in each local distribution system. However, the reliability level, for example, in North Cairo Distribution Company, which is primarily underground distribution, SAIFI is 2.588 and SAIDI is 151.178. Although the indices are worse than Japan and not good, it cannot be judged as an extremely bad situation. (SAIFI in Japan: 0.05 to 0.10, SAIDI: 5 to 10) The detailed data on each area is shown in the following table. For reference, 2008/2009 values are shown in the lower row of the table. SAIFI: 1.56, SAIDI: 110.19 and the indices got worse. However, the trend is not so extreme that it should be judged as not in a critical situation in terms of reliability.

Table 2-2-3-1 SAIFI and SAIDI in NCEDC in year 2015/2016

Sector	SAIFI (Inter. /Cust.)	SAIDI (Min. /Cust.)
East	1.36	80.93
Helmya	3.678	204.328
Helioplis	3.328	202.146
North	1.748	109.207
Total	2.588	151.178
Total（reference: 2008/2009）	1.56	110.19

Source: Interview survey to North Cairo Distribution Company

- ✓ Main causes of power failure in North Cairo Distribution Company:

  No.1: Cable disconnection under construction - 84 locations per month last year

  No.2: Cable joint failure (break down) - 29 locations per month

  No.3: Other causes - 70 locations per month

- ✓ Causes of the underground cable failures:

  Since the construction conditions of laying the cables are as follows,

  1kV network cable ⇒ 80 cm under the surface of the ground

  22kV network cable ⇒ 100 cm under the surface of the ground

The underground cable failures by the cut-offs of the cables could not be avoided by the distribution company because the construction conditions are relatively well maintained. However, there might be some room for improvement, such as improving the construction methods.

Regarding the underground cable joint failures, they should be caused by the deterioration due to aging.

According to the interview, the joints are to be replaced based on the annual plan. Therefore, as long as the management of the date regarding the joints is well handled, joint failures should be no big issue.

- ✓ SAIFI and SAIDI in other distribution companies

Figure 2-2-3-2 shows the values of SAIFI, SAIDI of the distribution companies that were derived as the answers to the questionnaire other than NCEDC.

As a trend, although there are variations depending on the years, there is no great improvement or deterioration in values. Based on the survey results, the reliability in distribution would be preserved if O&M of the facilities are well conducted.

As the causes of the incidents, taking the North Delta company, which mainly consists of overhead distribution, as an example, the first location cause is natural phenomenon, second location cause is equipment failure, and third location cause is repair failure. Regarding the natural phenomenon, the first location cause is wind, rain, and flooding. The second location cause is thunder. The third location cause is salt contamination.

Table 2-2-3-2 SAIFI and SAIDI of other distribution companies

○Alexandria

	2011/12	2012/13	2013/14	2014/15	2015/16
SAIFI	1.08	0.81	0.59	0.63	0.61
SAIDI	22.8	18.96	19.48	19.58	19.1

○North Delta

	2011/12	2012/13	2013/14	2014/15	2015/16
SAIFI	―――	―――	―――	―――	―――
SAIDI	606.66	372.66	472.54	239.2	266.69

○El Behera

	2011/12	2012/13	2013/14	2014/15	2015/16
SAIFI	7.992	10.45	7.45	6.59	5.67
SAIDI	827.94	987.9	876.05	667.2	765.3

○Middle Egypt

	2011/12	2012/13	2013/14	2014/15	2015/16
SAIFI	―――	―――	―――	―――	―――
SAIDI	161.97	227.74	185.38	132.23	116.22

○Upper Egypt

	2011/12	2012/13	2013/14	2014/15	2015/16
SAIFI	1.01	0.77	1.00	0.85	1.22
SAIDI	143.18	92.7	156.44	115.51	240.63

2－3 Power generation

2－3－1 Current status of the installed generating capacity

(1) Installed generating capacity Outline

Total installed generating capacity in Egypt is 35,220MW as of 30 June, 2015, which includes 2,800MW of hydro power, 687MW of renewable power, and 31,743MW of thermal power including BOOT’s. Table 2-2-1-1 shows the breakdown of installed thermal power capacity.

Table 2-3-1-1 installed thermal power generation capacity

Generation type	Capacity	Ratio
Gas turbine	4,847MW	15.3%
Steam turbine	15,083MW	47.5%
Combined cycle	11,777MW	37.1%

Source: Egyptian Electricity Holding Company Annual Report 2014/15

Nearly half of the total thermal power capacity is occupied by steam turbines. Capacity of the private sector BOOT's, which are all steam turbines, is 2,048MW. All the installed facilities, except hydro and BOOT's, are owned by five production companies.

Table 2-3-1-2 shows the statistics of each power unit.

After the year 2000, most of the newly installed generating facilities are either combined cycles or gas turbines. Still, some steam turbines, including BOOT's, have been also installed.

Table 2-3-1-2 Power plant data statistics (30/6/2015)

Comp.	Station		No. of Units	Installed Capacity (MW)	Actual Capacity	Fuel	Commissioning date
Cairo	Shoubra El-Kheima	(St)	4 x 315	1260	1260	N.G-H.F.O	84-85-1988
	Shoubra El-Kheima	(G)	1 x 35	35	35	N.G-L.F.O	1986
	Cairo West Ext	(St)	2 x 330 + 2 x 350	1360	1360	N.G-H.F.O	1995-2011
	Cairo South 1	(CC)	3 x 110	330	300	N.G	1989
	Cairo South 2	(CC)	1 x 110 + 1 x 55	165	150	N.G	1995
	Cairo North	(CC)	4 x 250 +2 x 250	1500	1500	N.G-L.F.O	2005-2006-2007-2008
	El-Tebeen	(St)	2 x 350	700	700	N.G-H.F.O	2010
	Wadi Hof	(G)	3 x 33.3	100	75	N.G-L.F.O	1985
	6 October	(G)	4 x 150	600	600	N.G-L.F.O	2012
	North Giza	(CC)	4 x 250 +2 x 250	1500	1500	N.G-L.F.O	2015-2014
	6 October Ext	(G)	3 x 150	450	450	N.G-L.F.O	2015
East Delta	Damietta	(CC)	6 x 132 + 3 x 136	1200	1164	N.G-L.F.O	89-1993
	Ataka	(St)	2 x 150 + 2 x 300	900	900	N.G-H.F.O	85-86-1987
	Abu Sultan	(St)	4 x 150	600	600	N.G-H.F.O	83-84-1986
	Shabab	(G)	3 x 23.5	100	91.5	N.G-L.F.O	1982
	New Gas Shabab	(G)	8 x 125	1000	1000	N.G-L.F.O	2011
	New Gas Damietta	(G)	4 x 125	500	500	N.G-L.F.O	2011
	Damietta West	(G)	4 x 125	500	500	N.G-L.F.O	2012-2013
	Port Said	(G)	1 x 24	24	22	N.G-L.F.O	1977
	Arish	(St)	2 x 33	66	66	N.G-H.F.O	1995-1996
	Oyoun Mousa	(St)	2 x 320	640	640	N.G-H.F.O	2001
	Sharm El-Sheikh	(G)	1 x 23.7 + 4 x 24. 27	120.5	109	L.F.O	1997-1979-1975
	Hurghada	(G)	6 x 24.2	145	131	N.G - L.F.O	1977-1979
	Ain-Sokhha	(St)	2 x 650	1300	1300	N.G-H.F.O	2015
	Zafarana(Wind)	**(W)**	**105 x 0.6 + 117 x 0.66 + 478 x 0.85**	**547**	**120**	**Wind**	**2007-2008-2009-2010**
	Suez Gulf(BOOT)	(St)	2 x 341.25	682.5	682.5	N.G-H.F.O	2002-2003
	PortSaid East(BOOT)	(St)	2 x 341.25	682.5	682.5	N.G-H.F.O	2002-2003
Middle Delta	Talkha	(CC)	8 x 19.0 + 2 x 40	236	236	N.G-L.F.O	79-80-1989
	Talkha 210	(St)	2 x 210	420	420	N.G-H.F.O	1993-1995
	Talkha 750	(CC)	2 x 250 +1 x 250	750	750	N.G-L.F.O	2006-2010
	Nubaria 1,2	(CC)	4 x 250 + 2 x 250	1500	1500	N.G-L.F.O	2005-2006
	Nubaria 3	(CC)	2 x 250 +1 x 250	750	750	N.G-L.F.O	2009-2010
	Mahmoudia	CC)	8 x 21+ 2 x 50	268	268	N.G-L.F.O	1983-1995
	El-Atf	(CC)	2 x 250 + 1 x 250	750	750	N.G-L.F.O	2009- 2010
	Banha	(CC)	2 x 250+ 1 x 250	750	750	N.G-L.F.O	2014
West Delta	Kafr El-Dawar	(St)	4 x 110	440	440	N.G-H.F.O	1980-1984-1986
	Damanhour Ext	(St)	1 x 300	300	300	N.G-H.F.O	1991
	Damanhour (Old)	(St)	3 x 65	195	105	N.G-H.F.O	1968-1969
	Damanhour	(CC)	4 x 25 + 1 x 58	158	154	N.G-L.F.O	1985-1995
	El-Seiuf	(G)	6 x 33.3	200	141	N.G-L.F.O	1981-1982-1983-1984
	Karmouz	(G)	1 x 11.37 + 1 x 11.68	23	18	L.F.O	1980
	Abu Kir	(St)	4 x 150 + 1 x 310	910	900	N.G-H.F.O	1983-1984-1991
	Abu Kir	(G)	1 x 24.27	24	23	N.G.-L.F.O	1983
	Abu Kir New	(St)	2 x 650	1300	1300	N.G-H.F.O	2012-2013
	Sidi Krir 1,2	(St)	2 x 320	640	640	N.G-H.F.O	1999-2000
	Sidi Krir	(CC)	2 x 250 + 1 x 250	750	750	N.G-L.F.O	2009-2010
	Matrouh	(St)	2 x 30	60	60	N.G-H.F.	1990
	Sidi Krir 3,4 (BOOT)	(St)	2 x 341.25	682.5	682.5	N.G-H.F.O	2001-2002
Upper Egypt	Walidia	(St)	2 x 300	600	600	H.F.O	1997
	Kuriemat 1	(St)	2 x 627	1254	1254	N.G-H.F.O	1997-1998
	Kuriemat 2	(CC)	2x250+1x250	750	750	N.G.-L.F.O	2007-2009
	Kuriemat 3	(CC)	2x250+1x250	750	750	N.G-L.F.O	2009-2011
	Assiut	(St)	3 x 30	90	60	H.F.O	1966-1967
	Assiut West	(G)	3 x 125	375	375	L.F.O -H.F.O	2015
	Mobile units	(G)	14 x 25	350	350	L.F.O	2015
	Kuriemat Solar / Thermal	**(S/G)**	**1 x 70 + 1 x 50 + 1 x 20**	**140**	**140**	**Solar/ N.G**	**2011**
Hydro Plants	High Dam		12 x 175	2100	2100	Hydro	1967
	Aswan Dam I		7 x 40	280	280	Hydro	1960
	Aswan Dam II		4 x 67.5	270	270	Hydro	1985-1986
	Esna		6 x 14.28	86	86	Hydro	1993
	Naga Hamadi		4 x16	64	64	Hydro	2008
	Total			35220	34455		

Source: Egyptian Electricity Holding Company Annual Report 2014/15

(2) Electric power generation

Total gross electric power generation in Egypt was 174,875GWh in the fiscal year of 2014/15. Approximately 8% of the total power generation, 13,822 GWh is from hydro, and 0.8% is from renewable energy. More than 90% of the total power generation is from thermal power. Table 2-3-1-3 shows the breakdown of the thermal power generation.

Table 2-3-1-3 Thermal power generation breakdown

	Generated power	Ratio
Gas turbine	15,446GWh	9.7%
Steam turbine (Incl. BOOT's)	78,262GWh	49.1%
Combined cycle	65,625GWh	41.2%

Source: Egyptian Electricity Holding Company Annual Report 2014/15

Power generation by gas turbines is relatively low compared to their total capacity in thermal power, while that of steam turbines and combined cycle plants are relatively high.

Table 2-3-1-4 shows capacity and power generation of each production company.

Table 2-3-1-4 Capacity and generated power of each production company

Production company	Cairo	East Delta	Middle Delta	West Delta	Upper Egypt
Capacity	8,000MW	7,092MW	5,424MW	5,000MW	2,169MW
Generated power	30,632GWh	31,919GWh	35,664GWh	27,657GWh	19,122GWh

Source: Egyptian Electricity Holding Company Annual Report 2014/15

Table 2-3-1-5 shows performance data statistics of the power plant units.

Table 2-3-1-5 Performance data statistics of the power plant units (2014/15)

Comp.	Station	Gross Gen. GWh	Net Gen. GWh	Net/ Gross %	Fuel Consump. .gm/ kWh gen	Thermal Eff. %	Peak Load MW	Load Factor %	Cap. Factor %	Av. Factor %
Cairo	Shoubra El-Kheima	6973.2	6571.74	94.2	242.21	36.2	1235	64.46	61.5	80.4
	Cairo West Ext	7494.09	7113.57	94.9	226.45	38.8	325	77.86	62.9	87.8
	Tebbin	2734.35	2548.22	93.2	210.65	41.6	700	44.59	44.6	45.2
	Wadi Hof	180.71	179.48	99.3	398.43	22.1	72	28.65	20.6	94.4
	Cairo South 1	1471.82	1445.77	98.2	247.4	35.5	363	46.29	37.3	89.2
	Cairo South II	221.59	219.97	99.3	264.9	33.1	142	17.8	15.3	48.3
	Cairo North	6861.21	6708.85	97.8	179.41	48.9	1414	55.39	52.2	79.4
	6 October	2969	2910	98	270.8	32.4	893	31	26	91.4
	Giza North	1727.6	1669.92	96.7	295.48	29.7	1019	18.25	12.4	76.15
East Delta	Ataka	1093.07	986.49	90.3	258	34.1	245	50.9	13.9	24.1
	New Gas Ataka	146.59	145.66	99.4	274.4	32.0	600	-	-	-
	Abu Sultan	3366.73	3113.17	92.5	261.1	33.6	560	68.6	64.1	85.6
	Arish	523.57	491.19	93.8	248.3	35.4	66	90.6	90.6	94.3
	Oyoun Mousa	3886.93	3739.41	96.2	218.49	40.2	615	72.1	69.3	80.7
	Shabab	345.81	343.70	99.4	338.3	25.9	79	50	39.3	98.6
	New Gas Shabab	4306.25	4275.42	99.3	275.2	31.9	964	51	49.2	97.1
	Port Said	84.37	84.13	79.7	378.06	23.2	33	29.2	20.1	58
	New Gas Damietta	3148.90	3120.58	99.1	272.12	32.2	515	69.8	71.9	92.7
	West Damietta	3274.96	3257.39	99.5	266.3	33	505	74	74.8	93.7
	Damietta	7333.93	7170.78	97.8	197.6	44.4	1071	78.2	69.8	86.5
	Sharm El-Shikh	59.42	57.93	97.5	377.73	23.2	86	7.9	4.7	86.7
	El-Huraghda	386.12	384.95	99.7	400.24	21.9	88	50.1	30.8	95.3
	Ein-Sokhna	3961.73	3829.31	96.7	214.8	40.9	1290	42.9	42.5	73.6
Middle Delta	Talkha steam (210)	2003.6	1857.7	92.7	260.6	33.7	360	63.5	54.5	73.6
	Talkha	1748.2	1727.5	98.8	273.5	32.1	246	81	84.6	82.2
	Talkha (750)	5688.2	5587.9	98.2	152.9	57.4	768	84.5	86.6	94.8
	Nubaria (1,2,3)	14694.7	14457.9	98.3	162.9	53.9	2236	75	75	92.8
	Mahmoudia	2275.8	2251.1	98.9	222.2	39.5	305	85.2	96.9	97.6
	Banha*	4514.2	4427.6	98.1	170.4	51.5	802	69.8	74.7	90.3
	El-Atf	4739.5	4651.4	98.1	168.1	52.2	811	66.7	72.1	80.6
West Delta	Kafr El-Dawar	2754.6	2541.9	92.3	287.4	30.5	440	71	71	87.2
	Damanhour Ext 300*	1764.5	1708.1	96.8	240.9	36.4	300	67	67	90.4
	Damanhour steam	751.04	688.7	91.7	316.3	27.7	140	61	44	86.3
	Abu Kir	5480.8	5159.4	94.1	258.3	34	868	72	67	89
	New Abu Kir	7064.4	6790.7	96.1	217.1	40.4	1250	64.5	62	79.4
	Sidi Krir 1,2	3386.1	3249.7	96	215	40.8	611	63.3	60	78.6
	Matrouh	343.81	317.86	92.4	287.7	30.5	57	69	65	93.3
	El-Seiuf gas	409.3	405	99	389	22.6	147	31.8	23.4	74.9
	Karmouz	7.85	7.74	98.6	376.9	23.3	18	5	4	53.1
	Damanhour	1082.13	1068.07	98.7	217.1	40.4	144	85.8	79	96.2
	Sidi Krir (C.C)	4612.2	4493.14	97.4	164.3	53.4	750	70.2	70.2	82.9
Upper Egypt	Walidia	2226.4	2126.69	95.5	255.7	34.3	465	54.66	42.4	61.3
	Assiut	198.3	173.49	87.5	317.3	27.7	64	35.4	25.2	38
	Assiut West*	100.9	99.83	98.9	293.7	29.9	-	-	-	-
	Kuriemat steam	7921.2	7684.2	97	211.9	41.4	1243	72.75	72.1	94.6
	Kuriemat 1	5081.5	4988.42	98.2	152.6	57.5	733	79.14	77.3	93.2
	Kuriemat 2	3572.8	3498	97.9	161.8	54.2	764	53.38	54.8	68
	Mobile units	20.8	20.6	99	266.9	285	1	1	32.3	-
Hydro Plants	High Dam	9805.2	9728.7	99.2	-	86.6	2220	50.42	53.3	92
	Aswan Dam I	1543.3	1523.7	98.7	-	90.1	275	64.06	62.92	95.9
	Aswan Dam II	1567.6	1558.6	99.4	-	94	270	66.28	66.28	87.4
	Esna	458.54	450.53	98.3	-	92.8	82.7	63.3	61.09	84.5
	Naga Hamadi	448.32	442.01	98.6	-	89.7	67.2	76.16	79.97	96.6
Total	Total-Hydro	13822	13704	99.2	-	88.1	2824	55.88	56.36	91.8
	Total-Thermal	144995	140350	96.5	214.8	40.9	-	68	65	-
	Total-Wind	1444	1391	96.31	-	-	420	39	22	-
	Kuriemat Solar / Thermal	-	-	-	-	-	-	-	-	-
	Private Sector BOOT	14338	13479	94	207	42.4	-	-	-	-
	Total	174599	168924	97	214.1	41	-	-	-	-
	Purchased from IPPs	32	32	100	-	-	-	-	-	-
	Isolated Plants	244	239	98	-	-	-	-	-	-
	Grand Total	**174875**	**169195**	**96.5**	-	-	**28015**	-	-	-

Source: Egyptian Electricity Holding Company Annual Report 2014/15

Note:

Load Factor = average kW during the period concerned / maximum kW

Capacity Factor = kWh during the period concerned

/ (rated kW of the unit x h (total period concerned))

Availability = length of period at which the facility is able to be operated

/h (total period concerned))

According to each factor in the statistics;

- Load Factor and Capacity Factor of gas turbines are relatively low.
- Load Factor and Capacity factor of combined cycle units are relatively high. Especially, those factors of combined cycle units which belong to Middle Delta Production Company are high.
- There are some gas turbines whose Load Factor and Capacity Factor are low, while their availability is high. This means these Gas turbines are operating at low output for a long period.
- Load Factor and Capacity Factor of some combined cycle plants owned by Cairo Production Company, including newly installed capacity such as Cairo North power station, are relatively low. On the other hand, there are some steam turbines within Cairo Production Company as well as East Delta and West Delta, whose Load Factor and Capacity Factor are higher than those of the combined cycle units owned by Cairo Production Company.

Performance of power plants are greatly affected by their roles and features in their facilities as well as their locations and roles in the power system, and sometimes the limitations of fuel supply such as gas pipeline capacity will become an important factor. Moreover, it should be noted that the useable amount of natural gas for electric power generation in Egypt tends to be limited; therefore, the units which are able to use both gas and oil, are inclined to be operated by oil before gas.

Incidentally, it is not desirable to operate gas turbines at a low output for a long period and not fully use the newly installed combined cycle units from a fuel efficiency point of view. The average thermal efficiency of EEHC owned thermal power stations is as low as 40% and average thermal efficiency of EEHC owned thermal power stations as well as BOOT's is a little better but still as low as 41%, which seems to be partly due to a lack in proper generation operation .

2－3－2 Generating facilities under construction and planning

(1) Thermal power facilities under construction

Table 2-3-2-1 shows thermal power facilities which are under construction. This table is based on the interview with EEHC project managing section. Incidentally, in the case that the commencement date of some plants, which will be converted from gas turbines to combined cycle plants, are different between the planning section and project managing section, data from the project managing section will be indicated in the Table.

Table 2-3-2-1 Thermal power facilities under construction

	2016/17	2017/18	2018/19	2019/20	
COAL					
Steam Turbine		South Helwan 650 650	South Helwan 650	Assuit 650 West Cairo 650	
Gas Turbine → Combind Cycle		West Damietta 250 El Shabab 500	6thOctober 340 West Damietta 2 250 West Assuit 500		
Combined Cycle	Siemens(Borollos, Beni Suef,The New Capital) 4,800 4,800	4,800			
					TOTAL [MW]
COAL	0	0	0	0	0
ST	0	1,300	650	1,300	3,250
GT→CC	0	750	1,090	0	1,840
CC	9,600	4,800	0	0	14,400
TOTAL [MW]	9,600	6,850	1,740	1,300	19,490

Source: Interview results by the survey team

Some portions of the combined cycle facilities, 14,400MW by Siemens, have already been in operation. Five units of the steam turbine, each output is 650MW, are also under construction. In addition, conversion from gas turbines to combined cycle plants by adding a Heat Recovery Steam generator (HRSG) and steam turbines to the simple cycle gas turbines have been carried out at five stations.

Since installation periods of gas turbines are relatively short, a large number of gas turbines had been installed in Egypt by the end of spring 2015, to overcome the power shortage. Those gas turbines are as follows.

a. 6th October 4x150MW
b. West Assuit 8x125MW
c. West Daimietta 4x125MW
d. Attaka 4x160MW
e. Mahamoudia 2x168MW
f. Assuit 8x125MW
g. Sharm El Shaekh 6x48M
h. Port Said 2x42MW

i. Gourgada 6x48MW
j. Mobile units 14x25MW

These reinforcements were called “Fast Track Plan 2015 summer”. At the three sites of the above gas turbines, c. West Daimietta, a. 6th October, and b. West Assuit, the conversion projects from gas turbines to combined cycle plants are in progress. These three projects are financed by Siemens, who installed gas turbines. At the two sites of the above gas turbines, d. Attaka, and e. Mahamoudia, other conversion projects are now under planning. All the projects, expect the Siemens projects, are carried out through a tendering process, and signed by the Ministry of International Cooperation; however, the signing does not mean a debt guarantee by the government.

There is no conversion plan at four sites g. Sharm El Shaekh, h. Port Said, i. Gourgada, and j. Mobile units, because these gas turbines are only operated during the tight supply-demand situation of electricity like peak load generation in Japan.

(2) Thermal power facilities to be in operation after the fiscal year of 2022/23

In Egypt, the coal fired thermal power plants are to be introduced in accordance with ISES2035Scenario4b strategy, whose intension is to diversify energy sources, and as a result, to allot natural gas resources from generating to other higher added value uses. There are two options for the introduction of the coal fired power plants as described below.

EEHC owned coal fired thermal power plants is the first option. EEHC is going to have six units of 1,000MW class coal fired thermal power plants at Hamrawein, along the Red Sea. The rated output of 1,000MW class coal fired thermal power plant varies depending on manufacturer, and EEHC recognizes up to 1,150 MW plants as 1,000MW class. As of May 2017, the project is in the tendering stage with eight short-listed bidders. The first unit is expected to commence its operation in the third Egyptian quarter (Jan – Mar) of 2023. The following units are scheduled to start operation one by one every 6 months. Operation and maintenance of the power plants for five years are requested in the tendering.

The second option is BOO scheme. Egypt is going to have 4 to 6 units of 660MW coal fired thermal power plants at Oyoun Moussa, Sinai Peninsula side of the Suez Gulf with BOO scheme. The successful bidder of the first phase, which consists of two 660MW units, has already been decided, and the contract is now under negotiation. The first unit is expected to commence operation between the year of 2022 and 2024.

At the two gas turbine sites, Attaka, and Mahamoudia, which are installed as part of the Fast Track Plan 2015 summer, conversion is under planning as mentioned above, and their financing has not yet been decided since the manufacturers of these gas turbines are Siemens and Ansaldo Italy respectively, In the case of conversion from simple cycle gas-turbine to combined cycle plant, it is often the case that the gas turbine manufacturers are ordered to do the conversion work, considering the adjustment to the gas turbine facility, as well as performance guarantee of the combined cycle plant. Furthermore, in the case that the conversion work is included in a bid, international manufactures will be able to produce the related steam generation facility and steam turbine to meet the conversion of this 160MW class gas turbines.

In addition to coal fired thermal power plants and combined cycle plants, Egypt is going to have steam turbine plants which use oil and/or natural gas. EEHC explains that the purpose of installing steam turbines is to compensate the output decline of gas turbines and combined cycle plants caused by high temperature in summer. It is supposed to mean that Egypt shall be in need of electric power adjusting function of thermal power with preferably oil use for fuel in order to secure flexibility in operating electric power systems. Since the base load plants, such as coal fired thermal power plants, combined cycle plants which are superior in high thermal efficiency, and nuclear power plants, will be increased in the near future, the adjustment function by thermal power would be a key element for the realization of efficient generation operation. .

2－3－3 Information on IPP contracts

(1) Outline of generating capacity development based on private sector investment

In Egypt, IPP is a power plant which is installed by private sector investment and provides electricity to eligible customers, but it does not exist at the present because electricity market deregulation is now under consideration. Power plants which are also installed by private sector investment but provide electricity to non-eligible customers is called BOO or BOOT.

"IPPs" mentioned as one of the electric power providers in the EEHC annual report is the so called "Auto-production", which are the power stations which provide surplus electricity of on-site power generation. It is classified into IPP in the EEHC annual report as the team omitted the survey on the generation because output is negligible.

The outline of BOO/ BOOT is as follows.

In Egypt, electric power demand around the year 2000 grew at a very high rate, and a large number of electric facilities were required to be installed. As EEHC could not afford all the funds to install the facilities, private sector investments are introduced. At present, as supply and demand of electricity tends to balance due to Siemens' large scale electric facility development and so on, there is not much need for BOO/BOOT schemes. Some BOO/BOOTs, which have been negotiated until now are going to start operation in the near future.

At the BOO/BOOT scheme, electricity is traded at the same charge for a long period, and it may not be consistent with the concept of electricity market deregulation where the electric charge is determined in accordance with market conditions. Therefore, electric facility development through BOO/BOOT scheme will decrease in the future.

Steam turbines are considered to have liferspans of around 40 years generally. In the beginning of introducing BOO/BOOT schemes around the year of 1997; steam turbines were the main target. Thus BOO/BOOT scheme was designed based on such an idea that private sector owned the facility for 20 years and transferred to EEHC, and EEHC operated and conducted maintenance work for the remaining 20 years. The existing BOOTs were installed based on this concept.

Combined cycle plants had become the main target of BOO/BOOT after that. Gas turbines, which are the main component of combined cycle plants, are considered to have lifespans around 20 to 22 years generally, and EEHC will gain no advantage if it is transferred the combined cycle plant after 20 years operation. Therefore, as for the combined cycle plants, the scheme was designed to be 25 year BOOs. A BOO scheme of the combined cycle plant is now under consideration based on this concept.

Since EEHC recognizes risks of operating and maintaining coal fired power plants after a long period of operation, the coal fired power plants now under planning will be designed to be 25 year BOOs.

In the case of natural gas fired BOOs, the fuel will be secured based on the supply contracts between the developers and MOP, and EEHC supports the contract negotiation. In the case of coal fired BOOs, the fuel shall be secured by the developers along with the private sector. EEHC and MoP will not be involved in coal procurement.

(2) The existing BOOs are as follows

a. Suez Gulf (ST)2x341.25MW commissioning date; 2002/03
   fuel; Gas/ Oil (East Delta)
b. Port Said (ST) 2x341.25MW commissioning date; 2002/03
   fuel; Gas/Oil (East Delta)
c. Sidi Krir3,4(ST) 2x341.25MW commissioning date; 2001/02
   fuel; Gas/Oil (west Delta)

No major challenge on operating these BOOTs has been envisaged.

(3) The outline of BOOs under planning is as follows.

a. Dairut (North Cairo Beheira)

- 3 x 750MW combined cycle (+F class Gas turbine), BOO of 25 years.
- Simple cycle gas turbines are scheduled to start operation from the year 2022.
- After that, they will be converted to combined cycle plant one by one.
- 19 companies bided for the first tender. Through quality screening, bidders were decreased and one company, Aqua, Saudi Arabia, bided for the final tender in 2015.
- PPA contracts have almost been completed and are in the final stage.

This BOO was scheduled to start operation from 2017. Now it is re-scheduled to start operation from 2022 till 2027, because of negotiation delays.

b. Oyoun Moussa (Sinai Peninsula side of the Suez gulf)

- 2 x 660MW x 3 phases of coal fired thermal power plants, BOO of 25 years
- The first phase is scheduled to start operation in the year 2024/25 at the earliest.

- The successful bidder of the first phase is ANI, United Arab Emirates. Approximately 70% of PPA contracts are completed. Jetties for coal unloading are financed by other investors and the joint contracts will be concluded.
- Commissioning dates of phase 2 and 3 have not yet been decided. In the beginning of the project, except for ANI, UAE, Egypt's Orascom, and Aqua, Saudi Arabia were regarded as stronger candidates.

Although there was a combined cycle plant for a 25 year operation BOO project at Kena (Upper Egypt), this BOO plan was cancelled and changed into a 2 x 650MW combined cycle project with EPC +finance procedure.

2－3－4 Hydropower generation facility (pumped power generation facility plan)

Since the development of Aswan in the 1960s, in Egypt, hydroelectric power has effectively contributed to the stable supply of the country by effectively utilizing the equipment of about 2.8 GW up to the present.

Currently, as a new way to utilize the functions of hydroelectric power generation facilities, completely different from the conventional effective utilization of water resources in Egypt, the development of a pumped-storage power station is now under way.

The outline of the current situation is as follows.

(1) Purpose of development of pumped-storage power plant

The goal is to shift the power generation energy to compensate for the difference between solar power generation peaks and the power demand peak time for the frequency control due to the massive introduction of renewable energy in the future. In addition, it is supposed to contribute to the economic operation of the base load power supply accompanying the introduction of coal and nuclear power (pumping up in a low demand situation, generating power in a high demand situation and saving on fuel costs).

Since Egypt is planning to introduce large amounts of renewable energy and steadily increase base load generation, the role of pumped-storage power plants is expected to be essential for the rational system operation.

(2) Plan for introduction of pumped-storage power plants: Ataqa pumped-storage power plant

For the time being, Ataqa pumped-storage power plant is in a concrete planning process.

- Proposal of EPC + FINANCE has been received.
- Selecting overseas consultants for the proposal review
- Start of the project: 2017
- Construction period: 86 months
- Final development capacity: 2.4 GW (300 MW x 8)

At present, there is no study conducted regarding the adoption of the variable speed pumped water generator.

(3) Subsequent pumped power plant planning

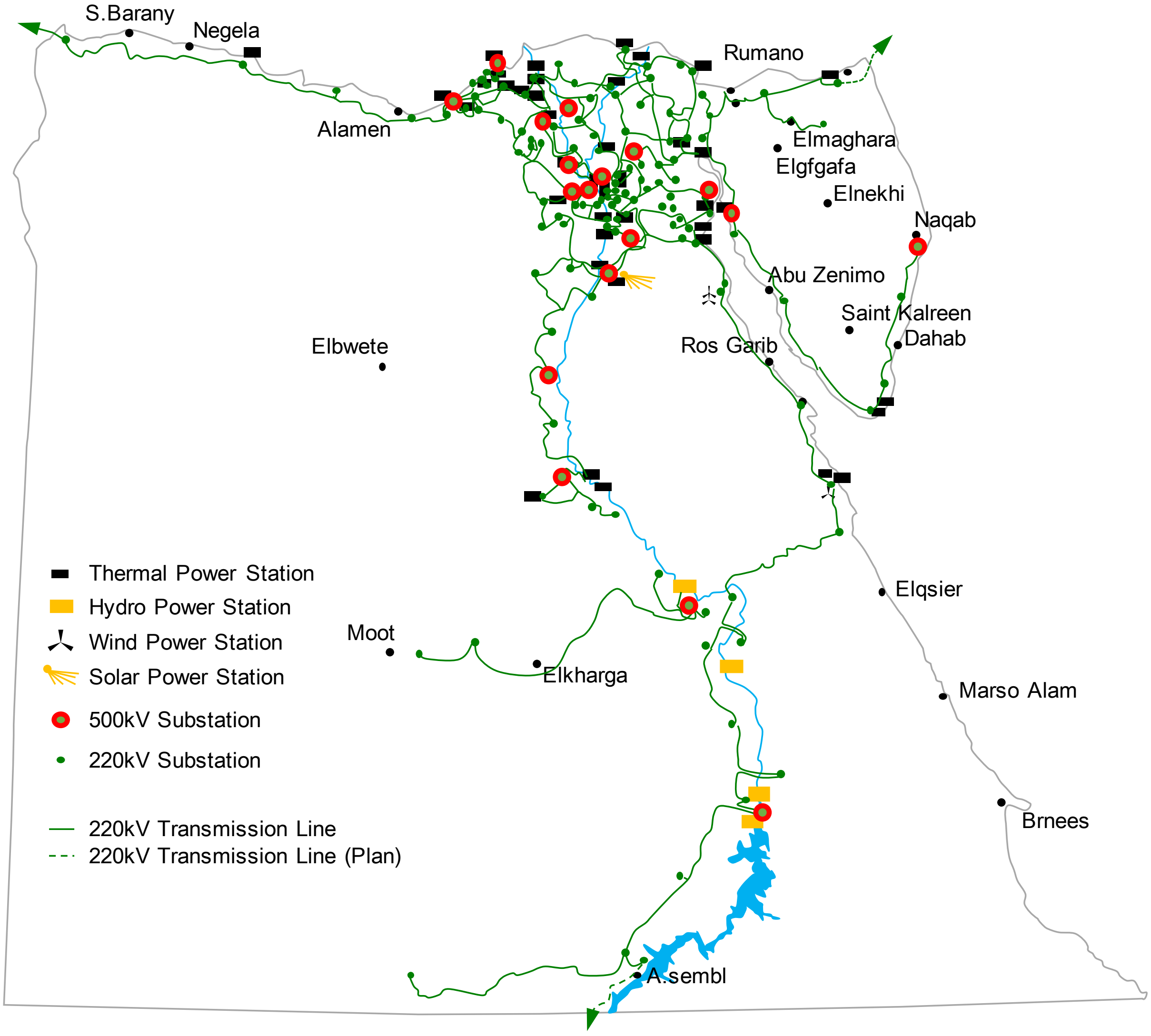
Two pre-studies on Upper Egypt have been conducted. It is proposed that one location will be required in addition to Ataqa. There is one other candidate spot for a seawater pumped plant near Red Sea.

2－4　Transmission

2－4－1　Basic information of transmission

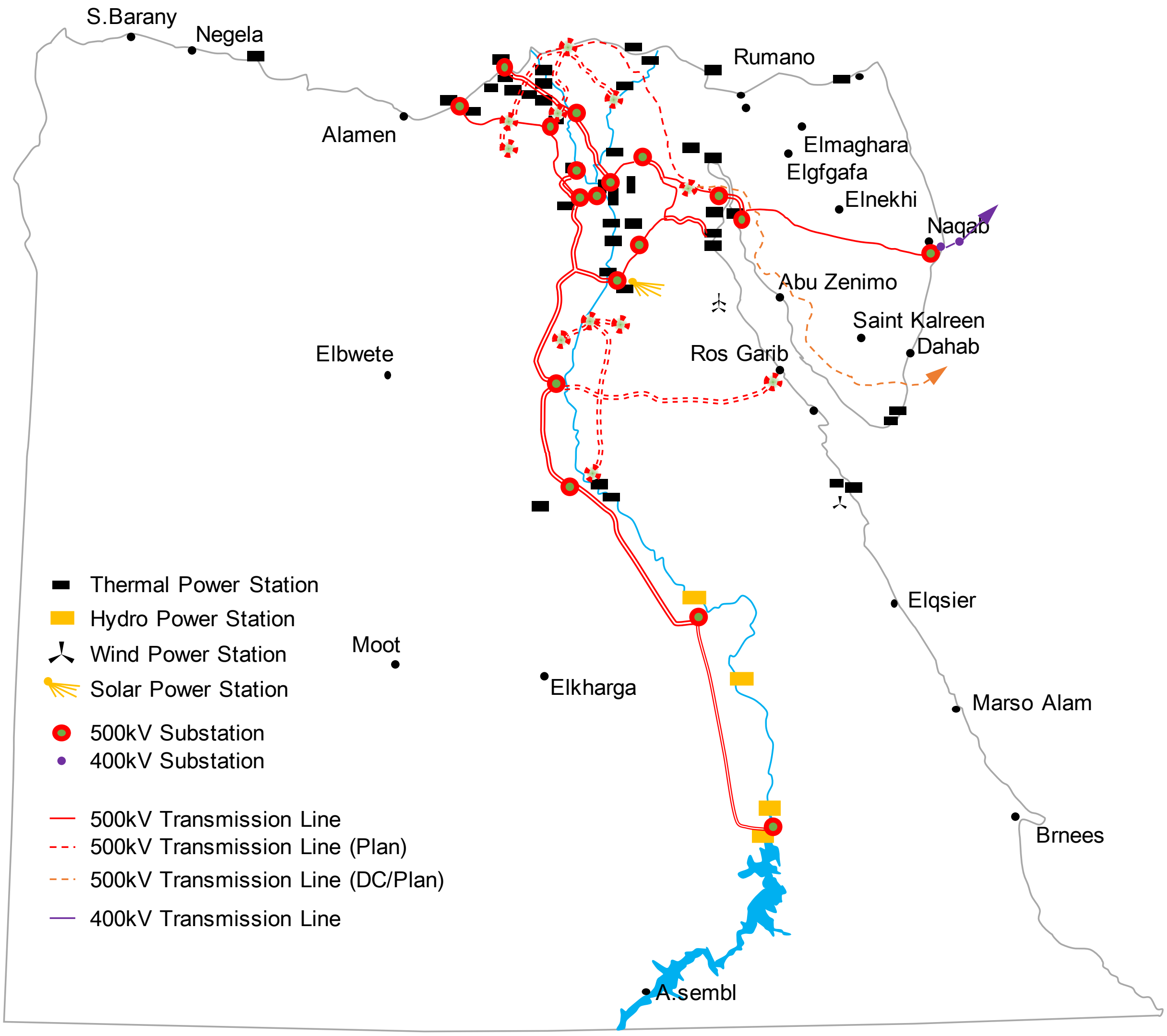
(1) Current transmission network

The 220kV and 500kV transmission network in 2015 is as shown in Figure 2-4-1-1, 2-4-1-2. The 220kV and 500kV transmission lines are constructed along the Nile River, which transmit the power to the areas centered on Cairo and other areas in northern Egypt. The wind power generation plants are built along the Red Sea, which are connected on 220kV transmission lines.



Source: EEHC Annual report 2014/15

Figure 2-4-1-1 220kV transmission network in 2015



Source: EEHC Annual report 2014/15

Figure 2-4-1-2 500kV transmission network in 2015

The amount of transformer capacity for each voltage and total length of transmission lines for each voltage are as shown in Table 2-4-1-1 and 2-4-1-2. The amount of transformer capacity in 2015 is 103,975MVA, which has increased by 4.4% from 2014. The total length of transmission lines in 2015 is 44,000km, which has increased by 0.4% from 2014.

Table 2-4-1-1 Amount of transformer capacity

Voltage (kV)	Transformer capacity (MVA)
500	10,175
220	42,796
132	3,515
66	45,796
33	1,693

Source: EEHC Annual report 2014/2015

Table 2-4-1-2 Total length of transmission lines

Voltage (kV)	Transmission line length(km)
500,400	3,060
220	17,570
132	2,490
66	19,300
33	1,990

Source: EEHC Annual report 2014/2015

(2) Power grid system operation

The grid code is established to efficiently operate the Egyptian power grid system.

1) Power factor of customers

The customers must make their best efforts to ensure that the aggregated power factor at a connection point falls inside the permissible range as shown in Figure 2-4-1-3. Many customers connected to 66kV or below voltage system are specified to keep the power factor within lagging of 0.9 to unity.

Table 2-4-1-3 Permissible ranges

Supply Voltage (nominal)	Permissible Rage of Aggregate Power Factor at the connection
500 /400 kV	0.98 lagging to unity
220 kV	0.96 lagging to unity
132 kV	0.95 lagging to unity
66 kV and below	0.90 lagging to unity

Source: Egyptian Electric Power Transmission Code

2) Maximum fault clearing time

The maximum fault clearing times are set as follows.

Table 2-4-1-4 Maximum fault clearing time

Voltage Level	Target Clearance Times
500 /400 / 220 / 132 kV	80 msec
66 / 33 kV	120 msec

Source: Egyptian Electric Power Transmission Code

3) Frequency variations

The nominal system frequency shall be 50Hz in the Egyptian power system network. The control of the system frequency shall be the responsibility of the transmission system operator. The transmission system operator shall maintain the fundamental frequency within the limits of 49.95Hz and 50.05Hz during normal conditions. The transmission system operator shall prepare and implement the program for load shedding and / or disconnection of the interconnections with neighboring countries if the frequency decreases to 49.5Hz and program to disconnect generating units if the frequency rises to 51.0Hz. If the frequency rises above 51.0Hz or falls below 48.5Hz, manufacturer instructions concerning the generation units for remaining in synchronism with the grid shall be applied.

4) Load shedding for frequency support

The transmission system operator automatically performs the load shedding as shown in Table 2-4-1-5. The relationship between the frequency drop and the load shedding is stipulated in Table. According to the table, 60% of the load is disconnected from the grid when the frequency drops to 48.7Hz.

Table 2-4-1-5 Load shedding for frequency support

Frequency (Hertz)	Required Load Dropping
49.2	6% of Original Load
49.1	3% of Original Load
49.0	4% of Original Load
48.9	7% of Original Load
48.8	20% of Original Load
48.7	20% of Original Load
48.65	15% of Remained Loads

Source: Egyptian Electric Power Transmission Code

5) Frequency control

The frequency control is performed in the following procedures.

- ✓ Governor control of generator (Fast control)
- ✓ Transmission system operator command generator output (Second control)
- ✓ Automatically load shedding (Third control)
- ✓ Generator disconnect by frequency rise
- ✓ Load control

In the first control, the speed regulation of generator machine is set to 5%, and the generator will respond for up to 5 minutes. Normally, the generator is determined to be in governor free operation.

