(4) Potential of Energy Efficiency in Transmission

Below summarizes the energy efficiency in the field of transmission lines.

- ✓ There are few lines under heavy loaded then there are few cases that transmission loss is too high.
- ✓ Operation of the network voltage and reactive power are in good condition. It shall be difficult to reduce further more of the losses by reactive power control.
- ✓ To cope with the growth of demand, there already exist plans for increment and augmentation of transmission lines, especially in Cairo and Canal zones which are the center of the heavy load. From this point, there are little possibilities of transmission loss to still increase.
- ✓ In the future, when development of large scale wind farm along the Red Sea coast around the depopulation electric power area, there might be transmission lines with its power flow bottle necked and from this point, an optimal plan to install transmission facilities taking into account the transmission loss.

Below summarizes the energy efficiency in the field of substations.

- ✓ Auxiliary machine loss is adequately low, to have difficulties for reducing loss any further.
- ✓ .Voltage class is integrated basically at 500kV, 220kV and 66kV. 220kV is directly dropped to 22kV near the consuming area so the electric transforming loss is relatively less.
- ✓ Along with the increasing electricity load, there are new construction and enhancement plans for 220kV/66kV substations near the consuming area and 500kV/220kV substations at trunk lines to have, for the moment, little possibilities of noticeable increase of losses coming up from voltage metamorphic.

Clause3 Potential of Energy Efficiency Improvement in Distribution

(1) Current overview of power distribution system

Distribution facilities in Egypt are operated by nine distribution power companies which have specific franchise area and responsibilities to supply power.
As these distribution companies are divided from Egypt Electricity Authorities, the most of the distribution facilities are the same standard, material and specification.

There are around five 11kV feeders in each 11kv bus in distribution substation and divided again in distribution point in the center of power demand. There is distribution transformer "DT" (11kV/0.4kV) in each Kiosk and supply power at 400V to the customers.

The most of these 11kV feeders are connected by open loop and interchange power by each other when the failures are happened.
Low Voltage line at 400V called LV is not long distance. The length of LV is around 300m in underground and 1,000m in overhead.

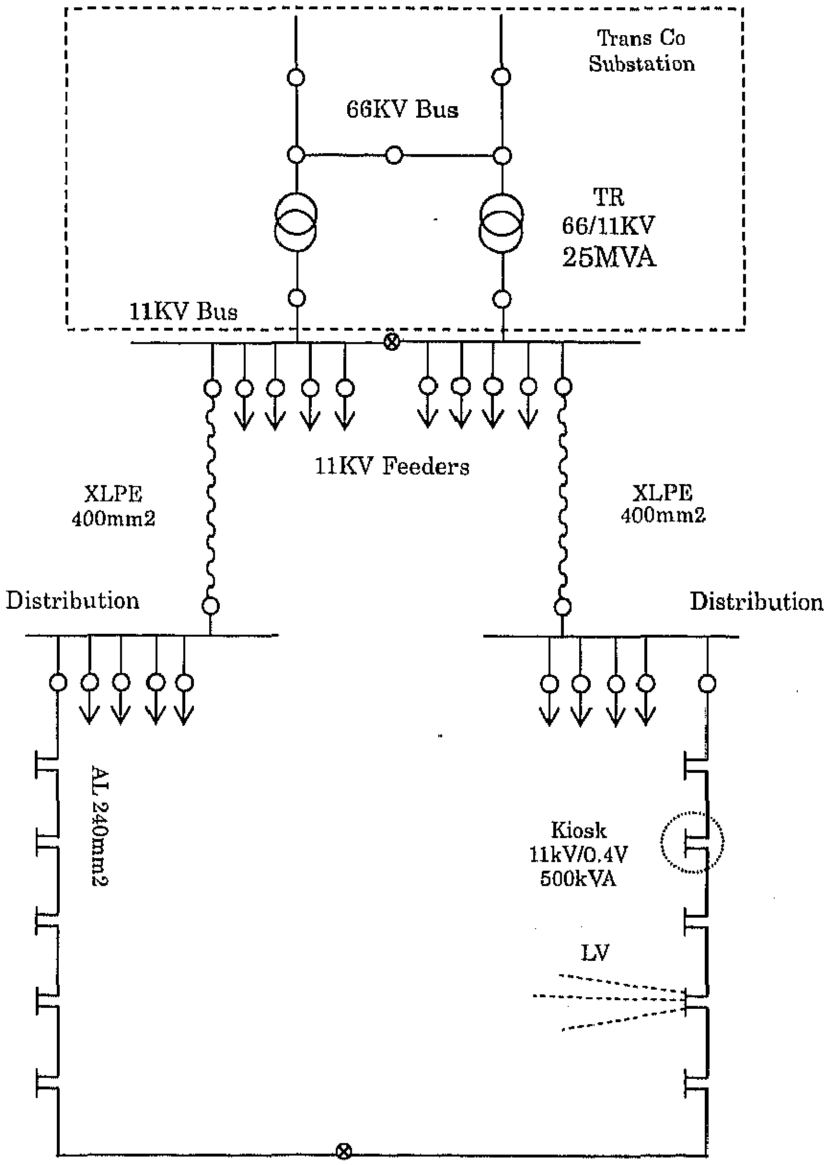


Fig. 3-1-3-1 System Diagram of Distribution System

1) 11kV Medium Voltage feeders
The electricity distribution system is supplied from the transmission system of the Egyptian Electricity Transmission Company. Primary distribution system is generally at 11KV and in some industrial regions at 6.6 KV. Because of the limitations of the 11KV voltage level, the tendency is to use the 20KV voltage level in newly supplied in urban area. Secondary distribution system is at 380/220 volts.

The electric transmission and distribution networks have extended at a very high rate in order to meet its demand. According to the statistics in 2008, the total length of 11kV medium voltage lines and cables was about 142,983 kilometers, and the total length of the low voltage lines and cables was about 230,187 kilometers.

The medium voltage distribution networks are supplied either by 66/11KV substations or 33/11KV substations. Fig.3-1-3-2 shows the single line diagram of a typical 66/11KV substation and distribution system.

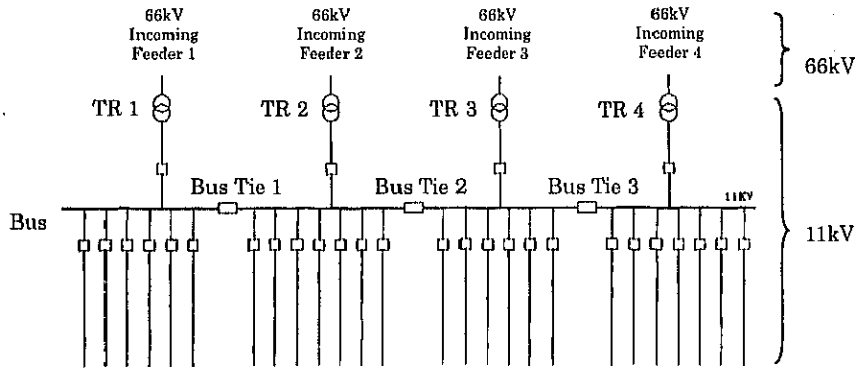


Fig. 3-1-3-2 Single Line Diagram of 66/11kV Substation

The medium voltage system extends from the 11KV bus bars of the 66/11KV substation to the distribution transformers including the feeders. The main purpose of the distribution point is several circuit outlets from one feeder. Generally four distribution feeders go into the distribution point and five to eight branches come out from the distribution point.

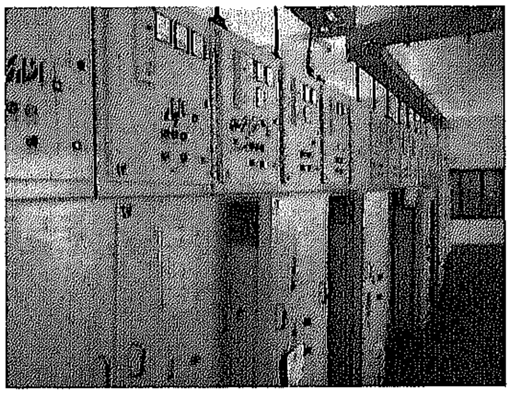
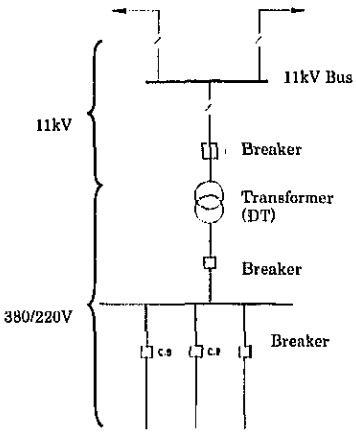



Fig. 3-1-3-3 Distribution Point and its 11kV Feeders

The bus bars of the distribution point are normally divided into two sections with a bus tie in between. Each section has two incoming feeders. The two sections are either fed from the same substation or preferably fed from two different substations in order to provide second source of supply and hence better reliability.
The incoming feeders are connected to the bus bars through circuit breakers and the outgoing branches as well.

2) Distribution Transformer points "KIOSKs"
The distribution transformers step down the voltage medium voltage to 220/380 volt. The distribution transformers are supplied from the M.V. cables or overhead by two circuit sections through switches.
Fig.3-1-3-4 shows a single line diagram for a transformer point, or KIOSK. The secondary of the transformer is the low voltage through a circuit breaker. Also, low voltage outgoing cables are connected to the bus bar from fuses.