In the third control, the transmission system operator is to perform load shedding when frequency drop d occurs

6) Allowable voltage standard

The reference voltage of the power system is planned at 95~105% of the specified voltage. This standard is also applied to design and operation of the transmission facilities. In addition, the maximum allowable voltage drop is 90% while the maximum allowable voltage increase is 110%. The allowable time should be within 1 minute. The voltage during the fault period is allowed at 0~140% within 1 minute.

7) Power system voltage control

The voltage control is performed in the following procedures.

- ✓ Terminal voltage adjustment of synchronous capacitor and synchronous generator
- ✓ Static synchronous compensator
- ✓ Phase modifying equipment
- ✓ Tap change of transformer

(3) Power system operation in the trunk power grid

The situation of the Egyptian trunk power grid operation is as follows.

1) Situation of NECC regarding the transmission network operation

NECC manages higher than 220kV voltage class transmission networks and generation. NECC uses the SCADA system to manage the frequency control, bus-bar voltage on the substations, power generation output and power flow while supervision is conducted for the circuit breaker states and the system alarms. This SCADA system made by ALSTOM works without any problems such as age defects.

2) Status quo on compliance with the grid code

The transmission system operation regulation is defined in the grid code. At present, the transmission system operation is within the regulation.

3) Reliability in the power system network

The power system network is so constructed to abide by the n-1 or n-2 criteria. The system operation is also conducted to abide by the n-1 or n-2 criteria. In the past 2 years, the load shedding has not been conducted under n-1 conditions. Since the power generation output is so adjusted and the load is switched over at the maintenance outage of one facility, power failure will not occur in the case that additional n-1(total n-2) should happen.

4) Control of the voltage in the trunk power grid

The voltage of the trunk power grid is maintained properly by NECC. It does not deviate from specified voltage as stipulated in the grid code.

The system voltage management shown in (2)7) is conducted.

The operation of the shunt capacitors and reactors can be operated directly from NECC. However, usually, NECC does not directly operate them to prevent the site operators from confusion caused by the direct operation. NECC will give instructions via designated telephone lines to the site operators in charge of the equipment operation. Incidentally, the tap operation of transformers is also conducted in this way.

The local power system is basically managed by the regional control centers. However, the operation of the local power system might affect the trunk power grid in some cases. Therefore, the local regional control centers and NECC exchange related information, and in order to maintain voltage of the trunk power grid, NECC sometimes orders the local regional control centers to conduct the voltage control operation.

5) Balance between supply and demand

In recent years, the balance between supply and demand has been maintained. Therefore, NECC has never carried out load shedding for frequency maintenance. A similar situation would continue because of temporary large-scale power plant introduction according to NECC.

6) Fault current in the power system network

In the power system network operation, loop operation is basically applied. For this reason and others, the fault current has been increased in some parts of the system and exceeded the breaking capacity of circuit breakers without some measures taken. As a countermeasure to this issue, NECC applies radial system operation by changing the bus-bar operation.

Since the large scale power plant developments are going to be in place in the future, it is expected that the fault current will increase over the whole trunk system substantially. Therefore, the EEHC plans to replace the circuit breakers to upgrade the current breaking capacity. The 500kV circuit breakers will be replaced from 40kA to 50kA, and the 220kV circuit breakers will be replaced from 40kA to 63kA.

7) Management of the maintenance outages of the power plants

In order to maintain a balance between supply and demand in the power system network at any time, it is necessary to manage the maintenance outage of the generators properly. In this regard, each power generation company has to keep the contracts regarding the amount of power generation output as a total with the EETC, and the power generation company decides the maintenance schedules while keeping the power generation output total amount within the contract and submits the generator facility maintenance outage plan to NECC. There is no problem with the generator maintenance outage management based on this procedure according to NECC.

8) Frequency control

The power system frequency control is performed by governor free operation of the generators which are applied to ones with more than 100MW generation capacity. Governor free operation is also applied to hydroelectric power generators.

9) The situation regarding the duration on the construction of transmission lines and substations

The construction period of the transmission line in desert areas is on average about two years, even for long distance transmission lines. A substation can also be constructed in about the same duration.

A military security examination will be carried out between the period of the transmission line plan and the contractor contract regarding transmission line construction in desert areas. Although it is necessary to acquire additionally about eight kinds of licenses for the construction, the required time for this license acquisition is relatively short. Therefore, there is no major obstacle which should prolong the construction period of transmission lines.

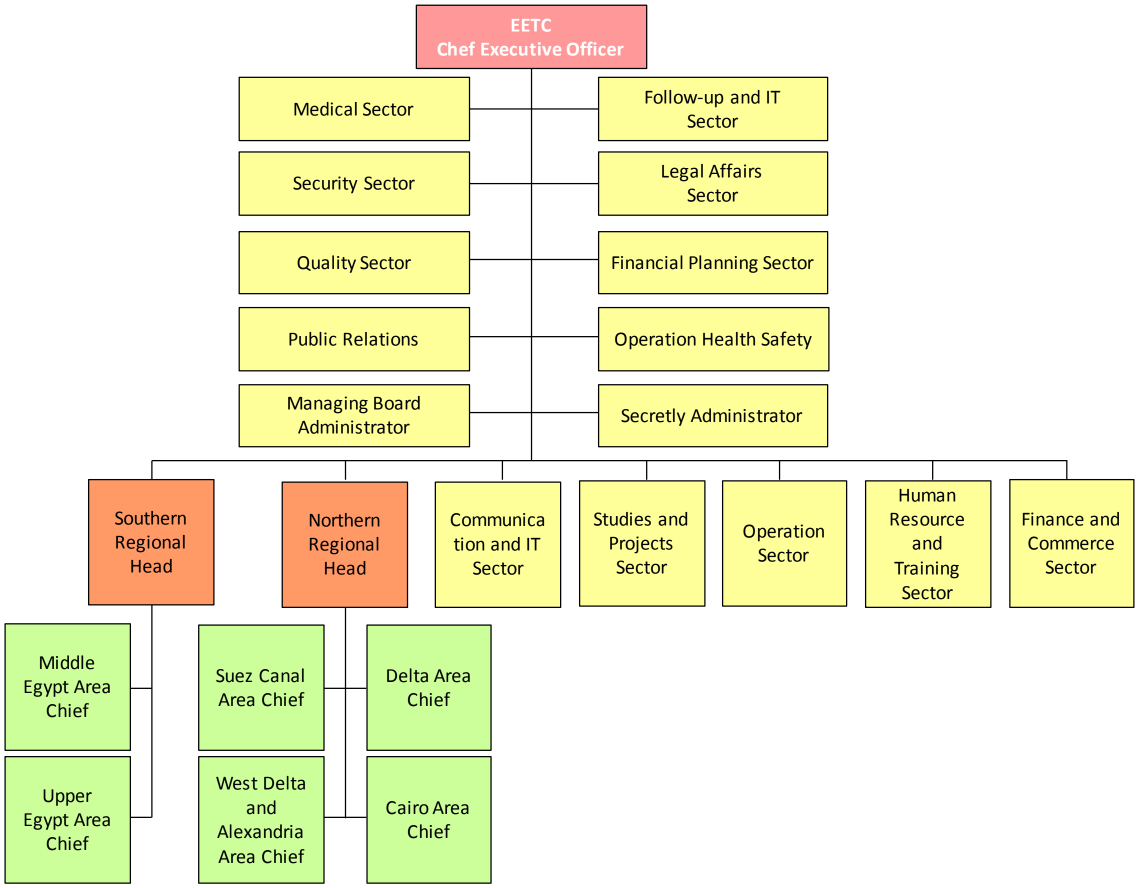
In areas other than desert areas, there are no procedural issues. Therefore, the facilities could be constructed as scheduled in the initial plan.

It appears that the current Egyptian transmission network and its operation are not faced with major problems.

2－4－2 Information on EETC organization and its current operation

The organization chart of EETC is shown in Figure 2-4-2-1. EETC is now in charge of the operation of the electric power system except for distribution, as well as reinforcement planning and maintenance of the transmission system as a member of EEHC group. Still, EETC retains the structure of an independent company with its autonomy, which has the functions of the related communication system operation and human resource management.

The number of EETC employees is 31,935 according to EEHC Annual Report (2014/2015).



Source: EETC Website

Figure 2-4-2-1 Organization chart of EETC

2－4－3 Information on the transmission system at present

(1) Existing transmission lines

The existing 500kV overhead transmission lines are presented in Figure 2-4-3-1.

The total length is 3379 km and the typical capacity of the line is 2,000A (1,732MVA). The existing 220kV and 132kV overhead transmission line length is 22,145km and invar electric wire is applied in some sections as shown below.

EL Bostan ~ EL Sadat	First line	32km	1*255/88 INVAR
EL Bostan ~ EL Sadat	Second line	32km	1*255/88 INVAR
Cairo 500 ~ ABU Ghaleb	First line	18.5km	1*255/88 INVAR
Cairo 500 ~ ABU Ghaleb	Third line	18.5km	1*255/88 INVAR
ABU Ghaleb ~ El Sadat	First line	39.5km	1*255/88 INVAR
ABU Ghaleb ~ El Sadat	Third line	39.5km	1*255/88 INVAR

Table 2-4-3-1 Existing 500kV overhead transmission lines

Transmission Name		No	Voltage [kV]	Length [km]	Availability Current [A]	Availability Capacity [MVA]	Maximum Current [A]	Conductor Type
From	To							
Eltiben 500	Elkrimate	1	500	62	2,000	1,732	2,000	3*490/65 ACSR
Elieen sakhna	Abo zahble	1	500	154	2,000	1,732	2,000	3*490/65 ACSR
Cairo Capital	El ein sakhna	1	500	87	2,000	1,732	2,000	3*490/65 ACSR
El tiben 500	Cairo Capital	1	500	43	2,000	1,732	2,000	3*490/65 ACSR
West 500	Cairo 500	1	500	16	2,000	1,732	2,000	3*490/65 ACSR
Basos	West 500	1	500	9	2,000	1,732	2,000	3*490/65 ACSR
Suez 500	Abo zahble	1	500	119	2,000	1,732	2,000	3*490/65 ACSR
Suez 500	Eiyon mosa	1	500	23	2,000	1,732	2,000	3*506 AAAC
Eiyon mosa	Taha	1	500	229	2,000	1,732	2,000	3*490/65 ACSR
Eiyon mosa	Taha	2	500	15	2,000	1,732	2,000	3*506 AAAC
Eiyon mosa	Taha	3	500	244	2,000	1,732	2,000	Equivalent
Suez 500	The temrsher of suez	1	500	13	2,000	1,732	2,000	3*506 AAAC
Suez 500	The temrsher of suez	2	500	13	2,000	1,732	2,000	3*506 AAAC
Basos	Kafr El zayat	1	500	100	2,000	1,732	2,000	3*490/65 ACSR
Kafr Elzayat	Abo zaable	1	500	126	2,000	1,732	2,000	3*490/65 ACSR
El Nobaria	Sidi krier	1	500	125	2,000	1,732	2,000	3*490/65 ACSR
Abu kir	Kafr elziat	1	500	96	2,000	1,732	2,000	3*490/65 ACSR
Abu kir	Kafr elziat	2	500	96	2,000	1,732	2,000	3*490/65 ACSR
Nobaria	Cairo 500	1	500	92	1,800	1,559	2,000	3*490/65 ACSR
High Dam	Nag- Hamady	1	500	236	2,000	1,732	2,000	3*506 AAAC
High Dam	Nag- Hamady	2	500	236	2,000	1,732	2,000	3*506 AAAC
Nag- Hamadv	Assut 500	1	500	212	2,000	1,732	2,000	3*506 AAAC
Nag- Hamady	Assut 500	2	500	212	2,000	1,732	2,000	3*506 AAAC
Samalout	Assut 500	1	500	141	2,000	1,732	2,000	3*506 AAAC
Samalout	Assut 500	2	500	141	2,000	1,732	2,000	3*506 AAAC
Samalout	Giza North	1	500	236	2,000	1,732	2,000	3*506 AAAC
Giza North	Cairo 500	1	500	29	2,000	1,732	2,000	3*490/65 ACSR
Samalout	Kurimat	1	500	152	2,000	1,732	2,000	3*506 AAAC
Cairo 500	Kurimat	2	500	122	2,000	1,732	2,000	3*506 AAAC

(2) Existing substation facilities

Since the data on the existing substation facilities are not provided by EETC, the related information on Upper Egypt area substations are presented here, which were derived at conducting JICA projects by TEPSCO in the past.

- Before 1970, equipment made by the former Soviet Union and Eastern Europe manufacturers was mainly installed. After 1970, equipment by Western Europe manufacturers became dominant.
- For most of the equipment after 1970, the specifications are referred to the IEC standard because they were made by Western Europe manufacturers.
- EGMAC is the domestic manufacturer in this field and mainly produces middle voltage equipment.

Regarding the protection control facilities, 90% of the protection relay systems are digital type and the remaining 10% are mechanical type according to the information provided by Regional Control Center; henceforth RCC). The manufacturers of the digital protective relay system are Alstom, Siemens, Schneider, and Toshiba, etc.

Regarding the Japanese equipment, one example is 500kV Assit substation (GIS type) installed in 1987. According to Hitachi Ltd, in addition, there is one 500kV/AIS substation and some 500kV transformers introduced between the mid- 1980s and early 2000s. According to Mitsubishi Electric Corporation, there are two 500kV/GIS substations installed in 1990s, however none in recent years.

Table 2-4-3-2 Existing substations facilities in Upper Egypt

Substation	Service Voltage	History	Suppliers
Nag Hamadi 500	500/220/132/66/33/11kV	1967: start 1988: 66kV 1990: 220kV 2005: 66kV	-
Toshky 1	220/66/22kV	2000: start	ABB
Toshky 2	220/66/22kV	2002: start	ABB
Aswan Connection	220/(132)/66/22kV	1991;: start 2006: 3T 2008: 66kV	ABB
Nokra	220/66/11kV	2000: start 2008: 220kV	EGMAC, Alstom
Selwa	220/66/33kV	1995: start 2010: 66kV	ABB, Alstom. Siemens
Luxor East 220	220/66/11kV	1995: start 2002: 5T 2006: 8T	Alstom
Quena South 220	220/132/66kV	1996: start	Novo, EDG
Girga 220	220/66/33/22/11kV	1991: start 2008-10:10. 11,12T	Yugo, BBC, ABB
Tema 220	220/66/33/11kV	1994: start 1995-2003:5. 6, 7, 8T	East Germany ABB
Aluminium 132	220/132/10.5kV	1975: start 1996:addition	ABB
Assuit 500	500/220/132/33/11kV	1987: start 2001: T233 2001: 11kV	Hitachi
Samalot 500	500/220/132/66/33/22kV	1967: start 2001: T233 2001: 11kV	Russia, ABB, Siemens
Abutartor	220/66/20kV	1993: start	ABB,Siemens
Refa	220/66/11kV	2001: start 2009:1,2,3T	ABB
Mallawy West	220/66/11kV	2000: start 2004: T5 2006: T3,4 2010: T1,2	Russia, Siemens
Maghagha West	220/66/33/11kV	1997: start 2010: 5T	ABB
Fayoum West	220/66/11kV	2005: start	ABB, Areva, SEL
Beni Suif East	220/66/22/11kV	1996: start 2010: 3T	GEC Alstom, Siemens
Demoo	220/132/66/11kV	1984: start 2000: 220kV 2005: T134	Sprecher+ Shuh, Areva
Ben-Suif West 132	220/66/33/11kV	1969: start 1985: 132kV 2000:66kV 2004: T5	Russia, Yugo, E- Germany, ABB

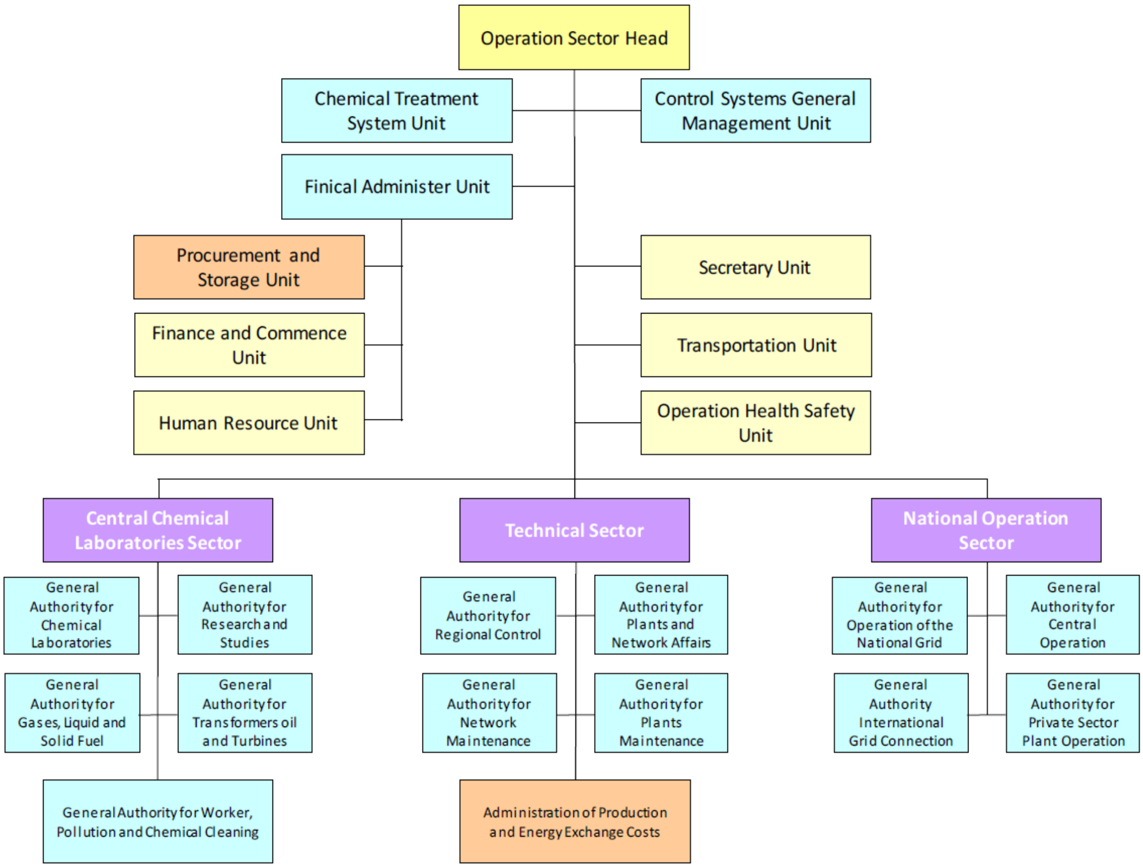
Source: Survey result by TEPSCO in the past

(3) Management and maintenance of the transmission system facilities

The organization chart of the electricity system operation and transmission system facilities management and maintenance in EETC is shown in Figure 2-4-3-1

The chemical analysis sector, engineering and the power system operation sectors are included in the department. The management and maintenance of the facilities are included in the technical sector. The maintenance divisions in EETC are constituted as the following divisions.

- Underground cable division
- Overhead transmission line division
- Substation equipment division
- Protective relay system division
- Transformer testing division
- Human health and safety division



Source: EETC Website

Figure 2-4-3-1 Organization chart of the Operation Department in EETC

The organization chart concerning the control center is shown in Figure 2-4-3-2.

The power system operation is conducted through the hierarchy structures as described here.

NECC (National Energy Control Center) bears responsibility of the management with the generation, 500kV and 220kV transmission systems which constitute the trunk power system.

Seven RCC (Regional Control Center) s monitor and conduct the system operation with 33-132kV transmission system under NCC. The supply of electric power control centers (hereafter Distribution Control Center: DCC) monitor and manage the 6.6-22kV voltage distribution system under RCC.

NECC not only administers the operation of the power plants and the management of the 500kV and 220kV transmission systems, but also directs RCC to change the transmission system operation such as from loop to radial and the voltage control such as transformer tap changing, reactive power control equipment switching for the voltage support and the overload solution countermeasures in the 500kV and 220kV transmission systems.

To monitor and manage the 33~132kV system, RCC is equipped with SCADA, which enables the operator to confirm the operation voltage in 33~132kV substations, and the flowing currents on transmission lines and transformers, and has the function to operate the circuit breakers and disconnecting switches in the substations. However, the latter functions are not usually used because the operation of such as the circuit breakers from SCADA might cause field work member disarray. Therefore, instructions are given by phone from RCC to the substation staff and the staff operates the switch according to the instructions. The communication lines are constituted by the optical fibers which utilize the overhead transmission line facilities.

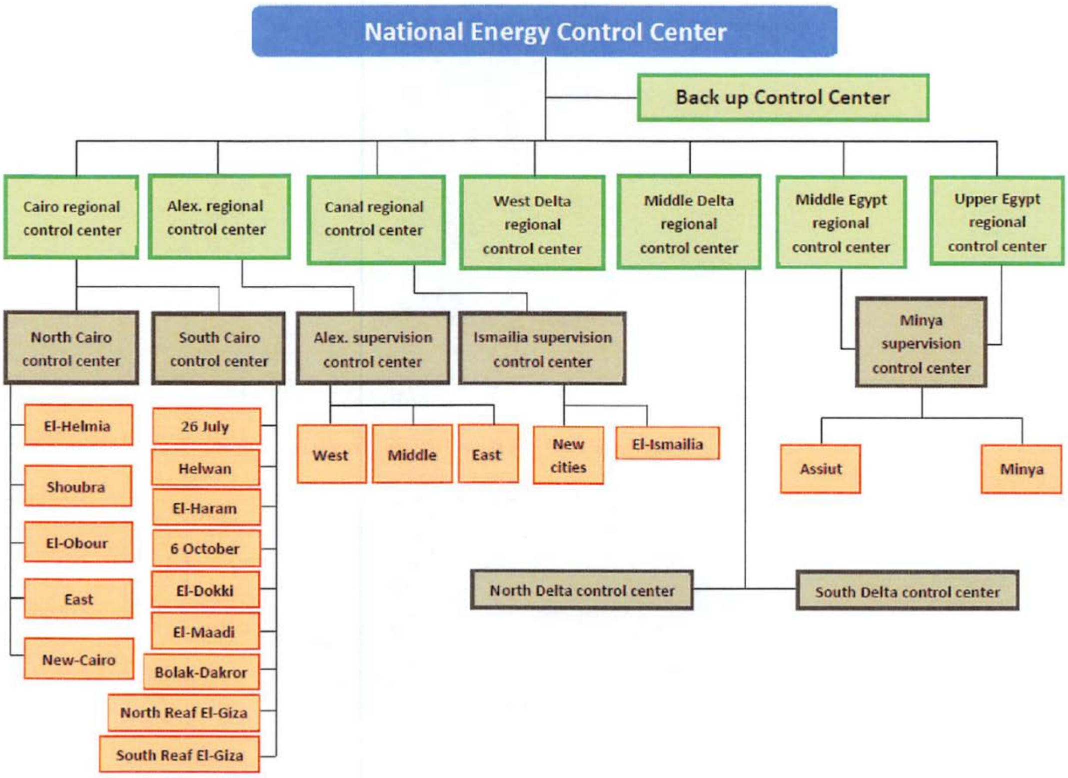
RCC also manages the short-circuit current decreasing measures if required not to exceed the breaking capability of the circuit breakers in the substations such as through applying the radial operation.

Moreover, RCC installed voltage support measures for 33~132kV transmission system such as changing the transformer tap changers and switching the shunt reactors or capacitors.

Similar management as is conducted by RCC is also conducted by DCC for its administrated distribution system.

This hierarchical operation system contributes to realize good quality electricity supply to the customers through monitoring the electricity system and putting appropriate solutions for cancelling the overload, short-circuit current increase and adverse voltage situations by NECC, RCC, and DCC, with good coordination.

This operation system is basically same as those in the developed countries including in Japan.



Source: Integrated Sustainable National Energy Strategy to 2035 Volume 2

Figure 2-4-3-2 Organization chart of the control center in EETC

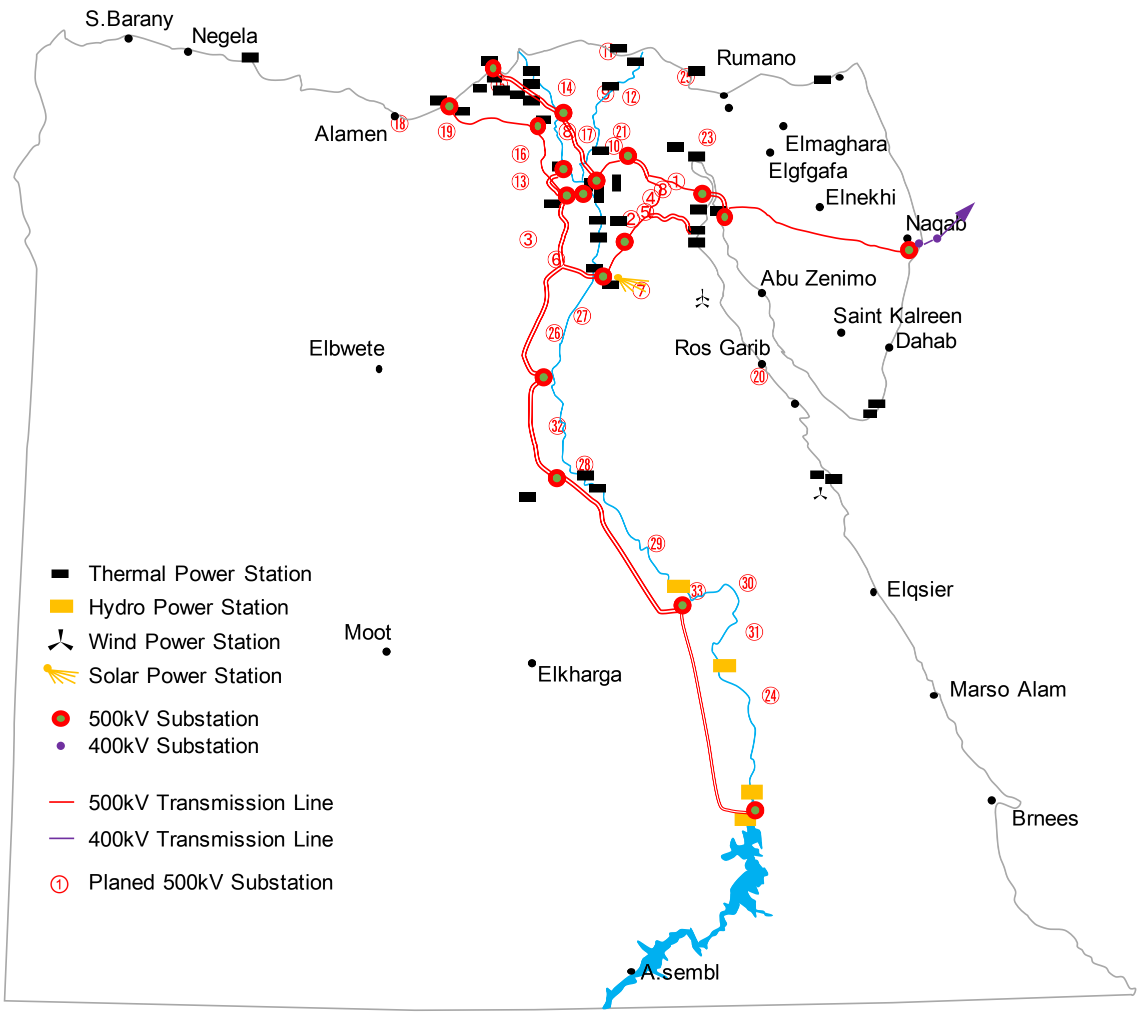
2－4－4 Information on the transmission system under construction and at planning stage

Regarding the transmission facilities under planning and construction, planned 500kV substations are 33 sites between 2017 and 2023 according to EETC. The related data is presented in Table 2-4-4-1. Some of the locations of the substations in Table 2-4-4-1 are located in Figure 2-4-4-1 based on the survey team estimation.

Table 2-4-4-1 500kV substation introduction plan

No.	Regional Name	Substation Name	Capacity [MVA]	Constriction Year	Location
1	Cairo	Badr	3x500	2017	①
2		Maady	4x500	2018	②
3		Octobar 500	3x750	2018	③
4		South Capotal	3x750	2018	④
5		South Project 110	2x750	2019	⑤
6		Hawamidia 500	3x750	2020	⑥
7		Capital S7	4x750	2021	⑦
8	Delta & Alexandria	Itay El Barod	2x500	2017	⑧
9		Samanood	3x500	2018	⑨
10		Banha East	2x500	2018	⑩
11		Damietta West	2x750	2018	⑪
12		Tami Elamdid	3x750	2018	⑫
13		Wadi El Natron	3x500	2018	⑬
14		New Kafr El Shiekh	2x750	2020	⑭
15		Abies	3x750	2020	⑮
16		Sadat 500	3x750	2023	⑯
17		Shebin El Kom 500	3x750	2025	⑰
18		El Alamin	2x750	2025	⑱
19		Industrial Borg Arab	3x750	2025	⑲
20	Canal	Ras Gharib 500	2x500	2017	⑳
21		Zagzazig 500	2x750	2017	㉑
22		Asher 500	2x750	2017	㉒
23		Ismailia	3x750	2017	㉓
24		Industrial substation	4x750	2022	㉔
25		Industrial zone	3x750	2022	㉕
26	Upper Egypt	Maghagha West	2x750	2017	㉖
27		Industrial Beni Suef		2018	㉗
28		Assuit East	2x500	2018	㉘
29		Sohag East	2x750	2018	㉙
30		Qena East	2x750	2018	㉚
31		Luxor 500	2x750	2022	㉛
32		Malawy 500	2x750	2023	㉜
33		New Nag Hamadi	2x750	2023	㉝

Source: EETC

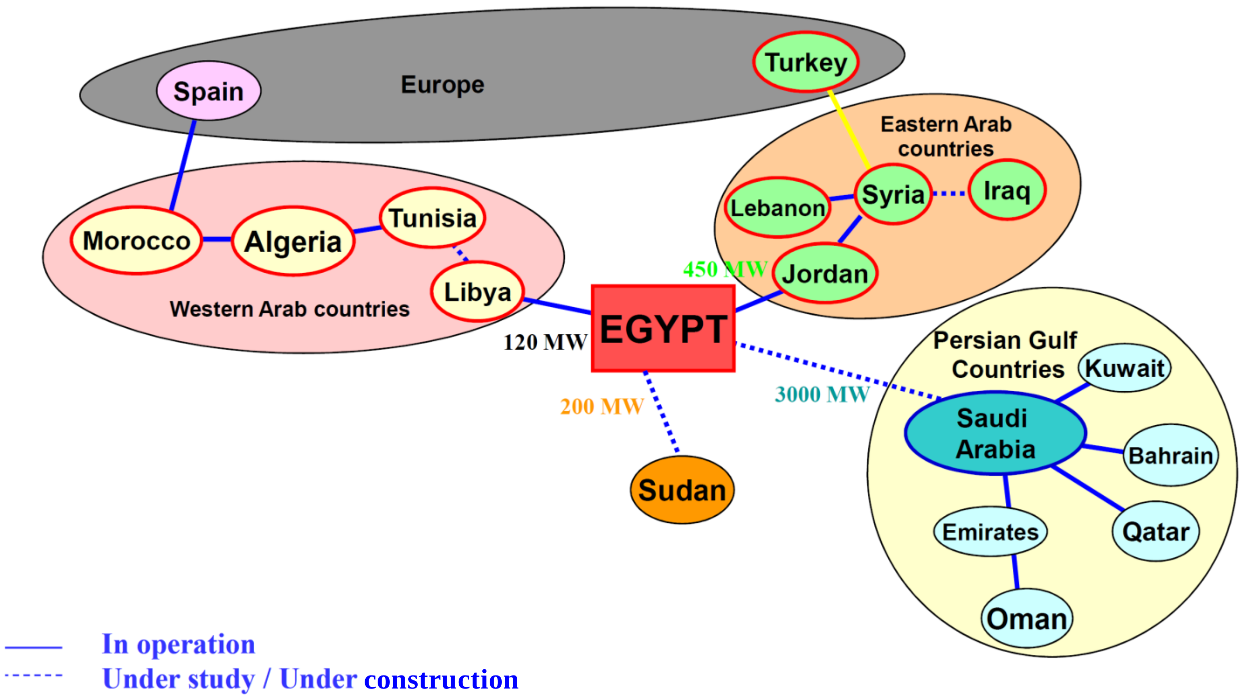


Source: Made by the Survey team

Figure 2-4-4-1 Locations of 500kV substations in the future

2－4－5 Status quo of international interconnections at present and in the future

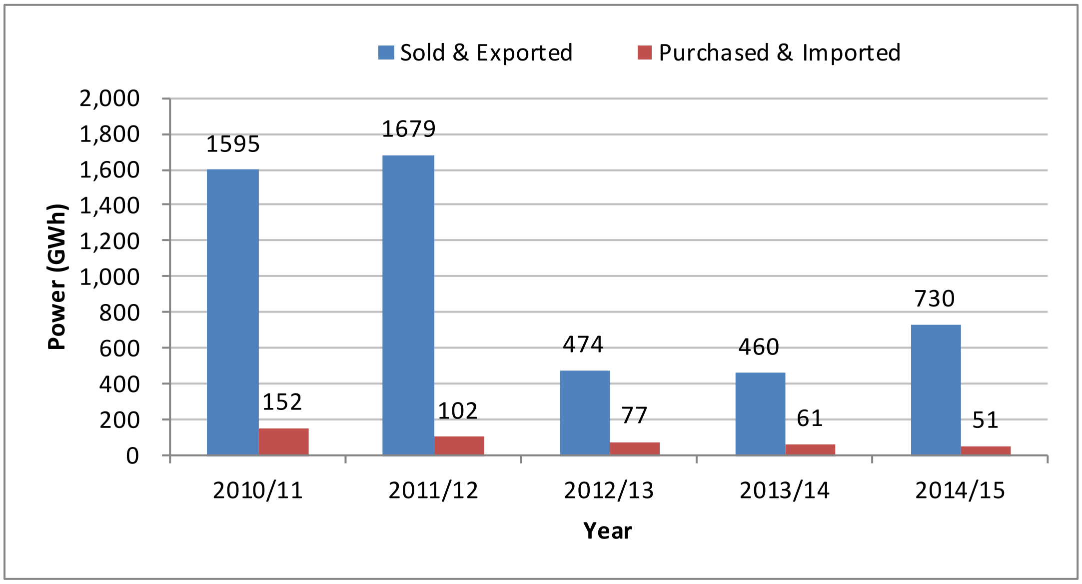
International interconnections in 2015 are shown in the next figure. There are two existing international interconnections between Jordan with the capacity of 450MW, and Libya with the capacity of 120MW.



Source: DPGEE(2017.2.17) EEHC Presentation

Figure 2-4-5-1 Existing international interconnections at present and in the near future

The total capacity of the interconnections is relatively small at about 600MW, about 2%, when compared with the electricity system scale of 30GW in Egypt. The functions of the international interconnections are incomplete, so to speak, because the links are not formed in Syria and Tunisia due to non-technical reasons. Therefore, the concept of the Mediterranean link will not be realized at present or in the near future. In this situation, the exchanged energy level was very low with, for example, 700GWh in 2014/2015, which is 0.4% of the generated energy in Egypt (174875GWh) as shown in the figure below. Incidentally, transactions were mainly conducted between Jordan of 683GWh in 2014/2015 according to EEHC annual report.



Source: EEHC Annual Report 2014/15

Figure 2-4-5-1 Total transactions in recent years

Table 2-5-5-1 Date on Interconnection

	Libya	Jordan
Interconnection start date	May 1998	October 1998
Interconnection voltage (kV)	220	400
Interconnection Capacity (MW)	120	450

Source: EEHC Annual Report 2014/15

On the other hand, in the near future, a new international interconnection between Egypt and Saudi-Arabia with the capacity of 3GW will be in service (1.5GW operation will start in 2018) via DC transmission system.

This capacity will surpass the existing capacity and occupy about 10 % of the generation capacity in Egypt and effective use of the interconnection will surely bring large benefits to the power sector in Egypt, such as improvement in the economy or reliability.

This interconnection will utilize the difference of peak power, namely evening peak in Egypt while daytime peak in Saudi-Arabia. In addition, a collaboration scheme during emergencies in one of the countries will help increase reliability. And further more options will be possible if agreed.

It is expected that international interconnection between Egypt and Sudan will be in place in the future with a relatively small capacity of 200MW and the capacity might be increased in the long run.

If the links between Libya and Tunisia, as well as between Syria and other countries, are connected and further expand their capacity, a Mediterranean-link will result in a win-win situation among the countries. However, it will take some time due to various reasons other than technical issues.

Therefore, for the moment, the experiences in the large capacity interconnection operation between Egypt and Saudi-Arabia will be important for helping accustom the interconnection to such as increase the benefits as much as possible while mitigating the adverse effects which might be brought about in some cases from the connected power system.

2－5　Distribution

2－5－1　Status quo in the distribution system

(1) Distribution loss

The trend of the distribution loss is shown in Table 2-5-1-as the total of nine distribution companies. The distribution loss tends to increase year by year and the major cause is theft. Distribution loss value (15/16) of North Cairo Distribution Company, for example, was 11.68%, which was a little bit higher than the average in Egypt.

Table2-5-1-1　Trend of distribution loss (Total of 9 Distribution Companies)

YEAR	12/13	13/14	14/15	15/16
Generation loss	3.28%	3.27%	3.25%	-
Transmission line loss	4.09%	4.21%	4.32%	-
Distribution network loss	8.89%	9.03%	10.79%	11.02%

Source: Interview survey with North Cairo Distribution Company

Table2-5-1-2 Details of distribution loss (Total of 9 Distribution Companies 2015/2016)

Name of EDC	Energy Purchase from EEHC[GWh]	Energy Sales[GWh]	Distribution Loss[%]
North Cairo	22110	18644	11.68
South Cairo	28099	24220	13.80
Alexandria	10503	9403	10.476
North Delta	24019	22098	7.99
South Delta	14251	12259	13.98
Canal	12668	11436	9.73
El-Behera	11130	9728	12.60
Middle Egypt	16325	14985	8.20
Upper Egypt	12480	11210	10.18
Total	**150584**	**133985**	**11.024**

Source: Interview survey with North Cairo Distribution Company

Causes of distribution loss,
No.1: Electricity theft (non-technical loss)
No.2: Cable (technical loss)
No.3: Other causes (non-technical loss) - Misreading of meter,
Other causes(technical loss) - Transformers

Regarding the measures to reduce distribution loss, the situation in North Cairo Distribution Company, with whom the interview was conducted, is as presented here.

1) Transformers

Because the load factor is high, analysis shows that reduction of the no-load and load loss is an effective way for loss reduction.

In this area, the amorphous transformers that reduce no-load loss have been installed for 10 years.

2) Power factor management

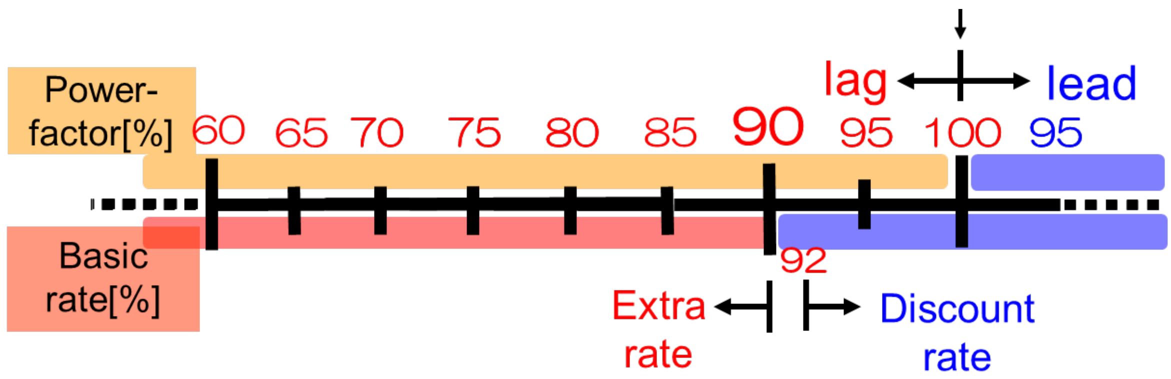
- ✓ The power factor of the distribution system of North Cairo Distribution Company in 2015 was 93% while the target value of the distribution system was 94%. Therefore, it is estimated appropriate in regards to the power factor management.
- ✓ Table 2-5-1-3 shows the power factor in each substation under heavy load and light load conditions.

Table 2-5-1-3 Average of power factor during 1/1/2016 till 31/7/2016

Substation	Power factor of substation(max load)	Power factor of substation(min load)
Alamerya	0.89	0.87
Pertrol	0.98	0.98
Tagned	0.96	0.96
Helmeya	0.94	0.94
Quba	0.91	0.91
Matar	0.94	0.92
Ideal	0.96	0.97
Balaks	0.94	0.92
Mostord	0.96	0.90
Heliopoles	0.94	0.94
Marg	0.96	0.97

Source: Interview survey with North Cairo Distribution Company

- ✓ Even at light load, the power factor value exceeds 90%, which is judged appropriate for power factor management. In Japan, power factor control at light load is worse than the situation shown in above. Therefore, the power factor control seems to be well conducted compared with management in Japan.
- ✓ Measures for power factor control are mainly the installation of capacitor banks in the distribution system and the installation of capacitors by customers.
- ✓ Regarding the installation of capacitor banks in the distribution line, the installation site is the secondary side of distribution transformers and kiosks. Among them, capacitor banks installed on the secondary side of the distribution transformers have the function of automatically opening and closing according to the monitored power factor value. In Japan it directly measures and controls the power factor value by program control (time setting), Egypt is more advanced than Japan. Capacitor banks can be automatically opened and closed in three steps (Capacitor situations are divided into: all open, 1 unit closed, 2 units closed). The capacitors installed in the kiosk cannot be opened/closed automatically, and they are manually operated.