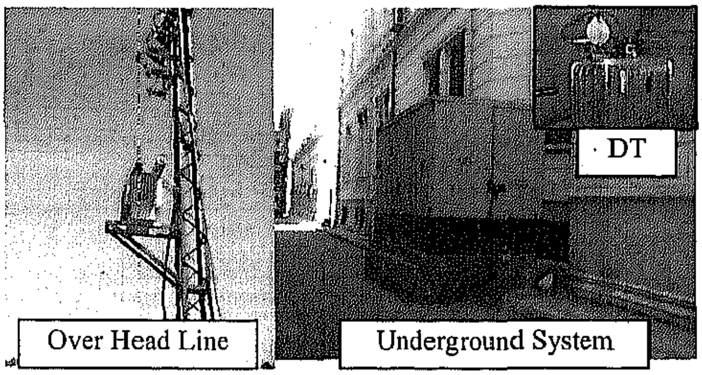


Fig. 3-1-3-4 Distribution Transformer "KIOSK" (Overhead / Underground)

In urban regions the transformer, together with its medium voltage and low voltage switchgear are housed either in a metal enclosures or kiosk, or put within a room in the ground level of a residential building or a workshop depending on the area served and the availability of space. The rating of the transformer in urban areas varies between 200 KVA and 3,000 KVA. They generally have an off-load tap changer.

In rural areas and in village pole mounted or pad mounted transformers are generally used. A transformer rating varies from 25 KVA to 100 KVA. 200 KVA and 160 KVA transformers are sometimes used with Pad mounting.

3) Low voltage system
The low voltage system begins at the low voltage bus bars of the distribution transformers by the main low voltage feeders. These main feeders either feed directly large consumers such as workshops, or large buildings or branch into several secondary branches to feed smaller customers. These branches may be three phase, double-phase, or single phase.

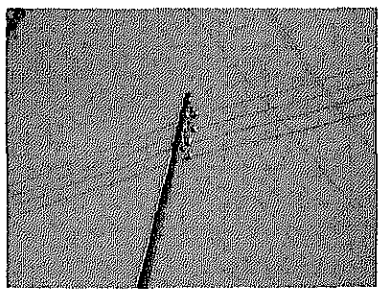


Fig. 3-1-3-5 Low voltage system

(2) Standard specification of existing distribution facilities

Distribution system is underground in urban area and overhead in outskirts of the city. The most of the underground power cable is 3 phases 4 wires and enough capacity especially in urban area.

In low load density outskirts area, overhead 11kV line is relatively long sometimes more than 10km from Substation to customer.

The standards of distribution facilities are classified as shown in Table 3-1-3-1, 2, 3, 4, and 5.

Table 3-1-3-1 Distribution Transformer (DT)

Voltage	Type		Standard Capacity (kVA)
11kV/0.4kV	3-Phase	Off-load tap changer	100, 200, 300, 500, 1,000, 2,000, 3,000

(Source: Answer to the Questionnaire from Distribution Companies)

Table 3-1-3-2 Underground (UG) Cable

Voltage	Type	Number of Conductor Nominal Section Area (mm2)
11kV	XLPE Cable (Cross-Linked Poly-Ethylene Cable)	3×240, 3×1×400
0.4kV	AL PVC Cable (Poly-vinyl-corridor cable)	3×70+35, 3×120+70,3×240+120

(Source: Answer to the Questionnaire from Distribution Companies)

Table 3-1-3-3 Overhead (OH) Line and Cable

Voltage	Type	Size
		Diameter (mm2)
11 kV	ACSR: Aluminum Conductor Steel Reinforced AAAC:All Aluminum Alloy Conductors	70, 120, 150, 240, 300, 400
0.4kV	AL, AAAC	16, 25, 35, 50, 70, 240

(Source: Answer to the Questionnaire from Distribution Companies)

Table 3-1-3-4 Line Capacitor (kVAR)

Voltage	Type		Size
11kV	3-Phase	Fixed Capacity Current controlled by manual	300, 450 & 600 kVAR only

(Source: Answer to the Questionnaire from Distribution Companies)

Table 3-1-3-5 Support for Distribution Line

Voltage	Type	Remarks
11kV	Lattice Steel Tower	There are neither reinforced concrete poles nor wooden poles
0.4kV	Steel Pole	

(3) Current system of Distribution Control Center

Distribution Company has Distribution management System (DMS) in Distribution Control Center (DCC) under national and regional control center owned by Transmission Company.

The main responsibilities of the DMS in DCC

- ✓ Quickly locate the place and reason of any interruption in the network which results in reduction of outage time.
- ✓ Frequently monitor the load of the distribution equipment and the status of the connection and disconnection equipment.
- ✓ Record the sequence of restoration of any network interruption and give notice of any faced problems.
- ✓ Programming of the regular maintenance schedules.
- ✓ Monitor and control distribution points and kiosks and main substations.

Distribution system data such as current, voltage, active and reactive power are monitored by DMS of model distribution companies. They monitor and operate distribution system efficiently to keep good condition of its power quality and reliabilities.

But communication system does not cover all their supply area. Then some of switchgears can be manipulated by remote control but the most of switchgears are manual and they need to dispatch staff to manipulate them.

Existing DMS in DCCs of two model distribution companies (AEDC and NCEDC) are established more than 10 years ago and they also have many troubles in the existing DMS in DCC because of its out of date system. The two main problems are

1) Data transmission speed can not follow the increase of the facilities
2) There are no spare parts at the market to fix the existing system

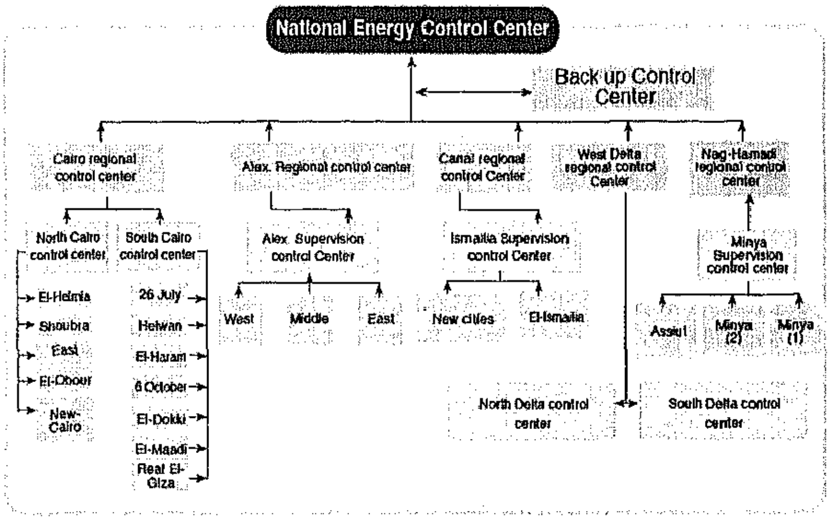


Fig. 3-1-3-6 DCC in Egypt

(4) Existing Condition of Energy Efficiency in Distribution

The rapid extension of the distribution networks goes with increasing its demand resulted in the increase of the electric energy the resistance of the system components. The efforts have been exerted by the electricity distribution companies in Egypt to reduce the network losses in the last decade and it was possible to reduce the percentage energy losses to

9.31% in the year 2007. However, this percentage of energy losses is still high in comparison to that in other developing countries.

Table 3-1-3-6 Distribution Loss of Nine Electric Power Co.

Distribution Companies	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
Available Energy*[mkWh]	14,026	17,199	6,805	7,657	7,139	14,301	5,360	7,370	6,375
Sold Energy[mkWh]	12,195	14,928	6,073	7,190	6,724	13,427	4,976	6,800	5,890
Distribution Loss [%]	13.06	13.20	10.75	6.10	5.81	6.11	7.17	7.74	7.61
	1: North Cairo E-Disco. 2: South Cairo E-Disco. 3: Alexandria E-Disco. 4: North Delta E-Disco. 5: South Delta E-Disco.				6: Canal E-Disco. 7: El- Behera E-Disco. 8: Middle Egypt E-Disco. 9: Upper Egypt E-Disco.				

**Available Energy = buying Energy + Self Generated*

(5) *Current measurement to improve energy efficiency in distribution*

Nine distribution companies are trying to reduce distribution loss supporting with EEHC. But there are no specific plan and goal mentioned in official report. Most of the measurements are strengthening network facilities to prevent overload condition and improve power factor to supply power efficiently.

Additionally to avoid connection losses of other conductors are one of the measures during installation and maintenance.

Each distribution company has implemented the following activities in order to improve the energy efficiency.

1) Strengthening to develop new feeders and transformers

-- Construction of additional 11 kV feeders and LV line to reduce over loaded feeder

-- Replacing old transformers to new low loss DT

The transformers are installed with an initial load not exceeding 60%. No new customers are connected when the load exceeds to 90% for residential loads in urban and rural areas and 80% for power load in urban areas. Transformers are replaced when the load reaches 100% of its capacity.

2) Improvement of power factor

EEHC encourage the distribution companies to improve power factor to install new capacitors in Kiosk which is both medium and low voltage.

-- Install 11kV Capacitor 20% of maximum load until 2010

-- Final goal is 30% of maximum load

New inventive tariff system will be introduced to industrial customers.

-- Pay back bonus at power factor: 0.92-0.95

-- No bonus and penalty 0.9-0.92

-- Penalty at power factor: 0.7-0.9

-- Double penalty at power factor: Less than 0.7

3) Proper conductor connection

Bad contact points mostly wrong size connector or connection both copper and aluminum may also cause losses because of the high contact resistance. Bad contacts cause increased heating which, in turn, increases the contact resistance still further, and

hence causes higher losses.
Measurement required for this bad contact is mainly using compressing connectors and monitoring pin point hot spot on the conductors by using infra-red detectors. The losses are done in all through Egypt, and while installation and maintenance, to tighten properly the bolts and nuts of the contact points and use spring washers are already done in the first of 2000's.

(6) Potential and counter measurements for energy efficiency in distribution
In general, technical loss reduction of distribution system is the greatest challenge for distribution sectors. Distribution network losses can vary significantly depending on the large current power flow caused by overload and load unbalance. Additionally low power factor will lead to increased current and hence increased loss and voltage drop.
Here are the potential for energy efficiency in distribution.