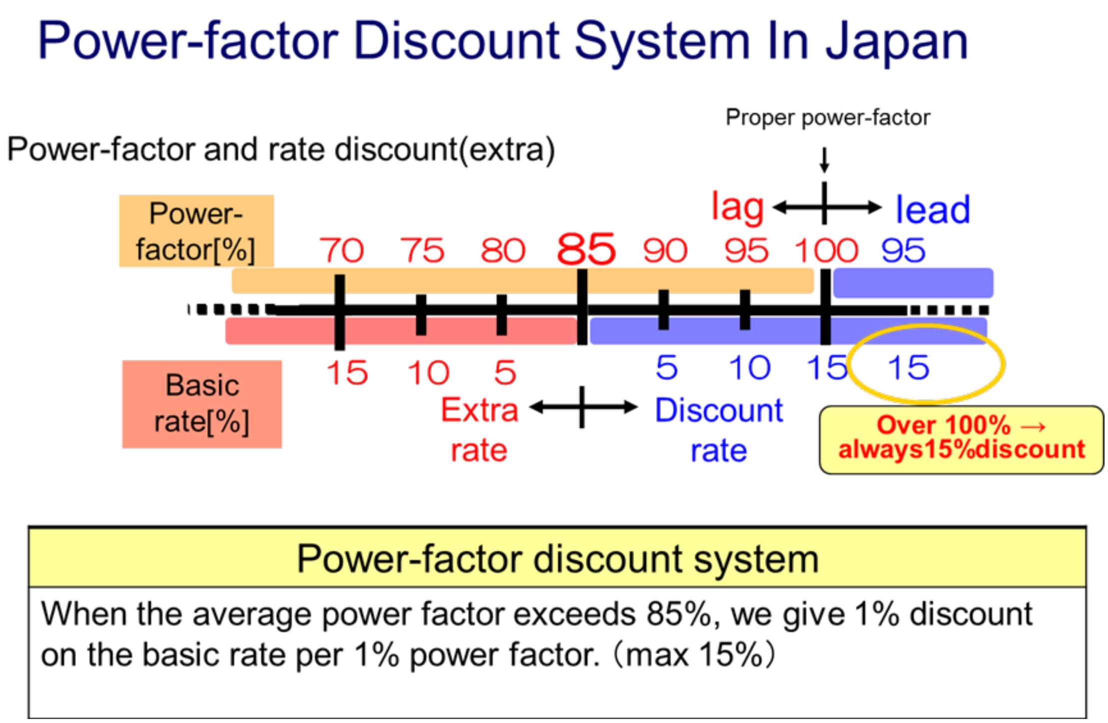


Source: Interview survey with North Cairo Distribution Company

Figure 2-5-1-1 Power-factor electricity tariff discount system in Egypt

- ✓ Power-factor > 92%: 0.5% discount from the total electricity charge
- ✓ 70 - 90% : 0.5% increase in total electricity charge
- ✓ 60 - 70% : 1 % increase in total electricity charge
- ✓ Less than 60% : 1.5% increase in total electricity charge
- ✓ If the power factor of the customer is bad, the distribution company demands improvement.

In comparison, the Japanese system for customers is shown in Figure 2-5-1-2 as an example of Tokyo Electric Power Company Ltd...



Source: Interview survey with North Cairo Distribution Company

Figure 2-5-1-2 Power-factor discount system in Japan (Reference)

The following comments could be made on the comparison between Egypt and Japan.

- ✓ Egypt has a power-factor discount system similar to that of Japan.
- ✓ Regarding power-factor control, in Japan, the capacitor banks in the distribution system are mainly installed for the purpose of voltage control but the amount is not so large. In Egypt, many capacitors are in service in the distribution system and automatic opening and closing control is also performed.

3) Improvement of unbalanced current

As a means for reduction of loss, improvement of the unbalanced current is effective in some cases. However, in the Egyptian distribution system, loss reduction effect seems to be relatively low like the Japanese distribution system.

4) Increase in thickness of the distribution line conductor

In the Egyptian distribution system, an increase in thickness is not adopted to reduce the loss. The thickness is decided for fulfilling the necessary capacity...

(2) Other efforts to reduce loss by the distribution companies are presented here which are derived from answers to the questionnaire.

✓ Technical loss

- · Check bolt tightness on bars and cable terminations and installation of ventilation fans, and replace damaged ones.
- · Re-compression of cable terminations.
- · Replacement of damaged bus bars.
- · Replacement of damaged LV and MV fuses.
- · Quick repair of LV cables loading should not exceed 80%.
- · Reduce the length of MV overhead transmission lines.
- · Opening the MV loops at the point that yields minimum losses.
- · Earthing of distribution network equipment.
- · Quick replacement of damaged meters and analysis of causes of damage.
- · Execution of smart meters and remote meter reading projects.
- · Replacing with transformers of bigger ratings to reduce losses.
- · Install fixed capacitors on the MV and LV voltage to improve the power factor.
- · Review the harmonics level in the network especially in industrial areas and work on reducing it to improve losses.

✓ Non-Technical loss

- · Intensive daily patrols by network technicians and police to find electricity thieves and take legal measures.
- · Review of the meter readings before issuance of bills to find out and investigate abnormal readings.

- Survey of installed meters and inspection of connections.
- Replacement of meters which exceed their life lime to eliminate inaccurate readings.
- Record of the street lighting meters, issue bills regularly and replace damaged meters.
- Follow up of the replacement of damaged meters and installation of new contract meters and regular review of reading factors for large customers.
- Installation of coded meters for unlicensed buildings.
- Eliminate uncollected bills.
- Follow up of reading of and soundness.
- Complete survey of malls, hotels and clubs in the large customer category to ensure correct connection and meter reading factor.

In addition, as a reference, the loss data of the distribution companies obtained by the questionnaire survey are shown in Table 2-5-1-4

Table 2-5-1-4 Distribution loss

○Alexandria

Percentage	2011/12	2012/13	2013/14	2014/15	2015/16
Non-Techinical loss %	8.2	7.197	6.262	6.696	6.676
Techinical loss %	4.333	4.00	3.71	3.71	3.80
Total percentage loss %	12.533	11.197	10.336	10.336	10.476

○El Behera

Percentage	2011/12	2012/13	2013/14	2014/15	2015/16
Non-Techinical loss %	—	—	—	—	—
Techinical loss %	—	—	—	—	—
Total percentage loss %	—	—	10.41	13.51	12.59

○South Cairo

Percentage	2011/12	2012/13	2013/14	2014/15	2015/16
Non-Techinical loss %	—	—	—	—	7.433
Techinical loss %	—	—	—	—	6.382
Total percentage loss %	—	—	—	—	13.825

○Canal

Percentage	2011/12	2012/13	2013/14	2014/15	2015/16
Non-Techinical loss %	—	—	—	—	3.24
Techinical loss %	—	—	—	—	4.86
Total percentage loss %	—	—	—	—	8.1

○South Delta

Percentage	2011/12	2012/13	2013/14	2014/15	2015/16
Non-Techinical loss %	—	—	—	—	3.79
Techinical loss %	—	—	—	—	5.27
Total percentage loss %	—	—	—	—	9.06

Source: Results of the questionnaire to the distribution companies

(3) Introduction of the smart meter

Over the next few years, EEHC plans to readily introduce smart meters.

Specifically, nearly 1 million smart meters are planned to be installed by the JICA project. In addition, 21.75 million smart meters are planned to be installed in phases. The annual plan for the introduction of the smart meter is as follows.

- 2016 - 2017: 250 thousand units (Phase1)
- 2017 - 2019: 1500 thousand units (Phase2)
- 2019 - 2023: 5000 thousand units (Phase3)
- 2020 - 2024: 5000 thousand units
- 2021 - 2025: 5000 thousand units

- 2022 - 2026: 5000 thousand units

As a whole, smart meters are planned to be introduced to about half of the 40 million consumers.

Table 2-5-1-4 Functions to be realized by introduction of the smart meter system

Remote meter reading	Operation by remote meter reading	○
Automatic meter reading	Power amount information can be acquired automatically at set time intervals	○
Remote opening and closing	Power supply can be started / stopped by remote control	○
Bidirectional communication	Bidirectional communication between smart meter and control source is possible	○
Communication to the device	Ability to send information to home displays, smartphones, etc.	×
Electricity rate calculation	It is possible to calculate fee based on meter reading information acquired by smart meter	○

×: No function

Source: Interview survey with North Cairo Distribution Company

(4) Distribution automation system (SCADA)

Regarding the existing distribution automation system (SCADA), the function of the current distribution automation system in North Cairo Distribution Company is as follows.

Only the functions of monitoring the condition of the switch as well as opening and closing by remote control are attached. "Opening / closing by remote control" is realized by issuing an opening / closing command to the on-site switch using communication from the central unit.

(5) Introduction of renewable energy into the distribution system

The situation and measures to the renewable energy introduction in the distribution system at the North Cairo Distribution Company are as follows...

- ✓ Twenty-one PVs with total capacity of 554 kW are installed in the distribution company's building and interconnected.
- ✓ In the case of an output of 500 kW or less, it is connected to the grid of the distribution company. Regarding the connection method, the measurements of the demand and PV generation are separated when utilizing the FIT system, regarding the

net measurement, which is the measurement of only the total received power by using the entire amount of metering in-house. The number of contracts in the category is currently only four.

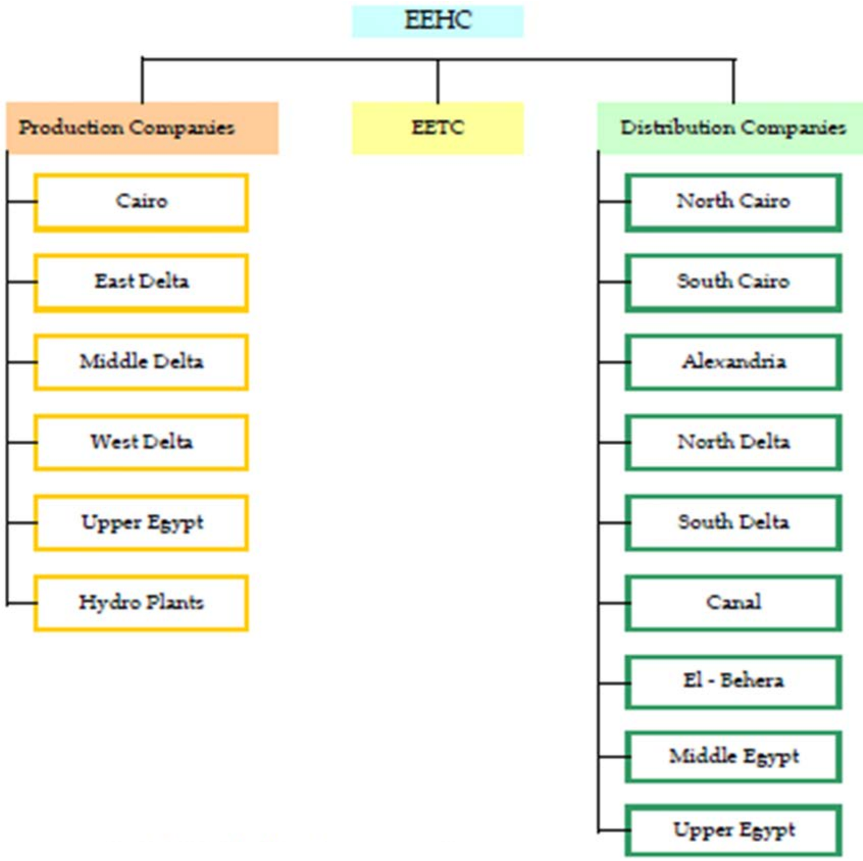
- ✓ Introduction in the future of renewable energy in North Cairo Distribution Company.
  PV: 83 Solar plants   Panel capacity: 3855kW (All LV linkage)
- ✓ 13 new plants of 700 kW will be completed in the near future.
- ✓ Regarding the control method on the power conditioner. In Japan, in the case where voltage rises due to photovoltaic power generation, a function to control the reactive power for suppressing the voltage rise is commonly applied, since such a method is reasonable if voltage control is necessary. In Egypt, although the distribution company conducts power control when the voltage exceeds the proper value, the method is to disconnect the photovoltaic power generation. In this case, the loss of power generation opportunities by PV might become large if the capacity of the PV increases.

  As a countermeasure against a rise in voltage by renewable energy in the North Cairo Distribution Company, the control of the power conditioner is taken as a basic measure. The company has not taken the measures with SVR or SVC. Since the countermeasure on the side of the power generation is reasonable, the countermeasures on the RE generation side are basically reasonable, which is the same principle as applied in Japan.
- ✓ As a countermeasure against the increasing in the short circuit current by the interconnection of distributed generation, the short circuit current is calculated beforehand so that the owner of the generation can install a circuit breaker commensurate with it.

2－5－2 Information on the distribution companies

(1) Structure

The organization and number of employees of the 9 distribution companies is as follows.



Source: Egyptian Electricity Holding Company Annual Report 2014/15

Figure 2-5-2-1 Organization of the 9 distribution companies

Table 2-5-2-1 Number of employees of the 9 distribution companies

North Cairo	13104
South Cairo	17778
Alexandria	12855
Canal	16413
North Delta	8758
South Delta	10233
El-Behera	8464
Middle Egypt	9563
Upper Egypt	7849
Total	105017

Source: Egyptian Electricity Holding Company Annual Report 2014/15

2－5－3 Information on the existing distribution facilities

(1) Information of North Cairo Distribution Company

Tables 2-5-3-1, 2-5-3-2 and Figure 2-5-3-1 show distribution equipment information, including distribution transformer capacity (MV&LV total) and distribution line length (MV/LV).

- ✓ RMU (Ring Main Unit) number of North Cairo Distribution Company: 60552(Last fiscal year). The reclosing scheme is not used because of the underground line system. Other equipment data is as shown in the annual report.
- ✓ Breakdown rate of distribution equipment: 1.123%
- ✓ Number of distribution substations: 66
- ✓ Specification of distribution transformer: Standard: 300, 500, 1000, 1500 KVA

The maximum current is controlled not to exceed 80% of the capacity of the facility shown in Table 2-5-3-1.

Table 2-5-3-1 Type of transformer and control value of maximum load current

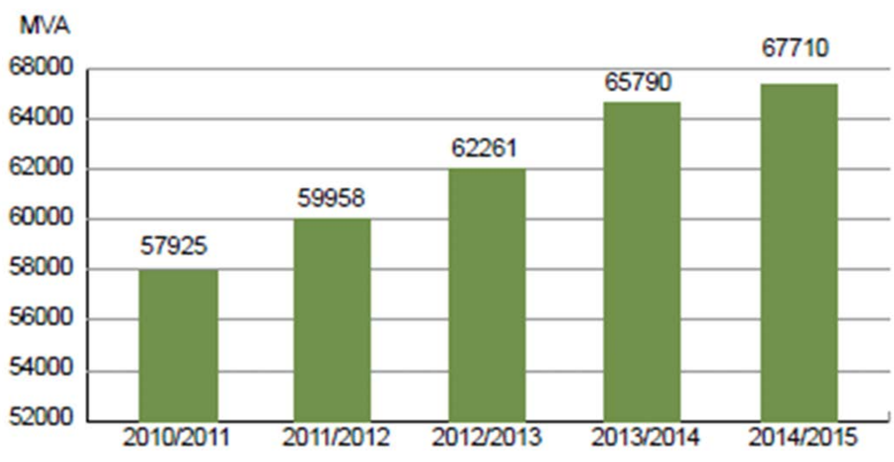
Transformer capacity	Max load in network
(KVA)	(KVA)
300	240
500	400
1000	800
1500	1200

Manufacturer, manufacture year (month), transformer utilization rate, etc. of individual devices (transformers, switches etc.) are kept in record and managed by the company. In addition, a record on the causes of power outages is also maintained.

Table 2-5-3-2 Distribution equipment information

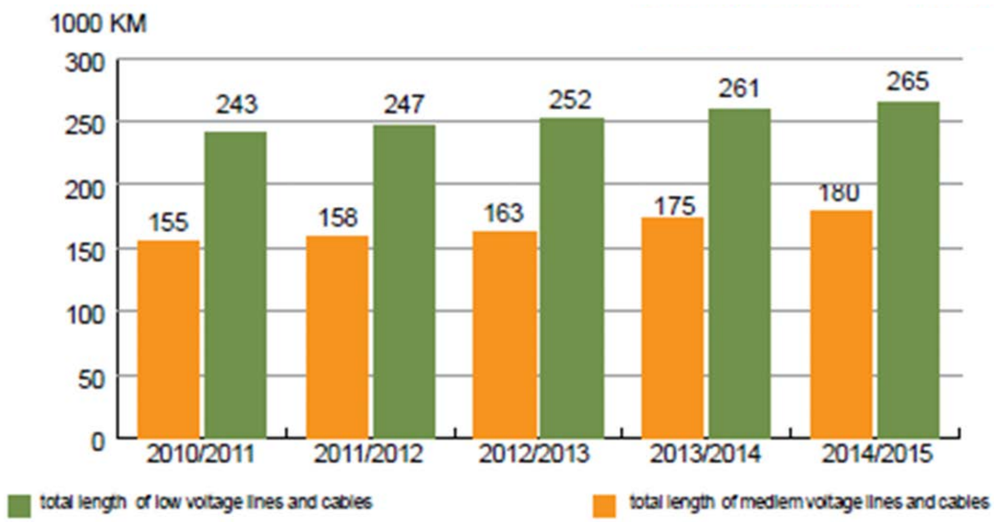
		North Cairo	South Cairo	Alex.	Canal	North Delta	South Delta	El Behera	Middle Egypt	Upper Egypt	Total
No. of Customers (millions)		4.1	5.1	2.5	3.7	3.7	4.2	2	3.3	2.8	31.4
No. of Switchboards		376	359	230	1198	189	194	261	137	103	3047
Percentage (%)		12.3	11.8	7.5	39.3	6.2	6.4	8.6	4.5	3.4	100
Length of MV Network (km)	Lines	195	2974	577	14,574	9,880	7,781	13,931	17,621	10,871	78,404
	Cables	21,502	21,619	11,339	18,887	6,147	3,779	4930	6,202	6,769	101,174
	Total	21,697	24,593	11,916	33,461	16,027	11,560	18,861	23,823	17,640	179,578
Length of LV Network (km)	Lines	3,146	4,558	3,588	31,054	22,846	17,986	16,492	34,715	30,975	165,360
	Cables	35,949	31,460	6,120	15,093	2,943	865	2,769	2,594	1,792	99,585
	Total	39,095	36,018	9,708	46,147	25,789	18,851	19,261	37,310	32,767	264,945
Total Length of MV&LV Lines & Cables (Km)		60,792	60,610	21,624	79,608	41816	30,411	38,122	61,133	50,407	444,523
Percentage (%)		14	14	5	18	9	7	8	14	11	100
Distribution Transformers	(NO)	16,074	19,394	8,020	30,832	16,606	15,822	20,710	23,341	20,737	171,536
	MVA	13,822	10,024	5,058	12,310	4,938	4,469	4,522	5,620	4,967	67,710
Percentage (%)		9	11	5	18	10	9	12	14	12	100
No. of LV Pillars and Panels		55,664	54,748	8020	43,843	18,401	15,925	24,383	13,524	22,001	256,509
Percentage (%)		22	21	3	17	7	6	10	5	9	100

Source: Egyptian Electricity Holding Company Annual Report 2014/15



Source: Egyptian Electricity Holding Company Annual Report 2014/15

Figure 2-5-3-1 Distributor transformer capacity (MV&LV total)



Source: Egyptian Electricity Holding Company Annual Report 2014/15

Figure 2-5-3-2 Distribution line length (MV/LV)

2－5－4 Information on the distribution facilities under construction and planning

The JICA project is being implemented at North Cairo Distribution Company. In Egypt overall, it seems that 250,000 smart meter procurement contracts have been concluded for the time being. The actual introduced number of smart meters for each distribution company is as follows.

- South Cairo: 50,000 units
- North Cairo: 53,000 units
- Cannal: 50,000 units
- Alexandria: 40,000 units
- South Delta 30,000 units
- Middle Egypt 27,000 units

In the northern Cairo area, large development is being continuously carried out in various locations, which will induce the related distribution reinforcements in the distribution system. It is expected that this situation will continue until the city area grows.

2－5－5 Information on collection of electricity fees from consumers

- ✓ Electricity bills are not deducted automatically from bank accounts. They are collected by collectors. Therefore, the efficiency improvement in this area can be expected by the spread of smart meters in the future.
- ✓ Fees are calculated every month.
- ✓ There is a penalty for a delay in payment. As a procedure,(1)Send a warning letter twice ⇒ (2)Supply cut (stop) ⇒ (3)Remove meter and cancel contract
- ✓ This is almost the same as in Japan.

2－6　Renewable Energy

2－6－1　Related policy and program including FIT system

- ✓ Information collection on FIT system

FIT system was legislated in 2014, and was applied from October 2014 to October 2016. However, there were few participants due to time limitations of the study period. Therefore, the implementation period was extended one year from October 2016 with some modifications to the FIT system.

Major modification points were regarding consideration of the risk hedge for investors such as purchase warranty by the government, though the purchase fee was decreased.

Incidentally, the following description was added to FIT in 2016 in order to reduce the financial risks.

“It should be taken into consideration that wind power projects shall be financed at the ratio of 60% foreign finance sources to 40% local finance forces. Solar power projects shall be financed at the ratio of 70% foreign finance sources to 30% local finance sources”

Regarding financing, as mentioned in 2-1-5, the European Bank for Reconstruction and Development (EBRD) and others have decided to finance the solar FIT for the total capacity of 2 GW.

Also, purchase prices are to be decided taking current exchange rates into account more instead of the fixed price of the Egyptian Pound which was partially (15% for PV and 30% for Wind) paid with a fixed exchange rate of US dollar and Egyptian Pound. This modification to the FIT system was to reduce risks caused by currency exchange rate fluctuations.

For the above reform of the FIT system, many investors are participating now, leading to a successful continuation of the system.

Table 2-6-1-1 Summary of FIT in 2014 and 2016

FIT for PV project

Year	**2014 (phase 1)**	**2016 (phase 2)**
Residential	84.4 Piaster/kWh	102.88 Piaster/kWh
C* < 200kW	90.1 Piaster/kWh	108.88 Piaster/kWh
200kW< C* <500kW	97.3 Piaster/kWh	
500kW < C* <20MW	13.6 dollars /kWh	7.88 dollars /kWh
20MW < C* <50MW	14.34 dollars /kWh	8.40 dollars /kWh
	➢ The PV project feed-in tariff has a flat rate during the entire 25 year contractual period. ➢ The PV project feed-in tariff, for installed capacity of more than 500kW, is paid in Egyptian pounds according to the following equation; $PV\ Projects'\ Feed\ in\ Tariff(L.E.) = [15\%\ of\ Feed\ in\ Tariff(\$) \times 7.15(L.E.)] + [85\%\ of\ Feed\ in\ Tariff(\$) \times exchange\ rate\ on\ the\ bill\ issuance\ day,\ as\ stated\ in\ the\ contract]$ ➢ The upper limit for the total contractual PV installed capacity are; a) 300MW for projects with installed capacity of up to 500kW and 2000MW for projects with installed capacity from 500kW and up to 50MW	➢ Contract period: Same(25 years) ➢ Payment equation for capacity from 500kW and up to 50MW; is paid in Egyptian pounds according to the following equation; [(30% of Feed in Tariff)×8.88(exchange rate for Egyptian pound to US dollar at the time tariff is issued)] / [(70% of Feed in Tariff)×(exchange rate for Egyptian pound to US dollar on maturity day)] ➢ Upper limit; same as follows ✓ 300MW for enterprises with capacity less than 500kW. 2,000MW for enterprises with capacity ranging between 500kW and 50MW.

C*: Installed Capacity

Source: Materials supplied by EgyptERA

FIT for Wind project

Year	2014 (phase 1)		2016 (phase 2)
Full Operating Hours (FOH)	Feed-in Tariff for the 1st tariff segment (5-year period) (Dollars/kWh)	Feed-in Tariff for the 2nd tariff segment (15-year period) Dollars/kWh	Purchase price for power over enterprise lifetime (Dollars/kWh)
2500		11.48	7.96
2600		10.56	7.65
2700	11.48	9.71	7.37
2800		8.93	7.11
2900		8.19	6.86
3000		7.51	6.93
3100		8.93	6.42
3200		8.33	6.33
3300		7.76	6.03
3400		7.23	5.85
3500	9.57	6.73	5.69
3600		6.26	5.53
3700		5.81	5.38
3800		5.39	5.24
3900		4.98	5.10
4000		4.60	4.97
4100			4.85
4200			4.74
4300			4.63
4400			4.52
4500			4.42
4600			4.33
4700			4.23
4800			4.15
4900			4.06
5000			4.00
	➢ The Wind project feed-in tariff has a segment tariff structure (5-year and 15-year periods) for a total 20-year contractual period. ➢ The Wind project feed-in tariff is paid in Egyptian pounds according to the following equation; $Wind\ Feed\ in\ Tariff(L.E.) = [30\%\ of\ Feed\ in\ Tariff(\$) \times 7.15(L.E.)] + [70\%\ of\ Feed\ in\ Tariff(\$) \times exchange\ rate\ on\ the\ bill\ issuance\ day,\ as\ stated\ in\ the\ contract]$ ➢ Required Capacity: 2000MW.		➢ No Segmentation Contract period is same (20 years) ➢ Payment equation; Paid in Egyptian pounds according to the following equation; [(40% of Feed in Tariff)×8.88(exchange rate for Egyptian pound to US dollar at the time tariff is issued)] / [(60% of Feed in Tariff)×(exchange rate for Egyptian pound to US dollar on maturity day)] ➢ Required capacity: 2,000MW

Source: Materials supplied by EgyptERA

2－6－2 Existing facilities and operation situation

- ✓ Total installation capacity of the PV systems has exceeded 50MW for isolated grid and independent loads of the remote areas.
- ✓ Except for the above, grid connection type PV systems for roof tops have been installed at more than 10MW. Final target will be 300MW.
- ✓ Existing installation capacity of wind energy has been up to 750MW with finalizing of the Gulf of Elzeit 200MW wind project supported by KfW. The other wind energy plants are 545MW in Zafarana and 5MW in Hurghada.

2－6－3 Development Plan

(1) Development plan for PV power plants

The plan to develop approximate 3000MW of PV power plants by 2022 is in progress. The actual situation is as follows;

- ✓ 90MW of the PV projects, mainly isolated to grid power supply have been implemented. This has already been calculated as capacity in the development plan.
- ✓ After implementing the Hurghada 20MW project supported by JICA and Komonbo 20MW project supported by AfD, a Hurghada 20MW project supported by South Korea, 50MW project supported by Arabian economical social finance and Safaga 50MW project supported by KfW are being planned and are now in the study stage.
- ✓ A feasibility study has been finished for the South Korean Hurghada 20MW project. A battery storage system has been proposed in this project for stabilizing the grid condition. The main purpose for this will be stabilizing output energy fluctuations.
- ✓ 50MW project supported by Arab economic social finance and Safaga 50MW project are now proceeding with preparation of the project.
- ✓ Requests for proposal began in July 2017 as BOO in Kommonbo and West Nile Valley. Regarding West Nile Valley, collection of weather data is currently under way and after that, the process for tender documents will start.
- ✓ Nine (9) candidates are expected for the first round FIT scheme projects in Kommonbo. Total capacity will be 450MW.
- ✓ Second round FIT projects will start from October 2017. Total capacity of 1500MW is expected from 32 companies.
- ✓ Except for the above, many BOO and development projects with FIT system are now under planning.
- ✓ Total capacity of PV development is expected to be 2300MW.

Incidentally, regarding the transmission system reinforcement in Kommonbo, in the first stage, four (4) and at final stage, five (5)220kV substations construction are planned for future large scale BOO projects.

Table 2-6-3-1 PV project

Project		Capacity (MW)	Site	Expected operation start
Existing	Current Facilities	90	Stand Alone and Roof Top Grid Connection. Excluding street lights	
NREA Project	Hurghada (JICA)	26	Hurghada	2019
	Kom Ombo (AFD)	20	Kom Ombo	2019
	Hurghada (Korea)	20	Hurghada	2019
	Zafarana (KfW)	50	Zafarana	Canceled
	Kom Ombo (Arab Fund for Economic & Social)	50	Kom Ombo	2020
BOO Project	BOO Kom Ombo	200	Kom Ombo	2020
	EETC BOO West Nile Valley	200	West Nile Valley	2021
FIT Project	Kom Ombo by Feed-in-Tariff	1565	Kom Ombo	2019
	Roof top small PV by FIT	290		2021
Total		2461		

(2) Development plan for solar thermal generation

Feasibility study for Kom Ombo Solar thermal power plant project was implemented in year 2013. As a result generation costs for solar thermal were estimated at 30cents USD/kWh. Therefore the project was suspended due to extremely high generation costs. If generation costs decrease in future, the project may resume.

The new project with BOO 52MW in West Nile River started in 2015.

(3) Development plan for wind energy

Development of approximately 6000MW of wind energy generation by 2022 is planned. The actual situation is as follows;

- ✓ Total capacity of existing wind turbines in operation is 750MW. All wind turbines were developed by NREA
- ✓ There is a plan to develop 2000MW plant in the Gulf of Suez using FIT scheme, but is 0 MW at present.
- ✓ NREA plans to develop 200MW West Nile Valley supported by JICA
- ✓ 220MW JICA project and 120MW Spanish project in the Gulf of El-zeit are under construction. Construction work is expected to finish on 2018.
- ✓ In addition to the above, the second phase of the KfW project is now being preparing for tender in the Gulf of Suez. Expected total capacity is assumed to be 200 to 250 MW
- ✓ NREA is planning to make a contract with Siemens as EPC and finance of 2000MW scale wind turbines in the Gulf of Suez

- ✓ Regarding the BOO project in the Gulf of El-zayet, the signing process is under way, where the Toyota trading company, using JBIC finance, will be expected to participate..
- ✓ The BOO 320MW project in the Gulf of El-zeit is now being planned using Italian finance. This project was studied by Italgen in 2008. The site is planned for the southern side of the JICA site.
- ✓ A feasibility study for a South gulf site project (located between Zafarana and the Gulf of El-zeit) is now being implemented. In addition, a 250MW project on the north side of the Gulf of El-zeit is being planned. This project is planned to use BOO Scheme by Lekela.
- ✓ The BOO project at West Nile River planned to start requests for proposal from July 2017.

Two projects for West Nile Valley are under way.

In summary, regarding wind power development, total developed capacity will be 6000MW and the breakdown is as follows;

FIT scheme 2000MW (FIT Wind is 0MW at present), BOO scheme 1000MW, NREA; 3000MW including Siemens 2000MW project.

Table 2-6-3-2 Wind power development project up to 2022 (including those already in operation)

Project		Capacity (MW)	Site	Expected operation start
Existing	Current Facilities	750	Zafarana, Hurghada and Gabal El-Zayet	
NREA Project	Ext. of Wind (Gabal El-zayte-1)	40	Gabal El-Zayet (KfW5)	2018
	Wind (Gabal El-zayte-2)	220	Gabal El-Zayet (JICA 2)	2018
	Ext. of Wind (Gabal El-zayte-2)	32	Gabal El-Zayet	2018
	Wind (Gabal El-zayte-3)	120	Gabal El-Zayet (Spain)	2018
	Wind (Suez Gulf-1)	200-250	Suez Gulf (KfW 6)	2019
	Wind Masdar and NREA	200	Suez Gulf	2019
	Wind West Nile (JICA)	200	West Nile	2020
	Wind AFD Ras Ghareib (Suez Gulf-3)	200	Suez Gulf (AFD)	2020
	Siemens – Wind	180	Suez Gulf	2019
	Siemens – Wind	1820	Suez Gulf and West Nile	Not confirmed yet
BOO Project	WIND BOO Suez Gulf	250	Gabal El- Zayet (Toyota)	2019
	Wind BOO (West Nile)	250	West Nile	2020
	Wind BOO (South Gulf)	250	Between Zafarana and Gabal El-Zayet	Not confirmed yet
	Italgen (BOO)	320	Gabal El-Zayet	2019
FIT Project	Wind Feed-in-Tariff Projects*	2,000	Suez Gulf	2020

Total	7,082		

* Wind Feed-in-Tariff Projects is 0MW at present.

(4) Development plan for Biomass generation

- ✓ Although FIT price has been decided at 92pt/kWh, there is no candidate for the project now.
- ✓ Biomass generation is required so there is a complex procedure related to many ministries such as the Ministry of Electric and Renewable Energy, Ministry of Agriculture, Ministry of Environmental etc. This is the reason for difficulty in the development of the project.
- ✓ The feasibility study for the waste generation project has been implemented before, and NREA has also participated in the project. However, concrete action has not yet been taken.

Regarding the 20% of power supply in 2022 by renewable energy in the national strategy, the existing 2800 MW hydroelectric power plants, 3000 MW solar power generation and 7000 MW wind power generation as mentioned above, will meet the target, assuming the average RE availability of 47%. .

In addition to the above projects, 35GW of wind power and 35GW of PV power could be introduced only in the West and East Nile River sites, therefore, further development will be well expected further in the future.

2－6－4 Condition of grid connection and technical issues including grid stabilizing

- ➢ Grid Code
  - ✓ Grid code for wind turbines was published in 2015.
  - ✓ Grid code for PV and solar thermal power plant has been approved
- ➢ Specific issues in the electricity system operation caused by the large scale introduction of RE and prospects for maintaining the stable operation. (System frequency maintenance issue in short term duration caused by RE)

  Although the about 9GW introduction of RE, except for hydro, is expected to be in service in 2022 due to efforts of the concerned parties, it is also crucial to prepare countermeasures against the introduction in the power system because of the specificities of RE as a generation system. According to the transmission reinforcement plan, the maximum output power of RE should be transmitted to the consumers through the reinforcement of the transmission system which is now being studied as the 2025 transmission system plan.

  On the other hand, RE, especially wind and solar have specificity in generation output, that is, basically the output depends on the natural phenomena and changes continuously due to their nature, which is rather different from that of the conventional generation plants.

According to CREMP which is, so to speak, the technical basis of ISES2035Scenario4b, the related issues are estimated as the frequency fluctuation analysis and concluded that it is within the limit of operational allowance in the power system. However, in the estimation, the conditions for the analysis are based on the experiences of the consultants and cannot be compared with the conditions in Egypt. The issues will be dealt with again in Chapter 3 to discuss required work for the solution. Here, some basic estimation has been conducted by the survey team to confirm the adequacy of the power system because this issue is essential for the large scale introduction plan of RE to be technically appropriate.

Although this estimation will only be at the level of screening before deciding the final option for analyzing the countermeasures, which will be conducted in due time, it should still be worthwhile to identify whether the situation around the year 2022 would suffice the basic conditions for maintaining stable operation.

- Estimated demand (kW) around 2022 at low demand level conditions. ,

28GW (Peak load in 2016 $(29\text{GW}) \times (1.055)^6 \times 0.7$)

1.055: demand increase/year 6: 6 year 0.7: low level demand ratio

Conventional generation capacity in operation around 2022 at low load conditions

30GW (28G x 1.1(including 10% reserve capacity))

Ratio of RE capacity in total generation capacity

0.23 (=9/ (30 + 9) assuming all RE in operation)

Assumed solar output rapid fluctuation*:

0.3GW (3GW×0.1*)

*In reality, large scale solar would be developed mainly in desert areas, rapid output fluctuations would be assumed to be relatively low.

- Wind output rapid fluctuation*:

1.2GW (6GW×0.2*)

* Rapid wind output fluctuations should be brought about with a rapid change in atmospheric pressure and geographical conditions etc. For the moment, the sites are in a relatively limited area until 2022, so there seems to be relatively low possibility of sudden unexpected change assuming proper observation of the related conditions is carried out.

Incidentally, since some of the solar and wind generators will be out of operation in actual conditions, all 9GW capacity facilities in service should be relatively severe assumption

- In the case that the rapid output fluctuations of solar and wind should occur simultaneously*, total output rapid fluctuations would be as follows: (*set the severe assumption)
  1.5GW (0.3 + 1.2)

- The ratio between the total output fluctuation and conventional generation capacity.
  1.5GW/30GW =0.05 :5%

In Japan, when deciding the maximum unit capacity of the generation unit, the sudden loss of service in low load conditions should be assumed to prevent adverse effects on the system frequency. In assessment of the effects, 5% of the electricity system capacity is applied for the threshold. In light of the threshold as the reference, “5%”, derived from the estimation above, would be just within the allowable limit of power system operation for unit capacity decision.

On the other hand, “5%” derived here might show that the fluctuation would be around the limit of the allowance level and might become larger based on the conditions which are determined through actual observation.

Considering the estimation has more uncertainties in the assumed conditions, it would be desirable to utilize the expected Ataqa hydro pumped storage generation (2.4GW) operation which will have very rapid response of output against sudden frequency change as a countermeasure.

The survey team judged that a large introduction plan by 2022 would be appropriate for the issue at present, however, recommended that further studies should be conducted and countermeasures should be introduced where required.

According to ISES2035Scenario4b, the development of RE would be gradually shifted from wind to solar.

Therefore, the main issues in RE mass development should be from unexpected output fluctuations to stable operation in the daytime with large output along with zero output in the evening, which would bring about the issue of securing conventional generation capacity for stable operation of the entire system. In the case that conventional generation should be out of service and unable to cope with large solar generation output in the daytime, issues of frequency fluctuation might surface again because the ability for maintaining frequency fluctuations rendered by the conventional generation will decrease.

From this prospect, the frequency fluctuation issue should be kept in mind by the concerned parties.

Incidentally, the countermeasures from a long perspective could be introduced, such as development of CSP, various types of battery cells or another hydro pump storage generation which would also be good for economical operation with further development of nuclear and coal plants. The study on the countermeasures should be made in due time in the future for comprehensively assessing the required capacity, operability and economy.

2－7　Environment and social considerations

2－7－1　Environmental Policies and Targets

The Ministry of Planning and Monitoring, Administrative Reform (MoPMAR) and Egyptian Environmental Affairs Agency (EEAA) have provided following six Environmental policies from 2001 to 2016.

- Sustainable Development Strategy: Egypt Vision 2030 (MoPMAR, 2016)
- Egypt's Status Towards Major Negotiable Issues in Climate Change (2016, EEAA)
- Egypt National Environmental, Economic and Development Study (NEEDS) for Climate Change (2010, EEAA)
- National Strategy for Environmental Communication (NSEC) (EEAA, 2005)
- National Strategy for Cleaner Production in Egyptian Industry (2003 EEAA)
- The National Environmental Action Plan 2002-2017 (NEAP) (2001 EEAA)

Among the above policies Sustainable Development Strategy- Egypt Vision 2030 (MoPMAR, 2016) and Egypt National Environmental, Economic and Development Study (NEEDS) for Climate Change (2010, EEAA) provisions detail programs, targets, and required funds.

(1) Sustainable Development Strategy: Egypt Vision 2030 (MoPMAR, 2016)

The Egyptian economy is to achieve prosperity through sustainable development, social justice, and ensuring balanced growth. It is supported by three dimensions and 10 pillars. The pillars have more than 330 indicators associated with the more than 50 strategic targets. Mechanisms were set in order to achieve these indicators and targets for about 200 projects and programs, all of which are based on achieving the basic targets and goals of the strategy.

The main target is “By 2030, Egypt will be a country with a competitive, balanced, and diversified economy, depending on knowledge and creativity, and based on justice, social integration, and participation, with a balanced and varied ecosystem, a country that uses the genius of the place and citizens in order to achieve sustainable development and improve the quality of life for all. Moreover, the government looks forward to lifting Egypt, through this strategy, to a position among the top 30 countries in the world, in terms of economic development indicators, fighting corruption, human development, market competitiveness, and the quality of life.”

Some of the indicators of the Energy Pillar of Economic Dimension are “Ratio of primary energy supply to the total planned energy consumption will be 100 % by 2030”, the decline of the percentage in greenhouse gas emissions from the energy sector will be 10% by 2030”, and others.

Some of the indicators of the Environmental Pillar of Environmental Dimension are “Percentage of decreased pollution caused by fine airborne dust (%) will be 50%”, “Percentage of hazardous waste, safely disposed (treatment, recycling, final disposal) (%) will be increased from 7% to 100%”, “Illegal industrial sewage pumped into the Nile River as a percentage of the total industrial sewage (%) will be 0% from 21%”, “Number of national monitoring air pollutants plants will be increased from 164 sites and 40 companies to 500 sites.”, and others.

One of the indicators of the Urban Development Pillar of Environmental Dimension is “Per capita green landscapes in cities will be increased from $0.85m^2$ to $3m^2$”.

Although the outline is shown in the following table, ambitious targets including a GDP growth rate of 10% or more are listed, but on the specific policy aspect such as the ratio of electricity supply of RE (solar light, wind power) at 30%, ISES 2035 Scenario 4 b is determined to be consistent.

Table 2-7-1-1 Main targets and indicators of Egypt Vision 2030

Dim.	Pillar	Main targets with Indicators			
		Indicator	Current	2020	2030
Economic Dimension	1. Economic Development	1. Real GDP growth rate (%)	4.2	10	12
		4. Poverty headcount ratio at national poverty lines (%)	26.3	23	15
		10. Unemployment rate (%)	12.8	10	5
		22. Net foreign direct investment (Billion USD)	6.37	15	30
	2. Energy	1. Ratio of primary energy supply to the total planned energy consumption	*	100%	100%
		5. Percentage decline in greenhouse gas emissions from the energy sector	*	5%	10%
		12. Percentage of fuel mix for electricity production	Oil and Gas: 91% Hydro: 8% Solar and Wind: 1%		Oil and Gas: 27% Hydro: 5% Solar: 16% Wind: 14% Coal: 29% Nuclear: 9%
	3. Knowledge, Innovation and Scientific Research	5. Knowledge transfer sub-index of the global innovation index (rank)	69	60	30
		9. Environmental sustainability sub-index of the global innovation index (rank)	65	50	30
		14. Quality of scientific research institutions	135	100	60
	4. Transparency and Efficiency of Government Institutions	3. Regulatory enforcement (score) (0 worst-100 best)	0.42	0.5	0.6
		10. Share of funds allocated to training as a percentage of wage bill	0.04	0.5	1
Social Dimension	5. Social Justice	1. Geographical gap in human development index	0.086	0.06	0.043
		4. International rank of the gender gap index	129	100	60
	6. Health	1. Life expectancy at birth (years)	71.1	73	75
		9. Number of deaths from road accidents per 100,000	13.2	10	8
	7. Education & Training	E2. Illiteracy rate (15-35 years old)	28%	7% (absolute zero)	7% (absolute zero)
		E6. Percentage of school drop-out under 18 years old	6%	2%	1%
		T1. Percentage of students enrolled in technical education (with outstanding performance at preparatory stage score more than 85%)	4%	12%	20%
		T2. Percentage of technical education graduates working in their fields of specializations	30%	60%	80%
	8. Culture	1. Tourism and travel competitiveness	85	70	60
		2. Geographical gap of the ratio of the number of public libraries / 100,000 people	0.35	0.2	0.1
Environmental Dimension	9. Environment	3. Percentage of decreased pollution caused by fine airborne dust (%)	157 Microgram/m3	-15%	-50%
		5. Percentage of hazardous waste, safely disposed (treatment, recycling, final disposal) (%)	7%	30%	100%
		8. Rate of reduction of the expected increasing rates of greenhouse gas emissions	276 equivalent tons of Carbon dioxide		
		10. Illegal industrial sewage into the Nile River as a percentage of the total industrial sewage (%)	21%	16%	0%
		13. Number of natural reserves, with an approved and activated management plan (reserves)	13	15-20	30
		16. Percentage of loss in water treatment plants (%)	30%	Less than 20%	Less than 10%
		17. Number of national monitoring air pollutants Plants	87 plants	92 plants	120 plants
		18. Number of monitoring sites at the national network of monitoring industrial emissions	164 sites 40 companies	250 sites	500 sites
	10. Urban Development	4. Per capita green landscapes in cities	0.85 m^2	1m^2	3m^2

(2) Egypt National Environmental, Economic and Development Study (NEEDS) for Climate Change (2010, EEAA)

ENERGY SECTOR Mitigation Priority Technology Options of NEEDS for Climate Change (2010) shows 7 basic programs, 8 programs of Meeting Country's Actual Demand and Promoting Energy Efficiency, 4 programs of Innovative Technologies for 2020 and beyond, and 5 programs of Support Capacity and Institutional Building. As a non-annex I country, Egypt is not requested to meet any specific emission reduction or limitation targets in terms of its commitments under the UNFCCC or Kyoto Protocol. However, mitigation measures based on national plans are already in progress, and NEEDS are providing programs for introducing renewable sources of energy; fuel switching in industry and transport from oil to natural gas; implementing domestic and industrial energy efficiency programs; promoting energy efficient buildings; and developing agriculture and plantation schemes aiming at enhancing public participation and cooperation with the purpose of creating a low carbon economic structure that prioritizes energy efficiency. The Basic program contains a Program of a series of gas-fired combined cycle modules of a total capacity of 9,000 MW up to the year 2020 lead by MoEE, EEHC etc. The programs of “Meeting Country's Actual Demand and Promoting Energy Efficiency” contains construction of Large-scale Grid-connected Wind Farms, expanding the Use of Domestic Solar Water Heating Units to around 500,000 units every year up to the year 2020 lead by MoEE and NREA. The programs of Innovative Technologies for 2020 and beyond contain the pilot projects of CO2 Capture & Storage lead by MoP, MoEE, and MoSfEA.

Table 2-7-1-2 Baseline Programs of “NEDDS’s ENERGY SECTOR Mitigation Priority Technology Options”

No.	Program	Activities	Responsible Entities	Required Finance	Time Duration (Years)
1	Large-scale Grid-connected Wind Farms	Construct a series of large-scale grid-connected wind farms at the areas of highest potential of wind speed, identified by the Egypt wind map. Yearly total capacity of 220 MW.	MoEE(1), NREA(2),	1.3 -1.5 M EUR/MW i.e. 2.85-3.3 Billion EUR	10
2	Integrated Combined Cycle Solar System (ICCS) Plants	Construct two similar 300MWcapacity plants, including solar thermal Portion of 60MW capacity each, by 2020.	MoEE, NREA,	1850-1900 US$/kW i.e. 1.11-1.14 Billion US$	10
3	Gas-Fired Combined Cycle Power Plants	Program of a series of gas-fired combined cycle modules of a total capacity of 9,000 MW up to the year 2020.	MoEE, EEHC and Affiliate Electricity Production Companies, Private Sector	725-775 US $/kW i.e. 6.53-6.98 Billion US$	10
4	Gas-Fired Steam Thermal Power Plants	Program of a series of gas-fired steam thermal units, mostly capacity of 650 MW each, in addition to a unit capacity of 350 MW. The total capacity amounts to 11,400 MW up to the year 2020.	MoEE, EEHC and Affiliate Electricity Production Companies, Private Sector	1000-1100 US$/kW i.e. 11.4-12.54 Billion US$	10
5	Nuclear Power Plants	Implement the first 1000 MW capacity nuclear unit by the year 2017.	MoEE, NPPA(2)	2100-2500 EUR/kW i.e. 2.1-2.5 Billion EUR	7
6	Expand the Use of Efficient Lighting Systems (Egyptian Efficient Lighting Initiative – EELI).	Program for transforming lighting market towards Compact Fluorescent Lamps (CFL), targeting utilization of additional 80 million lamps during the period 2010 – 2020. Safe Disposal of burnt lamps should be taken into consideration. Expected reduction of GHG emissions is about 4.0 Mt CO2eq by the year 2020. Expected saving is about 1.5 Mtoe.	MoEE, EEHC(1) and affiliate Electricity Distribution Companies, Private Sector	25 M EUR	10
7	Renewal of Aging Taxi Vehicles in the Greater Cairo Region (GCR)	Program for replacing aging fleet of taxis in the Greater Cairo Region (GCR) (about 43,000 taxis with fuel efficiency of about 14 liters per 100 km or more through phases of implementation with new gasoline vehicles that get about 12 liters per 100km or less, and CNG vehicles that get about 8km per 100 km) Overall GHG emission reduction estimated at 2,636,713 tons CO2eq over a period of 10 years.	MoF(1), MoI(2), Auto Dealers, Commercial Banks, Advertising Firms	508 M US$	5

(1) MoF = Ministry of Finance.
(2) MoI = Ministry of Interior.

Table 2-7-1-3 Meeting Country's Actual Demand and Promoting Energy Efficiency Programs of "NEDDS's ENERGY SECTOR Mitigation Priority Technology Options"

No.	Program	Activities	Responsible Entities	Required Finance	Time Duration (Years)
1	Large-scale Grid-connected Wind Farms	Construct a series of large-scale grid-connected wind farms at the areas of highest potential of wind speed, identified by the Egypt wind map. Yearly total capacity of 500 MW to satisfy the 20% target of renewable electricity, including hydro, by 2020, out of which 12% wind energy.	MoEE, NREA, Private Sector	1.3 -1.5 M EUR/MW i.e. 6.5- 7.5 Billion EUR	10
2	Nuclear Power Plants	Program of a series of 1000 MW capacity nuclear units, with a total of 4 units up to the year 2027	MoEE, NPPA	2100-2500 EUR/kW i.e. 8.4-10.0 Billion EUR	10 (2017-2026)
3	Expand the Use of Domestic Solar Water Heating Units (Solar Water Heaters Initiative – SWHI)	Typical domestic solar water heating units, containing 2 square meters flat plate collector area and 150 liters storage water capacity. Program of potential usage of around 500,000 units (i.e. total collector area of about 100,000m2) every year up to the year 2020. (Each square meter of solar collectors would result in 0.5 ton of CO2 eq. emission reduction per year. Expected saving is about 0.018 mtoe annually)	MoEE, NREA, Private Sector	250 M EUR	10
4	Expand the Use of Photovoltaic Systems for Different Applications.	Program of typical photovoltaic systems applications of total capacity of 20.00 MW up to the year 2020.	MoEE, NREA, Private Sector	6,000US$/kW Up to 2015 and 1,000 US$/kW beyond 2015 Total finance is around 70 M US$	10
5	Expand the Energy Efficiency Labelling (EEL) Applications (Egypt has already developed and issued four standards, together with corresponding labels, for electric appliances, namely, refrigerators, air conditioners, electric water heaters, and washing machines).	Develop and issue standards, together with corresponding labels, for electric appliances, such as irons, kettles, kitchen machines, video-audio equipment,… etc.	MoEE, MoTI(*), Private Sector	25 M EUR	10
6	Expand the Use of Efficient Lighting Systems (Egyptian Efficient Lighting Initiative – EELI).	Program for transforming lighting market towards Compact Fluorescent Lamps (CFL), targeting utilization of additional 80 million lamps during the period 2010 – 2020. Safe Disposal of burnt lamps should be taken into consideration. Expected reduction of GHG emissions is about 4.0 Mt CO2eq by the year 2020. Expected saving is about 1.5 Mtoe.	MoEE, EEHC and affiliate Electricity Distribution Companies, Private Sector	25 M EUR	10
7	Waste Heat Recovery Systems	Wide range of sizes from <25 MW to 300 MW. Water temperature above 60°C to 82°C (140°F to 180°F) is required for domestic applications. Some equipment acts as a silencer to replace or supplement noise reduction equipment needed to meet noise requirements. Waste heat recovery is used extensively at industrial facilities around the world. Represents an opportunity for a relatively low-cost increase in power capacity.	MoEE, EEHC, MoTI	Installation costs can be $1000/kW (for industrial systems).	10
8	Energy Management Systems (EMS)	Relevant for all sizes of systems. May be used with existing or applied to new systems. EMS is typically applied to the largest electrical loads, including HVAC equipment, cooling towers, pumps, water heaters and lighting. Control functions may include basic stop/start functions or more complex chiller optimization routines. Energy management systems have been implemented successfully in several countries including the United States, Argentina, Colombia, Portugal, Germany and more. Site-specific analyses must be conducted to determine the benefit of installing energy management systems. Systems work with distributed and direct networks.	MoEE, EEHC, MoTI	$ 100 Million (Energy savings of about 10% is typically achieved, although exact costs and savings are site-specific). (Typical cost of an energy system in a manufacturing plant with a load of 100 million kWh/year is about $ 750,000)	10

(*) MoT I = Ministry of Trade & Industry.

Table 2-7-1-4 Innovative Technologies for 2020 and beyond (NEDDS's ENERGY SECTOR Mitigation Priority Technology Options)

No.	Program	Activities	Responsible Entities	Required Finance	Time Duration (Years)
1	Grid-connected PV	Implement a series of Grid-connected PV power generating plants. Modules range from a few watts to multi-MW. For power generation, modules can be combined to produce 5-25 MW or larger. First pilot project may include two batches of grid-connected PV with capacity 25 MW each or more.	MoEE, NREA, Private Sector	Cost is about $ 1,000/kW by 2015 and as low as $ 700-800/kW by 2020-2030	10
2	Clean Oil Shale Technology- Fluidized Bed Combustion	Construct and operate a series of power plants utilizing clean Oil Shale fluidized bed combustion technology. Oil sale exists in Egypt within phosphate formations in plentiful quantities. Capacity ranges between 10 to 100 MW equivalents for industrial boilers and 75 to 325 MW for electric utility applications. First Pilot Project will include 325 MW thermal power generating unit by 2020.	MoEE, EEHC, Private Sector	AFBC(1) (200 MW): $1,500-2,000/kW PFBC(2) (commercial): $1,000-1,5000/kW	10
3	Use of Fuel-cell Power Generating Modules	Introduce fuel-cell power generation for distributed applications in industry and electricity sectors. Introduce fuel-cell grid-connected power generating modules. Pilot applications may be within the range of 100-500 MW up to 2020.	MoEE, EEHC, MoTI Private Sector	$ 1,700 – 1,200/kW by 2020	10
4	CO2 Capture & Storage (CCS)	Implement a series of projects using Carbon Capture and Storage (CCS) technique, capturing CO2 emitted from power plants for Enhanced Oil Recovery (EOR) in stranded oil and gas wells. Size will vary according to underground formations and distance between the power plant and stranded oil/gas wells. Potential storage of 6 million tons CO2 in the Suez Gulf area as "First Phase" application. First Pilot Project Will capture and store 3 million tons CO2 in the Suez Gulf area to be operational by 2020.	MoP(1), MoEE, MoSfEA(2), Private Sector	$ 60-80/tCO2 is expected to lower within 5-7 years to about $ 25/tCO2	10

(1) AFBC = Atmospheric Fluidized Bed Combustion.

(2) PFBC = Pressurized Fluidized Bed Combustion.

Table 2-7-1-5 Support Capacity and Institutional Building (NEDDS's ENERGY SECTOR Mitigation Priority Technology Options)

No.	Program	Activities	Responsible Entities	Required Finance	Time Duration (Years)
1	Instituting Customer- focused Educational and Informational Programs	Can be tailored to any situation or sector. Can include training, public information programs, creation of school, home, utility partnerships and more. Benefits lie in the avoided supply costs.	MoEE, MoP, MoM(1), MoSfEA, ESCOs(2) Private Sector	Lump Sum of US$ 50 Million	10
2	Supporting GHG Mitigation Research in Energy Sector	Collaborative research and related implementing agreements will be initiated between Egypt and Annex I countries.	MoEE, MoP, MoSRT(3), MoSfEA Private Sector	US$ 100 Million	10
3	Increasing Senior and Mid-level Management Performance and Efficiency	Applicable to all power plants, regardless of type or size. Requires both the tools (software and equipment) and training to use the tools effectively. Relative small capital expenditures are required to obtain the tools and training; large expenditures are required for equipment replacement. However, over time, these costs will be more than offset by improved plant performance.	MoEE, EEHC	Initial cost US$ 10 Million	10
4	Demand-side Management (DSM) Regulations and Incentives	DSM programs can be developed and implemented within a relatively short time period-a few years, at most. In the short-term, DSM is the only policy that can have a significant impact on reducing electricity consumption. DSM benefits end-users through cost savings as well as through improved environmental quality, economic competitiveness and energy security. May avoid or delay the need to construct additional capacity. These actions are dependent on the mix of fuels/technologies used to generate the electricity being displaced; a more precise estimate of carbon emissions reduced/avoided requires site-specific details.	MoEE, EEHC, MoSfEA, MoTI	Initial cost US$ 10 Million	10
5	Energy Efficiency Regulation and Incentives	May offer rebates, tax credits or involve setting standards. For example, could involve setting target level for emissions or fuel consumption, and charge consumers a variable fee when actual consumption is worse than the target level, and granting consumers variable (sliding-scale) rebates for those who do better than the target. Costs may be incurred; for instance, through foregone tax revenue for rebates. Some policies may be revenue-neutral-if fees are charged for non-compliance, these funds can be directed to pay for any rebates. As manufacturers or federal policies improve efficiency levels, targets can be adjusted to maintain a revenue-neutral program. Administrative changes can be made to make policies revenue-generating.	MoEE, EEHC, MoSfEA, MoTI	Initial cost US$ 10 Million	10

(1) MoM = Ministry of Media.
(2) ESCOs = Energy Services Companies.
(3) MoSRT = Ministry of Scientific Research and Technology.

2－7－2 Environmental Regulations

Main Environmental laws in Egypt are Law 4/ 1994 (Environment Law) amended by Law 9 /2009 and law 105/2015, Natural Protectorates Law Number 102/1983, Public Cleanliness Law Number 38/1967, Protection of Nile River Water Law 48/1982, Industrial Wastewater Disposal Law 93/1962, Traffic Law Number 121/2008, Labor Law Number 137/1981 Modified by Decision 12/2003 (Unified Labor Law), Renewable Energy Production Motivation Laws 203/2014, Expropriation of Properties for Public Benefit Law 10/1990, Rental and Sales of Premises Law 49/1977, etc. EIA procedures are explained by Guidelines of Principles and Procedures for Environmental Impact Assessment, Egyptian Environmental Affairs Agency (EEAA), 2nd Edition, January 2009.

The table below summarizes the legal articles applicable to power plants. Legal requirements under the provisions of these articles are discussed in the same section. Corresponding enforcement agencies and penalties on violations are also highlighted.

Table 2-7-2-1 Legal Framework for Power Plants

Issue	Law Addressing Issue	Applicable Articles to Power Plant	Relevant Executive Regulations (ER)	Formats, Standards and/or Specifications
Land Pollution	Law 4/ 1994 (Environment Law) amended by Law 9 /2009 and law 105/2015	Articles 19, 20, 21 and 23 on the preparation of EIA. Articles 22, 23 on the upkeep of Environmental Register.	Articles 10, 11 on the preparation of EIA. Articles 17, 18 on the upkeep of Environmental Register.	
	Law 38/ 1967 (General Public Cleaning Law) amended by Law 31/1976.			
	Traffic Law 121/2008	Article 72 on the disposal of polluting items by vehicle drivers.		
Air Pollution	Law 4/ 1994 (Environment Law) amended by Law 9 /2009 and law 105/2015	Articles 34, 35, 36, 37, 38, 39, 40, 42, 43, 47 on project site, permissible air pollution loads, use of machinery and vehicles, incineration and waste disposal, air emissions during construction, noise, and indoor air quality.	Article 42 on overall permissible air pollution loads.	Annex 5: Maximum Limits of Outdoor Air Pollutants Annex 6: Maximum Permissible Limits for air pollutants from different sources. Annex 6 bis 1: Continuous Emissions Monitoring Procedures from Facility Stacks (Decree 1095/2011)
Coal Import, Handling and Use	Law 4/ 1994 (Environment Law) amended by Law 9 /2009 and law 105/2015	Article 40 bis (added by amendment 105/2015) prohibit importing, handling or use of coal or petroleum coke without obtaining a permit from the EEAA.		Annex 12: includes the regulations for importing, handling and use of coal and petroleum coke by different facilities (added by ER amendment Decree 964/2015 with parts updated by ER amendment 618/2017)
Occupational Health and Safety	Law 4/ 1994 (Environment Law) amended by Law 9 /2009 and law 105/2015	Article 44 on temperature and humidity.	Article 46 on temperature and humidity.	Annex 7: Permissible Limits of Sound Intensity and Safe Exposure Times according to the amendment decree 710/2012 Annex 8: Maximum Permissible Limits for Pollutants inside the Work Environment. Annex 8, Table 4: Amounts of Air Required to Ventilate Public Places. Annex 9: Maximum and Minimum Limits for Temperature and Humidity. Annex 11: Municipal Solid Waste
	Law 137/1981 (Labor Law) modified by decision 12 in the year 2003			
Water Pollution	Law 4/ 1994 (Environment Law) amended by Law 9 /2009 and law 105/2015	Articles 69, 70, 71 and 72 concerning the disposal of any objects, waste, or untreated liquid in water.		Annex 1: Specifications regarding the disposal of Liquid waste in the water environment. Annex 10: Contaminating non- biodegradable material that the industrial facilities are

Issue	Law Addressing Issue	Applicable Articles to Power Plant	Relevant Executive Regulations (ER)	Formats, Standards and/or Specifications
				prohibited from disposing into the water environment.
	Law 48/1982 (Pollution protection of the River Nile and water ways)	Articles 1, 2, 3, 4, 6, 9 and 16: defining waterways, the control of effluent wastewater, licensing bodies and sanctions	Article 2, 6, 9, 10, 13, 15 and 16 for discharge on water ways Article 16, 17, 19, 20, 22 and 26 regarding licensing and monitoring of water quality.	Section 6, Article 49 detailing the quality of water ways where effluents are discharged article 50 concerning the quality of wastewater discharged to the River Nile and its branches
	Law 93/1962 (disposal of industrial waste water)			
Hazardous Waste	Law 4/ 1994 (Environment Law) amended by Law 9 /2009.	Articles 29, 30, 31, 33: Hazardous waste generation, collection, storage, transportation, and circulation.	Article 28: Hazardous waste generation, collection, storage, and transportation.	
Penalties	Law 4/ 1994 (Environment Law) amended by Law 9 /2009.	Articles 84 to 101: Sanctions mentioned regarding the violations of the provisions of the different articles of the law.		

(1) Environment Law Number 4/1994 amended by law 9/2009

Law Number 4 for the year 1994 on the Environment consists of Introductory chapter (Articles 1-18), Protection of land from pollution chapter (Articles 19 - 33), Protection of air from pollution chapter (Articles 34 - 47), Protection of water from pollution chapter (Articles 48 - 83), Penalties chapter (Articles 84 - 101), and Final provisions (Articles 102 - 104). Additionally, amendments of the law issued in 2009 and to the executive regulations issued in 2011 by the ministerial decree No. 1095, then decree 710/2012 and 964/2015.

1) Regulations for the Protection of Land Environment from Pollution

Environmental Law stipulates EIA and Environmental Register. The following sections explain the procedures. Strategic Environmental Assessment is not clearly mentioned in Law 4/1994 but a part of the law is interpreted as suggesting SEA.

a) Environmental Impact Assessment (EIA)

According to the provisions of Articles 19 through 21 and 23 from Law 4/1994 and Articles 10 through 16 in its Executive Regulations, the owner of the power plant must submit an EIA to the competent administrative authority or licensing authority in order to receive licensing for power plants. Power plants using natural gas as the primary fuel, and as such it is classified as “(C) listed project” according to the guidelines issued by the EEAA regarding the preparation of EIA studies. Therefore, the developer shall perform a complete Environmental Impact Assessment. The following procedures will be followed:

1. The developer should conduct a scoping meeting with the listed stakeholders by the EEAA to discuss the project objectives. A public consultation will be then held to present the environmental impact of power plants and the adopted mitigation processes.
2. The developer applies to the Competent Administrative Authority (CAA) or licensing authority a letter of intent to undertake a certain specific project which is classified as "(C) listed project". The developer attaches three hard copies and one soft copy of the full EIA study on the project in accordance with EEAA guidelines.
3. CAA registers the documents and checks whether the selected category is correct and whether the information included in the EIA study complies with the required information according to EEAA guidelines concerning the sector.
4. CAA checks the documents and formally submits applicant's documents to the EEAA for review and evaluation.
5. EEAA evaluates the documents and submits to the CAA its opinion and possible proposals for measures to be taken in order to ensure the protection of the environment within 30 days of the EEAA's receivable of the completed

documents. Failure to do so shall be considered as an approval of the assessment.

6. EEAA registers the documents, opinion and proposals in the EIA register at the EEAA.
7. CAA officially notifies the developer by registered letter with an acknowledgment of receipt of the final result of the evaluation.

b) Environmental Register

In accordance with Articles 22 and 23 in Law 4/1994 amended by law 9/2009, the developer of the power plants shall keep a written record of the environmental impact of power plants (the Environmental Register) in the standard form given in Annex 3 of Law 4/1994 amended by law 9/2009 and as stipulated in Articles 17 and 18 of the executive regulations. These articles outline regulations governing the upkeep of the Environmental Register as well as the time frame of the establishment obligation to keep it, and the data to be entered therein.

Table 2-7-2-2 List of data required for the Environmental Register as per Law 4/1994

- ■ Emissions and/or discharges from the establishment and respective loads
- ■ Specification of wastewater discharges to the public sewage network;
- ■ Environmental self-monitoring and safety procedures followed by the establishment
- ■ Regular tests and measurements, number of samples, frequency and location of sampling, measurements, results and recommendations.
- ■ Assigning person responsible for reviewing and following-up

2) Strategic Environmental Assessment

Strategic Environmental Assessment is implied in article 19 of Law 4/1994. Guidelines of Principles and Procedures for Environmental Impact Assessment 2nd Edition (2009) use the word “Integrated EIA” in Section 5.2 for Strategic and Regional EIA. Integrated EIA is applied for the group of projects in the same area, such as industrial parks. The procedures of the Integrated EIA are the same as EIA.

3) Regulation for the Protection of Air Environment from Pollution

According to the provisions of Articles 34 through 40, 42, 43, and 47 bis in Law 4/1994 amended by Law 9/2009, and Article 42, annex 5,6 in the Executive Regulations, the developer must ensure the following:

The site of the project must be selected properly in order to ensure that during the construction and operation phases of power plants, the emissions in the area (including power plants) will not result in exceeding the maximum permissible limits for the pollutants in the ambient air as listed below:

Table 2-7-2-3 Maximum Limits of Outdoor Air Pollutants (Annex 5 of the Executive Regulations amended in 2012)

Pollutant	Location Area	Maximum Limit [μg/m³]			
		1hour	8hours	24hours	1Year
Sulphur Dioxide	Urban Industrial	300 350		125 150	50 60
Carbon Monoxide	Urban Industrial	30 mg/m³	10 mg/m³	- -	- -
Nitrogen Dioxide	Urban Industrial	300 300	- -	150 150	60 80
Ozone	Urban Industrial	180 180	120 120	- -	- -
Total Suspended Particles (TSP)	Urban Industrial	- -	- -	230 230	125 125
Particulate Matter less than 10 μm (PM_{10})	Urban Industrial	- -	- -	150 150	70 70
Particulate Matter less than 25 μm ($PM_{2.5}$)	Urban Industrial	- -	- -	80 80	50 50
Suspended Particles Measured as Black Smokes	Urban Industrial	- -	- -	150 150	60 60
Lead	Urban Industrial	- -	- -	- -	0.5 1.0
Ammonia (NH_3)	Urban Industrial	- -	- -	120 120	- -

4) Regulations for Precautions, Permissible Limits and Stacks Specifications while Burning any Type of Fuel

All of smoke, gases, and fumes resulting from burning any fuel type whether for industrial use, power generation, construction or any other commercial purpose, should be within the permissible limits. The person in charge of this activity should take all precautions in order to decrease the amount of pollutants in the mentioned combustion products.

First: The precautions that should be taken to decrease the amount of pollutants in the combustion products to prevent or decrease the emissions of the pollutants from the fuel burning source. Suitable fuel should be chosen and the correct burner enclosure design should be applied. Also correct and efficient control methods should be applied according to the following standards:

- ✓ Open burning which does not follow the appropriate design to ensure full burning is prohibited, and the exhaust must be discharged through stacks according to the standard engineering specifications.
- ✓ The burner enclosure is designed to ensure full mixing of the amount of air needed for complete combustion, good temperature distribution, sufficient time and sufficient stirring that ensures complete combustion, in order to minimize incomplete combustion emissions and to ensure that the amount of pollutants emitted does not exceed the maximum allowable limits.
- ✓ Coal usage in the residential areas or with a distance less than the legally stated distance is prohibited.
- ✓ Use of heavy fuel oil, other heavy petroleum products, crude oil, and waste oil from industrial operations, equipment, and workshops is prohibited in residential areas.

- ✓ Sulfur content in used fuel should not exceed 1.5%, when used in residential areas or at a distance less than legally stated.
- ✓ Gases containing sulfur dioxide must be emitted through sufficiently elevated stacks according to the specified heights so as not to exceed the maximum limits.
- ✓ Facilities that will be built or equipment that will be developed after this executive regulation must use burners with standard specifications in order to decrease nitrogen oxide emissions so that it does not exceed the maximum limits.

Second: Stack Height

- ✓ Stacks with total emissions of waste between 7000-15000 kg/hr. should have a height between 18-36 meters.
- ✓ Stacks with total emissions of more than 15000 kg/hr. should have a height more than 2.5 times, at least, the surrounding buildings' height including the building which the stack is serving.

5) Permissible Limits of Air Pollutants in Emissions

Air pollutants in this context are gaseous, solid, and liquid pollutants or pollutants in a vapor state emitted by stacks of industrial establishments, hospital incinerators, machines, engines and fuel combustion within given periods of time that are likely to have an adverse impact on public health, animals, plants, material, or property, or to interfere with peoples' daily activities. Accordingly, if the emission of these pollutants results in the presence of concentrations thereof in excess of the maximum permissible limits for outdoor air, they shall be considered air pollutants.

It should be noted that as per Annex 6 of the executive regulations; the actual pollutant concentration from the stack is calculated at standard conditions using the following equation;

$$\text{Concentration at Standard Conditions} = \text{Measured Concentration} * \frac{(21 - \text{Reference Oxygen \%})}{(21 - \text{Measured Oxygen\%})} * \frac{\text{Measured Tempreture} + 273}{273} * \frac{1}{\text{Measured Atmospheric Pressure}}$$

Table 2-7-2-4 Maximum permissible limits for air pollutants from Energy production facilities and boilers (Annex 6 of the Executive Regulations amended by decree 964/2015)

Type of Fuel		Maximum limits of emissions (mg/m^3)					
		Total Particulate Matter	**Carbon Monoxide**	**Sulfur Dioxide**	**Nitrogen Oxide**	**Lead (in solid Particles)**	**Mercury Vapor**
Natural Gas		50	100	150	500		
Coke gas and treatment gases		100	300	350	500		
Diesel		100	250	1300	500		
Heavy Fuel Oil (HFO)		100	250	1500	500	2	1
Coal	**Less than 600 MW**	50	250	From 450(*)- to 1300	From 200(*)- to 500	2	1
	More than 600 MW			From 450(*)- to 850			
Agricultural Waste		50	250	100	500		

- Reference Conditions: (Oxygen Percentage of 4% in the case of steam boilers, 15% in the case of gas turbines, and 6% in the case of using coal and agricultural waste. Temperature of 273 Kelvin and Pressure of 1 atm.)
- The total amount of heavy elements in the emissions should not exceed 5 mg/ m3.
- In the case of using any solid waste that is not mentioned in the table for power generation, care should be taken that the dioxin and furan concentration should not exceed 0.1 ng/ m3.

(*) The lower limit is applied to environmentally sensitive areas

6) Standards and Regulations for the handling and use of coal or pet coke

The standards and regulations of handling and use of coal and pet coke are set in Annex 12 of the executive regulations amended by decree 964/2015, which includes electricity production facilities as one of the facilities authorized to use coal or pet coke.

These executive regulations state that the coal using facilities are responsible for coal shipments starting from the shipment release from the port until it reaches the facility, including the handling, transportation, use and disposal of waste.

a) Annex 12 First: General Provisions for coal handling and use

1. Any facility handling or using coal should submit an EIA in accordance with the provisions of law 4/1994, and is prohibited to operate without EEAA approval on the submitted study.

2. License to import, handle or use coal should be obtained from the relevant Ministry or Authority after obtaining EEAA approval. This approval is renewed every 2 years. (Amendment 618/2017 added) EEAA has the right to cancel or temporarily suspended a coal import, handling or use approval in the case that the facility does not abide by the conditions mentioned in the approval

3. If the implementation differs from the EIA, a Compliance Action Plan should be submitted, and in the case of the EEAA approving it,

the plan will be implemented based on the pollution emission levels indicators and environmental quality.

4. For coal imports, handling or use approval renewal, an annual environmental performance report should be submitted in accordance to the guidelines issued by the Head of EEAA after the approval of the management board.
5. The environmental minister shall issue a decree with the formation of a committee from professionals, governmental entities concerned and civil society members to carryout surveys and reports regarding coal use and give recommendations to EEAA regarding permit renewal.
6. All facilities handling or using coal should follow the maximum allowable limits of ambient air quality, work environment and water quality as stated in the relevant laws
7. Facilities permitted to handle or use coal are liable to any environmental damage that could occur due to negligence to follow the provisions of these Executive Regulations and other relevant laws
8. Annual environmental performance report should include a section regarding the environmental performance of coal imports, transportation and usage activities.

7) Annex 12: Third: Standards and Regulations regarding the use of coal or pet coke

1. Coal amounts: Annual required coal amounts are determined based on the amount of energy required to produce a unit of the product according to table (3) of Annex 12.
2. Location: Use of coal for industrial or energy production purposes is prohibited in any residential area, while it is permissible, for the sake of necessity and public benefit, to exclude the existing facilities before the issuing of this law based upon the approval of the EIA by the Ministerial Cabinet.
3. Importing: Coal using facilities are permitted, after obtaining necessary environmental approval, to import packed coal until the time that the preparations for transpiration, unloading and storage are completed.
4. Handling: Facilities using coal are prohibited to sell or give any amount of coal to any other entity that does not has a coal usage permit, in the case of violation, the EEAA has the right to inform the permitting bodies to stop the facility’s operation until it is reviewed by the environmental performance monitoring committee.

5. Exchange: Facilities that acquired permits to use coal are allowed to exchange any amount of coal between themselves after the approval of the EEAA and notification of the permit issuing authority
6. Environmental Impact Assessment: Facilities which intend to use coal must, before the beginning of operations, submit an EIA for the storage and use of coal, including the Air Dispersion Model results approved by the EEAA.
7. Global Warming: Facilities using coal must limit the increase in greenhouse gasses (GHG) emissions resulting from the burning of coal, and should state the exact procedures that will be followed to deal with GHG emissions as part of the EIA study and environmental performance reports.
8. Continuous Monitoring Plan: Facilities permitted to use coal are committed to implement a continuous Monitoring Plan based on what the EEAA determines based on the multilateral agreements related to climate change.
9. Conditions for Storage inside the facilities:

a. Maximum permissible pile height is 9m for compressed piles and 5 m for uncompressed piles above ground level.
b. A water sprinkling system should be installed above the coal piles to prevent coal dust emissions and to guarantee that humidity of the coal piles is about 10%: 15% and the storage area floor should be leak proof with a system for water collection.
c. Fence Monitoring Equipment should be installed at the facility fence in the downwind direction and connected to the national pollution monitoring grid.
d. CO sensors have to be installed in the unloading area, automatic transfer locations and storage areas for early detection of self-ignition.
e. Infrared cameras can be used to early detect hot spots inside the piles
f. Facility roads and floors should be regularly cleared of coal dust, and adequate space for vehicles movement should be ensured.
g. The storage location cannot be used for any other purposes.

8) Types of coal permissible

The different types of coal permitted to be used are stated in Table (1) of Annex 12 of the Executive Regulations amended by decree 964 for the year 2015 and are as follows:

Coal: According to the ASTM D121 standard accredited by the Egyptian Organization for Standardization (EOS) the types of coal are as follows:

Table 2-7-2-5 Types of coal permissible for use (Table (1) of Annex (12) of the ER amended by decree 964/2015)

Class/Group	Fixed Carbon Limits (Dry, Mineral-Matter-Free Basis), %		Volatile Matter Limits (Dry, Mineral-Matter-Free Basis), %		Gross Calorific Value Limits (Moist, Mineral-Matter-Free Basis) MJ/kg	
	Equal or Greater Than	**Less Than**	**Greater Than**	**Equal or Less Than**	**Equal or Greater Than**	**Less Than**
Anthracitic						
Meta-anthracite	98	--	--	2	--	--
Anthracite	92	98	2	8	--	--
Semi anthracite	86	92	8	14	--	--
Bituminous:						
Low volatile bituminous coal	78	86	14	22	--	--
Medium volatile bituminous coal	69	78	22	31	32557	--
High volatile A bituminous coal	--	69	31	--	30232	32557
High volatile B bituminous coal	--	--	--	--	26743	30232
High volatile C bituminous coal	--	--	--	--	24418	26743

Petroleum Coke: Volatile matter content (10%:12%) and a Net Calorific Value of about 31500 MJ/kg, with sulphur content of less than 8%.

9) Regulations and standards regarding the use of coal or pet coke in electricity production

Table (3) of Annex 12 details the standards and regulations regarding the use of coal or pet coke in electricity production plants after the issuing of these executive regulations as follows:

Table 2-7-2-6 Standards and regulations regarding the use of coal or pet coke in electricity production plants (Table (3) of Annex (12) of the ER amended by decree 964/2015)

Location Specifications and Standards	1. To be outside the valley area and the Red Sea and Mediterranean Sea coasts 2. Takes into consideration environmentally sensitive areas (natural protectorates, coral reefs, mangroves… etc.) also activities and tourist locations during the choice of location, in the case of disagreement during the choice of plant location, the issue will be presented to the Prime Minster for a final decision. 3. Use of air dispersion model to specify the areas affected by the gaseous emissions, taking into consideration the targeted production capacity at the project completion including future expansions 4. Adequacy of the location and its characteristics with the facility's proposal regarding the disposal of fly ash produced from the burning of coal as it contains heavy metals
Coal Amounts	Annual permissible amount of coal is determined on the basis of an efficiency of more than 40%, regarding that the coal use rate does not exceed 340 – 380 gram/kWh using a super critical boiler
Loading and unloading	Coal used in electricity production should be received at a dock that belongs to the plant, taking into consideration the unloading from ships regulations stated in Annex 12.
Handling and storage	1. All loading, unloading and handling operations are done automatically using tight equipment (conveyors, hopper,). 2. Coal to be stored inside semi-spherical storage areas, taking into consideration proper ventilation to reduce the concentration of emitted gases such as methane, or carbon monoxide.
Coal grinding	1. Coal grinding and sieving should be done in closed areas according to the Best Available Techniques (BAT) for pollution prevention (for example: using bag filters) and special fire proof equipment (ATEX approved). 2. Storage of ground coal in silos equipped with CO monitoring equipment inside the silo.
Coal feeding to boiler	Coal feeding to the burner should be conducted using a pneumatic transport system.
Stack emissions	Limits set by Table (1) of Annex (6) regarding electricity production units and boilers.
Solid Waste Disposal	➢ Fly ash: - The facility should determine, as part of the EIA study, all the technical methods for the disposal of fly ash produced during coal burning operations like reuse, recycling or export. - Sanitary landfilling for residual coal amounts can be used after obtaining the approval of the EEAA. ➢ Any produced gypsum is considered as non-hazardous solid waste: and is disposed of according to the provisions of the environmental law

10) Other regulations of Environment Law

In addition to the above, as the environmental standards related to the power sector in power plants etc., the following are set in relation to the environmental law and other laws.

・Discharge in Aquatic Environment
・Hazardous Waste
・Noise
・Provisions for the Occupational Health and Safety of Employees

(2) Other laws

In addition to the above regulations and standards, the following law has rules that may be related to power plant construction etc. An outline of each regulation standard is described in Appendix 2.

・Natural Protectorates Law Number 102/1983
・Protection of Nile River Water Law 48/1982
・Industrial Wastewater Disposal Law 93/1962
・Fishing and Aquatic Life Law 124/1983
・Public Cleanliness Law 38/1967

Traffic Law 121/2008

· Labor Law 137/1981 Modified by Decision 12/2003 (Unified Labor Law)

- Renewable Energy Production Motivation Law 203/2014
- Expropriation of properties for Public Benefit Law 10/1990
- Rental and Sales of Premises Law 49/1977

2－7－3 Management rules of fly ash after installing coal thermal power plants

Management of fly ash is stipulated under Environment Law (4/1994), because fly ash is categorized as nonhazardous solid industrial waste. Annex 12 of the Environment Regulation amended by decree 964/2015 concerning the use of coal or pet coke in electricity production plants mentions that "the coal using facilities are responsible for coal shipments starting from the shipment release from the port until it reaches the facility, including the handling, transportation, usage and disposal of waste" and the following are the statements regarding solid waste disposal.

- The facility should determine, as part of the EIA study, all the technical methods for the disposal of fly ash produced during the coal burning operation, like reuse, recycling or export.
- Sanitary landfilling for residual coal amounts can be used after obtaining the approval of the EEAA.
- Any produced gypsum is considered as non-hazardous solid waste: and is disposed of according to the provisions of the environmental law

The study team received the following information on environmental regulation concerning coal fired thermal power station installation from EEHC person in charge of coal;

- Basically fly ash is planned to be reused in the cement industry, however ash ponds will be set within the plant as a backup measure.
- Each power plant is regulated by the law of the year of its commissioning date.
- EP, FGD, and wastewater treatment facilities will be installed. In addition, measurement to prevent scattering of coal dust, as well as to prevent the spontaneous combustion of coal is necessary because Hamrawein is a resort area. However, as Egypt has no knowledge on handling coal, there are some concerns such as that mill will be choked because of wet coal particles as a result of water sprinklers to avoid spontaneous combustion.
- Exhausted gas and wastewater shall be monitored by continuous monitors installed within the plant. In addition, EEAA shall conduct periodic on-the-spot inspections and sample tests without prior notice, and if violations are found, the license for operating power plants will be expired. All the power plants should have this license, and none of them have ever expired so far.
- At the Hamrawein site, wind blows from the north-west to south-east, so there may be little influence of exhausted gas domestically.

As described in 2-3-2(2), Several Japanese corporations are now preparing for EEHC owned coal fired thermal power plant projects. The study team interviewed one of such companies and received the following information on environmental regulations concerning coal fired thermal power station installation.

- On entering the bid, EEHC instructs that bidders shall obey the environmental regulations which are uploaded to the EEAA homepage. (Concerning the regulation, please see 2-7-2.) This regulation seems to be established based on European laws, and some of it includes stricter regulations than Japanese law, such as the requirement of installing a roof over coal yards to prevent the scattering of coal dust.
- As there is little need for fly ash in the Egyptian cement industry, installation of ash ponds shall be indispensable, however, there are no regulations concerning ash ponds.

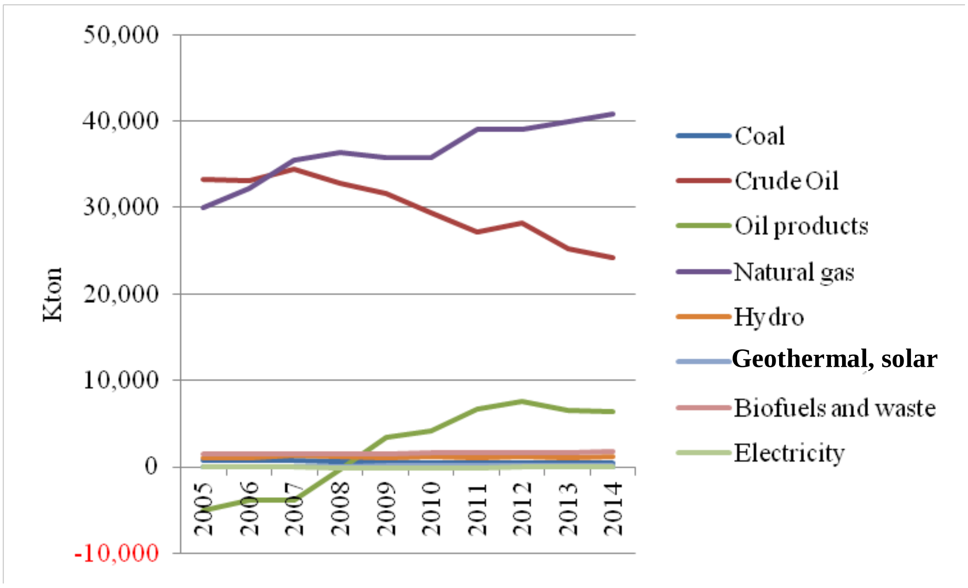
2－8 Energy Efficiency

2－8－1 Present Situation of Energy Consumption

(1) Energy Consumption Data

1) Consideration of primary energy and end use demand

The primary energy situation in Egypt is as shown below. The majority of primary energy depends on natural gas resources, followed by crude oil. It has been changing in the past decade and peaked in 2012.

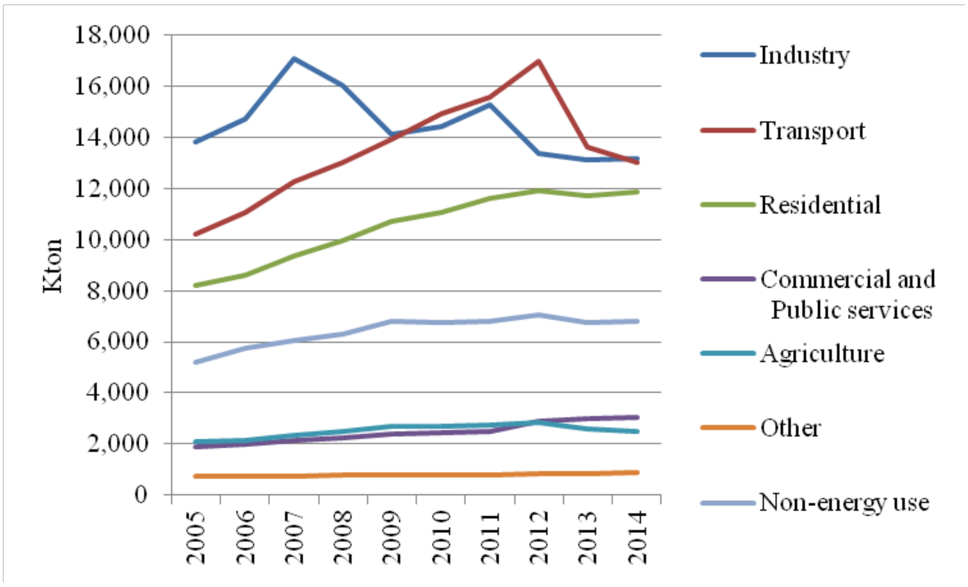


Source; IEA Website

Figure 2-8-1-1 Trend in Primary Energy Consumption

2) Trend of Energy Consumption by Sector

Around 75% of total consumption is covered by transportation, industrial use and residential use, the same trend as those in MENA countries where the political and economic situation are relatively stable.



Source: IEA Website

Figure 2-8-1-2 Trend in final energy consumption

3) Energy consumption data collected by EEHC and application
   - ✓ EEHC has measured power consumption of 3,032 customers in order to create a mid and long term power supply plan.
   - ✓ EEHC revises the data collection system and for operation in the future. However, the concerned section in EEHC currently doesn't have a concrete outlook for these installments.

4) Measures for more efficient use of energy in consideration by EEHC and distribution companies
   - ✓ There is an idea to promote a cogeneration system in industrial facilities with the utilization of both heat and power for improving energy efficiency.

(2) Energy audits on large customers

1) Objective of the energy audits

The objective is to analyze the consumption data for energy loss reduction while maintaining a testable supply as well as Demand Response analysis to help develop the potential of the power sector.