1) Strengthening conductor (Wire and Cable)
The technical losses of electricity in the distribution systems are the heat losses in the conductors of the different elements of the system due to the flow of the electric current in the resistance of the conductors. These losses may be in the conductors of the medium voltage overhead lines and underground cables and in the low voltage overhead lines and underground cables.
As the heat losses are proportional to the resistance of the conductors, and it should be taken to optimize the cross-sectional area of the conductors.
Basic measurement is to reduce the current of the power flow, in other words, improve overloading situation in wires and cables, for example, introducing higher voltage level or large size of conductors, developing of new feeder, or shortening LV line.

2) Strengthening distribution Transformer (DT)
Energy losses in the electricity distribution system is the energy losses in medium voltage/low voltage transformers due to copper losses as well as the hysteresis and eddy current losses in the magnetic circuit. In addition, the long length of LV line connecting to DT also causes to increase the technical loss.
To replace overloading distribution transformer to bigger size or to develop new kiosk in order to allocate appropriate load in transformer itself and shortening low voltage line are potential measures.

3) Improving low power factor situation
It is well known that for the same active power supplied a low power factor load will consume higher apparent power (KVA) and produce a higher current flow in the conductors. Hence low power factor loads cause higher energy losses. In Egypt motor load of factories and agricultural pumping motors lead to low power factors and this low power factor leads to increase current of the distribution system.
Capacitors may be connected at low power factor customers or at load centers in order to improve the power factor, hence reducing the current and the energy losses in the conductors of the network.

4) Improving unbalanced load current allocation of three phase line
When the load currents are not balanced on the three phase lines, a current will run through in the neutral line of the system. That causes additional heat losses contributing to the total losses of the distribution system. Additionally this unbalanced loading of the phases of the low voltage system is transferred to the upper voltage system through the distribution transformers.
The measurement of this problem is to monitor and find the unbalance situation and shift the load in the appropriate phase.

Clause4 Potential of Energy Efficiency Improvement by Demand Side Management

(1) Conceptual Benefit of Demand Side Management

Although the recent development of technologies is beginning to make changes, the major difficulty of power business is still there. The electricity cannot be easily stored; it has to be consumed immediately after generation. Therefore, power plants must be built to cope with the peak demand even though the peak demand may only happen once a year. This instantly means that some of the power plants only generate electricity for short period of time and remains at stand-by throughout the rest of year. These power plants, "Peakers" are more liabilities than assets to the power company. However, if the power company could coax its customers to shift the peak as shown in the fig.3-1-4-1 below, these Peakers would not be required and the power company can avoid significant construction costs. This is the primal benefit of Demand Side Management.

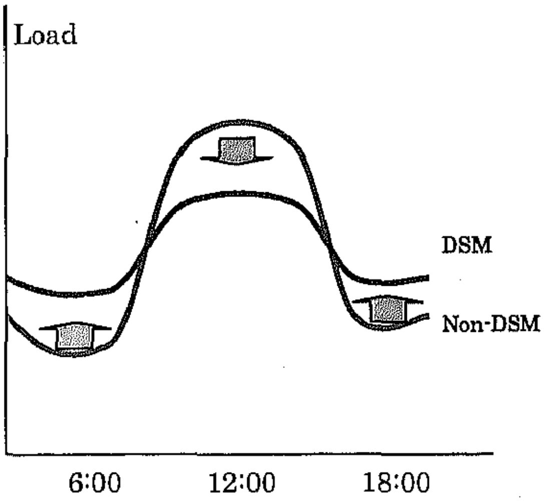


Fig. 3-1-4-1 Concept of DSM

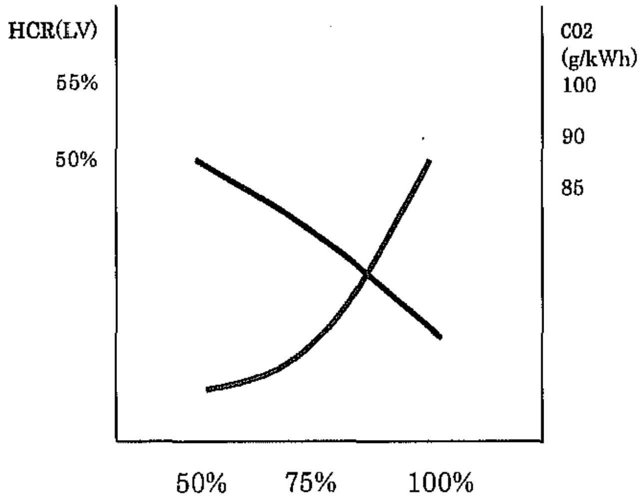


Fig. 3-1-4-2 Relation of OR, HCR and CO2 (image)

Other benefits of Demand Side Management can be seen at existing thermal power plants. As the result of peak shift, existing power plants can operate at higher, more stable operation rate. Combined Cycle Power Plants with multiple shafts are indeed capable of flexible operation; however frequent repetition of start-up and shutdown is not a desirable operation manner for longer asset lifespan and efficient use of fuel. Another benefit of peak shift could be CO2 reduction at existing power plants. Fig. 3-1-4-1 and fig. 3-1-4-2 above show the relations of Operation Rate, Heat Conversion Rate and CO2 emission. If the Operation Rate is higher, the Heat Conversion Rate increases and CO2 emission per kWh is reduced. Having said that, there is no intention to closely link CO2 reduction and peak shifting. Despite the reduced CO2 emission per kWh by peak shifting, it has to be noted that the power plant has to run during the off-peak hours and emit CO2, which would not have been emitted were it not for the peak shifting. Therefore the CO2 reduction is not yet quantifiably proved to be a benefit of peak shifting.

But yet, the peak shifting apparently contributes to more efficient new power projects planning and healthier operation of existing power plants, therefore it is thoroughly pursued by many major power companies. In exercising the Demand Side Management, the target demands are usually AC and hot water supply. This is because Demand Side Management is enabled by converting electricity which cannot be stored, to other form of energy i.e. heat or chill which can be stored. By producing Heat or Chill in low demand hours and storing until discharge in peak hours, peak demand will be reduced or shifted.

Other than energy conversion, direct electricity storage by NAS battery can serve for DSM. In Japan, NAS batteries are installed at large consumers and the installation costs are compensated by TOU that offers cheap tariff in low demand hours. However, the NAS battery requires large initial costs and this is causing hindrances for smooth diffusion.

(2) Successful example of Demand Side Management in Japan

1) Peak Shift by Heat Storage AC

Due to the scarcity of natural resources, efficiency of power sector is crucial in Japan. One of the measures power companies are taking on the Demand Side to improve the efficiency in power (generation) sector is "Peak Shifting". The major target demand to be shifted is AC demand. This is because of its significance in capacity and of its nature. As mentioned before, basically electricity cannot be stored. But once it is converted to heat energy, it can be stored, and AC is about producing heat energy. If an AC device produces chill or heat during off-peak hours and store it to discharge during peak hours, peak capacity of the AC can be significantly reduced.

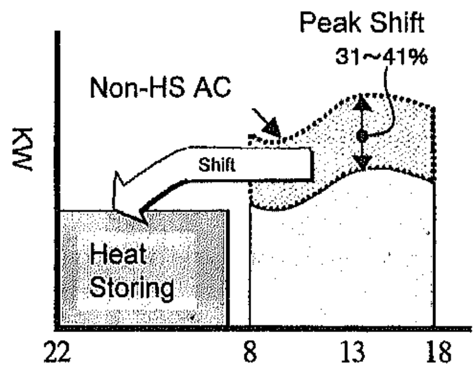


Fig. 3-1-4-3 Peak Shift Effect by Heat Storage AC

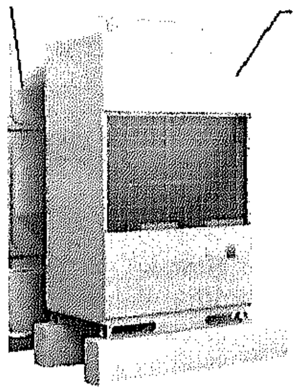


Fig. 3-1-4-4 Heat Storage AC device

As shown in Fig. 3-1-4-3 above, Heat Storage AC reduces up to 40% of its peak load. The heat or the chill is stored either as hot/cold water or ice depending on the size of building and its AC requirements. Also, these heat energies are produced by "Heat Pump", which utilizes heat energy in the air, thereby the Co-efficiency of Performance (COP: AC ability divided by energy input) exceeds 3. These Heat Pump ACs are helpful in energy conservation. But its usage is limited to large consumers since it requires installation space.

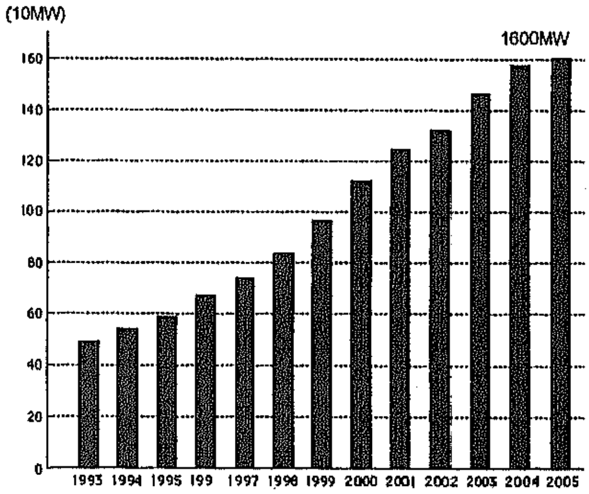


Fig. 3-1-4-5 Peak Demand shifted by Heat Storage

In Japan, so far 1,600MW of Peak Demand has been shifted by Heat Storage devices. This is equivalent of 1,000MUSD, subject to the market price of power plant construction costs.

2) Incentives to enable Peak-Shift
In order to enjoy such a benefit of Demand Side Management, power companies are offering tariff incentives to promote the diffusion of heat storage AC.

Table 3-1-4-1 Tariff example of TEPCO for office buildings (Unit=JPY)

(JPY)	Capacity Charge(/kW)	Energy Charge: Day (8:00-22:00)			Energy Charge: Night (22:00-8:00)	
		Peak(1:00-4:00)	Summer	Other	Summer	Other
TOU Tariff	1,638	16.60	15.92	14.56	9.20	
Regular Tariff	1,638	13.75		12.65	13.75	12.65

Note: Above Tariffs are applied to Office Buildings receiving power with lower voltage than 6.6KV. "Summer" herein means July to September and "Other" means the rest of year. "Peak" Tariff only applies to business days in summer.

Now, let's assume an Office Building with 100kW capacity. If its average load factor is 50%, the monthly bill of this Office Building under the regular tariff scheme is calculated as follows:

Capacity Charge (1638*100) +Energy Charge (100*0.5*24*30*13.75) =658,800(JPY)

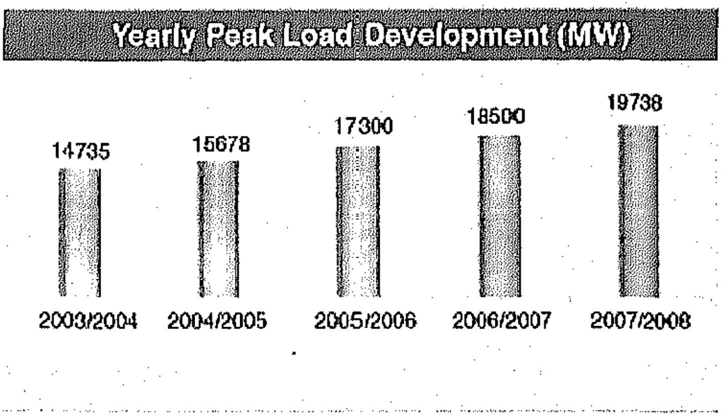
Note that the Capacity is the recorded actual peak load in a year. Since the AC load in office buildings is relatively significant, here we assume 50% of the peak load is AC. Assume that this Office Building replaced its conventional AC to Heat String type of same ability and change its contract to TOU. As explained before thanks to the Heat Storage, 30 to 40% of AC load would be shifted to nighttime. This reduces the Peak Load by 15 to 20% and allows the Office Building to enjoy 15 to 20% cheaper Capacity Charge. As for the Energy Charge, for the sake of simplicity, let us assume to remain in the same level due to set-off between the increased consumption in nighttime with lower tariff and decreased consumption in daytime with higher tariff. Therefore, a rough estimation of incentive to install a Heat Storage AC in 100kW Office Building is;

Assumed Annual Tariff Incentive for 100kW Office Building
=1638(¥)*20(kW)*12(m) =393,120 (JPY)

With such simple assumption, an initial investment for Heat Storage AC device will be recovered in 10 to 15 years. However, under the current circumstances, conventional package AC is improving its price competitiveness by mass production and that is making Heat Storage AC that requires sizable upfront costs less attractive to consumers.

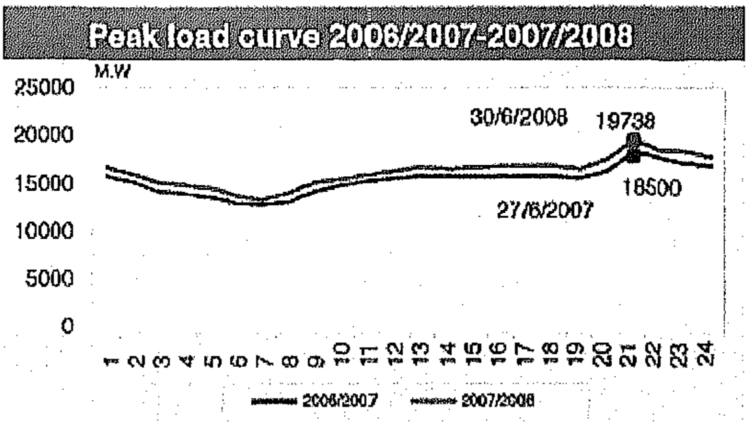
(3) Energy efficiency in Egypt

1) Energy consumption and economical development
Due mostly to the endeavor of the government to encourage foreign investments and facilitate economical growth, the economy enjoys a boom in the stock market and approximately 7% of annual GDP growth. The power demand is increasing in line with GDP growth as shown in the figure below. In facing such steep demand growth, it is important to manage the demand increase in an efficient manner, and Demand Side Management may prove useful. During the interviews with Distribution Companies, some opined that AC had been contributing to the recent demand increase. If AC demand is the cause of demand increase, DSM applied in Japan could be applicable, mutatis mutandis.



(Source: EEHC annual report)
Fig. 3-1-4-6 Yearly Peak Load Development

2) Energy Demand status in Egypt
As previously discussed, efficiency of power generation sector is of vital importance for sound management of power companies, and the Demand Side Management or Peak Shift has proved to be a useful strategy in Japan. Now, we would like to study if the similar approach is applicable to Egypt.



(Source: EEHC annual report)
Fig. 3-1-4-7 Peak Load Curve

In case of Japan, peak load is dominated by AC demand therefore the demand curve corresponds with temperature variation, showing a tip in the mid-day. However this is not seen in Egypt. The peak load appears in late evening, suggesting that it is mainly caused by lighting demand or dinnertime and that the AC may not be widely used yet. Or, as another explanation of flat daytime demand curve, insufficient exercise of energy conservation could be considered. If AC is kept "ON" throughout a day regardless of temperature, demand curve does not correspond with the temperature curve and the demand curve does not show "real" demand. Since AC demand is allegedly increasing in a rapid pace, insufficient Energy Conservation practice may be a rational explanation of the flat daytime demand curve. It should be noted that the Demand Side Management could only truly be beneficial if and when it comes with Energy Conservation practices. In case of Japan, Energy Conservation has been exercised as common social efforts in Japan since oil crisis in 70s. High tariff is also acting as deterrence for excessive energy consumption or an incentive to conserve energy.

In consideration of above, it is highly recommendable that EEHC and the government tackle Energy Conservation in concurrent with, or before pursuing Demand Side Management. Although Egypt still does not have Energy Conservation Law to enforce such activities, we have learned that EEHC and government have been promoting Energy Efficiency Labeling to electric appliances, Energy Efficiency Building Code, Awareness Program, Pilot Projects and so on. This endeavor should be further encouraged and continued.

For closer observation of power demand, we have acquired demand information from 3 regional distribution companies, i.e., Alexandria, North Delta and Cairo North.

(4) Demand status of Alexandria

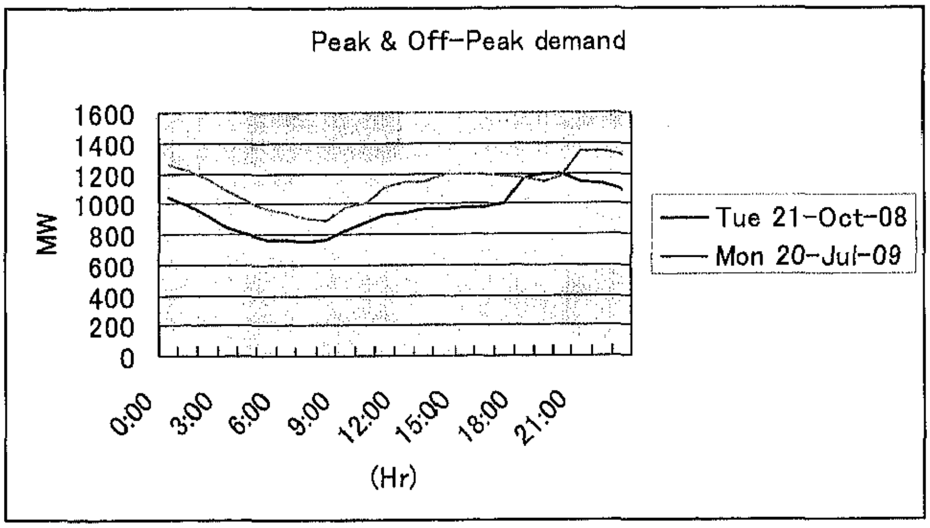


Fig. 3-1-4-8 Peak/Off-Peak Load Curve in Alexandria (Data by Alex DC)

The demand curve in Alexandria also has its peak in late evening. According to officers of distribution companies, Egyptian's general office hours are 8:00 to 15:00 without a lunch break. After 15:00 they have lunch, and dinner takes place after 20:00. From this general lifestyle, we can assume the peak demand being caused mainly by dinnertime demand. The time difference of peaks in high season and low season may be explained by the duration of daytime.
Another possible cause of evening peak we have considered is street lighting demand. The mission members noticed high density of streetlights in Alexandria.

<Street Lights Demand>

Table 3-1-4-2 Streetlights in Alexandria

	Total No of Lamp	Total Power (watt)
Elontaza Region	21883	6576740
Sharek Region	24525	7164500
Wastt Region	28850	9350090
Gharb Region	16397	4799510
Elsahel Elshmaly Region	12858	4305900
Borg Elarab Region	8698	2762115
Total	113211	34958855

(source: Alex DC)

As shown in the Table 3-1-4-2 above, the total demand for the streetlights is approximately 35MW, which is only about 2.5% of peak demand in Alexandria (1400MW) in capacity wise.
In consideration of small capacity and the nature of demand, i.e. lighting, we are in an opinion that the lighting demand is not a suitable target of DSM.
The capacity of streetlights may be relatively small, but we have learned that EEHC is encouraging distribution companies and customers to change conventional Sodium lumps to Compact Fluorescent Lights (CFL) to reduce the evening peak demand.
This is an effort of Energy Conservation and should show some effect.