2) Selection of customers for the audits

The local consultant, Shaker Consultancy Company, selected candidate customers, considering the feasibility of the measurements, realization of good communication with the customers, and relatively large scale etc. The customers should be from three categories, industrial, commercial and residential sectors. Shaker chose three customers from each sector, meeting these requirements. The measurement duration is for two weeks at minimum. Although it is better to conduct longer time measurement like one year to grasp the whole picture of the customer use, two weeks was set to at least realize a similar understanding of customer use as EMS could be applied and worked well in future. .

3) Test Trial Measurement

a) Date

12:00-15:00 24th January, 2017

4) Venue

Ceramica Granito (Sadat City 259 pieces - the fifth industrial zone)

5) Overall Description

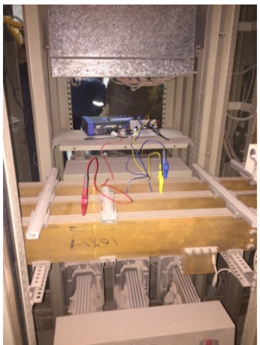
- ✓ Ceramica Granito, the test trial measurement site, produces 50,000 sqm of ceramic tiles per day. The company started 60 years ago with only an area of 30,000 sqm and is currently undergoing renovation. Shaker, the company which introduced the company, is in charge of design supervision of electrical equipment replacement as part of the renovation.
- ✓ Their process is as follows: material receiving, mixing (temperature of up to a maximum of 80℃), injection, molding, baking, painting, printing, heating in the furnace (temperature of up to maximum of 1200℃ depending on the material), testing and shipping.
- ✓ It operates, 24 hours a day; except during annual maintenance which can take 0-2 hours/day.
- ✓ Primary energy resource for the thermal furnace is LNG and the remainder is electric power, with the received power being 6MW and houses four electrical transformers. There are nine production lines at this factory, but they are separated by extension lines due to the difference in production line, of which 3 main transformers receive approximately 5MW at peak time.

6) Test Trial Measurement

- ✓ We, the survey team, Shaker and the customer decided the three energized point in electrical panels as measuring points. For safety reasons, we connected the wires to the measuring equipment (CT) and to a meter located in front of the panel, after checking all the situations for measuring.
- ✓ We successfully conducted the trial measurements and decided to start the measurement from 2nd February.
- ✓ We confirmed that Shaker will check for any trouble with the equipment every three days.

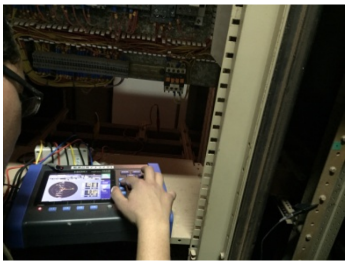
7) Other

- ✓ We agreed that the customer will offer annual energy related data.



Electrical Panel (Testing at the first location)

Voltage measurement



Equipment setting

Source: Study team

Figure 2-8-1-3 Test Trial Measurements in Ceramic Factory

(3) Energy Audit Report on Large Scale Demand Customers

1) Ceramica Granito (industrial customer)

a) Data collection date

2 February, 2017 ~ 16 February, 2017

2) Situation of overall energy consumption

- ✓ Two energy resources, LNG for furnaces and electric power for equipment, are used in this factory.
- ✓ The customer possess an annual report on energy consumption which the survey team could grasp the overall energy consumption trend as shown in Table 2-8-1-1 and 2-8-1-2, as well as Figure 2-8-1-4.

Table 2-8-1-1 Power Consumption at the factory

Time	Feeder 11	Feeder 9	Fixed Cost	Total ENERGY Feeder 9+Feeder 11	Power Primary Energy
	kWh	kWh	EGP	kWh	GJ
June-16	3,776,000	629,000	178,500	4,405,000	44,050
May-16	3,111,000	350,000	170,700	3,461,000	34,610
April-16	2,877,000	647,000	170,700	3,524,000	35,240
March-16	3,540,000	592,000	170,700	4,132,000	41,320
February-16	3,263,000	583,000	170,700	3,846,000	38,460
January-16	3,587,000	616,000	170,700	4,203,000	42,030
December-15	3,697,000	654,000	171,900	4,351,000	43,510
November-15	3,370,000	634,000	171,900	4,004,000	40,040
October-15	3,375,000	479,000	170,700	3,854,000	38,540
September-15	3,164,000	488,000	170,700	3,652,000	36,520
August-15	3,666,000	564,000	170,700	4,230,000	42,300
July-15	3,227,000	561,000	170,700	3,788,000	37,880
					474,500
					20%

Table 2-8-1-2 LNG Consumption and Primary Energy Consumption

Time	LNG for 1st half	LNG for 2nd half	LNG Total	LNG Primary Energy	TOTAL Primary Energy
	m3	m3	m3	GJ	GJ
June-16	1,638,236	1,664,715	3,302,951	147,821	191,871
May-16	1,726,067	1,756,769	3,482,836	155,871	190,481
April-16	1,647,111	1,692,642	3,339,753	149,468	184,708
March-16	1,670,132	1,801,638	3,471,770	155,376	196,696
February-16	1,651,496	1,554,762	3,206,258	143,493	181,953
January-16	1,539,122	1,869,527	3,408,649	152,551	194,581
December-15	1,752,050	2,068,881	3,820,931	171,002	214,512
November-15	1,771,982	1,799,709	3,571,691	159,848	199,888
October-15	1,661,805	1,914,290	3,576,095	160,045	198,585
September-15	1,887,745	1,447,221	3,334,966	149,253	185,773
August-15	1,715,308	1,793,530	3,508,838	157,035	199,335
July-15	1,683,979	1,724,650	3,408,629	152,550	190,430
				1,854,313	2,328,813
				80%	100%

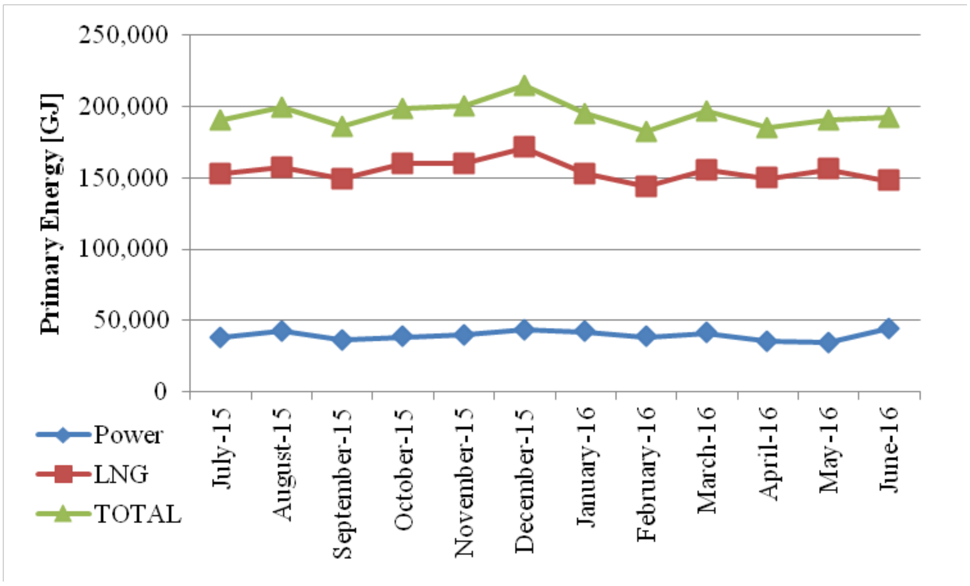


Figure 2-8-1-4 Annual Duration of Primary Energy Consumption

3) Power Measurement Results

- ✓ We measured power consumption for two consecutive weeks in order to grasp the consumption trend. Incidentally, the factory did not have other data except for the annual report on energy consumption as shown above.
- ✓ There are three main distribution lines in every production process and one supplemental line. We measured these three lines to grasp all power use at the same time. Incidentally, since the survey team had three pieces of measuring equipment, this measurement scheme was able to be put to full use.

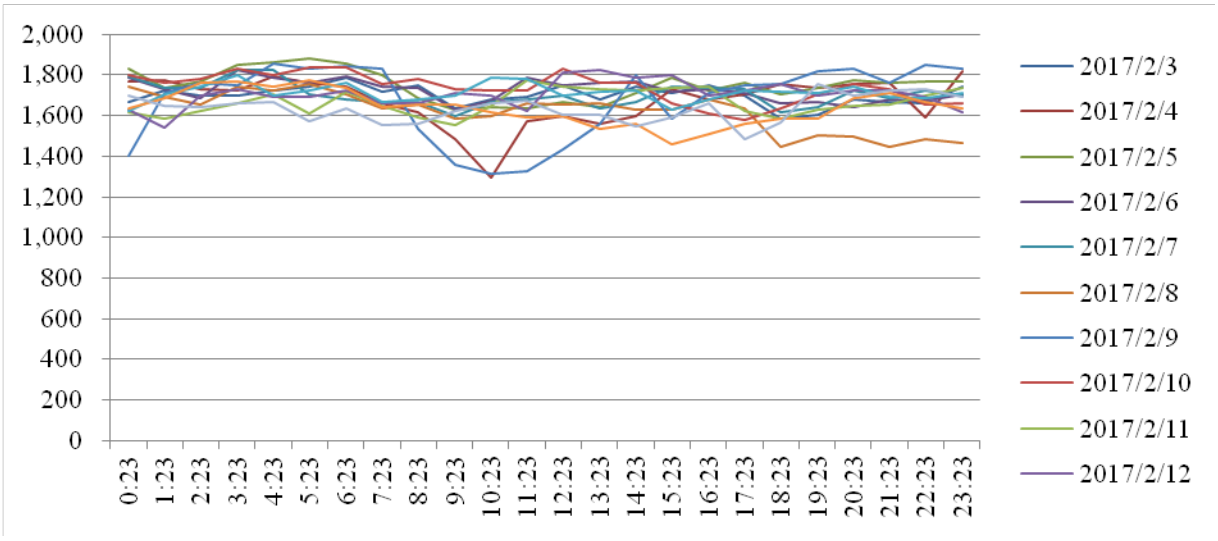


Figure 2-8-1-5 Daily Power Duration on TR No.1

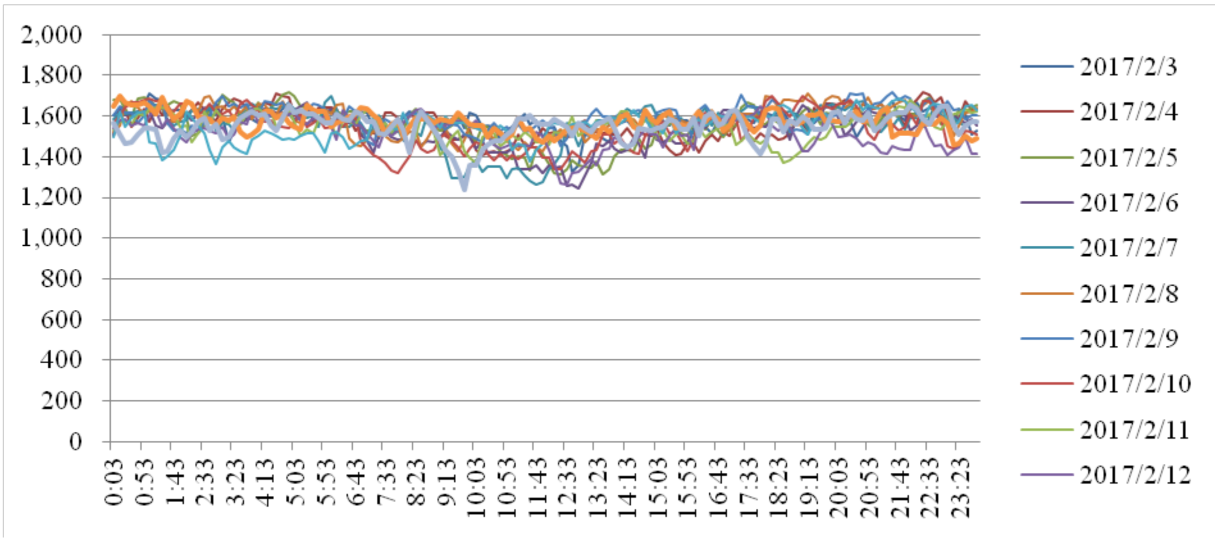


Figure 2-8-1-6 Daily Power Duration on TR No.2

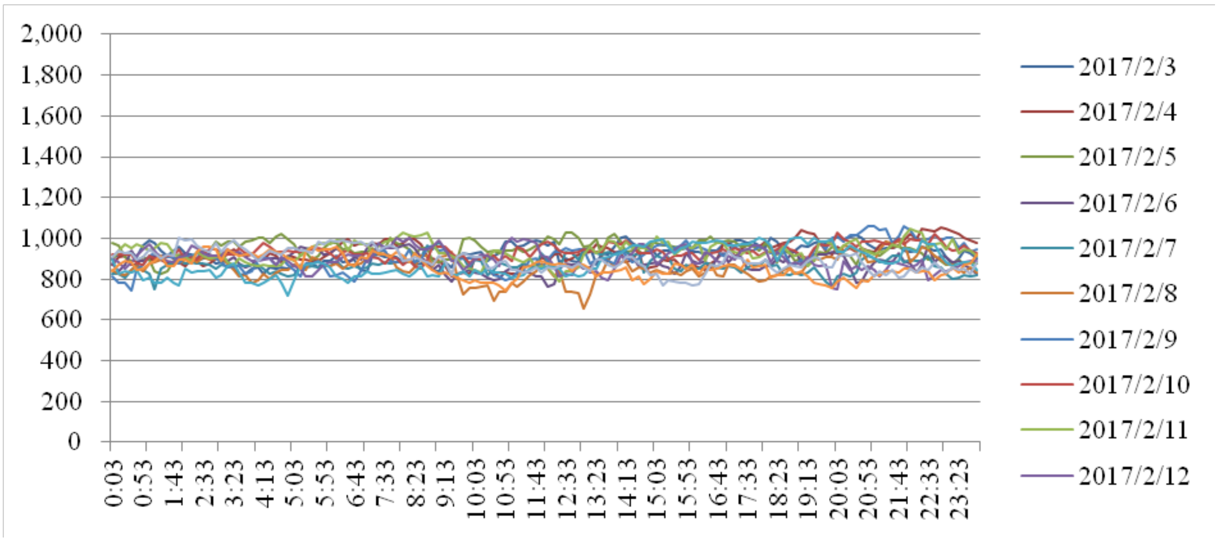


Figure 2-8-1-7 Daily Power Duration on TR No.3

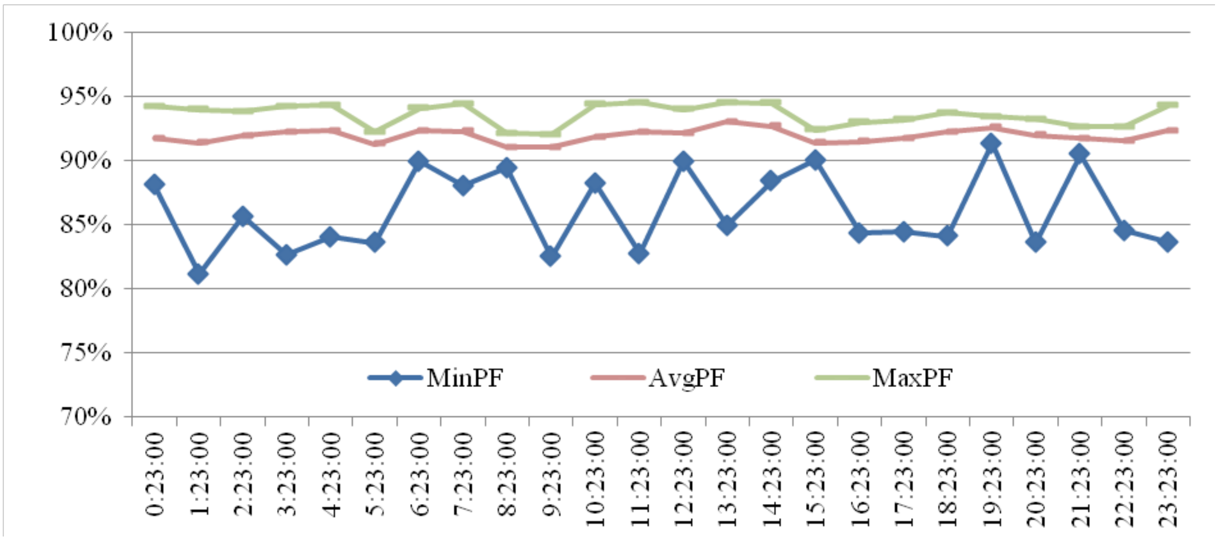


Figure 2-8-1-8 Daily Power Factor Duration on TR No.1 in 3 February

4) Remarks

- ✓ Around 80% of the energy is being consumed by the furnaces for tile production. There seems to be no gap based on cooling load by ambient air and even if they have equipment like a spot cooler or air conditioning machine for office space, it is still not affected. Energy consumption fluctuation is very minimal, so the survey team understands that the energy consumption is dependent on the factory operation.
- ✓ Based on the results of power measurement every 10 minutes, the fluctuation during the factory operation is around 200kW and shows that fluctuation is relatively small while maintaining a high load factor.
- ✓ In measurement of one of the transformers, the daily power factor duration on 3rd February was around 91% and minimum PF went down due to some manufacturing equipment operations.
- ✓ Based on the survey, the survey team identified that it is most important for this factory to improve the efficiency of thermal use for their energy efficiency. The factory does not apply a cogeneration system which could utilize waste heat from the generator in the furnace, nor regenerative burners that utilize exhaust heat from the burning furnace to preheat combustion air. The survey team expects that efficiency will improve significantly by introducing these systems. The factory is currently renovating the equipment that has been in operation for 60 years, therefore, the survey team considers that higher energy efficiency will be achieved by introducing motor replacements or compressor replacements with the piping system.
- ✓ Although the use of natural daylight such as skylights is being implemented throughout the factory for energy conservation, the use of LED lighting system

would reduce night power consumption. Incidentally, and the condensers against PF improvement will have energy savings of less than 10%.

- ✓ Incidentally, since the factory doesn't have an effective ventilation system, the working environment in this factory seems unsatisfactory. Still, it will consume more energy with installment of the ventilation equipment for improving health conditions.

5) City Stars Heliopolis (Commercial customer)

a) Data collection date

February 23 ~ March 8, 2017

In addition, on April 18 and 23 in 2017, a walk-through audit and interview was conducted.

6) Venue of the audit

City Stars Heliopolis (Hotel resorts, Mall and Residence)

7) Overview of the Facilities

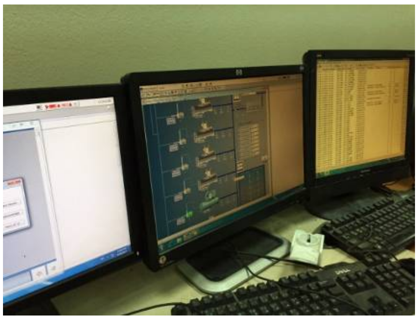
- ✓ Started operations in 2007. Located in Cairo City. Composed of City Stars mall, hotel (2 towers) and high-rise residences (10 towers). This is a major development by a Saudi private company. Total floor area is 750,000 m2 (plan).
- ✓ Both Phase 1 and 2 of the mall are already in full operation. There are 7 floors above ground level and 1 floor below. The building has a floor area of 230,000 m2. The hotel is also already in full operation. However, for the high-rise residences (parts of which are being used as offices), because there are parts which are still under development, it can be broadly said that it is only partially in operation.

Source: Study team

Figure 2-8-1-9 Outline of City Stars Heliopolis

8) Overview of Electrical Equipment/Facilities and BMS

- ✓ 11kV MVSG (Medium Voltage Switchgear) is owned by EETC. All of the data is managed by EETC. There are three (3) substations and six (6) feeders for each substation. From these connecting points, electric power is distributed to each building with the 11kV/400V transformer.
- ✓ There is a BMS (Building Management System) installed to monitor the entire mall. From the central monitoring room, the switching on and off of each device is controlled. It is not equipped with data storage equipment for the operating data



Source: Study team

Figure 2-8-1-10 Low Voltage Switch Gear for chillers and BMS

9) Overview of the chiller plant system

- ✓ There is a centralized chiller plant in the mall. For other buildings, there are separate individual chillers. The chillers in the mall are 1450RT x 8 units (Manufacturer: YORK).
- ✓ For each chiller, there is 1 unit of chilled water pump (100 HP) and cooling water pump (150 HP) each. This one-pump system performs cooling operations throughout the year. The annual maintenance of the chiller plant is conducted by the manufacturer.
- ✓ The status of the maintenance of the documents and daily reports is good. The data gathered is mainly utilized for the maintenance of the chillers. The recorded data is not utilized for energy conservation initiatives.

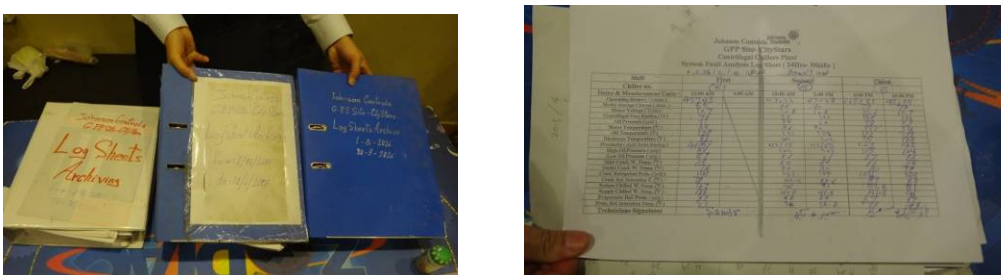
Source: Study team

Figure 2-8-1-11 Chillers and condenser water pumps

10) Estimation of Demand: Annual Cooling Load

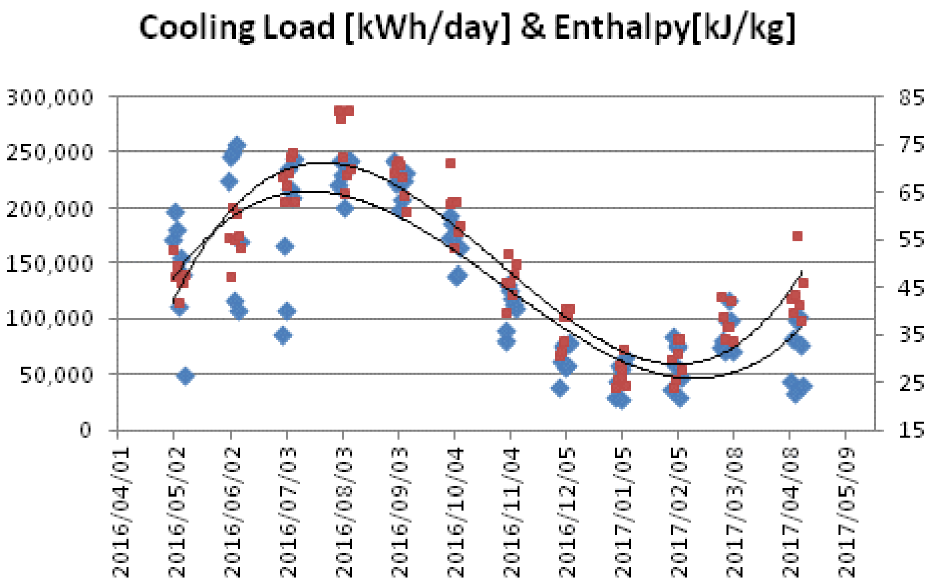
- ✓ Energy consumption of commercial buildings can be broadly divided into lighting and power outlet load, pump power load and air conditioning load. There are not many fluctuations in the lighting and power outlet load throughout the year. However, the air cooling load is a big factor in forming peak power demand.
- ✓ The survey team estimated the air cooling load based on the daily report data in possession of the maintenance team. The survey team recorded the power current, voltage, temperatures and pressures of each water and vane opening in intervals of 10:00, 14:00, 18:00, 22:00 and 24:00.
- ✓ Estimated cooling load is shown in the graph below. The primary axis shows the air conditioning load, while the secondary axis shows the enthalpy of the outside air (amount of heat).
- ✓ From this, the survey team recognized the correlation between the outside air enthalpy and air conditioning load recorded in the chiller operation monitoring sheet. The survey team can explain that the annual cooling load peaks during the summer season and the difference in the cooling load during the summer and winter seasons can be calculated to be approximately 6,000 kW.*

* Comparison between Feb 3, 2017 and Jun 4, 2017



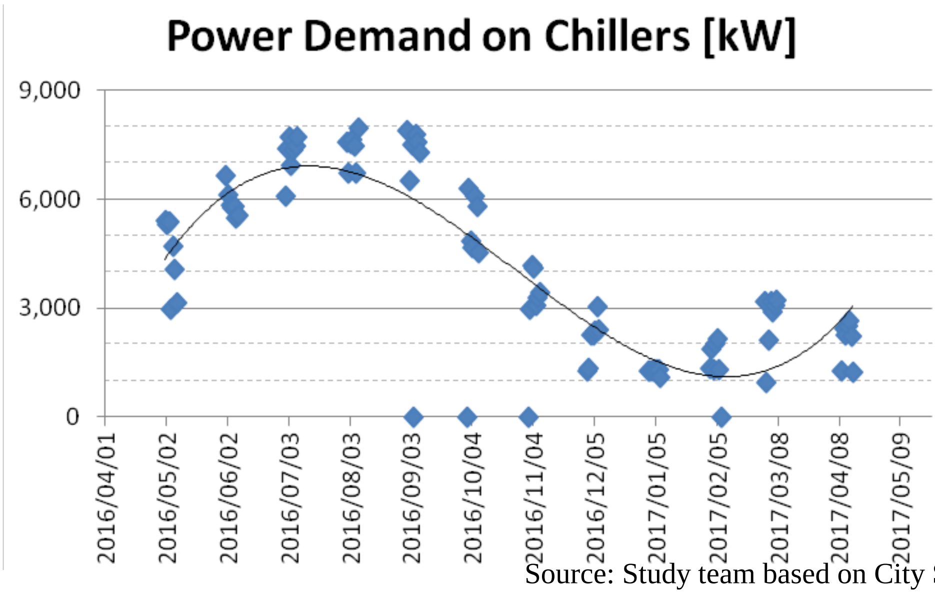
Source: Study team

Figure 2-8-1-12 Monitoring sheets on chillers



Source: Study team based on City Stars data

Figure 2-8-1-13 Cooling load (Blue, left axis) and enthalpy (Red, right axis)

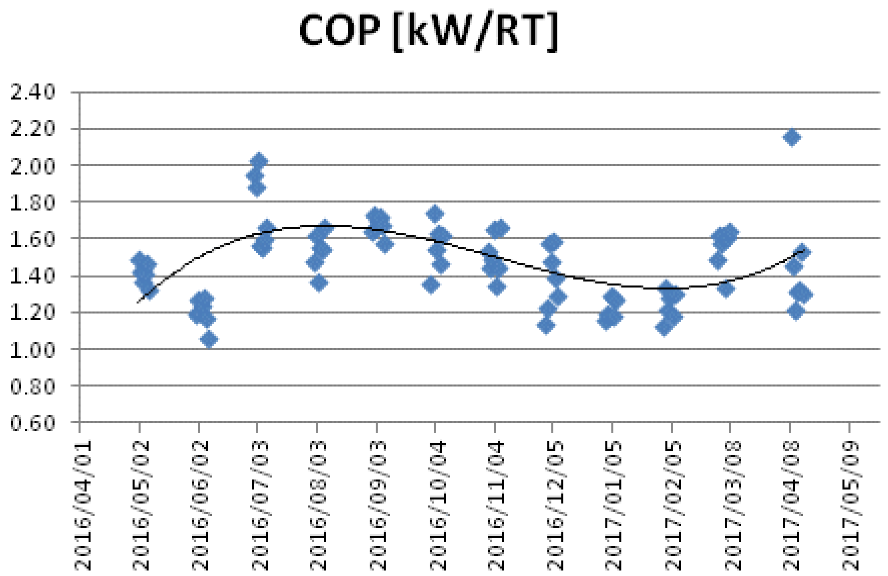


Source: Study team based on City Stars data)

Figure 2-8-1-14 Power demand on chillers

11) Energy Saving Potential from Chiller Plant Retrofit

- ✓ From our power measurement data, Co-efficient of Performance (COP) of the chillers is shown below.
- ✓ Chillers are designed to meet the peak demand. The COP during the summer is approximately 1.6[kW/RT]. Based on the specs in the YORK catalogue at the time of installation, the current performance is only around 40% of the full capability. The temperature of the supplied chilled water during summer is between 42°F (5.5°C) ~ 44°F (6.6°C) and does not meet the set temperature of 40°F (4.4°C), so the chiller is underperforming.
- ✓ This chiller plant consumes 8,000kW of peak power and 15GWh/y of energy. With the retrofit, the survey team anticipates a reduction of around 4,000 kW of peak power and 8GWh/y of energy.
- ✓ Because the annual power load was not disclosed, the power load was estimated based on the actual load of similar facilities. Including the chillers, if the peak load is 60~80W/m^2 and energy consumption is 150~200 kWh/m^2 per year, then, the survey team anticipates 20% reduction for both peak power and energy consumption.
- ✓ On the other hand, the anticipated annual cost reduction is EGP8.3 million/yr (EGP1=JPY6, EGP1/kWh). If the retrofit cost of the chiller plant is EGP5,000/RT, then the payback period will be around 7 years.

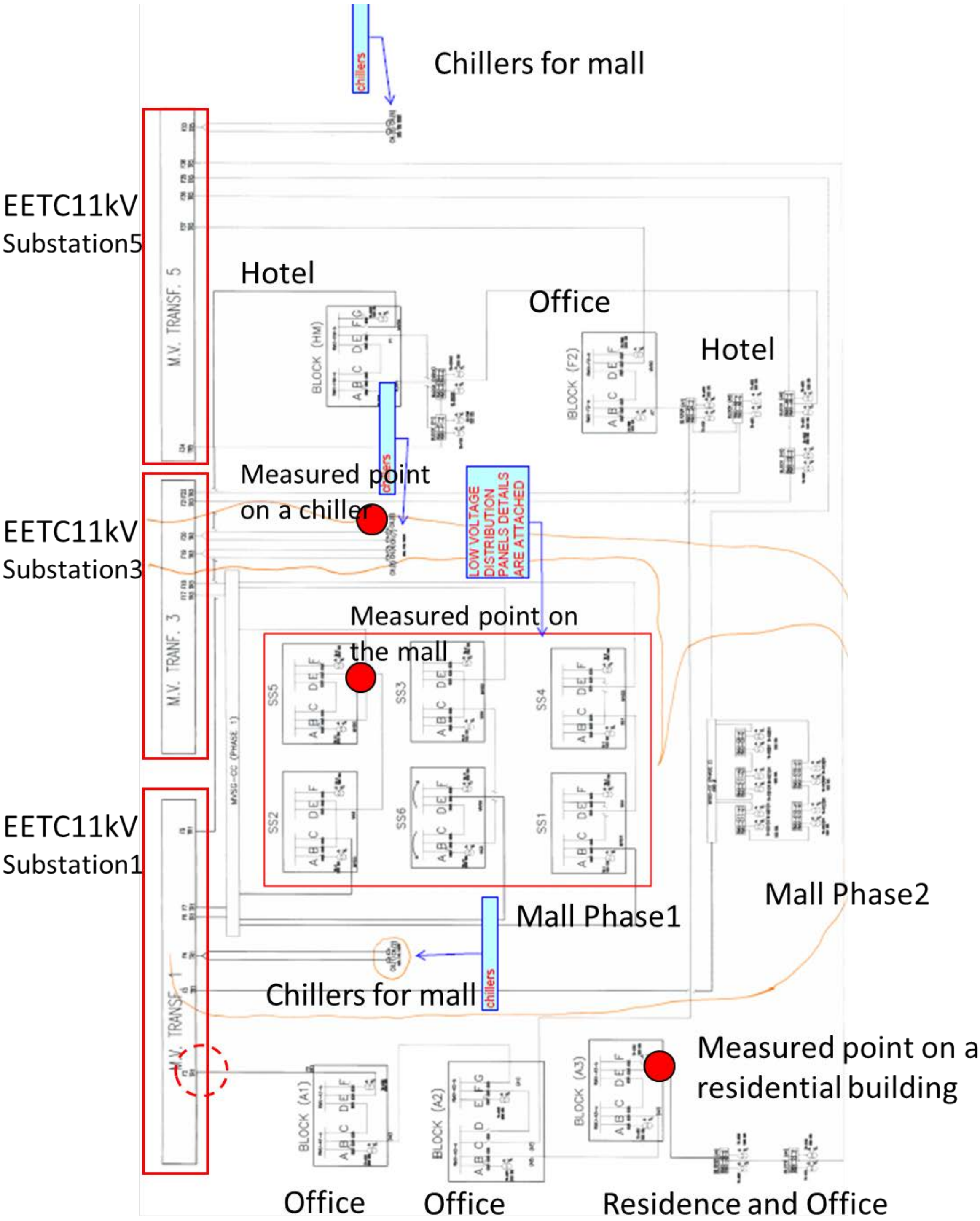


Source: Study team based on City Stars data

Figure 2-8-1-15 Annual COP curve on chillers

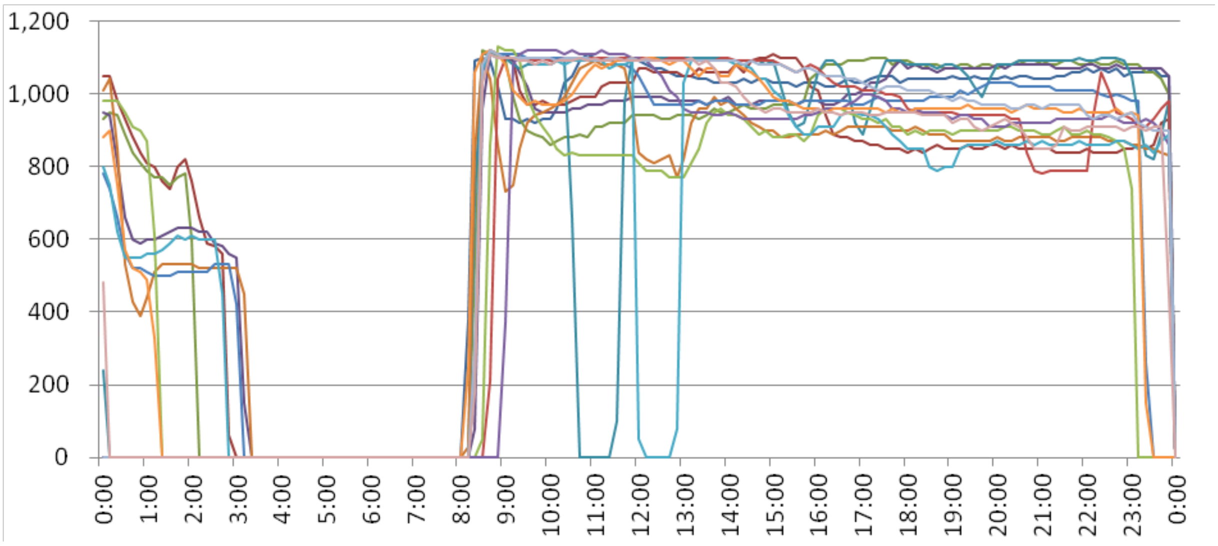
12) Analysis Based on Measured Data

- ✓ As stated above, the site has 18 feeders (MVSG) for power distribution. Because the survey team could not simultaneously measure all feeders, the team selected and measured three (3) locations continuously for two (2) weeks. We selected the high-rise residence and mall (including the chiller plant) for this as these are safe to measure.
- ✓ The single line diagram (including measured point) provided by the site manager and measurement results are shown below.



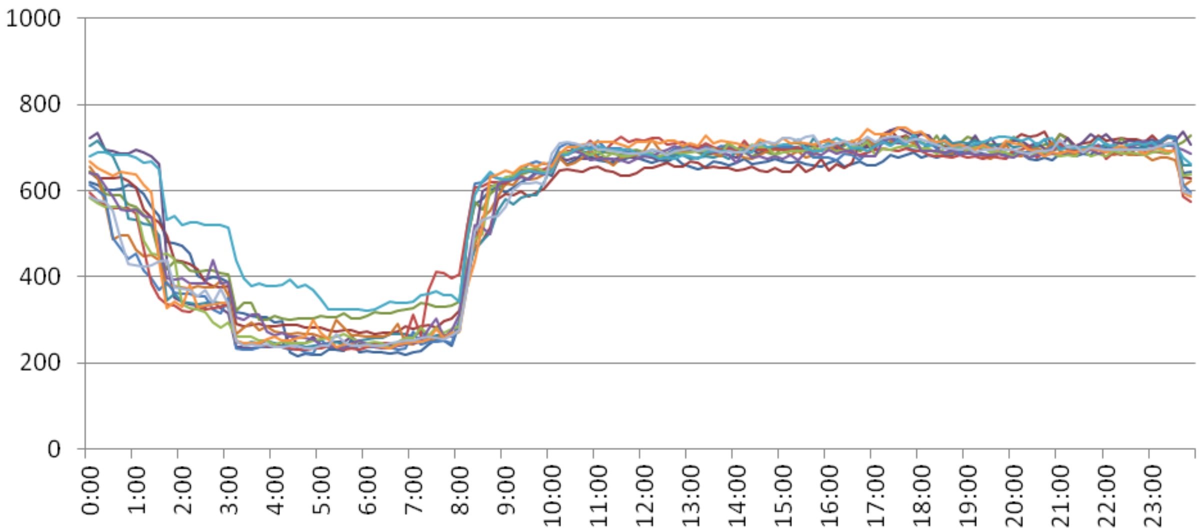
Source: City Stars

Figure 2-8-1-16 Single line diagram and measured point



Source: Study team from measured data

Figure 2-8-1-17 Measurement results on power for chillers (kW)



Source: Study team from measured data

Figure 2-8-18 Measurement results on power for mall building (kW)

13) Additional Remarks

- ✓ The survey team recognized that there was less than 10% variance between the results of the actual measurement of the chiller power against the chiller daily monitoring sheets. The daily monitoring sheet measurement is dependent on the figures shown in the chiller panel boards, which seems to be due to the deterioration of these panel boards.
- ✓ During time of low cooling load like winter, chillers control the vane opening rate for energy saving purposes. Chillers are monitored every 4 hours by operators and measurements are conducted every 10 minutes by automated equipment. However, the team was not able to find any reduction in energy consumption. This shows that the deterioration of the chillers is progressing.
- ✓ There was less load fluctuation during the operation hours of the mall. The team was able to confirm in the commercial buildings that air-conditioning and lighting load are variable depending on the time of the day, while other systems energy consumption remained stable.
- ✓ At the central control room of the mall, there is a BMS system installed (high performance at the time of installation). It is partially operated unmanned. With the upgrading of the BMS to BEMS, it will be possible to support energy saving activities with a relatively small investment.
- ✓ Considering that there is a seasonal temperature gap similar to Japan, it is possible to realize around 10% energy saving through methods such as installing a Variable Frequency Drive to motors or fans.

14) City Stars Heliopolis (Residential customer)

a) Data collection date

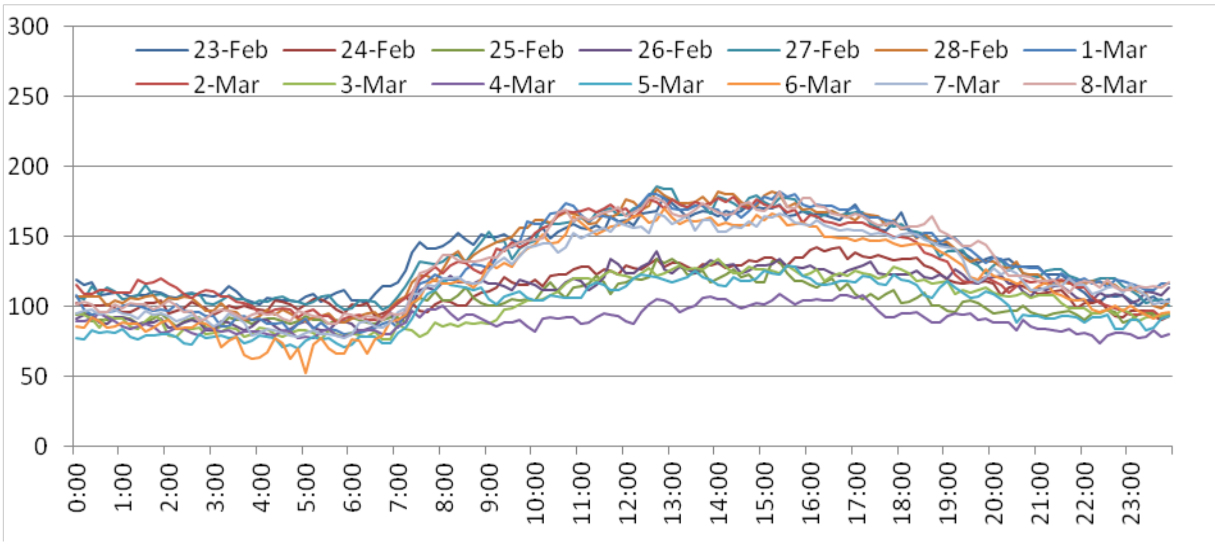
February 23 ~ March 8, 2017

15) Venue of Activity

City Stars Heliopolis (Hotel resorts, Mall and Residence: Residential and office part)

16) Overview of Facilities

- ✓ Measured one of the two transformers in the receiving room, which is attached to the aforementioned commercial facility and residential facilities.
- ✓ Measurement points are as shown in the figure in the previous section



Source: Study team from measured data

Figure 2-8-1-19 Measurement results on power for residential buildings (kW)

17) Remarks

- ✓ Survey team found less power load in the residential towers (including office areas) during the day time of non-working days/holidays, which is due to the demand in the office part of the residential tower such as the lighting, power outlet, and air-conditioning in the area.
- ✓ However, as the night time power load of the residential towers gets high, it is necessary to have further analysis on energy saving. In general, there may be wasted energy in refrigerator use or standby-power in the residential areas. For common areas, a new way of thinking like timer controls for fans in parking areas, or turning off excess lighting will help reduce wasted energy.

2－8－2 Act, Regulations and latest situation regarding Energy Efficiency Improvements

(1) Overall description regarding countermeasures towards energy efficiency

As explained before, energy consumption in heavy industries like cement, fertilizer and steel is major, and residential is also a big energy eater with 150% comparison to that in 2005. It is supposed that power usage in commercial areas will grow in the coming years because of the many urban infrastructure development projects like shopping malls, hotels etc. in Cairo and its suburbs corresponding to population growth. On the other hand, interviews with EEHC and distribution companies show that the government and EEHC have implemented evening lighting peak reduction activities from around 2000. Specifically saying, the target items are lighting system and home appliances. Although there are measures for the next step for the mid- and long-term future according to EEHC, it will be necessary to further improve energy efficiency. In addition, there seems to be almost no efforts to utilize waste heat like so-called cogeneration in factories while energy efficiency utilization by customers is also relatively limited. Therefore, the process regarding energy efficiency is judged as in the early stage of development.

Regarding energy efficiency improvement policy in compliance with the Arab Framework according to the decision made by the Executive Office of Arab Electricity Ministers, the National Energy Efficiency Action Plan (NEEAPA) of Egypt has been set for 2012-2015.