Table 3-1-4-3 Breakdown of market and its historical change (MWh: Data by Alex DC)

Year	2004		2005		2006		2007		2008		04-08 Variation
MV Commercial	422.5	8%	416.8	7%	440	7%	456.8	7%	457.68	6%	23%
MV Industry	1236.2	23%	1276.4	22%	1437.9	23%	1522.3	23%	1524.73	21%	8%
LV	3802.4	70%	4156.1	71%	4390.2	70%	4771	71%	5190.1	72%	36%
Total	5461.1		5849.3		62 68.1		6750.1		7172.51		31%

For further analysis of power market, the above table shows a breakdown of consumer groups and historical changes. LV is the dominating group in the market and the most of LV is assumed to be households and small shops. The peak demand is again assumed to be caused by dinnertime demand of households. The demand curve will be largely influenced by introductions of new electric appliances to households, therefore the power company needs to monitor the consumption trend of household users to efficiently cope with *demand increase.*

As for the AC demand, it can be measured by taking the difference between high and low peak demand. In case of Alexandria, the gap is about 400MW at 13:00 when the temperature tops and 200MW at 4:00 when the temperature is the lowest. Theoretically, AC demand could occupy more than 30% of Middle to Low voltage customers of Alexandria. Although we did not conduct any detailed monitoring of AC demand, AC demand could be target of DSM because of its size and nature, which is about producing chill.

<DSM effort>

As the effort related to Demand Side Management of Alex DC, they have been testing AMR. 790 units are experimentally installed to low voltage customers, to monitor voltage, demand (kW) and consumption (kWh). The purpose of this experiment is to improve the meter reading quality and avoid power theft by meter tampering. The information dispatched from these AMR uses power line communication, but this measure often involves considerable uncertainty and further improvement may be required. However this effort should prove useful in improving their monitoring on demand side for further countermeasures.

(5) Demand status of North Delta

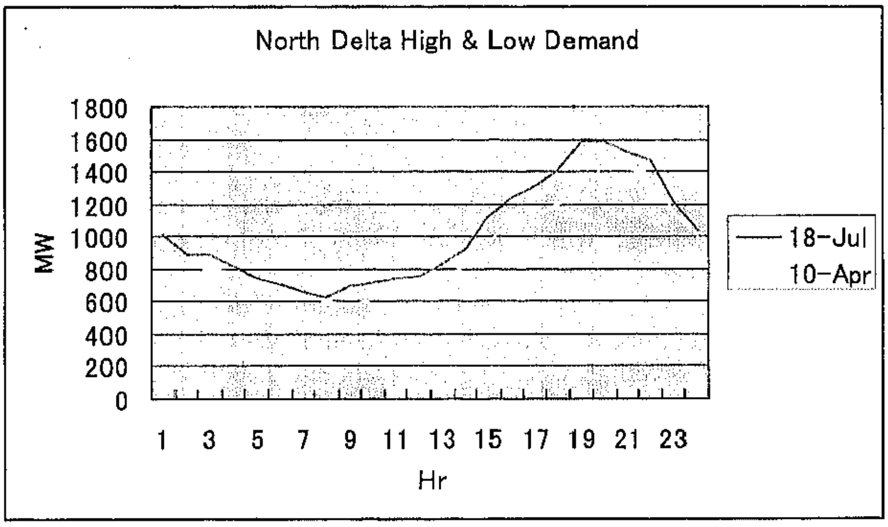


Fig. 3-1-4-9 Peak/Off-Peak Load Curve in North Delta (Data by NDEDC)

North Delta region also has its peak hours in evening time, likely due to dinnertime demand. An interesting point is that there are not much differences between highest demand day (18 July) and lowest (10 Apr). Together with this, daytime demand curve not corresponding with temperature variation indicate lack of AC diffusion.

Table 3-1-4-4 Breakdown of market and its historical change (MWh: Data by NDEDC)

Year	2004		2005		2006		2007		2008		04-08 Variation
MV Commercial	419.45	7%	443.5	7%	448.21	7%	492.83	6%	524.59	6%	25%
MV Industory	215.799	4%	207.905	3%	188.968	3%	187.157	2%	201.351	2%	-7%
LV	5274.62	89%	5653.8	90%	6132.22	91%	7165.31	91%	7675.92	91%	46%
Total	5909.87		6305.21		6769.39		7845.3		8401.86		42%

The above table shows that the North Delta region is further dominated by low voltage customers (household) than Alexandria and has fewer commercial or industry. This indicates that the region is a residential area and has limited large industrial or commercial entities such as hotels for tourism. And this trend seems to continue on

<DSM effort>

Same as Alex DC, North Delta is also keen to apply AMR. So far 2,000 AMR have been experimentally installed at 3 Distribution Trans and low voltage customers receiving power from these DT, aiming to improve the accuracy of meter reading, power theft prevention and so on. By crosschecking data of AMR at DT and total sum of consumption by customers receiving power from the DT, distribution losses will be better identified. Furthermore, their AMR can detect various fluctuations of supply conditions such as voltage and amperage, and it transmits signal when these fluctuations are detected. This function should prevent power theft from the upstream of AMR, as well as power theft by usual meter tampering. Their AMR also allows NDEDC to stop power supply remotely when necessary. As for the data exchange device, unlike AMR of Alex DC, GPRS is used. The quality of communication should be better, however security in terms of information protection and communication fee for telecom may be the issues to be considered.

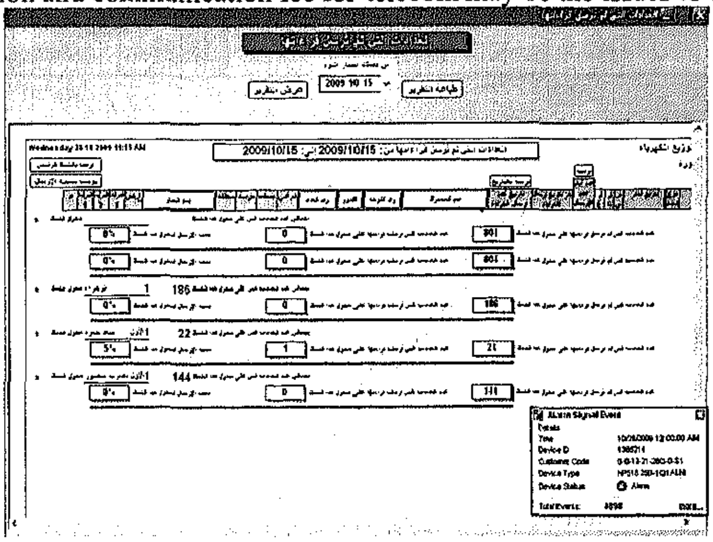


Fig. 3-1-4-10 AMR control program of North Delta DC

Note: This AMR is a product of a local maker, Gia International

(6) Demand status of Cairo North

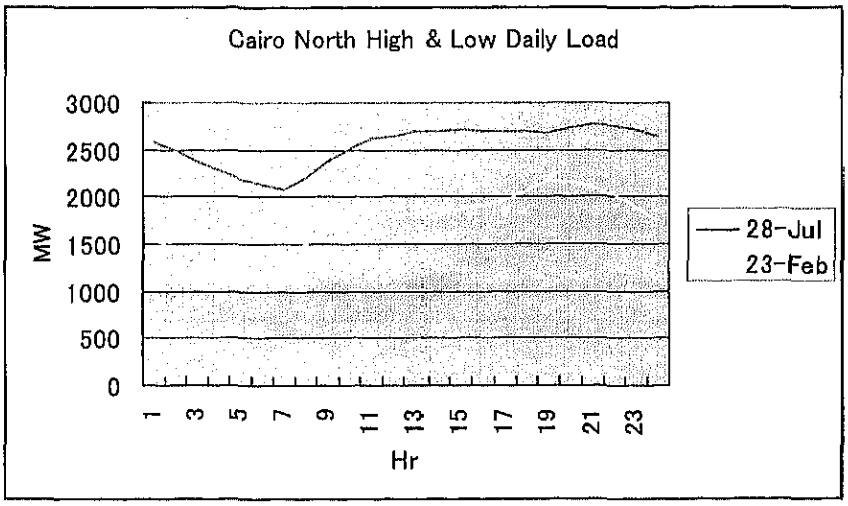


Fig. 3-1-4-11 Peak/Off-Peak Load Curve in Cairo North (Data by CNEDC)

Cairo North also has its peak in evening or late at night and again these peaks are assumed to be caused by dinnertime demand. As for the AC demand, mid-day demand gap appears in the graph could be the capacity of AC, which is about 700MW, representing about 30% of total demand. But unique feature of the demand curve is that the gap of highest and lowest demand remains in a same level throughout the day. Usually the gap is the biggest in mid-day and smallest in early morning, which is often caused by AC usage. Further analysis of demand requires installation of data loggers at selective customers.

Table 3-1-4-5 Breakdown of market and its historical change (MWh: Data by CNEDC)

Year	2006		2007		2008		06–08 Variation
MV Commercial	1280.0	10.9%	1286.3	9.9%	1285.5	9.4%	0.4%
MV Industory	1602.3	13.6%	1882.2	14.6%	2041.3	14.9%	27.4%
LV	8913.6	75.6%	9763.0	75.5%	10380.4	75.7%	16.5%
Total	11795.9		12931.4		13707.2		16.2%

Same as the other regions, the dominating consumer group in Cairo North is low voltage customers, assumed to be household and small shops. However a unique aspect of the market trend of Cairo North is the growth of industries. According to an officer of CNEDC, this trend is because of new development of industrial cities (El Obour City as an example). This is a result of industrial investment increase in many industrial fields such as food, Pharmaceutical, modern textile, furniture, electrical appliances, steel and petroleum industries.

North Cairo DC is also tackling demand monitoring by AMR. 1000AMR are experimentally installed to LV customers so far, aiming to reduce non-technical loss by tampering, erroneous meter reading and so on.

Section2 Candidates of projects for improvement in Energy Efficiency

Clause1 Candidate List of Power Generation project

Based on the review in the previous section, following projects can be selected as energy efficiency projects.

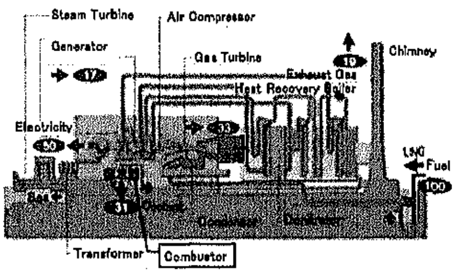
- ✓ Introduction of C Cycle
- ✓ Retrofitting & rehabilitation for inefficient power plants
- ✓ Combining existing plant with new GT

Table3-2-1-1 shows each project and candidate project sites as a long list and Table 3-2-1-2, 3-2-1-3, and 3-2-1-4 show a feature of each project.

Table 3-2-1-1 Long List of Power Generation

Project		**Candidate Project Site**
Introduction of C Cycle	To switch planed ST to CC	Tebin plan, Cairo West Exp plan, Abu Kir plan, Oyoun Masa plan
	To replace inefficient ST with CC	El-Seiuf, Matroh
Retrofitting & rehabilitation for inefficient power plants		Damanhour, Demietta, Mahmoudia, Atala. Abu Sultan, Kafr El-Dawar, Damahour Ext, Damanhour(old), Abu Kir
Combining existing plant with new GT		All STs which have appropriate size boilers

Table 3-2-1-2 Project Feature 1

Project	**Introduction of C Cycle with 1,300 degree class GT (ACC)**
Technical Feature	Advanced Combined Cycle (ACC) has achieved 55% of efficiency under LHV condition (50% under HHV) by using 1,300 degree gas turbine and ST which can be operated under higher temperature and pressured steam conditions. 
Merit	Higher efficiency accomplish to decrease energy consumption and emission of CO2 & NOX
Demerit	Higher capital costs
Issue about introduction of technology	Thermal efficiency of a combined cycle plant depends on the gas turbine firing temperature. In Egypt, it's necessary to study on gas supply & storage system in addition.

Rough Estimation of Mitigation & Benefit	Comparison of energy consumption ■ On assumption that the installed capacity of a target existing plant is 350MW and the capacity factor is 70% ■ Energy consumption of existing plant(350MW) of which efficiency is 38% 350MW×8760h×70%÷38%×860kcal/kWh÷1010kcal/ktoe=486ktoe ■ Energy consumption if newly introduced plant(350MW) of which efficiency is 55% 350MW×8760h×70%÷55%×860kcal/kWh÷1010kcal/ktoe=336ktoe ■ Decrement of consumption 150ktoe/yr (0.6% of total energy consumption of power generation companies in Egypt) 42 mill USD (on assumption natural gas price is 7 USD/MMBtu. 7USD/MMBtu can be presumed as a typical international gas price.)
Rough Estimation of Costs	Apprx. 300-400 mill USD (for 350MW unit; the costs was estimated based on many experiences of international & Japanese projects)

Table 3-2-1-3 Project Feature 2

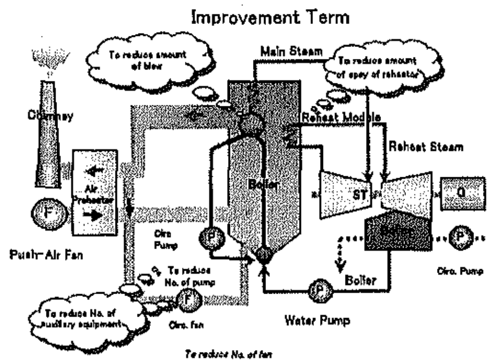
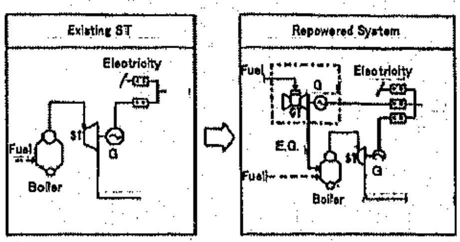
Project	Retrofitting inefficient power plant
Technical Feature	This project is to retrofit an existing plant using technology and knowhow of operation & maintenance which power utilities possess. Right hand figure shows an example that some Japanese electric power company implemented. The efficiency improvement depends on existing plant situations. 
Merit	This project can decrease capital costs compared with replacing (scraping & building).
Demerit	When this project is implemented, the existing plant should be stopped. The duration depends on a project. However in some cases a few years should be required.
Issue about introduction of technology	In some case, it may take much time to inspection on subordinate system such as circulator, circulation pump). The inspection is necessary for improving captive energy fact.
Rough Estimation of Mitigation & Benefit	Comparison of energy consumption ■ On assumption that the installed capacity of a target existing plant is 60MW and capacity factor is 50% ■ Energy consumption of existing plant of which efficiency is 28% 60MW×8760h×50%÷28%×860kcal/kWh÷1010kcal/ktoe=80ktoe ■ Energy consumption if the plant's efficiency is improved into 34% 60MW×8760h×50%÷34%×860kcal/kWh÷1010kcal/ktoe=66ktoe ■ Decrement of consumption 14ktoe/yr (0.06% of total energy consumption of power generation companies in Egypt) 4 mill USD (on assumption natural gas price is 7 USD/MMBtu. 7USD/MMBtu can be presumed as a typical international gas price.)
Rough Estimation of Costs	Apprx. 10-30 mill USD (for 60MW unit; the costs was estimated based on many experiences of international & Japanese projects)

Table 3-2-1-4 Project Feature 3

Project	Combining existing plant with new GT
Technical Feature	This project is to make an old existing ST plant combined with a new GT unite and to utilize exhausted gas heat from GT for the existing ST boiler. 
Merit	This project can decrease capital costs compared with replacing (scraping & building).
Demerit	When this project is implemented, the existing plant should be stopped. The duration depends on a project. However in some cases a few years should be required.
Issue about introduction of technology	This project should select a proper size of boiler based on investigating in detail and study on firing more fuel additionally and alternative heating system of supply water. In Egypt, it's necessary to study on gas supply & storage system in addition.
Rough Estimation of Mitigation & Benefit	Comparison of energy consumption ■ On Assumption that capacity factor is 70% ■ On Assumption that this project will make an existing plant (Cap.300MW, Effi.40%) combined with a new GT (Cap.100MW, Effi.30%) and improve into C Cycle (Cap.400MW, Effi.45%) ■ Energy consumption before project (ST) 300MW×8760h×70%÷40%×860kcal/kWh÷1010kcal/ktoe=396ktoe (GT) 100MW×8760h×70%÷30%×860kcal/kWh÷1010kcal/ktoe=176ktoe ■ Energy consumption after project 400MW×8760h×70%÷45%×860kcal/kWh÷1010kcal/ktoe=469ktoe ■ Decrement of consumption 103ktoe/yr (0.4% of total energy consumption of power generation companies in Egypt) 29 mill USD (on assumption natural gas price is 7 USD/MMBtu. 7USD/MMBtu can be presumed as a typical international gas price.)
Rough Estimation of Costs	Apprx. 40-60 mill USD (for combination of 100MW GT unit; the costs was estimated based on many experiences of international & Japanese projects)

Clause2 Candidate List of Transmission project

The following methods shown in Table 3-2-2-1 can be conceivable for countermeasures on loss reduction for transmission and substation sector.

Table 3-2-2-1 Potential Methods for Energy Efficiency in Transmission

Conceivable Methods	Conceivable Outcome	Application Issues
Countermeasure for Transmission Line		
Augmentation of heavy loaded transmission line	Lessening the power flow to reduce transmission loss	Currently, problems due to heavy load are not observed. Moreover, the advantages of injecting large amount of cost aiming for loss reduction is very little. But in the future, along with the increase of power demand, the loss will likely to rise, so enhancement plans for the transmission lines are needed.
Improving power factor of heavy loaded transmission line	Maintaining proper voltage level and improvement of reactive power flow reduction	Currently, most of the transmission lines have power factor nearly to 1. There are still transmission lines with room for improvement of power factor but this will not be effective enough for loss reduction.
Voltage rising of heavy loaded transmission line		When in long-distance transmission lines, the losses will not be ignorable. In this case rising voltage may be effective to reduce transmission loss.
Countermeasure for Substation Facility		
Reduction of in-house power of substation	Loss reduction from in-house power load	Most of the transformers are self-cooling type, so the space for loss reduction is very small.
Simplification of the using voltage levels	Simplifying voltage metamorphosis to reduce transformer loss	In Cairo and Canal zones where main power generation and center of the demand exists, the voltage levels are already set to 500, 220 and 66kV.
Installation of automatic voltage regulator	Installation of voltage regulator, VQ controller	Power saving in adjusting voltage and rapid response to sudden change.

Basically regional balance of power generation facilities and demand are appropriate, also mid- and long-term development plans of transmission lines and substations are adequately made to have the result of relatively less occasion of noticeable loss occurring to high voltage facilities.
But in the future, revised plans for the mid- and long-term development plans of transmission lines are needed considering the development of large scale wind farm along the Red Sea coast around the depopulation electric power area which might cause bottle necked transmission lines in its power flow.
In current situation, the voltage adjustments by reactive power of high voltage transmission facilities are properly done, but in some substations voltage control is done manually. In these facilities, installation of automatic voltage regulator for power saving can be thought of.

Clause3 Candidate List of Distribution project

There are eight potential methods for energy efficiency in electric distribution sector. After conducting the site survey, the study team evaluated these eight potential methods and concluded two of the methods are not feasible in Egypt because of the cost benefit.