In NEEAPA, improvement in energy efficiency at a rate of 5% per annum from the average consumption of the last five years was targeted through of some procedures in the sectors (domestic - public utilities and government agencies - tourist)

The biggest challenges NEEAPA in 2012-2015 faced were as follows;

- Lack of an institutional framework that ensures coordination and exchange of information by the parties involved in implementing the plan, especially those from outside the electricity sector.
- The absence of a verification mechanism on follow-up and evaluation of the plan's output, and no follow-up reports to implement the plan.
- Not completing the establishment of energy efficiency improvement units in the economic sectors in accordance with the institutional framework for the application of energy efficiency programs.
- Limited capacity building programs and the non-activation of some programs such as disposal of low-efficiency equipment and machines, as well as dealing with research entities.

The Second National Energy Efficiency Action Plan (NEEAPA) (2018-2020) for Egypt is being finalized at the moment. The Plan has also taken into account the requirements of the Arab Energy Efficiency Framework. The plan took into account the challenges facing the implementation of the previous plans to achieve the desired results. The plan is committed to the energy strategy in Egypt until 2035, which was approved by the Supreme Council of Energy in October 2016, which aims to reduce energy consumption by 18%, matching the vision of Egypt 2030.

Also, in the Energy Efficiency Technical Report under the INTEGRATED SUSTAINABLE ENERGY STRATEGY TO 2035 that was approved by the SCE (Supreme Council of Energy) in October 2016, the energy saving targets by 2035 (vs. 2010 figures) were stipulated for the industrial sector (18%), commercial sector (16%), tourism sector (13%), street lighting sector (41%) and transportation sector (23%). This is the so-called Energy Master Plan for Energy Efficiency and Conservation. The plan points out that inexpensive energy costs, the absence of central institutions, underdeveloped energy saving markets and absence of players (operators), lack of information and knowledge on energy saving diagnosis and energy saving are impeding factors for promoting energy saving activities.

(2) Relations between Electric Law and Power companies on energy efficiency

1) Electric Law

Electric law stipulates below on rational use of energy.

✓ Article Forty Eight

Network Operator or Electricity Distribution Licensee shall purchase or pay for the surplus electric power generated by the customers and other recoverable energy production units with capacity of less than 50 MW, provided that such transactions shall be conducted under conditions and at prices set by the Agency. Also, the generator shall bear the cost associated with connection to the network and optimization.

✓ Article Forty Nine

Network Operator and Electricity Distribution Licensee may enter into load reduction and peak reduction contracts with customers without exception. Details are set separately.

✓ Article Fifty

Based on separate laws, customers who exceed 500kW should record their efforts on energy conservation as well as their energy consumption and report it to relevant agencies.

✓ Article Fifty One

Network Operator or Electricity Distribution Licensee shall create a proposed annual plan to be approved by the Agency for the purpose of implementing projects and programs serving the Consumers in the following fields:

1. Management of electric power demand.
2. Improvement of electric power usage efficiency.
3. Promotion for renewable energy uses.
4. Raising awareness of power usage efficiency.

In the course of issuance of a license validity certificate, the Agency shall verify the scope of applying the annual plan.

✓ Article Fifty Two

The entity assigned by the Cabinet to improve electricity usage efficiency shall, in cooperation with other competent authorities, develop policies aiming to:

1. Expand the scope of developing power efficiency specifications and cards for electricity-consumptive devices and equipment.
2. Replace low-efficiency devices and equipment with others, as set forth in the Executive Regulations.
3. Improve the electric power usage efficiency in the industrial and commercial systems.

- ✓ Article Fifty Three

Producers and importers of the electricity consumptive devices and equipment shall place power efficiency cards on the electric devices, in accordance with the Ministerial Decrees issued in this respect and the provisions of the Executive Regulations.

Executive regulations are confidential and these subsidized activities mentioned below are implemented in accordance with these regulations.

2) Subsidies for energy efficiency

- ✓ As per energy efficiency obligations stipulated in the Electricity Law, there is a subsidy that EEHC distributes LED lighting systems to power distribution companies which has been implemented from 2011 through 2018. The distribution of 13 million LED lights to consumers in houses on installments is an ongoing process, and LED lighting that has already been provided is 11 million LED lights. In addition 1 million LED lights are provided to the private sector.
- ✓ MOERE and the Ministry of Local Development replaced 3.9 million conventional lights with LED lights by agreement, to reduce consumption of electricity used in street lighting. In addition, has been reduced to 2.7 million street lights, by introducing a control system to street lighting. At present 1.7 million street lights have been replaced with LED lamps.

  At the same time, there is a LED provision plan for governmental buildings and hotels. This is an up to 50% subsidized scheme and has a budget of 250 thousand L.E. for the 1st phase and 500 thousand L.E. for the 2nd phase.
- ✓ The budget has been subsidized by GEF project reported later.
- ✓ Enlightening activities on energy efficiency have been demonstrated, not by each distribution company, but by EEHC.

3) Load leveling activities based on power tariff system retrofit

- ✓ EEHC already has a plan for customers with large power consumption like heavy industries, petrochemicals or cement factories. EEHC has asked customers to switch their operation from peak time to off-peak time via EDC or EETC. Customers with a contract over 20MW are distributed power over 66kV by EETC.
- ✓ There is Time of Use (TOU) for both on-peak and off-peak. The on-peak time slot is for five hours from 6 p.m. which is stipulated in each contract.
- ✓ EEHC is now planning peak shift activities from the daytime peak to off-peak in early morning for residential customers by TOU which is utilized by smart meters set at each customer in the next five years.

- ✓ The chart of power usage duration in peak day of 2013/2014 in EEHC annual report includes 10% growth on consumption during daytime hours and EEHC due to Ramadan.

(3) Standard and Labeling (S & L) activities

- ✓ Standard and labeling activities for appliances have been implemented since 2003. The energy efficient specifications of household electrical appliances that consume more electricity have been released (refrigerators, air-conditioners, washing machines, LED lamps, and compact HF lighting systems), by coordinating with Egyptian Organization for Standardization & Quality. The Ministerial decrees have already been activated, and the specifications of the following household electrical appliances (water heaters and distribution transformers) have been released. However, the Ministerial decrees to activate them haven't been released yet regarding the specifications of the following household electrical appliances (TV and its accessories, equipment for emergency power supply and accessories, communication and connection devices, fans, and electric motors) are being prepared. These verifications on S&L have been implemented by NREA.
- ✓ Studying/investigating appliances with new energy, renewable energy and energy efficiency. Has also been implemented in NREA. This activity also includes imported products.
- ✓ Energy efficiency standards for all residential, commercial and governmental buildings have been prepared and the Ministerial decrees have already been issued as there has been a memorandum of understanding signed by both MOERE and the Ministry of Housing, to activate energy efficiency standards in new residential buildings.
- ✓ Traceability systems for appliances have been installed in cooperation with the Ministry of Industry and this activity will help in quality control.

Source: UNDP

Figure 2-8-2-1 Example of labeling

(4) Energy Management Systems

- ✓ As per Energy Manager System, Regional Center for Renewable Energy and Energy Efficiency (RCREEE) is now planning to set up an institution for energy management certification and training facility for instructors in 2017.
- ✓ For this realization, they have asked the World Bank for support and an Indian consultant is now taking an active part in establishing it.
- ✓ This activity includes a suggestion that the energy saving initiatives of MoERE, NREA or EEHC should be cross-sectional, which will be a follow-up measure to the NEEAP of 2012 to 2015. As this report also states the specific roles and responsibilities as well as the phasing plan for the Capacity Building, it would be possible that, in the future, the establishment of the energy management system based on this survey report.
- ✓ EEHC doesn’t have a department specifically for energy efficiency but the Leadership Development Sector is in charge.

(5) Activities of other Donors

- ✓ There is a GEF (Global Environment Facility) project by UNDP (United Nations Development Programme) in Cairo and energy efficiency activities on LED provision and S&L is being performed in this project.

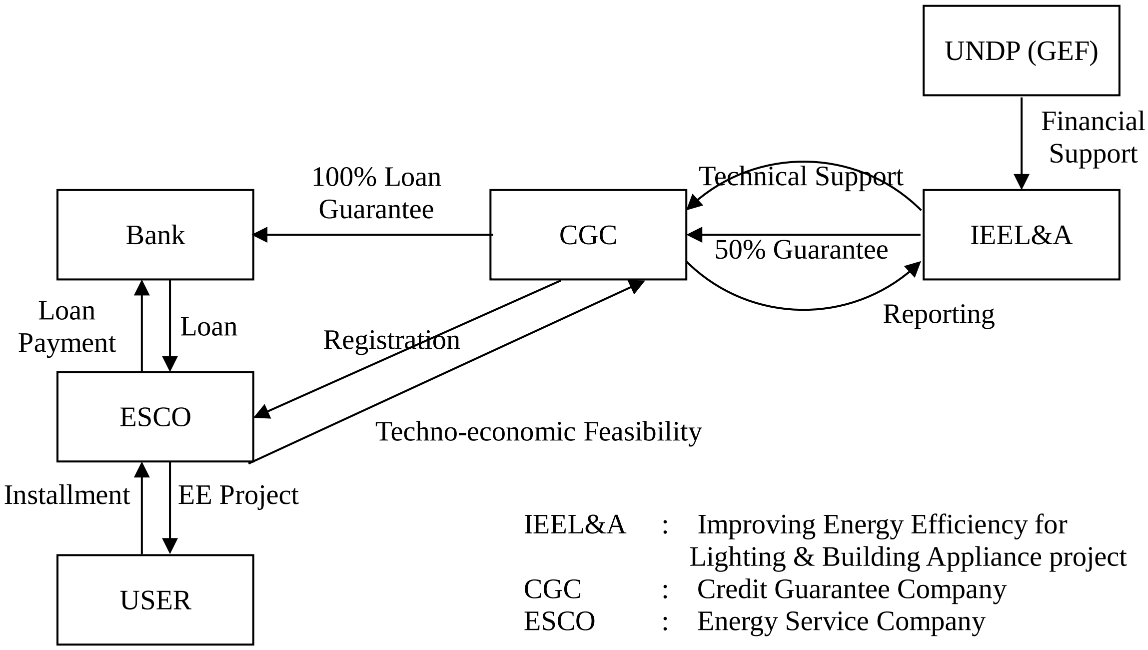
- ✓ There are regular meetings among the World Bank, Islamic Band and UNDP etc. and UNDP plays an important role in terms of overlooking Egyptian policy and its decision-making in regard to technical support. UNDP has been supporting these activities from the 1970s and will continue to do so for many years to come.
- ✓ As completion of the 3rd phase of the project, UNDP plans to accomplish LED provision and setting up of a certificate institution by 2017 or 2018 with the 2nd phase continued from 2010.
- ✓ UNIDO has investigated energy efficiency potential in the industrial sector which comprises of relatively large energy users like cement factories, fertilizer or steel factories. This study was implemented in 2014 and the supervisory authorities of this activity are the Egyptian Environmental Affairs Agency (EEAA), the Ministry of Industry and Foreign Trade of Egypt (MoIFT) and the Federation of Egyptian Industries (FEI).
- ✓ Operation of these industries is dependent on fossil fuel. For example, typical cement factories consume huge amounts of heat energy and 7% in electric power, but it is common that they don’t utilize heat recovery technology like CHP (Combined Heating and Power).
- ✓ In some factories, load shifting to off peak hours has been conducted and this kind of activity will help with the reduction of peak power in Egypt.
- ✓ The European Bank for Reconstruction and Development (EBRD), along with Agence Française de Développement (AFD), European Investment Bank (EIB) and the EU started Green Economy Financing Facility (GEFF) activities from March, 2017. This is a loan program with a budget of €140 million. However, by meeting the set energy saving conditions stated below, 10 to 15% of the loan will be converted to subsidies instead. Also, to support the progress of the project, the EU has shouldered €24 million of the €140 million mentioned above.

Table 2-8-3 Conditions for GEFF (Source: Study team from EBRD website)

GEFF Benefits	Technology Selector Loans	Assisted Project Loans	Supplier and Vendor Loans	
			ESCO Loans	Equipment Vendor & Producer & Service Provider Loans
Maximum Loan Amount	USD 300,000	USD 5 mil.	USD 5 mil.	USD 1 mil.to USD 5 mil.
Investment Grant	10%	10% or 15% depending on efficiency	10% or 15% depending on efficiency	N/A
Free Technical Assistance	Yes, to select equipment	Yes, to select best solution, assess profitability, prepare loan application, make idea bankable		

(6) Energy Efficiency on demand side and ESCO

- ✓ Though subsidies from power related organization for customers were only for implementation of more efficient lighting, as mentioned above in the EBRD activities started March 2017.
- ✓ Another scheme without power related organization is a business utilized by Credit Guarantee Company (CGC). ESCO owns energy related equipment on behalf of the owners in this business scheme, and financial institutes and CGC take on this debt. Half the amount of this debt from CGC is taken over for Improving Energy Efficiency for Lighting & Building Appliance project (IEEL & A) and their activities are also supported by UNDP.
- ✓ It should be noted that the ESCO project is being conducted in parallel with the energy management system.
- ✓ According to the New Electricity Law, power consumers exceeding 500 kW are requesting the establishment of full-time personnel of energy management, but the energy management system as a state qualification has not yet been established.



Source: JICA Study team with UNDO documents

Figure 2-8-5. CGC Business Scheme

- ✓ According to UNDP, the project should be implemented after verifying the potential for energy conservation based on the actual demand side usage study. At the same time, UNDP remarked that it will be helpful if there is cooperation through the CGC for supporting hardware such as high efficiency boilers, EMS system, and high efficiency lighting.

2−9 Human resource development system in electric power sector

2−9−1 Human resource development system in electric power sector

(1) Management system

Training Sector of the EEHC headquarters takes charge of the operation and management of the entire group regarding human resource development in the EEHC group. The Sector is included in the Human Resources & Training Division: (Head of the Division is Vice Chairman of EEHC) as shown in Figure 2-1-3-5. EEHC is also in charge of training concerning RE along with NREA. Therefore, EEHC plays a central role in human resource development in the power sector in Egypt.

Figure 2-9-1-1 shows the organization chart of Training Sector in EEHC headquarters.

Source: Material obtained from EEHC

Figure 2-9-1-1 Organization chart of Training Sector in EEHC headquarters

Moreover, Training Sector is also set up by each subsidiary company of EEHC, which manages the training facilities in each company. The organization chart of the training sectors in the West Delta power company, hydro-power company, South Cairo Electricity Distribution Company, and EETC are shown in Figure 2-9-1-2, 3, 4, 5 as examples.

Source: Material obtained from EEHC

Figure 2-9-1-2 Organization chart of the West Delta power company's Training Sector

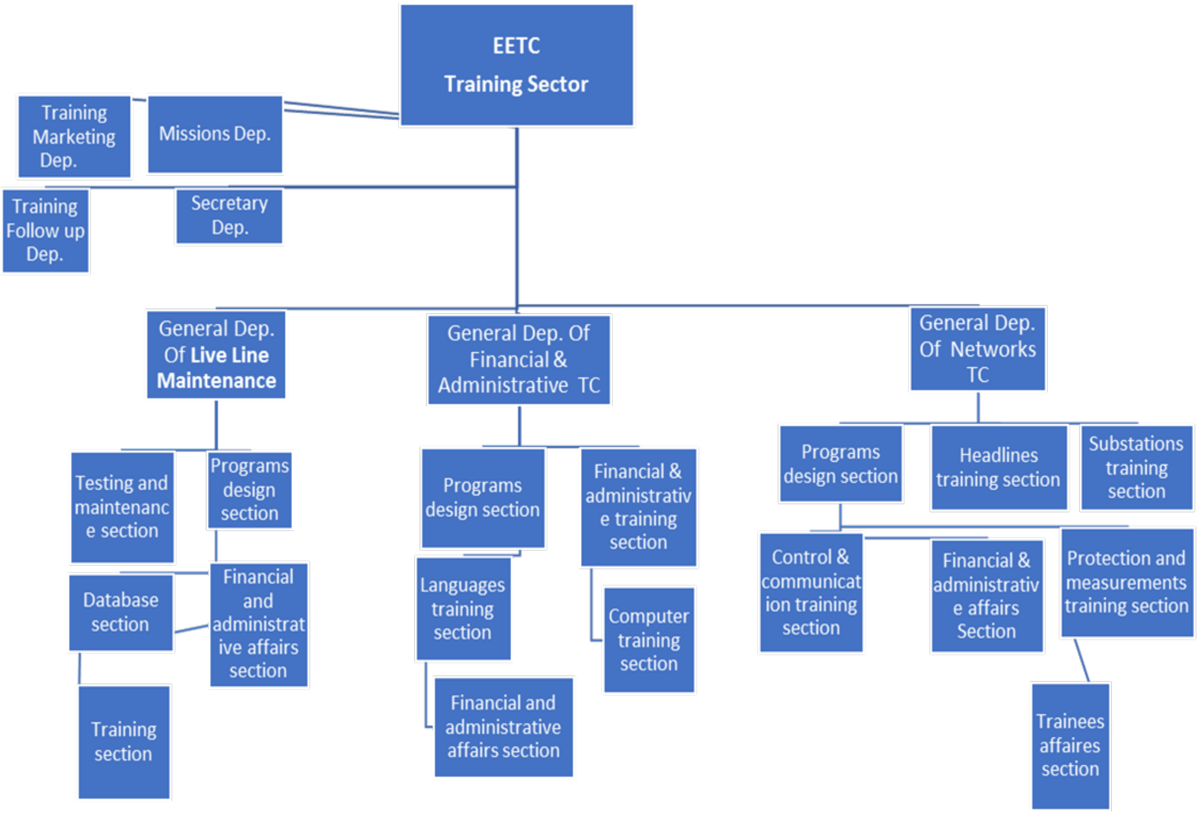
Source: Material obtained from EEHC

Figure 2-9-1-3 Organization chart of Training Sector of the hydro-power company

Note) The South Cairo Electricity Distribution Company has two training facilities.

Source: Material obtained from EEHC

Figure 2-9-1-4 Organization chart of Training Sector of the South Cairo Electricity Distribution Company



Source: Material obtained from EEHC

Figure 2-9-1-5 Organization chart of Training Sector in EETC

(2) Action to promote human resource development

The measures to promote the human resource development are conducted through the actions as shown in Table 2-9-1-1 in the EEHC group, aiming to breed personnel who can adequately cope with the development of the related technology.

Table 2-9-1-1 Human resource development activities in EEHC group

	Human resource development activities
1	Establishment of a new administrative culture (Management of Leadership Training Center etc.)
2	Development of work procedures to provide services according to a high standard of quality and efficiency
3	Coordinate between the management plan of human resources and EEHC strategic plan (Management of the Supreme Committee of Training etc.)
4	Development and improvement of a human element to increase competitiveness capability (Maintenance of the training curriculum etc.)

Source: EEHC Annual Report 2013/2014

The policy related to human resource development in EEHC group is deliberated on and decided at the Supreme Committee of Training where the Chairman of the EEHC headquarters assumes the top position. This committee is composed of the directors in charge of t planning, research, distribution, generation, human resource management and development of each director in charge of the human resource management and promotion division, and directors from group companies. The management of the committee is conducted by the Training Sector at EEHC headquarters.

(3) Training plan, curriculum for the newly employed staff, and their allocation after the training

Table 2-9-1-2 shows the eight year training plan for newly employed staff (engineering area). The training courses in each year is systematized and the upper row indicates the contents and duration (days) of the general management training while the lower indicates the content and training duration (weeks) of the technological training. The curriculum is shown in Table 2-9-1-3-4 as the new employment staff technological training for seven weeks and safety training for one week, which is held in the first year.

Moreover, the eight year training plan for new employment staff (clerical work) is also shown in Table 2-9-1-5 and the first year curriculum is presented in Table 2-9-1-6.

Table 2-9-1-2 Eight year training plan for newly employed staff (engineering work)

Training courses classification for the promotion periods for standard jobs

Engineering group (financial class:660)

1- Standards positions in the general courses

A- General administrative courses

Target Group	Training courses		Years required for promotion							
	Sr.	Course Name	1	2	3	4	5	6	7	8
Engineering group (financial class:660)	1	Organization values and culture	3							
	2	Company regulations			5					
	3	Correspondence & reports writing skills				5				
	4	Effective communication skills					5			
	5	HR management, position analysis and C.V writing						5		
	6	Administrative skills							5	
	7	Promotion from class (660) to class (840)								10
	8	Computer courses (ICDL)	√	√	√	√	√	√	√	√
	9	English courses	√	√	√	√	√	√	√	√

B- General engineering courses

Target Group	Training courses		Years required for promotion							
	Sr.	Course Name	1	2	3	4	5	6	7	8
Engineering group (financial class:660)	1	A- New recruits (electrical – mechanical)	7							
		B- Safety and occupational health	1				1			
	2	Loss source in the distribution network		1						
	3	Earthing		1						
	4	Feeding quality			1					
	5	Energy rationalization				3				
	6	Financial accounting for non-accountants				1				
	7	Auto Cad						2		

Training days (yellow)
Training weeks (green)

Source: Material obtained from EEHC

Table 2-9-1-3 Training curriculum for newly employed staff (engineering work) (part-1)

New recruits Engineers Courses
1- (Electric – Mechanic)

Week	Day	Subject
One	One	▪ Introduction about EEHC and affiliated companies (Roles & Tasks) ▪ Training regulation – trainees' responsibility and rights
	Two	▪ Basics of Electrical engineering ▪ Effective and Non-effective power – how to measure the electrical changes and energy types. ▪ Electrical power systems (network components and operation)
	Three	▪ Components and design principles of distributors ▪ Types of MV breakers (operation theory – installation – maintenance) (theoretical – practical)
	Four	▪ Principles and types of protection equipment(Theoretical) ▪ Field visit to the protection lab (Practical)
	Five	▪ Current transformers, voltage transformers, measurement equipment connections and distribution panel protection. (theoretical – practical)
	Six	▪ On job training on distributor maintenance ▪ Evaluation test
Two	One	▪ Components, specifications and types of MVTL (towers and insulators) (Theoretical – practical)
	Two	▪ MVTL supplementary (circuit breakers – junction – surge arrestor) ▪ Establishing the overhead transmission line
	Three	▪ Networks components (Overhead transmission lines – cables)
	Four	▪ Principles of electrical feeding for customers. (practical example)
	Five	▪ Types of LV & MV cables and components ▪ Types and function of LV & MV cables joints and terminals
	Six	▪ Cable testing (Theoretical – practical) ▪ Cable Fault detection (Theoretical – practical) ▪ Evaluation test
Three	One	▪ Transformers (theory & types) ▪ Transformer testing, maintenance – types of transfomer oils
	Two	▪ Transformer faults and maintenance ▪ Practical training in the transformers workshop
	Three	▪ Transformer kiosks and units of rings connection ▪ Kiosks components maintenance according to MPIS model
	Four	▪ Earthing system for the electrical tools and how to implement ▪ Testing methods of the earthing systems.
	Five	▪ Power factor improvement by condensers ▪ Feeding quality – technical losses
	Six	▪ Safety rules ▪ Software used in distribution networks ▪ Communication skills with costumers ▪ Evaluation test
Four	One	▪ Theory of the mechanical meters and how to connect with loads ▪ Mechanical meters calibration

Source: Material obtained from EEHC

Table 2-9-1-4 Training curriculum for newly employed staff (engineering work) (part-2))

Week	Day	Subject
	Two	▪ Theory of digital meters and load connection ▪ Digital meter calibration
	Three	▪ Standards specification for distribution networks equipment (IEC)
	Four	▪ Commercial regulation and commercial losses ▪ Contracting and purchasing regulation
	Five	▪ Field visit (factory – substation ….)
	Six	▪ Evaluation test
Five		▪ Safety and occupational health
Six		▪ On job training and field visits to equipment producers
Seven		
Eight		

Source: Material obtained from EEHC

Table 2-9-1-5 Eight year plan for newly employed staff (clerical work)

Training courses classification for the promotion periods for standard jobs

Accountants group (financial class:660)

A- General administrative courses

Target Group	Training courses		Years required for promotion							
	Sr.	Course Name	1	2	3	4	5	6	7	8
Accountants group (financial class:660)	1	Organization values and culture	3							
	2	Company regulations			5					
	3	Correspondence & reports writing skills				5				
	4	Effective communication skills					5			
	5	HR management, position analysis and C.V writing						5		
	6	Administrative skills							5	
	7	Promotion from class (660) to class (840)								10
	8	Computer courses (ICDL)	√	√	√	√	√	√	√	√
	9	English courses	√	√	√	√	√	√	√	√

B- General financial courses

Target Group	Training courses		Years required for promotion							
	Sr.	Course Name	1	2	3	4	5	6	7	8
Accountants group (financial class:660)	1	New recruits (Accountants)	7							
	2	Unified accounting system		1						
	3	Advanced Excel			2					
	4	Preparing planning budget						2		

Training days (yellow)
Training weeks (green)

Source: the material obtained from EEHC

Table 2-9-1-6 Curriculum for newly employed staff (clerical work)

New Recruits Accountants

Training Program

Week	Day	Subject
One	One	Introduction to EEHC and affikliated companies, as well as staff, training and penalty regulations
	Two	Financial regulation and planning
	Three	General information about financial statements (Consolidated accounting system)
	Four	Introduction to accountant standards
	Five	Introduction to cost accounting
	Six	Documentary session in the financial sector
Two	One	Commercial regulations
	Two	Documentary session (Detection and collection)
	Three	Introduction to commercial contracts types Purchasing regulations
	Four	General information about meters and power factor calculations and losses
	Five	Banks and cash flow
	Six	Evaluation and closing

Source: Material obtained from EEHC

After the new employment staff training has ended in the first year, training for gaining the understanding of the work flow in about two weeks in each office is executed, and then staff begins work, based on the job description. In addition, the trainer who is in charge of the staff should report the achievement level of the staff to the manager every 6 months as part of the management system.

(4) Actions in each area

1) Thermal power generation

EEHC and each production company have their own training centers, and train their employees. Although their training programs are a little bit different depending on the training center, a wide variety of training programs, such as operation and control of plants, maintenance, welding technology, and safety, are implemented. Training at EEHC headquarters focuses on lectures of leadership development, etc. operation and maintenance of the plants is done by employees basically, thus there are enough opportunities for on-the-job training. Training for electricity organizations in some foreign countries has also been implemented. Accordingly, human resource development systems for steam turbines, gas turbines, and combined cycle plants seem to be adequate.

(According to another JICA study conducted in February 2017, although training seemed to be adequate, the area of the training was limited, such as welding skills, lathe processing, overhauling of pumps and motors, basic electrical theory, etc. Therefore it seems that Japanese support, concerning the human resource developments on operation and maintenance of power plants, may be necessary.)

On the other hand, as Egypt has no experience on coal fired thermal power plants, there will be a high likelihood that Japanese support, concerning the human resource development on coal handling, including prevention of spontaneous combustion of coal as well as O&M of coal fired thermal power plants, is required.

2) Renewable energy

NREA and EEHC collaborate to implement training programs related to RE and implement programs. NREA already has a facility and materials to carry out training RE for several years.

3) Distribution

Regarding the content of training at North Cairo Distribution Company,

No.1. Human resource (personnel) training

No.2. Technical training

No.3. Financial training

No.4. Commercial (sales) training

Every year, 15% of the total staff takes the training.

2－9－2 Situation at the training facilities

(1) Glimpse of the training facilities

Table 2-9-2-1 shows the training facilities owned by the EEHC group and in these 20 facilities, the training is executed. In addition, the training is executed at EEHC headquarters.

Table 2-9-2-1 Training facilities in EEHC group

S/N	Name of the Training Center	Company Name	Sector
1	Cairo North Power Plants	Cairo Electricity Production Company	Production
2	Shoubra El - Kheima		
3	Abo - Qir	West Delta Electricity Production Company	
4	Fayed	East Delta Electricity Production Company	
5	Kureimat	Upper Egypt Electricity Production Company	
6	Aswan	Hydro Power Plants Generation Company	
7	Networks	Egyptian Electricity Transmission Company	Transmission
8	Live Line Maintenance		
9	Talkha		
10	Financial and Administrative		
11	El - Mokatam	South Cairo Electricity Distribution Company	Distribution
12	El - Dokki		
13	Tanta	South Delta Electricity Distribution Company	
14	El - Fardos	North Delta Electricity Distribution Company	
15	El - Canal	Canal Electricity Distribution Company	
16	Mid Egypt	Middle Egypt Electricity Distribution Company	
17	Moharam Bek	Alexandria Electricity Distribution Company	
18	Upper Egypt	Upper Egypt Electricity Distribution Company	
19	Pyramid Extra High Voltage Research Center	Egyptian Electricity Holding Company (Headquarter)	
20	Leadership Development		

Source: Materials obtained from EEHC

(2) Contents of the training facilities and curriculum

The training facilities and the curriculum are shown in Appendix 5.

The lecturers of these training courses are conducted basically by the staff at EEHC, who are also brought up in the training courses according to Training Sector of EEHC headquarters.

Incidentally, the training for RE as shown in the appendix 5 is also conducted by EEHC in consultation with NREA.

(3) Training results

Table 2-9-2-2 shows the training results of EEHC group in recent years. The training is also conducted for university students in addition to EEHC group and MoERE personnel.

Table 2-9-2-2 Training results of fiscal years 2013/2014 and 2014/2015

No.	Report	no. of trainees 2013/2014	no. of trainees 2014/2015
1	Total number of trainees from EEHC,affiliated companies and Ministry of Electricity and Energy	35527	38395
2	Conferences and seminars in various fields from EEHC,affiliated companies and Ministry of Electricity and Energy	3768	3970
3	Cooperation with Faculty of Engineering, Cairo Univesity: 1- Number of Power Plant Diplomas 2- Number of Protection & Diplomas	 21 25	 20 25
4	Enrolled for post graduate studies of the holding company and affiliated	28	108
	Total	39369	42518

Source: EEHC Annual Report 2014/2015

The results of the training for Arab Africa nations in fiscal year 2014/2015 are shown in Table 2-9-2-3.

Table 2-9-2-3 Training results for fiscal year 2014/2015 to other countries

No.	Country	Contracted Parties	Total of Trainees 2014/2015
1	Iraq	Japan International Cooperation Agency - JICA	29
2	Nile Basin countries	African Union Commission Ministry of Electricity and Energy Japan International Cooperation Agency - JICA	25 132 23
3	Sudan	Merowe Dam Electricity Company Dams Implementation Unit Company Sudanese Company to the Limited Hydro Generation Sudanese Company to the Limited Thermal Generation Sudanese Company to the Limited Electricity Distribution Sudanese Company to the Limited Electricity Transmission	17 21 16 25 41 68
	Total		397

Source: EEHC Annual Report 2014/2015

Incidentally, the results of the training to other countries conducted between 2003and 2017 are attached in Appendix 5.

2－9－3 Assessment on human resources development in the power sector

Training Sector of the EEHC headquarters bears the central role in human resource development in the Egyptian power sector and the well-coordinated training curriculums are formulated as part of EEHC group. Also, the training facilities to execute this training are well maintained as EEHC group, as mentioned above. Moreover, almost all of the lecturers for the training are conducted by

EEHC group staff. Considering all of the facts, it is seen that human resource development for the maintenance and operation of the power system is well promoted with the appropriate training system and management.

For power engineers, it is also necessary to train professionals who can engage in daily work such as maintenance operations and experts (called meister in Germany) who can make advanced judgments. Since the survey team could not confirm the situation in that field in this survey, a check would be required to watch the human resources development methods with well-balanced manners in the power sector.

However, human resource development for new technology and know-how should be a new challenge in areas such as operation technology of the coal fired power plants and pumped-storage power stations to be introduced in the near future, and their optimum operation skills coordinated with various types of the other power plants whose operational characteristics and efficiency are not identical to each other.

Japan has some technology and experience in these areas. In addition, when a large amount of RE is introduced, such issues as voltage and frequency maintenance in the power system would become conspicuous and a big challenge for the concerned parties. Japan can also provide the skills and experience in this field.

2－10 Information on Japanese technology

(1) Thermal power generation

As for the coal fired thermal power plants which will be largely developed in the future, several Japanese companies are now preparing for tender. The advantage of Japanese companies is their excellent environmental performance, high thermal efficiency, and reliability. However, the required level of the Egyptian environmental regulations, applied to Hamrawein site this time, is not so high and worldwide manufacturers will be able to deal with the regulation. Therefore, it will be pretty difficult for Japanese companies to show their technical advantage. Operation and maintenance offers for the power plant for 5 years are requested to be submitted in the tendering process as an option. However, any high efficiency plants cannot overcome the low priced facilities based on cheap personal expenses. Therefore, at the moment, it seems to be difficult for Japanese companies to show their technical advantage in coal fired power plants.

It may possible for Egypt to introduce next generation technology such as IGCC in the future, however, as IGCC needs strict management of process and safety, it may be premature to introduce in Egypt, which has no experience with coal fired power plant.

On the other hand, the influence of coal fired power plants on the environment is basically recognized in Egypt. Therefore, if the importance of installing facilities of adequate and continuous performance, as well as proper maintenance of this performance, is properly recognized, it may be a chance for Japanese companies to differentiate their products from those whose advantage is only low price.

As Egypt has no experience in coal fired power plant O&M, there will be a high likelihood that support concerning knowledge on coal handling and environmental monitoring. This knowledge shall be provided by the contractor basically, therefore, it may be difficult to provide only knowledge if a Japanese company cannot be the successful bidder. However, in the process of O&M by Egypt alone, a need for support may arise.

Highly efficient combined cycle plants are one of the advantages of Japanese companies which have a history in supply. However, in Egypt, as large scale combined cycle facilities provided by Siemens have already been introduced, there will be no more need for newly planned combined cycle plants. Conversion is considered at the two gas turbine sites. However, since gas turbines are not manufactured by Japanese companies, there may be no advantage for Japanese manufacturers to challenge conversion projects.

(2) Transmission

Regarding substation facilities, there have been sales of 500kV switch gears in the past.

From now on, rather strong demand for substation equipment will be expected to be seen because large scale reinforcement in transmission systems expected are predicted to cope with rapid increase in generation capacity, large scale RE introduction and reinforcement of international interconnections along with steady demand growth. The equipment will include 500kV switch gears, 500/220KV transformers and 500kV, 220kV transmission bays.

Concerning the 500kV facilities, the role of the 500kV system will be expanded from the generation transmission for Aswan hydro power to maintaining the total system stability and reliability in the Egyptian electricity system where there is bulk power exchange among the large generation plants and demand areas.

With this background, especially, 500KV substations should become the important intersections in

In the system, so to speak, the 500kV facilities should realize high reliability and operability with reasonable economy. From this perspective, the new 500kV substations in the vicinity of Cairo should be, preferably, all GIS (Gas Insulated Switchgear) 500kV facilities. Regarding all GIS substation techniques, especially outdoor-type, Japanese companies have, for a long time and in many cases, experience in design and operation, which will be compatible or possess higher potential compared with companies in other countries.

In the area of power supply in the metropolitan area, 220kV underground cable system is expected to be developed in large scale to meet demand growth. In this area, Japanese manufacturers have abundant experience and know-how, especially, in underground substations or in-house substations with extra high voltage of such as 275kV because the bulk power supply in metropolitan areas like Tokyo has been a serious issue for utilities. For example, gas insulated 275kV transformers have been developed and in operation for mitigating the possibility of fires, which assures a high safety level for the utility and society.

Concerning the extra-high voltage underground cables, since the related technology is standardized, Japanese manufacturers do not have conspicuous advantages, though they have much experience in Japan and abroad. However, if high transmission capacity is required for economy or other reasons in the cables, the indirect cooling system for the cables have been used in Japan and the manufacturers and utility have much technological expertise and know-how in the operation, which is unique to Japanese technology. This technology would be beneficial for Egypt to realize a reliable and higher economy system.

Regarding the overhead transmission lines, the 500kV transmission system would be formed with a standardized method, such as application of the same capacity in each transmission line section.

However, in the case that high power transmission might appear in limited sections, extra-large capacity lines with a specific type conductor might be required. In such situations, Japanese manufacturers have abundant capability of producing the conductors which have been widely applied in Japan with good performance, which might be advantageous for Japanese manufacturers.

If the 500 system needs be reinforced, the interconnected 220 kV system will receive the power and send it to the lower voltage system, which might require the reinforcement of 220kV facilities. Regarding the reinforcement of overhead transmission lines, such as replacement of older lines with new high capacity lines utilizing the same transmission route, or replacement of the old conductors with new high capacity conductors without replacing the transmission tower, Japan has abundant experience and expertise because transmission lines are strongly perceived by the residents as a “Not In My Back Yard” facility.

As the 500kV transmission system reinforcement proceeding, the system operation will become complicated in general. To cope with such situations, such as bulk power network control system, special protection system for emergencies, a network stabilizing system should be introduced.

In Japan, such a system has been developed to meet the needs of transmission planners and operators, and as a result, Japanese manufacturers have abundant experience and expertise. However, this technology is selectively applied, considering the network situation now and in the future because the technology is user -orientated (utility-orientated in Japan).

Therefore, in this field, at first, technical assistance will be required to identify the issues and solutions followed by Japanese technologies being applied with some finance to develop a system most suitable for Egypt.

(3) Distribution

Regarding the advanced distribution system, smart meter, it is expected to spread in the future. Regarding the above, the survey team exchanged opinions with representative companies in Japan.

- ✓ Advanced distribution system manufacturer

Currently, they are working on spreading Japanese distribution automation system to Western / Southeast Asia. First of all, they hope to take the development in Europe, the US and Southeast Asia on track. In other areas, they think after taking advantage of the know-how of deployment to West, Southeast Asia. Still, they are interested in Egypt.

- ✓ Smart meter manufacture.

They have been working on deploying smart meters overseas. However, due to price competition with other rival manufacturers in other countries, it did not go well. Currently they are conducting a demonstration test of smart meters with the main objective of preventing theft by India. In the meantime, they plan to introduce it in India. They think it is necessary to demonstrate superiority in the proposal content such as usage method according to the need of introducing smart meters.

(4) Hydro power area (Hydro pumped storage)

In Egypt, hydro pumped storage plant, Ataqa with a capacity of around 2GW is under development.

Although the technology concerning Hydro pumped storage is standardized around the world, in Egypt, the plant will have multi-purposes to meet the stable operation of nuclear and coal as base-load generation, along with maintenance of system reliability after bulk power RE introduction.

It will be highly challenging and might require some consideration on the specifications of the facility and additional control system. In this area, Japanese manufacturers have abundant know-how and expertise because similar situations have been in place in Japan where utilities and manufacturers tried to seek the best solutions for realizing the purpose over a long period.

Incidentally, issuance of water leakage would be essential in Egypt because water resources are relatively limited and might affect the environment of the surrounding areas. In Japan, there are a lot of pumped storage plants and the utilities have tackled with these issues for long time. In hydro pumped storage technology this along with other related technology, Japan has a good advantage.

(5) Energy Efficiency

1) In the Energy Management System, while the target schedule for the establishment of the institution for energy management certification and instructor training is 2017, Egyptian side would like to request support for this area.
2) As per energy efficiency countermeasures, UNDP has expressed expectations for hardware support like efficiency boilers, EMS systems or high efficiency lighting systems for demand side management. As a separate energy conservation/efficiency countermeasure for the demand side, hardware support such as high efficiency boilers, EMS system, and high efficiency lighting was mentioned.

2－11 Seminar in Egypt

The seminar was held to disseminate the survey results that were included in the Inception Report and exchanged opinions on the issues held by concerned Egyptian counterparts. The results of the seminar are to be reflected in the Final Report.

(1) Date and venue

Date: 10:00-13:50, Thursday, July 13th, 2017

Venue: Intercontinental City Stars Hotel, Cairo, Egypt (Al Montazah Room-Floor B3)

(2) Program

<table>
<tr><td>09:30-10:00</td><td>Registration</td></tr>
<tr><td>10:00-10:15</td><td>Welcome address
▪ H.E. Minister of Electricity and Renewable Energy, Dr. Mohamed Shaker
▪ JICA Deputy Director General of Middle East and Europe Department, Ms. Chie Miyahara</td></tr>
<tr><td colspan="2">Short Break</td></tr>
<tr><td>10:20-10:40</td><td><u>Overview of Egyptian Power Sector</u>
▪ Dr. Mohamed Mousa Omran, First Under Secretary of the Ministry of Electricity and Renewable Energy.</td></tr>
<tr><td>10;40-11:00</td><td><u>Results of Survey on Egyptian Power Sector</u>
▪ Mr. Tsutomu Watanabe, Team Leader of JICA Survey Team</td></tr>
<tr><td colspan="2">Coffee Break</td></tr>
<tr><td rowspan="2">11:25-12:25</td><td><u>Current Issues of the Egyptian Power Sector and Applicable Japanese Technologies- Part 1</u></td></tr>
<tr><td>Thermal Power Generation
▪ Mr. Tetsuro Sasayama, Expert, JICA Survey Team
Renewable Energy
▪ Mr. Hirozaku Tsujita, Expert, JICA Survey Team
Transmission System
▪ Mr. Hidekazu Takase, Expert, JICA Survey Team</td></tr>
<tr><td colspan="2">Coffee Break</td></tr>
</table>

<table>
<tr><td rowspan="2">12:45-13:25</td><td><u>Current Issues of the Egyptian Power Sector and Applicable Japanese Technologies- Part 2</u></td></tr>
<tr><td>Distribution System
▪ Mr. Hoshi Koichi , Expert, JICA Survey Team
Energy Efficiency
▪ Mr. Hoshi Koichi, Expert, JICA Survey Team</td></tr>
<tr><td>13:25-13:30</td><td>Closing Remarks by JICA (To be determined)</td></tr>
<tr><td colspan="2">Lunch (13:30-….) at Shahrazad room-Floor B4</td></tr>
</table>

(3) Attendance

1) Egyptian side

Affiliation	Name	Position
MoERE	Mr. Mohamed Shaker	Minister
	Dr.Osama Asran	Vice Minister
	Dr.Mohamed Mousa Omran	First Under Secretary
	8 other people	
MoIC	Ismail shawaky Ismail Amr	Senior Economic Researcher
EEHC	Eng.Gaber Dousky Mostafa	Chairman
	12 other people	
EEHC Production Company	10 people	
EEHC Distribution Company	6 people	
EEHC Finacail Affairs	1 person	
EETC	6 people	
HPPEA	7 people	
NREA	2 people	

2) Japanese side

Affiliation	Name	Position
JICA Headquarters (Tokyo)	Ms. Chie Miyahara	Deputy General of Middle East and Europe Dept.
	Ms. Mayumi Matsuda	Middle East and Europe Dept.
JICA Egypt Office	Mr. Teruyuki Ito	Office Chief
	Mr. Kei Ikegami	Representative
	Ms. Mayada Magdy Ragheb	Chief Program Officer
	Ms. Dina Karam	Program Officer
	Ms. Jaidaa Sakr	Program Officer
TEPSCO (JICA Survey Team)	Mr. Tsutomu Watanabe	Leader
	Mr. Koichi Hoshi	Sub Leader
	Mr. Hirokazu Tsujita	Renewable Energy

	Mr. Tetsuro Sasayama	Thermal Power Generation
	Mr. Hidekazu Takase	Transmission
	Moderator	
Shaker	2 local consultants	

57 participants from Egyptian side and 16 participants from Japanese side.

(4) Summary of the speech by Minister of MoERE Mr. Mohamed Shaker

- ✓ Japan International Cooperation Agency is a credible partner, and has been supporting the power sector since 1983.
- ✓ It is hoped that the seminar becomes the guidepost for strengthening the coordination between Japan International Cooperation Agency and the Egyptian power sector.
- ✓ The power sector in Egypt has been challenging to overcome the shortfall in fuel supply and delay in the reinforcements of the generation plants and transmission facility installments for the past several years.
- ✓ Power failure occurred when the power shortage reached 5400MW in the summer of 2014, and President Sisi promised to tackle the energy problem on maintenance of a stable power supply as a national security issue.
- ✓ To fulfill this mission, the following countermeasures were executed to improve the supply-demand balance.
  - ➢ Installation of simple cycle power plants with a total capacity of 3632MW using EPC
  - ➢ Securing of the gas supply for power generation in cooperation with the oil ministry
  - ➢ Review on efficiency in the existing power plants
- ✓ Plan of the new coal fired power plant, gas fired power plant and renewable energy plant installation were announced at the Egyptian Economic Development Board held in March, 2015.
- ✓ In the three months after the Board, President Sisi concluded the contracts regarding the combined cycle power generation plant plans (Beni Suef, Burullus, New Capital) , the total capacity 14.4GW using Siemens technology as turnkey projects (six billion euro).
- ✓ Now it is in the phase of securing power for the power supply, reform of the power sector system and the creation of the corresponding electricity regulations.
- ✓ Since Egypt has great potential for wind and solar power energy, the following programs to promote the participation of the private sector is advancing for facilitating this energy potential.
  - ➢ Introduction of special incentive taxation measures
  - ➢ Development of legal systems where NREA can promote the construction and operation of the RE in cooperation with the private sector
  - ➢ Issuance of the renewable energy law

- ✓ Supreme Energy Council approved the sustainable energy strategy for 2035 in October, 2016, which shows that the renewable energy will occupy 37.2% of the total energy by 2035.

(5) Subjects of the presentation by MoERE undersecretary Dr. Mohamed Mousa Omran

On the basis of the PowerPoint document, the following content was made in the presentation.

- ✓ Present situation of the power plants and development plans for the future
- ✓ Integrated sustainable energy strategy until 2035
- ✓ Present situation on the revision of the electricity law
- ✓ Potential and development plan for renewable energy
- ✓ International interconnection plans
- ✓ Promotion of energy efficiency

(6) Presentation summary by Mr. Tsutomu Watanabe (Leader of JICA Survey Team)

- ✓ Summary of Interim Report
- ✓ Explanation on the candidate technical cooperation projects

(7) Presentation of each argument

Each specialist in the survey team explained the survey results and related candidate technical cooperation projects in each field, and potential Japanese technology applied for the candidate loan projects.

(8) Questions and answers as well as the exchange of opinions

1) Regarding the presentation by the survey leader

Q: Effects on the Egyptian power sector by the “digitization trend”

A: Digitization is still in progress in Japan and judged as an issue for the future. In Egypt, since big data will be derived through the smart meter system, utilization will be the first step.

Q: Plan of a double circular system with 500kV should be included in the TC for the Cairo metropolitan area study.

A: The issue will be included.

2) Regarding each presentation field

a) Renewable energy

Q: Concentrated solar power generation (CSP) can manage the output with storage of generated heat while conventional solar power would require batteries to realize the same function. Since the cost of batteries are relatively high, CSP might be more competitive than conventional solar power.

A: The battery prices are on a downward trend although they are still expensive. While CSP requires laborious O&M on the system, the combination of solar power and batteries is a far easier system to handle. Therefore the combination of solar power and batteries would be more advantageous at present.

Q: The battery system has a system frequency maintenance function similar to the adjustable speed pumped storage generation. Why does the survey team recommend the latter option?

A: Pumped storage generation is a concentrated system while battery generation is a diversified system. Since system frequency should be controlled in a centrally controlled manner and the duration of the control is relatively long and requires a large capacity (kWh). Therefore, it is advantageous to apply the pumped storage generation in order to maintain the frequency in general. Batteries are advantageous in terms of voltage maintenance or short period kW adjustment.

3) Power transmission system

Q: The trunk power transmission system plan is now in progress with the help of Siemens. Still, since the transmission system around Cairo area has many issues to be solved, experiences in Japan can be deemed as useful. Therefore, cooperation from Japan is anticipated.

A: Favorable cooperation will be realized when information on the plan is commonly shared and the issues are well identified.

4) Distribution system

Q: What is the situation regarding smart meter introduction in Japan and what suggestions do you have for Egypt?

A: The introduction of the smart meter has been advanced for five years in Japan. We are aiming for 27 million installations through the plan by 2020, and 10 million have already been introduced. Therefore, we can share information with the Egyptian power sector concerning smart meter system experience in the near future.

(9) Snapshot of the Seminar

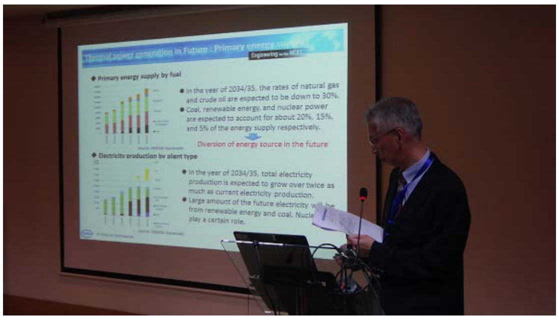
Registration

VIP seats at the opening of the Seminar

Overall Appearance

Speech by the Minister of MoERE

Participants



Presenters

Chapter 3 Main Issues in the Power Sector and Expected Solutions

3－1 Understanding of the Overall Situation in the Power Sector in Egypt

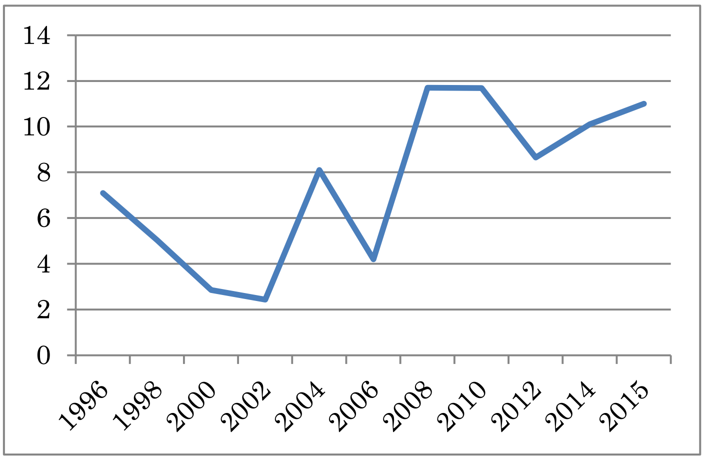
1) Average annual growth in electricity demand was 4.21% over the last four years and there has been shortage of generators against power demand. Moreover, outages have frequently occurred because of difficulties in fuel procurement and other causes, which is a social issue in the country.
2) Thermal power generation facilities, which dominate 91% of electric generation, have been strengthened up to 3.6GW in 2014/2015 as a so-called FAST-TRACK generation to cope with the situation. Moreover, new 2.5GW generation, financed by the World Bank, will be in service from now and in the near future. Therefore, new generation development has been and will progress steadily and secure stable power supply for the time being.
3) ISES2035 Scenario4b was officially approved as the national energy plan. According to this scenario, we will see generation capacity reaching 57026 MW by the end of June, 2021, CREMP and other plans.
4) Moreover, ISES2035 Scenario4b shows the energy diversification strategy with deployment of coal-fired generation, nuclear generation and renewable energy. Although the timing of large scale deployment of coal and nuclear power would be in the middle or after 2020, total capacity would surpass 10GW. A large amount of renewable generation will also be developed until 2035.
5) Regarding the transmission system, drastic reinforcement of the bulk power system is now under study to cope with ISES2035 Scenario4b, which also includes the reinforcement of international connections.
6) To realize the large enforcement plans of the power sector, the required funding has been secured or can be expected. The enforcement of the transmission network systems is similarly developed by EPC.
7) According to the 2015 Electricity Law No. 87, the Egyptian Electricity Transmission Company (EETC) is separate from the Egyptian Electricity Holding Company (EEHC) in order to establish an independent transmission system operator (TSO).
8) On the other hand, recent demand growth has slightly increased by 3.5%. According to ISES2035 Scenario4b, GDP growth will be around 5.2% during the period 2014 – 2035.

   Furthermore, regarding the energy tariff, 70% of the actual cost in the power sector will be reflected in the electricity tariff in 2018, in accordance with the World Bank Group Development Policy financing. It would mean that 30% of the remaining portion of the cost will be reflected at a later date, which will be a rather heavy burden on the customers. Furthermore, applying the floating policy for the Egyptian Pound and a decrease in energy subsidies, especially on fuel for thermal power, will push up factors on the tariff and might become a stagflation factor in the Egyptian economy.

   However, the energy tariff will be restructured. The restructuring program was launched in July 2014 for a period of 5 years, with the aim of eliminating electricity subsidies which will benefit the renewable energies to provide real and actual energy prices. This program was implemented until its fourth phase, but was extended for an additional 3 years to be fully implemented by the end of 2022.

9) Considering these factors, basically, Egypt has potential for relatively high economic growth as a solid basis and is expected to have steady electricity demand growth in the long run. However, during the period of the ever-rapid growing economy, there may be a transition period of fluctuating economy.

Incidentally, in Japan, the power sector experienced the same path and the economy eventually transitioned from the rapid growth era to moderate growth era.



Source: IMF

Figure3-1-1 Transition of inflation (%)

Table3-1-1 Economic forecast (Source: IMF)

	2016	2017	2018	2019	2020	2021
Real GDP (LE Bil)	1,871	1,945	2,039	2,152	2,277	2,414
Real GDP increase (% change)	3.83	3.95	4.83	5.54	5.83	6.00
Real GDP / person	20,550	20,881	21,397	22,074	22,836	23,663
Total investment (% to GDP)	14.53	16.08	15.26	16.75	18.35	19.62
GNS (% to GDP)	8.72	10.88	10.66	13.73	15.72	17.38
Inflation (%)	10.20	18.24	13.15	9.64	6.98	7.11
Imports goods & services (%)	14.52	-6.64	9.44	1.12	4.35	6.72
Exports goods & services (%)	-3.24	6.45	9.56	8.59	7.40	7.07
Unemployment rate (%)	12.67	12.27	11.34	9.98	8.41	6.70
Population (mil)	91.05	93.14	95.28	97.48	99.72	102.01

Source: IMF（International Monetary Fund, World Economic Outlook Database, October 2016）

3－2　Issues on power sector policy and basic frames of the solutions

Based on the understanding as presented above, the survey team identified issues in the power sector and presented the basic frames of the solutions

3－2－1 Ensuring Power Supply to cope with increase in uncertainty regarding demand increase

The following figure shows the possible situation in the demand growth trend in Egypt based on the experience in Japan.

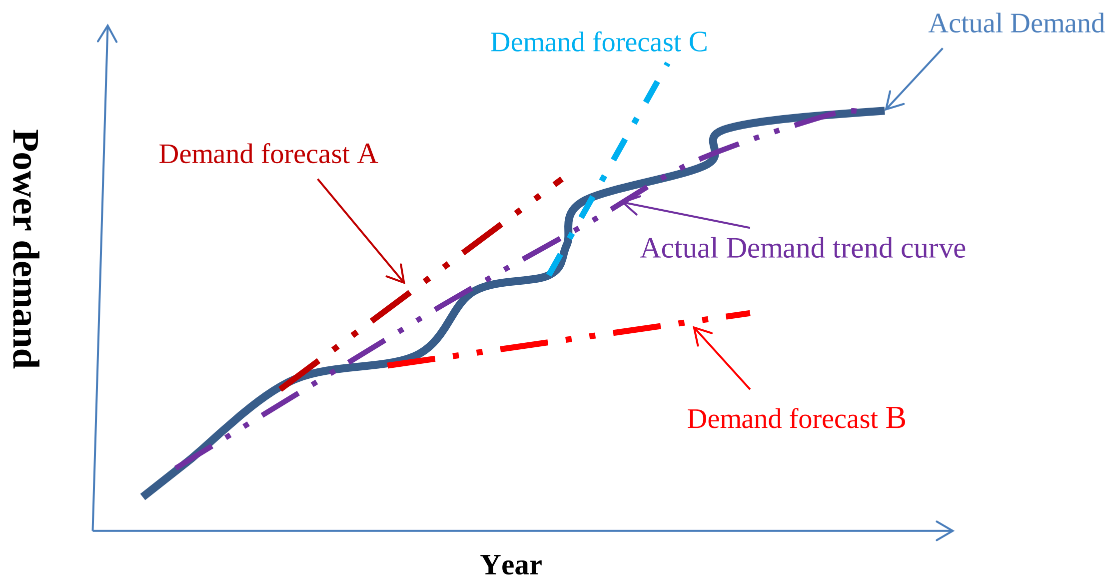


Figure3-2-1-1 Trend of electricity demand and demand forecast

ISES2035 Scenario4b Plan basically assumes 5.5% GDP growth/year will continue until 2035. From this projection, the demand growth is estimated as dotted line A

However, there is a sign of demand slowing down in demand growth recently. In the case that this trend continues for a relatively long time, demand forecast may change to dotted line B. On the other hand, there is a good possibility of recovery in demand growth because Egypt has enough potential for future economic development. Therefore, B might be too pessimistic as a demand growth projection. In Japan, when the recovery started, there appeared to be very high demand growth (known as the “bubble economy”) and the forecast was changed reflecting the trend as dotted line C. Since the reinforcement of the electric power system should normally take several years or more from the planning stage, precise projection on demand growth should be essential. Otherwise, excess or short capacity of the system can be envisaged. In the case of Japan, the actual demand trend curve is depicted as the dotted purple line and the economy and demand growth was transitioned from a high growth era to a steady growth era while going through repeated high and low periods.

(1) Possible Solution 1; Improvement in capability on the demand forecast as EEHC group

(Short-term to Mid/Long-term)

In this circumstance, improvement in capability on the demand forecast as EEHC group should be pursued for management of the power sector. Although various efforts have been in place for the demand forecast, it would require more effort to meet the increasing uncertainty in demand growth.

From the experiences in Japan, it would not be insufficient to follow the trend of electricity use in the past and require large scale customer information, including management policies in the future derived from direct interviews with customers. Incidentally, in Japan, some customers with big factories expressed the intention to leave Japan if tariff levels increased level, and actually left Japan when the tariff was raised

Information on individual customer demand obtained by the smart meters would also be useful measure to analyze information such as changes in customer attitude in electricity usage corresponding to the tariff hike.

[Possible field of Japanese contributions]; Providing Experiences of Demand Forecast in Japan

(2) Possible Solution 2; Deployment of the Tariff System Leading the Demand Trends

(Short to Mid/Long-term)

To cope with increasing uncertainty regarding demand growth, introduction of the tariff system, which will help suppress extreme changes in demand growth, may be developed. For example, the tariff system with high kW rates in heavy-loads and low kW rates in light-loads may be introduced. Many tariff systems may be effective in Egypt because the tariff would be increased and the customers would try to reduce payments by reflecting the tariff system. On the other hand, since new high efficiency generation plants will be introduced in Egypt in the future, it may be reasonable to induce the customers to use more electricity. In such cases, tariff systems will encourage electricity use (kWh) while preventing demand (kW) during peak periods. This energy use would be efficient and economical in the national interest of Egypt. In the power sector, this energy use will bring about higher availability in the generation and transmission system, and more efficient management will be realized.

Incidentally, a smart meter system could cope with such flexible tariff system.

[Possible field of Japanese contributions]; Offering of Japanese tariff system.

(3) Possible solution 3; Employment of system to promote cost-reduction in the supply side

(Short to Mid/Long-term)

In the past, since electricity was heavily subsided, the tariff system was implicitly promoting electric power use. However, a rather drastic increase in the tariff would result in a downward trend of electricity use. In such a case, a hike would bring about a decrease in electricity use and possibly result in Egyptian economy shrinking. Namely, after the end of electricity tariff subsidies, some kind of paradigm shift may appear.

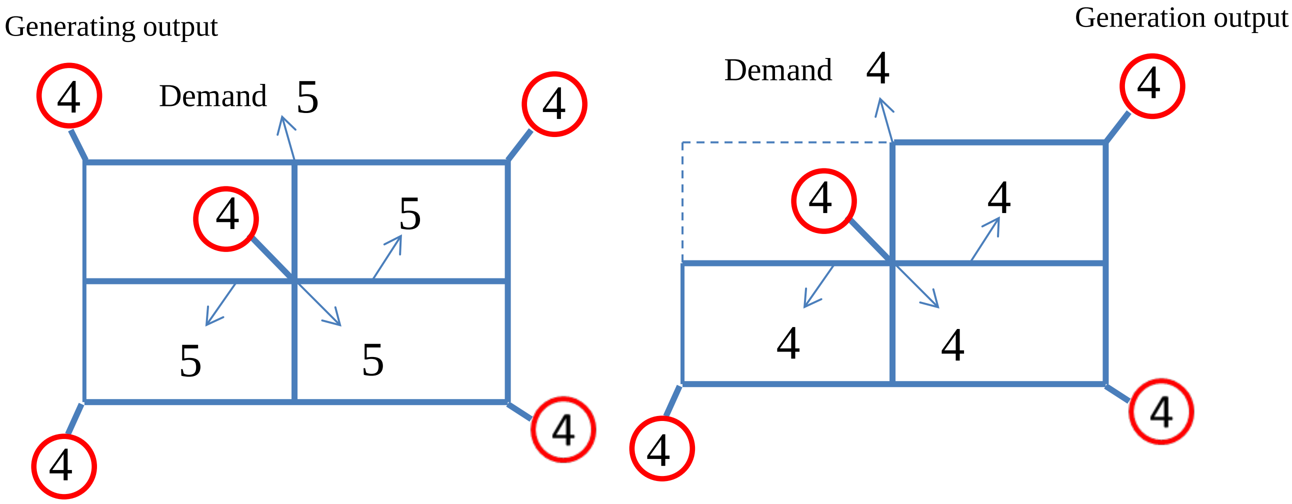
In Japan, the national government, especially the Ministry of Economy Trade and Industry, has been trying to rationalize the power sector and prevent the drastic increase in the tariff to nurture the national economy.

In Egypt, this role might be mainly assumed by EgyptERA as stipulated in the Electricity Law and E-ERA should have appropriate actual power and human resources for realizing this purpose. Moreover, since this function is be very important for sound development in the power sector as well as Egypt itself, MoERE may also be involved in this activity.

[Possible field of Japanese Contribution]; Providing experience in tariff assessments for increasing electricity tariffs

3－2－2 Reinforcement of the transmission system under the condition of increased uncertainty in demand growth

Increases and decreased in demand could bring about change in the transmission system as shown below.



Transmission system with 20 demand　　　　Transmission system with 16 demand

Figure3-2-2-1 Trend of Electricity Demand and Review of Transmission and Transmission System (Conceptual Diagram)

As shown above, demand increase or decrease in the bulk transmission system generally occurs rather uniformly all over Egypt. On the other hand, generation plant facilities vary according to the total demand. In the figure, one of the generation plants is eliminated in the right hand system to meet the reduction in demand growth.

According to the rather large change in generation plant arrangements in the power system, the structure of the transmission system is re-configured as shown in the right hand diagram where the upper left corner of the transmission system could be out of the reinforcement plan.

This change in the transmission system may bring about a change in the characteristics of the total network and affect the reliability of the entire system. In response to the situations mentioned above, a careful study on the network system change is required. This study would normally require advanced expertise and profound experience in transmission system analysis, which will be conducted repetitively and swiftly in accordance with the latest demand forecast and the related renewal of the generation plan.

- Basic frame of the solution;

Improvement in technology in power system analysis, and acquisition of the know-how to flexibly cope with the changing situation (Short to Mid/Long-term)

This study would require personnel with fairly advanced technological knowledge and understanding of the EETC and EEHC plan for the future. The survey team assumes that there is already be well experienced and highly versed personnel with expertise in EETC.

However, in some cases, since the network structure might be rationalized by introducing FACTS or highly tension-resistant conductor transmission lines, more sophisticated expertise will be required.

Therefore, capacity building in EETC should be essential in this field.

In Egypt, since the transmission reinforcement plan to 2025 is now under study and will be established in the near future, it is strongly recommended to foster the personnel with abundant expertise from the long term perspective to cope with a period of more uncertainty.

[Possible field of Japanese Contributions]; Providing network analysis skills for rationalizing the transmissions system with high expertise

3－2－3 Coping with the Mass Introduction of renewable energy from a long term perspective

The vital goal of ISES2035 Scenario4b Plan is introducing mass renewables based on CREMP up to 2022, specifically, achieving 20% of electric power demand(kWh) in 2022, including existing hydro energy. For these objectives, currently, an introduction of 6GW wind power and 3GW solar power energy is in progress and it will not be changed even if the demand forecast is reexamined. From the plan, conventional hydro power with 2.8GW would act as a major energy supplier in 2020, and after that a larger capacity of wind and solar will be introduced. When the large capacity of renewable energy is introduced, an important issue will be how to maintain the integrity of the electricity system such as the maintenance of stable operation of conventional generation and securing frequency. Since the output of the renewable energy plants should be maintained preferably according to the input by wind or solar energy, these issues should be studied and countermeasures should be established. According to the survey, it was revealed that CREMP had analyzed these issues, based on experience in Europe and concluded that the electricity system would be maintained at acceptable conditions from an operational point of view. However, theoretically, the review on the study is indispensable, reflecting the conditions of the expected prospective plant sites in Egypt because Europe and Egypt have rather different conditions. The study and countermeasures should be established and realized by middle of 2020s when the full-fledged introduction of renewables is expected.

(1) Possible solution 1; Accumulation of data in the field for estimating the expected wind and solar power (Short to Mid/Long-term)

Regarding solar, it is expected that the fluctuation of output will be relatively small because the expected sites will be in desert areas. However, data collection on the weather in each field should be conducted and an appropriate output forecast method for total output in Egypt should be established.

Regarding wind, output will be varied according to atmospheric pressure and geographical features. Therefore, more attention should be paid to such as selection of data collection sites and duration of the data collection from a scientific point of view. Anyway, the output forecast method on the day before and on the day, as well as the estimation on the rapid output change as a total in Egypt should be established.

(2) Possible solution 2; Application of countermeasures to cope with adverse effects on the local system before large capacity introduction (Short to Mid/Long-term)

In some regions, the adverse effects of the output fluctuation might bring about adverse voltage change to the customers. The voltage control system in renewable energy or SVC may be countermeasures that can be introduced to mitigate the effect.

[Possible field of Japanese Contribution]; Introduction of voltage countermeasure equipment to the distribution system to realize mass introduction of energy.

(3) Possible solution 3; Strengthening the organization and capacity of related human resources in EETC to cope with the issues inflicted by renewable energy plants (Short to Mid/Long-term)

Technical issues caused by renewable energy on the network are rather different from the conventional generation plants. They should be analyzed, reflecting all the related factors along with the existing transmission system characteristics. It should, therefore be preferable to establish a specific division in EETC and nurture the expertise of the human resources.

(4) Possible solution 4; Study on countermeasures for large introduction after 2025 and identify of required preparations. (Short to Mid/Long-term)

According to ISES2035 Scenario4b, large facilities for renewable energy will be introduced in and after 2022, and most (except CSP) are basically predicted to be operated without output control. Thus, it should be most probable that issues related to renewable energy will increase and be critical to system operation.

It also is expected that large capacity of coal and nuclear generation will be in service almost simultaneously. On the other hand, large capacity hydro pumped storage plants (about 2GW) will also be introduced around that time, which will be a positive contribution for better system operation. From our experience in Japan, generators with proper specifications for hydro pumped storage plants will be very beneficial for the system operation.

Anyway, since it will be a very big challenge for the network operator to cope with the system issues in the mid and late 2020s, solid preparation to help maintain the stability of the system should be incorporated while pursuing a strong economy.

[Possible field of Japanese Contribution];

Offering integrated operational technology on power networks including base load power such as RE, coal, nuclear power, and pumped-storage power generation.

Offering pumped-storage operational technology which can realize various functions such as adjustable speed type generators.

Considering these various issues, it might be an option to introduce a renewable national control center (RNCC) where renewable energy operations are concentrated. Although NECC would be a last resort for the entire system operation, the role allotment between NECC and RNCC may result in better coordination between renewable energy and conventional generation.

to realize this scheme, t preparatory work such as signal ends in renewable plants for the remote control may be required.

[Possible field of Japanese Contribution]; Technical assistance on the study for RNCC

(5) Possible solution 5; Study on the expected change of the load curve and application of proper countermeasures (Short to Mid/Long-term)

In Egypt, peak hour is in the evening and the output of solar power is not able to contribute to the peak hour supply. (Excluding CSP) On the other hand, it will contribute to the power supply during the day.

Thus, with an increase in solar power, it is expected that there will be steep demand increases from the afternoon to evening.

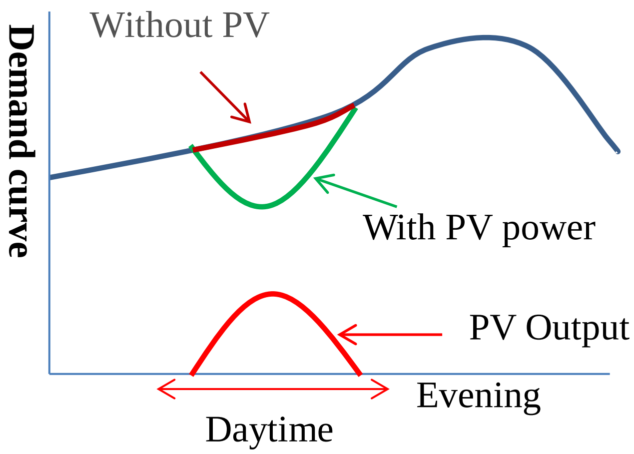


Figure3-2-3-1 Influence of PV introduction and influence on load curve

It is planned that the 3GW new international interconnection between Saudi Arabia and Egypt will be in service and power exchange will be conducted to send power to Saudi Arabia in the daytime and receive power in the evening to utilize the difference in the peak times in both countries. This operation is surely expected to reduce the steep rise in the demand supply curve. However, since the international interconnection will be operated based on the principle of "stable operation in own country should be first priority", too much dependence on international interconnection should be avoided. Therefore, other countermeasures such as introduction of contracts with customers who can enable a peak shift from evening to day time would be a good candidate for mitigating the steep rise. Smart meter systems will become the good measures to realize these contracts.

[Possible field of Japanese Contribution]; Offering technology utilizing Smart Meter System in introducing RE

3－2－4 Issues related to FIT (Additional reminding comment)

In the case where there would be a difference between the RE generation costs and conventional generation costs. Usually, the cost difference is a burden, so it should be compensated at customer expense or by government subsidies. There is no clear system to compensate the cost difference in Egypt and this will become an issue in the future if the total amount of the difference should become too large to be neglected. To tackle this issue, two measures need to be studied with consideration shown to transparency and efficiency The first measure is to analyze transactions among the concerned parties, that is, the generation companies, EETC and the distribution companies, and estimate the incurred costs at a time when RE incorporates a relatively large part of power generation.

The second measure is to establish a burden sharing system to make the FIT system sustainable, which should be rational and accountable to customers. The burden might be shared by the government through subsidies to the electricity bill for reducing the burden on customers. In any case, TSO, presently EETC should play an important role because TSO stands between the generation and demand sides. For the time being, mainly the distribution companies will play a role for the customers.

3−2−5 Regarding Reform of the Electric Power Sector

(1) Issues related with the introduction of TSO

From the experience in Japan, it is expected to take some time to set up the following issues when the first step of the Reform is introduced:

- ✓ Transaction rules which were applied in EEHC group will be transformed into market rules and the electricity system operation of TSO.
- ✓ Markets such as day-ahead markets, on-the day markets, and ancillary-service markets will be set up while transparency and transactions will be recorded in clear formats in regard to financial settlements.
- ✓ Automated system with a high security communication system will usually be essential for swiftly deciding transactions and reflecting them in the electricity system operation without hampering the electricity system stability
- ✓ Elaborate checks and tests should be conducted at the design stage and actual operation stage because a minor defect might cause adverse effects to the electricity system.

➢ Basic frame of the solution;

Elaborate study on the issues related with TSO introduction and appropriate measures to realize the required functions (Short-term)

Consultancy will be expected to proceed, while keeping all the issues mentioned above in mind. Still, from our experiences in Japan, most attention should be focused studies, especially on the transaction areas, and ample time should be secured before entering real operations while the enhancing of human resource skills is realized.

[Possible field of Japanese Contribution]; Introducing the experiences of setting up electricity markets in Japan

(2) Issues after TSO establishment

After TSO is established, the legal ramifications may be enough to realize liberalization. If so, EEHC may operate as a stock holding company with other existing companies. On the other hand, a disbanding of EEHC may also be possible. Therefore, discussions on reform will continue for a while after TSO establishment and drastic changes will not be conducted prior to ample discussions.

➢ Basic frame of the solution;

Decisions on the next step reflecting the specificity in Egypt (Mid/Long-term)

In Egypt, EEHC has surely played a very important role to secure power sectors. Prudent discussions must be conducted on whether EEHC should be operated or not.

In the case that EEHC will be in operation, rationalization of the power sector might become an issue because EEHC will still have influential power in the electricity market. To solve or mitigate adverse effects with this option, the system to enforce cost-reduction in the sales-side may be put in place or reinforced in addition to the supply-side cost-reduction system for realizing more rationalization in the power sector.

[Possible field of Japanese Contribution]; Providing Experiences of tariff assessment especially when increasing electricity tariffs to encourage rationalization

3－3 Regarding Issues on Individual Sectors

3－3－1 Power Supply

In this field, the planned power reinforcement until 2022 has materialized; however, as the increase of demand is expected to be lower than expected, it is expected that the abolishment of the existing generation plants will be required to avoid excess generation capacity whilst new power developments are rescheduled. In this situation, the priority list of generation plants to be decommissioned will be formalized according to age, inferior performance in efficiency or environmental aspects and so on. According to experiences in Japan in the past, viable generation plants might become candidates. On the other hand, as aforementioned, Egypt has sufficient potential for rapid economic growth in the future, and if certain conditions are met, a rapid increase in demand could occur in the future.

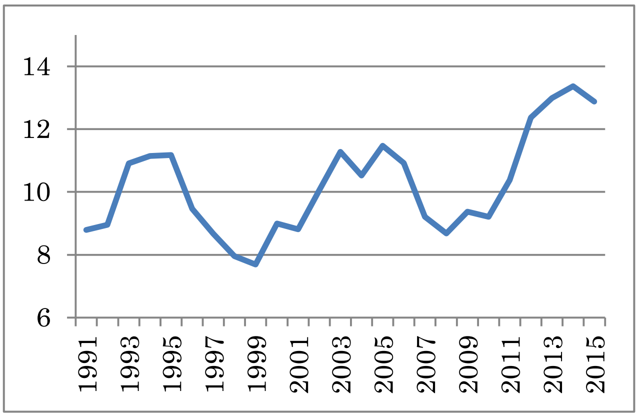
- Possible solution; Designation of Temporary Suspended Operation Plants (TSOP) (Mid/Long-term)

In the light of the above, "temporary (usually more than one year) suspended operation plants", instead of decommissioning the plants, an alternative option is to respond to a request to restart operations while maintaining the plant at certain level for future operation.

In applying this option, since some maintenance crew and related costs will be required, a proper study beforehand and maintenance organization is necessary.

[Possible field of Japanese Contribution]; Introducing Experiences on TSOP

Incidentally, since the new generation plants will require fewer personnel compared to the old plants, decommissioning or TSOP may result in excess personnel in power generation. In Japan, some personnel were transferred to the sales area. This may be the issue in Egypt because the unemployment rate is relatively high.



Source: IMF

Figure3-3-1-1 Transition of unemployment rate (%)

3－3－2 Transmission and Substation Networks

(1) Issues regarding upgrade of fault current levels

A large enhancement of the electric power network would bring about a drastic fault current increase. In Egypt, the fault current level will be upgraded to 50kA in the 500kV network, and 63kA in the 220kV network. Although it is generally assumed that the replacement of circuit breakers would be enough for the upgrading, an additional study additional study on the other substation facilities, and even, transmission line facilities, will be required.

➢ Possible solution; Appropriate survey on effects of the upgrade to transmission facilities. (Short to Mid/Long-term)

[Possible field of Japanese Contribution]; Introduction of Experiences on Fault Current Levels

(2) Issues on Plan for Underground Supply System in the Metropolitan Area (Cairo area)

In Egypt, approximately 40% of the population is concentrated in Cairo and surrounding area. (Here after, Metropolitan area) The growth of the entire country will be likely to be brought about by the continuation of development in the Metropolitan area. Regarding electricity supply, the increase in supply capability will be mainly shouldered by an under-ground cable system in the future because overhead transmission line reinforcement will face limitations. Thus, the expansion of the extra high-voltage 220kV underground cable system will be the essential part for stable energy supply well into the future. In the Metropolitan area, realization of high reliability is essential because many important functions are concentrated in the Metropolitan area and a blackout will bring about disastrous effects on the city functions.

- ➢ Possible solution; Formation of Metropolitan Supply Vision and related Road Map (Short-term)

Based on the prospects mentioned above, a plan of 220kV underground cable network systems needs to be formalized with the potential sites for 220kV substations, while projecting a long-term plan (20 years or so) , considering reliability while also considering a reduction in required costs. In the vision, specificity of the underground system, such as compactness of the facilities and sufficient anti-disaster ability should be incorporated. This would include, for example, gas-transformers and an indirect cooling system for cables.

[Possible field of Japanese Contribution]; Provision of Experience on Formulating Extra-High-voltage Underground Cable Network Systems with Specific Equipment

(3) Issues regarding loss reduction in transmission and distribution systems

In the transmission system, according to results of the visit to NECC, voltage in the bulk transmission system is suitably maintained and the power factor is controlled by the control of shunt capacitors. Regarding the future, reinforcement of the transmission system should be expected. Therefore, considering these factors, transmission system loss is not expected to worsen.

In the distribution system, according to the result of the visit to the overhead distribution system company and underground distribution company, although conspicuous improvement in distribution loss was not identified, voltage maintenance and power factor management is intentionally conducted along with the reinforcement of the distribution system. Considering these situations, distribution loss would not be expected to worsen.

Therefore, regarding total technological loss, a step by step approach will be appropriate with the replacement of old high loss equipment with new low loss equipment when the aging level reaches certain intolerable conditions.

On the other hand, regarding non-technical loss, it may worsen because electricity tariffs will be substantially raised in the coming years, which may provide incentives for electricity theft. Therefore, non-technical loss reduction will continue to be an important subject for the power sector.

- ➢ Possible solution; Establishment of electricity metering system to reduce non-technical loss including the application of smart meter system (Short to Mid/Long-term)

In the future, electricity metering will become more important in order to project a more correct demand trend as mentioned before, not only for the revenue issues. Therefore, establishment of an electricity metering system which includes the measures with social factors such as more severe punishment as stipulated by law. In the metering system and smart metering system, which should have many functions, will also play a key role.

[Possible field of Japanese Contribution]; Effective installation of smart metering system for reducing non-technical loss

3－3－3 Issues regarding Energy Efficiency

In Egypt, energy efficiency has been mainly focused on reduction of peak demand in the evening because the supply capacity in the power sector has been seriously and chronically short to cope with the demand increase. Therefore, replacement to LED lamps from conventional lamps should be rigorously promoted and assisted by the national government or international organizations such as UNDP for a direct reduction of evening demand.

In the future, at least for the moment, supply capacity would surpass the demand with the addition of new generation. Energy efficiency policy may be changed according to the situation into the style of a Customer Oriented Energy Efficiency Scheme (COEES).

Reflecting the rather large increase in electricity tariffs in the coming years, customers, especially heavy electricity use customers will appear to have an incentive for reducing electricity payments. Therefore, along with a tariff system with a more flexible structure such as more flexible selection of kW and kWh charge, flexible TOU and so on, the customer itself would pursue a reduction of kW in peak times and total kWh in the energy efficiency improvement system.

In the survey, energy use for some customers would be monitored and analyzed. Although this effort might not directly realize efficiency improvement of the customer, these analyses would show the potential of energy efficiency incentives to customers and the dialogue between the customer and the survey team would bring about a win-win solution for the supplier and customers through the better use of electricity energy, which, in the end, may bring about new opportunities for the development of a more efficient electricity use system in Egypt.

- Possible solution; Development of energy efficiency improvement system to meet customer energy use (Short to Mid/Long-term)

Based on the survey results conducted by the survey team and a tariff system reflecting customer needs, an energy efficiency system would be more customer oriented and, moreover, competitive power in Egyptian industry would be reinforced with high efficiency. In the process, the smart meter system would help develop a flexible tariff system while its original effect on the rationalization of the distribution system will be realized.

[Possible field of Japanese Contribution]; Introducing experiences of energy efficiency promoting a tariff system and measuring system (including Smart Meters)

Incidentally, national law or other systems in this area have already been rather highly promoted along with the voluntary activity system. These systems, which were strongly promoted by UNDP, should be continued in the coming new era and hopefully Japanese organizations can be included.

3－3－4 Issues regarding Finance

At present, the conventional finance system is working and facing no difficulties.

However, introduction of TSO would bring about a rather large effect on the finance and accounting system. TSO would require independency and neutrality as its nature in transmission system operation as well as accounting and finance. It would force the EEHC group to clarify transactions between TSO and other EEHC group companies. For example, borrowing or lending money should be clearly identified and put in the balance sheet while the transaction should be internally conducted.

At the moment, although the survey team has not derived enough information on the issues, they will become big issues in the process of establishment of TSO in near future. According to E-ERA, it should also commit the issues and appropriate policy on finance and accounting must be presented in a clear way, which would be significantly different from the conventional methods in EEHC group.

- Possible solution; Clarification of accounting and finance in response to the TSO establishment (Short-term)

In general, TSO should be monitored closely from the viewpoint of accounting and financing to keep independency and neutrality, and to secure sustainability of the organization. TSO should have the responsibility to maintain accountability with strict rules and appropriateness regarding transactions between other companies. Then, these processes should be clearly reflected in the Balance/Sheet and Profit and Loss Statement. Considering the situation in the near future, management of assets, including depreciation fittings with related appraisal in TSO should be established. It is also preferable to introduce an internal control system for proper management of the organization. Since all these effort will result in serious effects for the related companies such as EEHC groups, the companies should cope with the changes caused by TSO establishment.

[Possible field of Japanese Contribution]; Advice on development of accounting system in TSO and EEHC group

3－3－5 Issues regarding Environment

Regulation in relation to coal-fired thermal power, which is one of the main objectives in the survey, is estimated to be comparable to international standards. An Environmental Impact Assessment will be also conducted in due time. Based on these facts, it would be appropriate from an environmental point of view to develop new coal-fired plants.

Measures for conserving the environment after starting operations are also contemplated in EEAA.

Although all these efforts are well appreciated, a very large-scale power development with 6GW will affect the surrounding area, and it would become the greatest symbol in Middle-East and Africa for energy diversification.

It will be expected to maintain good performance in environmental factors for a long time and hopefully be expected to surpass environmental performances around the world.

- Possible solution; Execution of the countermeasures to realize good environmental performance in the long-term (Short to Mid/Long-term)

[Possible field of Japanese Contribution]; Long-term experience in maintaining environmental efficiency regarding coal-fired thermal power plants (including surrounding facilities)

Regarding environmental measures at pumped storage power generators, the Ataqa Pumped Storage Power Plant, of which a detailed feasibility study is currently under way, will be the first pumped storage with a large-scale of 2.4GW in Egypt. Taking sufficient environmental measures, including leakage control, into consideration will be essential for long-term operation.

- Possible solution; Setting of environmental measures based on overseas driving situation etc.

[Possible field of Japanese Contribution]; Provide knowledge on environmental measures of pumped storage plants

3－3－6 Issues regarding Human Resource Development

EEHC, power production companies, EETC, and distribution companies are actively working on human resource development. Thus, they own the appropriate facilities for the development of human resources. However, some expectations were expressed to enhance the quality/substance of the latest technology in each sector.

Regarding the environmental area, according to the interview, environmental specialists in EEHC do not possess enough knowledge or skills to review EIA conducted by the electric utilities, monitor the regulation of environmental and social activity plans, review the quantitative risk assessment, or consider the issues related with the coal fired power plants. These special resources regarding the environment will be reinforced with a step by step approach.

- Possible solution; Supply of the latest technology in the required fields

(Short to Mid/Long term)

[Possible field of Japanese Contribution]; Introduce up-to-date knowledge on thermal power such as coal-fired and the latest gas-fired combined cycle, distribution including IT, energy efficiency and environmental areas.

3－3－7 Issues regarding Distribution area (Tentative)

In EEHC, regarding the distribution area, it is perceived that some issues will be dealt with properly to improve performance.

However, based on the survey, the team could not identify a clear picture of issues in the area, which is partly due to the issues being locally oriented, even in distribution companies, and such specific situations may not be well understood among the concerned donors.

- Tentative solution; Autonomous issue of findings and finance toward solving the issue

EEHC managing sector and distribution companies will identify the issue autonomously and set an effectiveness appraisal index and work out concrete measures.

Required finances for conducting the measures should be decided and submitted to a financer. The financer should estimate the contents and decide financing for the first year.

Receiver of the finance should conduct measures and submit the index at the end of the first year along with a second year request for finance.

The financer should check the index and decide on second year finance.
This process will continue for 3~4 years.

This idea is only tentative and not a proposal at the moment.

Chapter 4 Candidate projects to cope with the issues

4－1 Candidate projects as technical cooperation for realizing the solutions

The survey team proposes the candidate projects as Technical Cooperation as shown in Table 4-2-1. These projects are selected based on the analysis in Section 3, which presents the issues, solutions in the Egyptian power sector and potential Japanese contributions, while considering the available resources in Japan at the moment.

In addition, the proceeding of the projects each year is shown in Table 4-2-2.

In Egypt, since the power sector has been supported by Europe and International organizations in many fields, the issues have been dealt with to some extent. Therefore, at first, the projects with technical assistance are proposed and the projects required for the loan are proposed at the next stage. In 2018, some projects for the short and mid-long term will be proposed based on the survey analysis, especially in the area of countermeasures to cope with more uncertainty in demand growth and other factors. Namely, the management of diversified generation and stabilization of the largely reinforced transmission system along with the coordinated Reform of the power sector are mainly focused on.

To cope with these subjects, the survey team assumes that specialists with abundant knowledge on the issues will start the related work and clarify the needs and priorities in the other candidate projects. Based on these activities, the long mid/long term loan projects which would fit the Egyptian power sector best will be identified.

4－2 Contents of the candidate projects

In this section, the concrete contents of the projects such as required budget, duration, and support activities are tabulated in Table 4-2-1, 2, 3...

Incidentally, candidate project No.14 was deleted from the list at the final stage because the other donor had already committed to the project. However, since this project includes the crucial contents for a solution in the operation of the Egyptian power system in the future, the data of the project is tabulated as a record of intention by the survey team.