Table 3-2-3-1 Potential Methods for Energy Efficiency and its Priority

	Potential Methods	Evaluation
1	Higher voltage of distribution feeder	× Loss reduction is effective but large investment is needed due to Various changes on many facilities
2	New construction of 11kV feeders	○ Big effectiveness to strengthen supply capacity and allocate overloaded feeders but Space to develop new feeders is needed
3	Large size of cable and line conductor	× The most of existing conductors are enough large size
4	Shortening LV line by installing small size DT	○ Big effectiveness of loss reduction for OH network △ The most of existing LV lines for UG are enough short and the loss is not so large
5	Replace old DT to new low loss DT	○ Big effectiveness to reduce cupper and iron loss The most of existing DTs are old.
6	Improvement of power factor by installing capacitor	○ Big effectiveness and potential to reduce current and loss Installed capacitors should be controlled appropriately
7	Balancing distribution feeder load Balancing Phase unbalance of LV side	○ Effectiveness of loss reduction is expected but is limited to overload feeder and phase-unbalance feeder.
8	Install Step Voltage Regulators (SVR) to improve its voltage drop	○ Effectiveness is limited to big voltage drop location such as OH feeder with long distance

(1) Higher voltage of distribution feeder

Current system voltages are 66kV, 11kV and 380V. These voltage levels are appropriate for system capacity in Egypt and to introduce another higher voltage level takes not only cost a lot but also causes various changes on facilities itself and O&M of Distribution Company. Therefore, higher voltage of distribution feeder is not good measures in Egypt.

(2) New construction of 11kV feeders

The main countermeasures against overload in medium voltage feeder in Egypt are allocation load to other existing 11kV feeders. But the most of the existing feeders have not enough availability and newly construction of 11kV feeders is the drastic measures against rapid growth of power consumption especially in outskirts area.

New constructions of 11kV feeders are beneficial to reduce system power flow on 11kV feeders. Distribution companies plan their development schedule and conduct properly their measures to expand and develop new 11kV feeders. But these development plans are behind schedule due to the international increase of the equipment cost and wages of workers especially in rural area as mentioned before.

(3) Large size of conductor of cable and line

Distribution companies have specific limited index of its distribution load. Maximum operating level of planning is 80% of conductor capacity and load allowance for distribution line in emergency condition is rated load +10% less than two hours.

Main conductor size of cables and overhead lines are relatively large capacity such as 3×300mm2 in 11kV XLPE cable and 150 and 240 mm2 in 11kV line.
In these condition, install and replace large size of conductor on distribution line can NOT expect the big effect to reduce distribution losses.

(4) Shortening LV line by installing small size distribution transformers
Regarding low voltage distribution line, the average distance per Distribution Transformer is 750m in OH and 300m in UG. These figures are not long to supply power and seem to be appropriate.
In outskirts OH area, there are some cases to supply power from big capacity transformer and long distance low voltage line. Most of these areas are effective to reduce LV line by replacing big capacity to small capacity DT. There are some potential cases to reduce loss to shortening LV line by installing small capacity DT, but these cases are NOT many for UG network and can not expect big effects.

(5) Replace old distribution transformer (DT) to new low loss DT
Egyptian transformer companies supply transformers to distribution companies have been developed low loss transformers. These low loss transformers can be reduced about 30% of cupper loss.
According to hearing from distribution companies, they are planning to replace old transformers to new low loss ones and proximally 75% of transformers are still old type *and about 80% of transformers are overloaded during peak time.*
There are potential to reduce distribution loss by installing low loss transformers.

(6) Improvement of power factor by installing capacitor and control it
In Egypt there are many ceramics factory having electric motors and grinders. Distribution companies regulate its power factor and set its target on 0.95 that current average power factor is 0.85.
During the discussion with Egyptian counterpart, they believe that the ideal capacity of capacitors is about 30% of total system capacity and they expect Japanese side to support this option. Power factor is fluctuating from hour to hour influenced by system power flow. Then control on and off its capacitor consistently can keep its power factor at a best condition.
And more, new inventive tariff system will be introduced to industrial customers.

- -- *Pay back bonus at power factor:* 0.92-0.95
- -- No bonus and penalty 0.9-0.92
- -- Penalty at power factor: 0.7-0.9
- -- Double penalty at power factor: Less than 0.7

(7) Balancing distribution feeder load and 3 phase of load
The most of 11kV distribution feeders are connected each other to allocate and interchange the power. The dispatchers of control center supervise the load and try to balance it among some existing feeders. But the switchgears of connecting point are not remote controlled and can not manipulate from control center.
Installing remote controlled switchgears and frequent controlling its load balance enables to reduce feeder current and improve its reliability in addition.

(8) Install Step Voltage Regulator (SVR) *to improve its voltage drop*
Egyptian distribution companies should supply power at ±5% of standard voltage. But there are many cases that voltage drop sometime exceeds the regulating values especially in rural area which power line are long.
Installing SVR can be expected to improve voltage level. Stepping up voltage can reduce its electric current, so that distribution loss can be reduced in square ratio.

Clause4 Candidate List of Power Demand Side project

(1) Efficiency Improvement by Demand Side Management targeting on AC

This study can show a theoretical impact of DSM by Heat Storage AC.
For example, we can take the demand status of Alexandria and assume that their demand is a miniature of whole Egypt. Referring to the Demand Curve of Alexandria in Chapter3, Section1, Clause4, (3)-2), we can assume the difference of peak and off-peak demand being the AC demand. In case of Alexandria, AC demand appears to be as much as 400MW as seen in the Fig. 3-1-4-8. The total demand of Egypt is about 14 times of demand of Alexandria. Assuming that the demand pattern of Alexandria being miniature of the country, 5,600MW can be the theoretical AC capacity of all Egypt. If all of these ACs are replaced by highly efficient Heat Storage AC introduced in Chapter3, Section1, Clause4, (2)-1), 30 to 40% of AC demand or 1,680 to 2,240MW can be theoretically shifted. This is equivalent of 1,000 to 1,400MUSD of avoided cost that would have been spent on power plant construction. These avoided costs can be passed through to the consumers as TOU incentives. Even after such pass-through, the power company will enjoy higher and more stable operation ratio of existing generation units and avoided maintenance costs.
Nevertheless it must be noted that the Heat Storage AC are only available for large customers such as building because of its size and that the majority of consumers in Egypt are low voltage. Therefore above-mentioned effect is not likely to be realized. DSM targeting AC proved effective to some extent in Japan because 63% of its power market is middle to high voltage customers to whom. Heat Storage AC is applicable. However the Heat Strong AC could still be a reliable option in the future.
Therefore in case of Egypt, under the current situation, rather than relying on Heat Storage AC, Energy Conservation should be promoted to pave way for effective DSM. The daytime demand curves not corresponding with temperature variation indicates the necessity of Energy Conservation. As stated before, the Demand Side Management only serves well if it comes with Energy Conservation practices. These things considered, under the current situation of Egypt, recommendable policies for DSM are;

-- Promotion of Energy Conservation prior to or in concurrent with DSM by learning from experienced countries.
-- Experimental Peak-Shifting by Heat Storage AC at selective large consumers such as hotel, factories for impact analysis and TOU design as a study for future TOU implementation.

(2) Demand Side Management by AMR

One of the interesting findings for the mission team was the experimental installation of Automated Meter Reader (AMR). In Japan, AMR are installed to large consumers to monitor their power demand to utilize such information for Demand Side Management, since larger consumers naturally have bigger influences to demand-supply balance. On the contrary, Egyptian power companies install AMR and Prepaid Meters to low voltage customers to improve the meter reading accuracy and to avoid tampering or power theft. AMR installation is eagerly promoted in each Distribution Company to reduce "Non-technical Loss" and we believe this strategy will have a significant effect on such purposes. However the benefit of AMR is not limited to reduction of Non-Technical Loss.
As introduced in the previous section, these AMR are capable of detecting tampering, voltage drops, sending hourly voltage/amperage data and etc. Hourly data recording/sending function enables power companies to record consumption of certain time of day and this is a prerequisite to introduce TOU tariff system.
Therefore these things considered, as a conclusion, installation of AMR to reduce

non-technical loss and to better monitor the power consumption is recommendable. And in addition to the foregoing, it is recommendable to try out experimental TOU with the AMR customers to study the market response so that the result of study can serve in designing suitable TOU for Egypt.

Section 3 Candidate of Japanese ODA loan project

Clause1 Evaluation for candidates of projects

In order to prioritize the potential in the candidate lists and select model projects for Egypt among them, the team made evaluation criteria taking into account project effectiveness, feasibility, promptness and so on.

- ✓ Total costs (A : Small, B : Medium, C : Large)
- ✓ Costs & Effectiveness (A : Very Good, B : Good, C : Medium)
- ✓ Implementation period (A : Short, B : Medium, C : Long)
- ✓ Impact to reliability of power system during implementation period (A : Non, B: Minor Little, C : Significant)
- ✓ Necessity of additional technical study (A : a little, B : Some, C : Much)
- ✓ Urgency (A: Urgent, B: Medium, C: Moderate)

Table below shows a rough estimation of prioritizing each project based on the criteria.