Table 4-2-1 Candidate projects

No. of Issue	Issue	Solution		Potential Japanese Contribution	Project Name	
３－２	Issues and basic frame of possible solutions in the Power Sector Policy	－	-	-	-	-
３－２－１	Ensuring power supply to cope with increase in uncertainty of demand increase	(1)	Improvement in capability on the demand forecast as EEHC group	Providing Experiences of Demand forecast in Japan	-	-
		(2)	Deployment of the Tariff System Leading the Demand Trends	Offering of Japanese tariff system	-	-
		(3)	Employment of the system to promote the cost-down in supply side	Providing Experiences of the tariff assessment for increasing electricity tariff	-	-
３－２－２	Reinforcement of the transmission system under the condition of the increased uncertainty in demand growth	－	Improvement in the technology on the power system analysis and acquisition of the know-how to cope with the changing situation flexibly	Providing network analysis skills for rationalizing the transmissions system with high expertise	1	Technical Assistance on improvement of voltage / reactive power planning technique and introduction of power stabilization system in 500kV bulk power system
					2	Introduction of Voltage/Reactive Control System and Power Stabilization System in 500kV bulk power system
					5	Introduction of 500kV Substation construction which would serve for the 220kV underground cable system starting point
３－２－３	Coping with the mass introduction of renewable energy from a long term perspective	(1)	Accumulation of the data in the field for estimating the expected wind and solar	-	-	-
		(2)	Application of countermeasures to cope with adverse effects on the local system before the large capacity introduction	Offering pumped-storage operational technology that various roles can play such as adjustable speed type pumped-storage generators	6	Introduction of voltage countermeasure equipment in distribution system to cope with massive renewable energy generation
		(3)	Strengthening ability to respond to issues at EETC	-	-	-

No. of Issue	Issue	Solution		Potential Japanese Contribution	Project Name	
３－２－３	Coping with the mass introduction of renewable energy from a long term perspective	(4)	Study on countermeasures regarding the large introduction after 2025 and identification of required preparation for the time being	RE, coal, basic power supply of nuclear power, supply of comprehensive operation technology including pumped storage power generation	13	Technical assistance on optimization of power source planning for meeting peak demand as well as securing stable operation
				Provision of pumping operation technology based on various roles such as variable speed specification of pumped-storage power generation	14	Construction Project of Ataqa Pumped Storage Power Plant (Concerning the two adjustable speed pumped storage system)
				Establishment of the command center concept centered on RE and examination, and specification of requirements	-	-
		(5)	Study on the expected change of the load curve and application of proper countermeasures	Offering technology utilizing Smart Meter System in introducing RE	8	Technical Assistance on utilization of smart meters to realize support for searching of theft locations, support for electric bill menu setting
３－２－５ (1)	Issues related with the Power Sector Reform	–	Elaborate study on the Reform issues and appropriate measures to realize the expected changes	Introduce experience in setting up electricity markets in Japan	7	Technical Assistance on formation of the implementation policy and realization of practical roadmap regarding the Reform
３－２－５ (2)	Issues after TSO establishment	–	Decision on the next step reflecting the specificity in Egypt	Providing experiences of tariff assessment for increasing electricity tariffs		
３－３	Issues and possible solutions in individual sectors	–	-	-	-	-
３－３－１	Power Supply	–	Designation of Temporary Suspended Operation Plants (TSOP)	Introducing experience in TSOP	10	Human resource development on halted thermal power plants for long-term preservation methods

No. of Issue	Issue	Solution		Potential Japanese Contribution	Project Name	
３－３－２ (1)	Issues regarding upgrading of fault current levels	－	Appropriate survey on the effects on the transmission facilities due to the upgrade	Introducing experience on fault current levels	1	Technical assistance on improvement of voltage / reactive power planning techniques and introduction of power stabilization system in 500kV bulk power system
					2	Introduction of Voltage/Reactive Control System and Power Stabilization System in 500kV bulk power system
					5	Introduction of 500kV substation construction to serve 220kV underground cable system starting point
３－３－２ (2)	Issues regarding the plan for underground supply system in Metropolitan Area(Cairo area)	－	Formation of Metropolitan Supply Vision and the related Road Map	Provision of experience on formulating Extra-High-voltage Underground Cable Network Systems with specific equipment	3	Technical assistance on development of 220kV Cairo and the metropolitan area supply strategy from a long term perspective
					4	Introduction of 220kV Cairo and its conurbation metropolitan area supply system facilities
３－３－２ (3)	Issues regarding loss reduction of transmission and distribution system	－	Establishment of electricity metering system to reduce non-technical loss including the application of smart meter system	Effective installation of smart metering system for reducing non-technical loss	8	Technical assistance on utilization of smart meters to realize the support for searching theft locations, support for electric bill menu setting
３－３－３	Issues regarding energy efficiency	－	Development of energy efficiency improvement system to meet customer energy use	Introducing experiences of energy efficiency promoting tariff system and measuring system (including Smart Meters)		
					9	Demonstration on energy efficiency support by load leveling equipment installments and operational technology
３－３－４	Issues regarding finance	－	Clarification of accounting and finance in response to TSO establishment	Advice to development of accounting system in TSO	7	Technical Assistance on formation of the implementation policy and realization of practical roadmap regarding TSO establishment

<table>
<tr><th>No. of Issue</th><th>Issue</th><th colspan="2">Solution</th><th>Potential Japanese Contribution</th><th colspan="2">Project Name</th></tr>
<tr><td>３－３－５</td><td>Issues regarding environment</td><td>－</td><td>Execution of countermeasures to realize good environmental performance in the long-term</td><td>Long-term experience in maintaining of environmental efficiency regarding coal-fired thermal power plants (including surrounding facilities)</td><td rowspan="2">11</td><td rowspan="2">Human resource development on O&M of coal fired thermal power plant, especially in the area of environment and coal handling</td></tr>
<tr><td rowspan="2">３－３－６</td><td rowspan="2">Issues regarding human resource development</td><td rowspan="2">－</td><td rowspan="2">Supply of the latest technology for the required fields</td><td rowspan="2">Introducing up-to-date knowledge on thermal power (such as coal-fired and the latest gas-fired) and distribution (including IT)</td></tr>
<tr><td>8</td><td>Technical assistance on utilization of smart meters to realize support for searching theft locations, support for electric bill menu setting</td></tr>
<tr><td>３－３－７</td><td>Issues regarding distribution</td><td>－</td><td>In EEHC, regarding the distribution area, it is perceived that some issues should be dealt with properly for improving performance.</td><td>-</td><td>-</td><td>-</td></tr>
</table>

Table4-2-2　Annual expansion of candidate Projects

Program	Concept of Projects	Title			TA or Loan	Counter Parts	2017	2018	2019	2020	2021	2022	2023	2024
Assistance for Network in short and mid/long term with high reliability	Improvement in planning and operational technology to maintain the reliability of the bulk network and application of suitable control systems and facilities	Transmission	1	Technical assistance on improvement of voltage / reactive power planning techniques and introduction of power stabilization system in 500kV bulk power system	TA	EETC			▬	▬				
		Transmission	2	Introduction of Voltage/Reactive Control System and Power Stabilization System in 500kV bulk power system	Loan	EETC					▬	▬	▬	
	Establishment of a supply vision for Cairo and surrounding Metropolitan area from a long term perspective along with the reinforcement of the 220kV underground cable system and foothold 500kV substations	Transmission	3	Technical assistance on development of 220kV Cairo and its metropolitan area supply strategy from a long term perspective	TA	EETC		▬	▬					
		Transmission	4	Introduction of 220kV Cairo and its conurbation metropolitan area supply system facilities	Loan	EETC					▬	▬		
		Transmission	5	Introduction of 500kV substation construction to serve the 220kV underground cable system starting point	Loan	EETC					▬	▬		
	Introduction of countermeasures to mitigate the adverse effects of mass Renewable Energy	Distribution	6	Introduction of voltage countermeasure equipment in distribution system to cope with massive renewable energy generation	TA	EEHC or DEC			▬					
Reform Assistance	Power Sector Reform support from optimization point of views	Transmission	7	Technical assistance on formation of the implementation policy and realization of practical roadmap regarding the Reform	TA	EETC	┅	▬	▬					
Support for Energy Efficiency improvement	Development of potential application area for smart meter diffusion	Distribution	8	Technical assistance on utilization of smart meters to realize support for searching theft locations, support for electric bill menu setting	TA	EEHC					▬			
	Introduction of a model energy efficiency system in large customers	Ene.Efficiency	9	Demonstration of energy efficiency support with load leveling equipment installments and operational technology	Loan	EEHC					▬	▬	▬	▬

Program	Concept of Projects	Title			TA or Loan	Counter Parts	2017	2018	2019	2020	2021	2022	2023	2024
Short-period technology transfer	Support for diversification of thermal supply resources	Generation	10	Human resource development on halted thermal power plants for long term preservation method	TA	EEHC								
		Generation	11	Human resource development on O&M of coal fired thermal power plants, especially in the area of environment and coal handling	Training	EEHC								
Stable operation of the entire system from a long term perspective	Support for the introduction of hydro pumped storage system along with development of proper operation of the entire system from a long term perspectives	Generation	12	Preparatory survey on the Construction Project of Nile Valley Pumped Storage Power Plant	Loan	HPPEA								
		Generation	13	Technical assistance on optimization of power source planning for meeting peak demand as well as securing stable operation	TA	EEHC, EETC, HPPEA								
		Generation	14	Construction Project of Ataqa Pumped Storage Power Plant (Concerning the two adjustable speed pumped storage system)	Loan	EETC, HPPEA								

Table 4-2-3-1 Contents of Candidate Projects (No.1; Technical Assistance)

Name of Project: Technical Assistance project on improvement of voltage / reactive power planning technique and introduction of power stabilization system in 500kV bulk power system
Budget: 200 million yen
Location for the services: ・Status quo of the Egyptian 500kV bulk power system plan in future and its expected operation system ・Provide training course to acquire technology regarding bulk power system planning and operation in Japan ・Establishment of voltage/reactive power planning techniques in 500 kV bulk power system in the future where the system would be drastically reinforced along with setting up of basic policy on power system stabilization
Implementation Schedule: April, 2018 ～ March, 2019
Counterparts: ・Egyptian Electricity Transmission Company: EETC

Content:

Egyptian bulk power system configuration, especially 500 kV system is expected to be drastically changed in the near future as a large-scale power supply development, major reinforcement in the 500 kV transmission lines and substations, large-scale international interconnection with Saudi Arabia, and massive introduction of renewable energy generation, etc.

Along with this, it is expected that the system planning and operation will be greatly complicated, especially concerning system planning and operations related to voltage and reactive power, maintaining voltage across the entire system, reducing power transmission loss, securing voltage stability and so on, assuming various system operational conditions and setting them.

Since the system operators need to cope with these difficult duties, an automated control system is essential, along with time based control to meet the requirements for bulk system operation.

On the other hand, when the power system becomes complicated, multiple accidents or similar rare accidents such as a relatively small problem in part of the system occurring that spreads to the entire power system in a chain reaction, developing into a large blackout.

In assuming such a case, a predetermined or instantaneous judgement stabilization control system by tipping or reducing generation output, prevention of influences from the accident by compulsory separation of the defected system, voltage stability maintenance system for large-scale load shedding while maintaining the supply for socially important customers, or emergency control with a large-capacity DC interconnection system, etc., these systems should basically automatically judge and respond without judgment of the operators.

Although it is assumed that EETC already operates the systems for realizing system stabilization, since the level of the bulk power system scale up and increase in complexity in the future is expected to be very large, utilization of Japanese technology that has been developed based on long experience in bulk power system operations will contribute to securing bulk power system operation.

For securing the system as much as possible, although it is assumed that EETC already operates systems to realize system stabilization, since the level of the bulk power system scale up and increase in complexity in the future is expected to be very large, utilization of Japanese technology that has been developed based on long experience in the bulk power system operation will contribute to establishing a concept of countermeasure policy and specific measures (systems to be introduced) suitable for the Egyptian system.

Necessity level in Egypt:

EETC is currently developing the 2025 transmission system expansion plan and will recognize that the main power grid will undergo extensive and drastic development in the future, and in the process of rearranging the issues leading to realization of the plan, a similar approach for the solutions should be common among the concerned parties in Egypt

Expected Results：**(short- term subjects)** On the Egyptian side, the project will contribute to stable operation of the electric power system, especially preservation of a stable system and prevention of large scale blackouts in Egypt On the Japanese side, introduction of control systems that take advantage of experience and high expertise in Japan will be expected.
Issues or Concerns： In Egypt, it is assumed that related technology exists based on original or Western technology etc., and there is a possibility that sufficient cooperative effects cannot be obtained unless technological compatibility between Japanese and Egyptian technology exist. This technical assistance assumes the establishment of policies and concepts, however, if the concerned parties in Egypt and Japan should sufficiently agree beforehand on the extent to which it is to be made. Still, there is a possibility that satisfaction of both implementers and the Egyptian side will not be obtained sufficiently at the end of the assistance.

Table 4-2-3-2 Contents of the Candidate projects (No.2; Loan)

Name of Project: Introduction of Voltage/Reactive Control System and Power Stabilization System in 500kV bulk power system
Budget: 3 billion Yen (27 million dollars)
Location for the services: ・Some 500kV substations, some Large scale generation plants（decided by TA） ・Training of Egyptian experts to acquire Japanese expertise in bulk transmission system planning and operation　such as preventing large scale blackouts in Japan
Implementation Schedule: April, 2019~ March, 2021
Counterparts: ・Egyptian Electricity Transmission Company: EETC

Content: Egyptian bulk power system configuration, especially 500 kV system is expected to be drastically changed in the near future as a large-scale power supply development, major reinforcement in the 500 kV transmission lines and substations, large-scale international interconnection with Saudi Arabia, and massive introduction of renewable energy generation, etc. Along with this, it is expected that the system planning and operation will be greatly complicated, especially concerning system planning and operations related to voltage and reactive power, maintaining voltage across the entire system, reducing power transmission loss, securing voltage stability and so on, assuming various system operational conditions and setting them. Since the system operators need to cope with these difficult duties, the automated control system is essential along with time based control to meet requirements for the bulk system operation. On the other hand, when the power system becomes complicated, multiple accidents or similar rare accidents such as a relatively small problem in part of the system occurring that spreads to the entire power system in a chain reaction, developing into a large blackout. In assuming such a case, predetermined or instantaneous judgement stabilization control system by tipping or reducing generation output, prevention of influences from the accident by compulsory separation of the defected system, voltage stability maintenance system for large-scale load shedding while maintaining the supply for socially important customers, emergency control with large-capacity DC interconnection system, etc. these systems should basically automatically judge and respond without judgment of the operators. Although it is assumed that EETC already operates the systems for realizing the system stabilization, since the level of the bulk power system scale up and increase in complexity in the future is expected to be very large, utilization of Japanese technology that has been developed based on long experience in bulk power system operations will contribute to securing stable bulk power system operation. Based on the study results derived from related technical assistance by Japanese experts, the concrete design of the systems to be introduced in Egyptian system will be established and the facilities will be set at the designated sites.
Necessity level in Egypt: EETC is currently developing the 2025 transmission system expansion plan and will recognize that the main power grid will undergo extensive and drastic development in the future, and in the process of rearranging the issues leading to realization of the plan, a similar approach for the solutions should be common among the concerned parties in Egypt
Expected Results:**(short- term subjects)** On the Egyptian side, the project will contribute to stable operation of the electric power system, especially preservation of a stable system and prevention of large scale blackouts in Egypt. On the Japanese side, introduction of control systems that take advantage of experience and the control system with high expertise in Japan will be applied

Issues or Concerns:

For development of the systems, detailed specifications should be decided based on the results of sufficient simulation and study of the electric power system, therefore, a considerable amount of personnel is to be required. On the other hand, the acquired know-how of the Egyptian power system may end with introduction of the control systems, so there is a possibility that sufficient profit cannot be realized from the viewpoint of corporate sales in the long run.

On the other hand, if the quality of the study should be lowered to reduce development costs, the quality of the developed system may deteriorate and furthermore, there is a risk that the technical evaluation of Japanese technology itself may become lower in Egypt.

Table 4-2-3-3 Contents of the Candidate projects (No.3; Technical Assistance)

Name of Project:

Technical assistance on development of 220kV Cairo and its conurbation metropolitan area supply strategy from long time perspective

Budget:

100 million Yen (0.9 million dollars: may be change according to contents of the study)

Location for the services:

・Survey on the plan in and around the Cairo area in Egypt

・Training on the extra high voltage metropolitan supply system development strategy, operation and control system, including a site visit in Japan

・Establishment of the supply strategy for 10 to 20 years in the future in Egypt

Implementation Schedule:

April, 2018 〜 December, 2018

Counterparts:

・Egyptian Electricity Transmission Company: EETC

Contents:

In Egypt, steady electric power demand is expected to increase in the future, but in particular the electric power grid in the Cairo Metropolitan area, where the nation's important functions are expected to be concentrated and population increase is expected to continue, will respond appropriately to the increase in electricity demand. It is considered important to set and realize a power system with a good economy while realizing high supply reliability to meet the requirements for migrating social influences due to power failure in the system from a long-term perspective.

Japan has large metropolitan areas similar to Cairo and has realized a highly reliable electric power system through long-term efforts. Utilities have cultivated know-how and applicable technologies to meet the specific characteristics unique to a metropolitan supply network, for example in the case of underground transmission system where transmission line impedance is relatively small with large charging current, and the overload tolerance is relatively small.

Based these experiences, by sharing related technology as much as possible while keeping in mind the unique situation in Egypt, basic policy and a roadmap on the power supply network development suitable for the Cairo metropolitan area from a long term perspective will be formulated. The policy will include, for example, a required control system to support the operation.

Necessity level in Egypt:

According to the 2025 Network reinforcement plan currently under study by EETC, it is assumed that the system expansion in the Cairo area will be manly realized with 220 kV underground lines and substations. Regarding system expansion for the 220 KV underground lines, it is recognized that there are technical issues different from the overhead transmission line system, and its importance is recognized together with construction of 500 kV substations serving as the supply source. (Common understanding should be formalized through discussions with the survey team and their counterparts)

:Expected Results:(short- term and mid/long term subjects) **T**he realization of a highly reliable and cost-effective electric power system through the introduction of Japanese technology in the Cairo area, which is one of the biggest metropolitan capital cities in Africa and the Middle East, has a strong effect on the country's stable growth. Through the realization process, if it is recognized that the usefulness of the Indirect Cooling System for underground cables and gas insulated transformers, All- GIS 500kV facilities in the substations where 200kV underground cable systems will be interconnected, which are adopted in the important selected sections in the metropolitan area supply systems in Japan, the facilities made by Japanese manufactures with very technical superiority can be introduced.
Issues or Concerns: Since the 220kV cable is a standard product worldwide, it is unknown how much the Japanese companies can commit to the formation of facilities. Also, depending on the demand trend in the metropolitan area (drastically slowing down), it is unclear whether or not this project will lead to subsequent commitment by Japanese companies.

Table 4-2-3-4 Contents of the Candidate projects (No.4; Loan)

Name of Project: Introduction of 220kV Cairo and its conurbation metropolitan area supply system facilities
Budget: 5～10 billion Yen -One 220kV substation in the underground cable system: with 2 220kV gas transformers, 220kV shunt reactors -One underground indirect cooling system for 220kV underground cable with 1 root of two circuits
Location for the services: ・Cairo, Egypt
Implementation Schedule: Starting in 2020 ~ 1.5 years (depending on the TA results to be conducted in 2018)
Counterparts: ・Egyptian Electricity Transmission Company: EETC

Contents:

In Egypt, a study to develop 220 kV underground cable system in Cairo metropolitan area is being conducted. Since the Cairo Metropolitan Area is an important region forming the heart of the country, it is essential that the system should realize high reliability with good economy and be operated stably over a long term.

On this issue, it is effective to adopt a gas insulated transformer that does not use insulating oil for parts for the purpose of disaster prevention in underground substations installed in downtown areas etc. in order to increase the safety.

On the other hand, since underground cables have low impedance and relatively low overload tolerance; there is concern that damage to the cables from overheating may occur if a large current flows during system operation. In response to this, it is useful to secure required transmission capacity with an indirect cooling system to the underground cables (water cooled system in Japan).

In addition, the underground lines, since a relatively large amount of leading reactive power is generated, shunt reactors to control the reactive power is assumed to be required. In Japan, from the viewpoint of appropriately controlling the total current through the cables, extra-high voltage shunt reactors are installed in 220 kV substations located in the middle part of the 220 kV underground cable system. This is an on and off operation according to the needs of the system operation in the bulk power system.

Whether or not to set up a shunt reactor in such a role in Egypt as in Japan will depend on the study results which would be preferably included in TA by Japan. If it is decided to apply a similar scheme, there is a high possibility of frequent opening and closing of the extra high voltage shunt reactor operation with proper specifications including the related facilities.

For deciding and implementing these subjects, it is basically assumed that EETC will cultivate technology and select facilities and improvements, but especially in the early stage of facility formation, it might be better for the facilities to be formed while receiving technical support from Japan as a so-called model case, which would, in the end, become the technical bridge for development from the first stage onwards.

Necessity level in Egypt:

According to the 2025 Network reinforcement plan currently under study by EETC, if it is approved, the issues stated above will be perceived as realizing the plan. In conducting the TA before beginning facility construction, the necessity of the scheme will be clarified by EETC, which would, in the end, confirm the merit of the project supported by Japan.

Expected Results:**(short- term and mid/long term subjects)** On the Egyptian side, the realization of a highly reliable and cost-effective electric power system through introduction of Japanese technology in the Cairo area, which is one of the biggest metropolitan capital cities in Africa and the Middle East, would have a strong effect on the country's growth. On the Japanese side, through the realization process and its long term operation, if it is recognized that the usefulness of such as the Indirect Cooling System for underground cables, gas insulated transformers made or assisted by Japan should be confirmed. This would result in a new business area for the manufacturers in and around Egypt.
Issues or Concerns: Japan's technology in this field has been cultivated according to the planning and operational needs of the electric power system. Therefore, it can be imitated because the advanced nature of technology (other than gas transformers) is not so obvious. It would be an issue to what extent the original technology of Japan is provided to EETC at the facility formation.・

Table 4-2-3-5 Contents of the Candidate projects (No.5; Loan)

Name of Project: Introduction of 500kV substation construction which would serve as the 220kV underground cable system starting point
Budget: 30 billion Yen (maximum) ?（ One 500/220kV substation with All-GIS 500kV outdoor type bay）
Location for the services: ・Around Cairo, Egypt
Implementation period: From 2020～ 2 years
Counterparts: ・Egyptian Electricity Transmission Company: EETC
Contents: In Egypt, steady electric power demand is expected to increase in the future, but in particular the electric power grid in the Cairo Metropolitan area, where the nation's important functions are expected to be concentrated and the population increase is expected to continue, will respond appropriately to the increase in electricity demand. It is considered important to set and realize a power system with good economy while realizing high supply reliability to meet the requirements for migrating social influence due to power failure in the system from a long-term perspective. From this perspective, among the 500kV substations to be introduced as the starting point of the underground transmission lines, especially substations serving as a starting point for supplying the important areas of the city (below, base 500kV substation), high reliability at a reasonable cost should be pursued. In this case, the 500 kV bus at such 500 kV substations becomes very important as the role of "intersection" through which large amounts of electric power flows, and the flow of the power will be supplied to the city center or very important customers. Considering these factors, it should be effective to make the 500 kV bus system with All-GIS and make the insulation part of equipment unaffected by the external atmosphere. In this case, since the building covering All-GIS is not essential, it can be considered to be an outdoor installation type All-GIS that is generally used in Japan. Since this type of extra high voltage substation is not common in Egypt, this project aims to realize highly reliable facilities while acquiring related technology.
Necessity level in Egypt: According to the 2025 Network reinforcement plan currently under study by EETC, if it is approved, the issues stated above will be perceived for realizing the plan. In conducting the TA before beginning the facility construction, the necessity of the scheme will be clarified by EETC, which would, in the end, confirm the merit of the project supported by Japan.

Expected Results:**(short- term and mid/long term subjects)** On the Egyptian side, The realization of a highly reliable and cost-effective electric power system through introduction of Japanese technology in the Cairo area, which is one of the biggest metropolitan capital cities in Africa and the Middle East, would have a strong effect on the country's growth. On the Japanese side, through the realization process and its long term operation, if it is recognized that the usefulness of the technology should be confirmed, this would bring about a new business area for manufacturers in and around Egypt.
Issues or Concerns: Japanese technology in this field has been cultivated according to the planning and operational needs of the electric power system. Therefore, it can be imitated because the advanced nature of technology is not so obvious. It would be an issue to what extent the original technology of Japan is provided to EETC at the facility formation.

Table 4-2-3-6 Contents of the Candidate projects (No.6; Technical Assistance)

Name of project: Introduction of voltage countermeasure equipment in distribution system to cope with massive renewable energy generation
Budget: Approximately 10 million yen up to 1 billion yen maximum (Assumed 5 million yen / distribution line)
Location for the services: ・Distribution system in which a large amount of renewable energy is introduced
Implementation Schedule: 2019 ~ 2021; Measuring by field measurements and simulations Measuring instrument specifications, scale determination 2022 ~ 2025; Measuring equipment installation, effect verification
Counterparts: ・Distribution company in Egypt
Contents: In the future, massive introduction of photovoltaic power generation etc. is scheduled in Egypt. As fluctuations spread, the fluctuation of the system voltage increases, and it is expected that it will deviate from the proper voltage. The introduction of countermeasure equipment is effective as a response to this. Specifically, it is expected that the proper voltage will deviates due to the influence of backward flow due to the massive interconnection of REs. Application of SVR is effective as a countermeasure. SVC is also effective for transient instantaneous fluctuations such as rapid weather fluctuations. In the Egyptian system, it is aimed at maintaining the voltage with instrument introduction by measuring and simulating whether instantaneous voltage fluctuation or constant voltage deviation is a problem. · Introduction of countermeasures for maintenance of system voltage (SVR, SVC, etc.), which becomes a problem when introducing large quantities of RE · As an introductory step, obtain information on which renewable energy is locally installed. In the measurement and simulation, determine the necessity of countermeasure equipment, the number of units, capacity and control method. We will introduce countermeasure equipment before the facility is opened. · The scale of the project is about one distribution company and 20 distribution lines, and a total of 200 power distribution lines is expected to be 1 billion yen. In other cases, it is not a local response like the installation of countermeasure equipment, but a planned response by the RE generator's side, such as power restraint of the power conditioner and constant power factor control, is cost effective and reasonable..
Necessity level in Egypt: The introduction of voltage countermeasure equipment at the time of introducing renewable energy has been reported not only in Japan but also in other countries.

Expected Results：**(short- term subjects)** ・Smooth introduction of renewable energy
Issues or Concerns Competition with overseas manufacturers with similar technology

Table 4-2-3-7 Contents of the Candidate projects (No.7; Technical Assistance)

Name of project: Technical cooperation project on establishment of implementation policy, comprehensive viewpoint on the Power Sector Reform
Budget: 180 thousand dollars (20 million Yen)
Location for the services: ・Survey on the process of establishing the TSO in Egypt ・Providing advice for setting up the policies and roadmap and concrete measures in the process in Egypt
Implementation Schedule: April, 2018 ~ March, 2020
Counterparts: ・Egypt Electric Utility and Consumer Protection Regulatory Agency:EgyptERA ・Egyptian Electricity Holding Company: EEHC
Contents: In the Egyptian power sector reform, establishment of TSO and other related changes will be an important point for the time being, but it is assumed that various items will be included and priorities are set from a comprehensive viewpoint among the concerned parties. It is necessary to steadily prepare and expand to reach the final goal. In the process, it is necessary to pay attention to ensuring transparency and accountability for new market participants, eligible customers, and overseas donors without impairing the stable operation of the power system. In Japan careful steps have been taken in promoting liberalization. Therefore, experienced parties or experts in Japan understand the stance of promoting realistic countermeasures, taking into account the historical background of the power sector in Egypt. For this reason, we will provide the experience of dealing with liberalization in Japan in each step of the Reform and contribute to the smooth changes in a sector experiencing the actual situation in Egypt.
Necessity level in Egypt: Administrative level persons in MoERE、EEHC、EgyptERA、EETC acknowledge various challenges in realization of the Reform
Expected Results:**(in short- term subjects)** On the Egyptian side, it is beneficial for the smooth and practical implementation of future power sector reform to oversee, analyze and advise the situation cross-cutting, as the work of each organization might be carried out in a vertical manner. . On the Japan side, although Japan cannot expect direct benefit with this cooperation, since the situation of the power sector reform can be grasped in the process, useful information will be expected to be provided for setting up commitments to Egypt in the future.

Issues or Concerns

- Unexpected tasks may be revealed as far out of reach from the initial TOR
- Japanese commitment by the assistance may be unnoticed by the Egyptian side unless properly managed.

Table 4-2-3-8 Contents of the Candidate projects (No.8; Technical Assistance)

Name of project: Technical assistance on utilization of smart meters to realize support for searching theft locations, support for electric bill menu setting
Budget: Scale of about several hundred million yen
Place for the services: ・Basically in Cairo
Implementation Schedule: One year from 2021 (Assuming implementation after smart meter installation has spread to a certain extent)
Counterparts: ・Egyptian Electricity Holding Company: EEHC
Contents: By transferring technology to utilize smart meters based on the latest knowledge, we will realize energy efficiency utilization by load leveling and respond to changes in electricity demand due to the introduction of large amounts of RE. Technical support will be implemented utilizing the feature that electricity consumption data of 24 hours 365 days by the smart meter will be available in the future. Specifically, we will analyze usage data for each time period, set a charge menu to suppress power peaks and promote power demand, and support to achieve effective load leveling. Although it is effective to introduce the load leveling menu sequentially from customers with high electricity demand, it is also possible to support the development based on the experience in Japan. Also, as sunlight increases, it is expected that the rise of the evening load will become steep, but if the smart meter usage spreads in the future, it will be necessary to estimate demand with high accuracy using acquired data. Support is possible.
Necessity level in Egypt: In Egypt, smart meters are in the process of being introduced and there is a need to support a specific utilization policy.
Expected Results:**(in short- term subjects)** It is expected that the power system operation will be flexible by realizing load leveling and energy saving by utilizing smart meters and highly accurate demand assumption.
Issues or Concerns: It will be technology transfer only and will not lead to the export of systems etc. It is necessary to spread the installation of smart meters to a certain extent in order to use it for demand forecast based on mass introduction of RE.

Table 4-2-3-9 Contents of the Candidate projects (No.9; Loan)

Name of project: Demonstration on energy efficiency support by load leveling equipment installments and operational technology
Budget: Approximately 1 billion yen is assumed for each house
Location for the services: ・A few large energy-use consumers and MoERE etc.
Implementation Schedule: First step; One year for study Second step; One year for installment Third step; Two years for starting up support and MRV
Counterparts: ・MoERE, EEHC, Ministry of Industry or Ministry of Oil etc.
Contents: To create awareness of energy conservation to citizens, form a program that employs cost incentives. First step; Study present conditions Second step; Understand a gradual subsidy removal. Using this removed subsidy, power companies discount their tariffs to the demand side with high load factor or having power peak in night time by subsidizing load leveling equipment installment. Equipment for load leveling is like CHP(co-generation system), battery system or thermal energy storage system Third step; For high efficient operation realization, operational technology is transferred though technical training under the same/similar situation in Japan and dispatch of supervisors.
Necessity level in Egypt: At present, subsidies are applied uniformly to each sector, and electricity charges are inexpensive, so maturity of energy saving efforts utilizing the electricity price system is low.
Expected Results:**(in short- term subjects)** This program helps demand sides to use energy rationally and keep a high load factor on each demand side. Their activities also help power companies to supply power with a high load factor so power companies can be free from facilities retrofitting or reinforcing. Furthermore, CHP systems also reduce CO_2 emissions and can be sold to the third party countries.

Issues or Concerns

Generally speaking, PBP (Pay Back Period) is long and takes much manpower because there are many counterparts. Demonstration sites are better to be chosen from state hold companies and require other schemes if not. It still remains a possibility that this demonstration will not spread so a new funding scheme or utilization on an existing funding scheme is required

Table 4-2-3-10 Contents of the Candidate projects (No.10; Technical Assistance)

Name of project:
Human resource development on halted thermal power plant for long term preservation method

Budget:
Approximately 30 million yen
(It is assumed that about 20 people including fire engineering engineers etc. participate)

Place for the services:
・Thermal power plants in Japan, which are being preserved

Implementation Schedule:
Implementation time: January - March, 2019 (implementation period of1~ 2 weeks)

- ✓ Desk work; 2 ~ 4 days (in Headquarters Development Center etc.)
  - ➢ Japanese Electricity Business, Types and Facilities, Thermal Power Plants, etc. of Thermal Power Plants
  - ➢ Anti-rust and anti-corrosion measures, insulation degradation prevention measures, environmental disaster prevention measures, etc.
  - ➢ Storage target equipment and storage standard
  - ➢ Tours such as development centers
- ✓ Practice; 2 ~ 5 days (in Thermal power plants in Japan, which are being preserved)
  - ➢ Equipment outline, equipment operation history, maintenance method and system
  - ➢ Inspection of actual equipment storage situation
  - ➢ Keeping contents and notes on restart
  - ➢ Note: Basically, it covers storage technology of steam power plants (boiler + steam turbine).

Counterparts:
・EEHC, Power production companies

Contents：

Egypt has some large scale power plants development plans in the near future in order to match increasing electric power demand. However, there is a prediction that electric demand will not increase as much as the current estimation. In this case, some old power plants may be shut down. Then, if demand increases again, it will be possible to re-operate the shut- down plants rather than developing new power plants.

It should be noted that enormous cost and time will be needed to re-operate the long term shut-down plants. In order to reduce costs and time for re-operation, it is effective to preserve the plants to keep facilities healthy as much as possible at the time of shut down.

Japanese electric utilities have much experience in re-operation of long term shut-down plants for the purpose of meeting the sudden increase in electric power demand. Based on this experience, they have plant preservation methods which allow long term shut-down plants to be re-operated relatively easily.

The eligible persons of this project are persons who will be engaged in shutting down, long term preservation, and re-operation of thermal power plants. During this project, they will be able to learn effective plant preservation methods as well as examples of the methods and re-operation.

As a result, this project will help human resources with knowledge on preservation methods for long term shut-down plants, and provide Egypt a more flexible way to correspond with electric demand fluctuation.

Necessity level in Egypt：

To ascertain the needs for this project, further investigation is required

Expected Results：**(short- term subjects)**

If long term shut-down plants are re-operated smoothly thanks to appropriate preservation, these plants can contribute to meeting sudden electric power demand increase.

In addition, job security will be achieved because some engineers would be needed for appropriate preservation.

Issues or Concerns

Some new facilities may be needed, such as nitrogen gas generating devices, in order to preserve the plants.

Some parts of the Japanese preservation method may not be adopted in Egypt because of plant specification differences

Even if the plants are preserved properly, there is a possibility that the plant is not able to re-operate because of a lack of spare parts such as cards for control panels.

Table 4-2-3-11 Contents of the Candidate projects (No.11; Technical Assistance)

Name of project: Human resource development on O&M of coal fired thermal power plants, especially in the area of environment and coal handling
Budget: Approximately 50 million yen
Location for the services: ・Coal fired thermal power plants in Japan
Implementation Schedule: About two weeks in 2022
Counterparts: ・EEHC, Power production companies
Contents: Egypt has some large scale coal fired power plant development plans for the near future. However, as there has been no coal fired power plants, no expertise on Operation & Maintenance of coal fired power plants, such as environmental monitoring and coal handling, has been accumulated. While coal is expected to play a key role in the process of fuel diversification in Egypt, coal fired power plants may cause serious damage on surrounding areas if they are not operated accurately, which may result in opposition. In order to achieve the expected goals of introducing coal, it is necessary to operate coal fired plants strictly and appropriately from the beginning, and if possible, it is desirable to set the right specifications from the tendering stage and select proper constructers. The eligible persons for this project are engineers who will be engaged in O&M of coal fired plants, as well as persons who take part in technical evaluation of the process of introducing coal fired power plants. They will be able to acquire knowledge on coal unloading facilities, coal yards, conveyer belts, mills, FGD, ash ponds, and environmental monitoring systems at an actual coal fired power plant in Japan, while touching real coal. In addition, they will be able to learn knowledge on prevention methods of scattering of coal dust and spontaneous combustion of coal, ash pond managing methods, etc. As a result, this project will help human resources with a wide range of knowledge on coal fired power plants O&M to be developed, and make development of coal fired power plants in Egypt easier.
Necessity level in Egypt: Necessity of developing human resources with knowledge of coal fired power plant O&M seems to be widely recognized. For example, coal fired power plants which will be installed by the private sector will be introduced in the form of BOO, not BOOT, because operating and maintaining coal fired power plants, which have already been operated for a long time, are recognized as a risk in Egypt at the moment. Therefore, this project is judged to be necessary.

Expected Results：(in short- term subjects) Coal fired power plants will be operated and maintained properly by engineers who have proper and ample knowledge through this project. As a result, no damage on surrounding areas will be caused by the plants, and it will lead to smooth development of later plants. Coal fired power plants with more appropriate specifications may be introduced through judgement by persons who have practical expertise in coal.
Issues or Concerns If Japanese constructors fail to win the bid, it may be difficult to conduct practical training because plant specifications may be relatively different between Japan and other countries.

Table 4-2-3-12 Contents of the Candidate projects (No.12; Loan)

Name of project: Construction Project of Nile Valley Pumped Storage Power Plant in Egypt
Budget: About 300 million yen
Place for the services: ・Cairo and Luxor, Egypt
Implementation Schedule: 2019 – 2020
Counterparts: ・Hydro Power Plants Executive Authority: HPPEA ・Egyptian Electricity Transmission Company: EETC
Contents: The preparatory survey will be conducted in focusing on the application of an adjustable speed pumped storage system. The candidate construction points for the Nile Valley Pumped Storage Power Plant are in Luxor, Upper Egypt. (Luxor North 2000MW, Luxor West 2000MW)
Necessity level in Egypt: The survey team explained the benefits of the adjustable speed pumped storage system to the first undersecretary of MoERE, chairman and vice-chairman of EEHC, and the chairman of HPPEA. The team received some interest from them. According to HPPEA, the pre-feasible study (network study and site study) for the candidate points for the Nile Valley pumped storage power plant has been completed. Thus, they would like to conduct a detailed study.
Expected Results:**(short- term subjects)** Realization of suitable and economical operation of the power network system in Egypt, where plans of mass introduction of renewable energy, new introduction of coal-fired power plants and nuclear power plant are being developed, is expected. Installation of an adjustable speed pumped storage system, which Japanese companies have an advantage through past installation projects, is also expected.
Issues or Concerns: ・ In pre-FS, the framework Lahmeyer International has accommodated with support from the EU is exactly the same framework for implementing Combined Renewable Energy Master Plan(CREMP). Therefore, how much support Egypt expects from Japan is not clear at this point. ・ As the FS report is not been available, yet, confirmation especially on whether any impact on the social environment is necessary.

Table 4-2-3-13 Contents of the Candidate projects (No.13; Technical Assistance)

Name of project: Technical assistance on optimization of power source planning for meeting peak demand as well as securing stable operation
Budget: About 100 million yen
Place for the services: ・Cairo (field survey) and Japan (training)
Implementation Schedule: One year in 2018
Counterparts: ・Hydro Power Plants Executive Authority: HPPEA ・Egyptian Electricity Transmission Company: EETC
Contents: With the introduction of functions of adjustable speed pumped storage system and benefits of power network system operations to the relevant agencies of pumped storage system planning and power network system operations in Egypt, it will be expected that realizing of suitable and economical operation of the power network system in Egypt, where plans of mass introduction of renewable energy, new introduction of coal-fired power plants and nuclear power plants are being developed.
Necessity level in Egypt: The survey team explained the benefits of the adjustable speed pumped storage system to first undersecretary of MoERE, chairman and vice-chairman of EEHC, and the chairman of HPPEA. The team received some interest from them.
Expected Results ・ Realization of suitable and economical operation of the power network system in Egypt, where plans of mass introduction of renewable energy, new introduction of coal-fired power plants and nuclear powers plant are being developed, is expected. Installation of an adjustable speed pumped storage system, which Japanese companies have advantage through past installation projects, is also expected.
・ **Issues or Concerns:** For the construction plan of the Ataqa Pumped Storage Power Plant (300MWx8) which is in the progress with China's EPC+F, it is not clear at this point if it has space for the adopting adjustable speed pumped storage system. There is another plan to construct a pumped storage power plant in Upper Egypt (pre-FS has been conducted supported by the EU.) ・ Tentatively, in the case of Japanese companies being responsible for installing the generators for Ataqa Pumped Storage Power Plant, it will actually be the achievement of Chinese companies installing the adjustable speed pumped storage system.

Table 4-2-3-14 Contents of the Candidate projects (No.14; Loan)

Name of project: Construction Project of Ataqa Pumped Storage Power Plant (Concerning the two adjustable speed pumped storage system)
Budget: Approximately 40 billion yen (equivalent to the cost increase of two adjustable speed pumped storage system due to change in plan from the regular pumped storage system)
Place for the services: ・Suez, Egypt
Implementation Schedule: 2020 — (projecting technical assistant project for promoting understanding on adjustable speed pumped storage in 2018 and cooperation preparatory survey in 2019)
Counterparts: ・Hydro Power Plants Executive Authority: HPPEA ・Egyptian Electricity Transmission Company: EETC
Contents: For the construction plan of Ataqa Pumped Storage Power Plant (300MWx8) which is in the progress with China's EPC+F, two plants will be adjustable speed pumped storage, by which will realize the stability and economical operation of the power network system in Egypt, where the plans of mass introduction of renewable energy, new introduction of coal-fired power plants and nuclear power plants are being developed. At this point, the difference of approximately 40 billion yen, which is incurred due to the change in plan of constructing two adjustable speed pumped storage power plants out of eight for which were all supposed to be regular pumped storage power plants, is expected to be financed by Japan.
Necessity level in Egypt: The survey team explained the benefits of the adjustable speed pumped storage system to the first undersecretary of MoERE, chairman and vice-chairman of EEHC, and the chairman of HPPEA. The team received some interest from them.
Expected Results:**(short- term subjects)** Realization of suitable and economical operation of the power network system in Egypt, where plans of mass introduction of renewable energy, new introduction of coal-fired power plants and nuclear power plants are being developed, is expected. Installation of an adjustable speed pumped storage system, which Japanese companies have advantage through past installation projects, is also expected.

Issues or Concerns:

- For the construction plan of the Ataqa Pumped Storage Power Plant, the selection of consultants has been already completed. (JV of Ertiala: France and AF: Switzerland) Sino Hydro of China has submitted a final proposal of EPC+F. Currently it is at the stage of waiting on evaluation and project implementation for the proposal. Thus, it is not clear at this point that a change in plan from the regular pumped storage power plant system to an adjustable speed pumped storage system is feasible.
- In the case of expecting Japanese companies to be responsible for the installation of the adjustable speed pumped storage system, sufficient disclosure of the characteristics of watermills by watermill manufacturers will be required.

Appendix（separate volume）

- **Appendix 1 Financial Analysis of Egyptian Government**
- **Appendix2 Outline of environmental standards necessary for project implementation**
- **Appendix 3 Transmission related data**
- **Appendix 4 Human resource development materials**
- **Appendix 5 Seminar materials**