	Project	Total costs	E/C	Imp. period	Impact to Sys. Reliability	Necessity of tech study	Urgency	Total
Power Generation								
1	Introduction of C Cycle	C	A	B	A	B	B	**B**
2	Retrofitting & rehabilitation for inefficient power plants	A	A	A	C	C	B	**B**
3	Combining existing plant with new GT	B	A	C	C	C	B	**C**
Transmission								
4	Newly-built high voltage transmission line	C	C	B	A	B	C	**C**
5	Reduction of load factor by increasing the number of paralleled transmission line	C	C	B	A	B	C	**C**
6	Augmentation of transmission line (heavy lining, usage of multiple conductor)	C	C	B	A	B	C	**C**
7	Reduction of in-house power of substation	B	C	A	B	B	C	**C**
8	Reduction of load factor by expansion of transformers	B	C	A	B	B	C	**C**
9	Installation of automatic power factor adjusting device	B	C	A	B	B	C	**C**

10	Installation of automatic voltage regulator	B	B	A	B	B	C	**B**
11	Utilization of transformer waste heat	B	C	B	A	C	C	**C**
Distribution								
12	Higher voltage of distribution feeder	B	C	A	A	B	C	**B**
13	New construction of 11kV feeders	A	A	A	A	B	A	**A**
14	Large size of cable and line conductor	B	C	A	A	B	C	**B**
15	Shortening LV line by installing small size DT	A	A	A	A	B	A	**A**
16	Replace old DT to new low loss DT	A	A	A	A	B	A	**A**
17	Improvement of power factor by installing capacitor	A	A	A	A	B	A	**A**
18	balancing distribution feeder load	A	B	A	A	B	A	**A**
19	Install Step Voltage Regulators (SVR) to improve its voltage drop	A	B	A	A	B	A	**A**
DSM								
20	Efficiency Improvement by DSM targeting on AC	A	B	A	A	C	C	**B**
21	DSM by AMR	A	A	A	A	B	B	**A**

In the study, many projects regarding distribution sector obtain high scores. The reasons should be as follows;

- ✓ They have highly energy saving effectiveness.
- ✓ Additionally amount of their budget is very suitable for "Cool Earth Partnership Fund" which will be expected to fund these projects.
- ✓ Many additional studies on the distribution project and EIA may not be required at present.
- ✓ Hereby, preparation period until beginning of project implementation can be very short. (Cool Earth Partnership Fund's implementation period may be limited)

Chapter 4

Model projects in Distribution

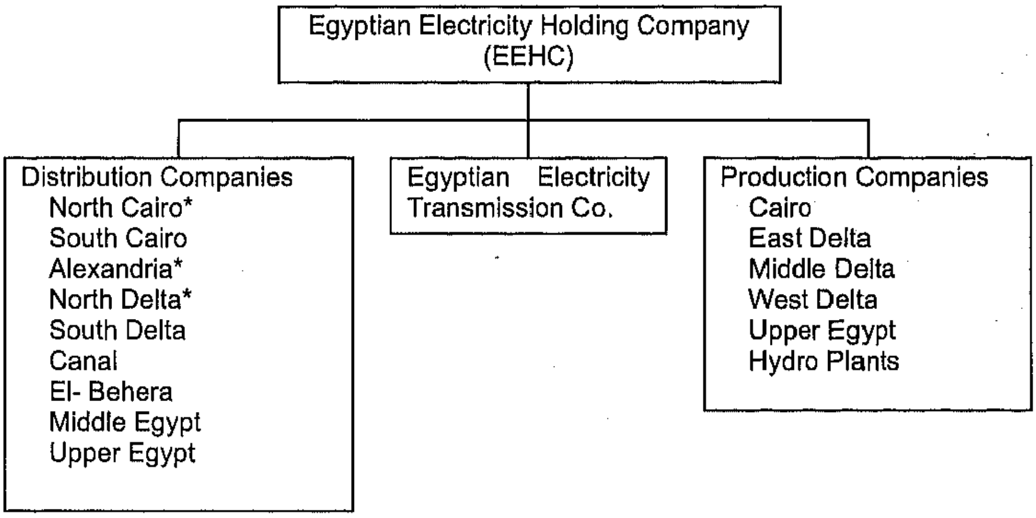
Chapter 4 Model projects in Distribution

Section 1 Overview and Activities for Improving Energy Efficiency of Executing Agency of Model Projects

Clause1 Overview of Model Distribution Companies and Model Areas

(1) Model distribution companies

There are nine distribution companies under the EEHC. Out of the nine companies, the following three are selected as model distribution companies for this study: North Cairo Electricity Distribution Company (NCEDC), Alexandria Electricity Distribution Company (AEDC), and Delta North Electricity Distribution Company (NDEDC).



(Source: EEHC Annual Report 07/08)
*(Model Distribution Companies are marked with *.)*

Fig. 4-1-1-1 EEHC and Model Distribution Companies

Table 4-1-1-1 Number of Shares and Capital of Distribution Companies

Distribution company	Capital (Million EGP)	No. of Medium Voltage Distributors (No.)	No. of Customers
North Cairo*	52.922	327	3,240,201
South Cairo	59.678	295	4,066,723
Alexandria*	195.443	177	1,952,913
Canal	152.87	1007	2,719,509
North Delta*	213.597	138	2,669,062
South Delta	222.746	102	3,016,718
El Behera	97.75	225	1,499,097
Middle Egypt	176.887	103	2,636,356
Upper Egypt	101.539	93	1,981,632

1) Supply Area
The supply areas of the model distribution companies are as follows: North of Cairo; South of Kalubia Government; Central Alex; East Alex; West Alex; Montaza; El Sahel; North Dakhalia; South Dakahlia; Damietta; and Kafr El Sheikh.

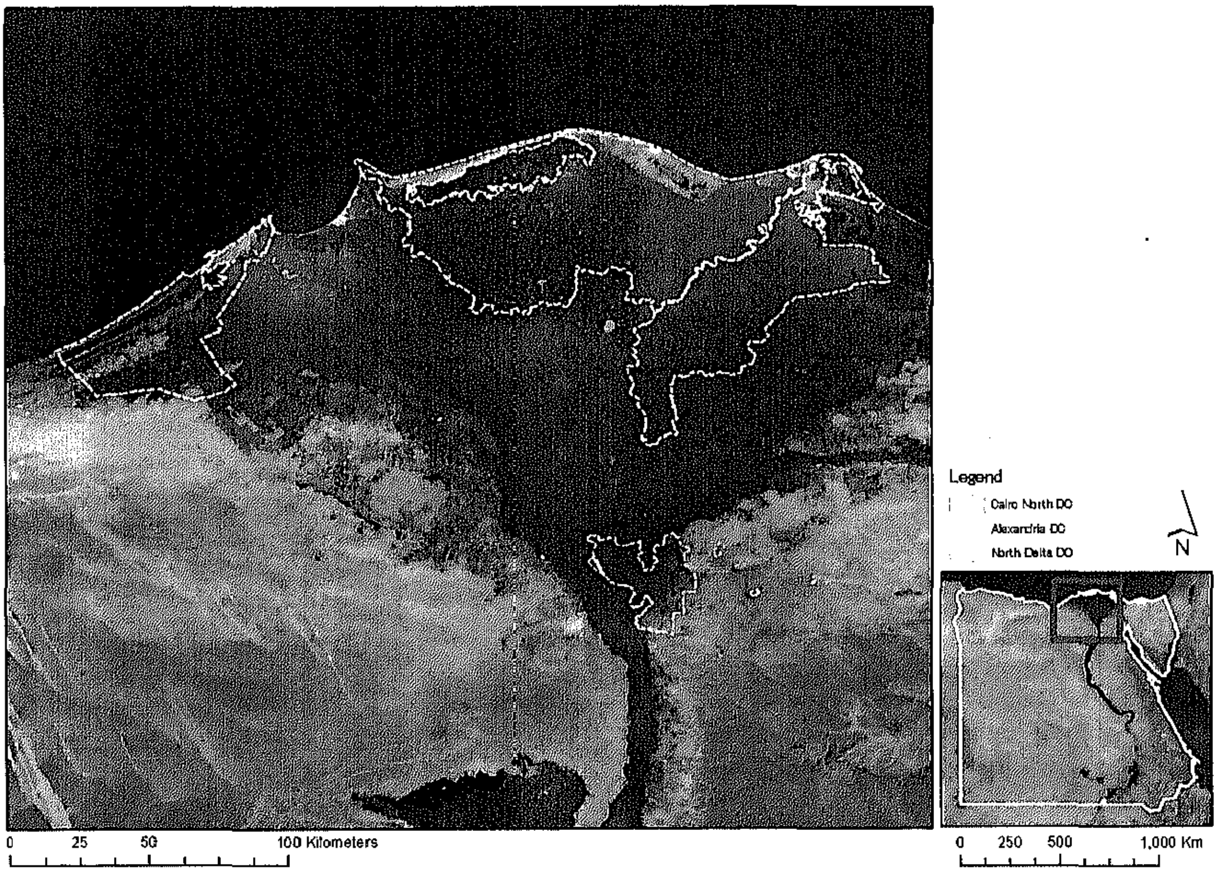


Fig. 4-1-1-2 Supply Area of Model Distribution Companies

2) Roles of distribution companies

1. Distributing and selling to customers on medium and low voltages, electric power purchased from the Egyptian Electricity Transmission Company and from the Egyptian Electricity Production Companies on medium voltage, and also electric power purchased from industrial and other independent power producers (IPPs) exceeding their needs, provided that the approval of EEHC Board is obtained.
2. Managing, operating and maintaining medium and low voltage grids in the companies, in compliance with the dispatch center instructions to meet the economic needs.
3. Preparing forecasts on loads and energy for customers of the companies and economic and financial forecasts for the companies.
4. Researching, designing, and implementing electric projects for different purposes on medium and low voltages, and carrying out all necessary works.
5. Managing, operating, and maintaining isolated units.
6. Carrying out any other relevant work to fulfill the companies' objectives, in addition to any other work that may be entrusted by EEHC.
7. Carrying out other relevant and necessary work entrusted to the companies by other parties for profit.

3) Finance
The companies' resources consist of the following.

1. Funds allocated in the state budget (Currently not used).
2. Proceeds from the issuance and renewal of licenses to different service providers of the electric utility sector.
3. Proceeds from services rendered by the Agency to different customers of the electric utility sector.
4. Proceeds from the investments of the Agency funds.
5. Donations, subsidies, and grants that do not contradict the Agency objectives.
6. Any other sources.

4) Peak demand (MW)
Peak demand and electricity consumption have been growing. The peak demand growth rates of all the model distribution companies are between 4.8% and 9.3%; the average is 7.0%. The electricity consumption growth rates are between 1.1% and 15.9%; the average is 7.4%.

Table 4-1-1-2 Peak Demand and Electricity Consumption

Fiscal year	Alex.				North Delta				North Cairo			
	Peak Demand		Electricity Consumption		Peak Demand		Electricity Consumption		Peak Demand		Electricity Consumption	
	MW	Growth (%)	GWh	Growth (%)	MW	Growth (%)	GWh	Growth (%)	MW	Growth (%)	GWh	Growth (%)
2003/2004	1,024		5,461.0		1,178		5,843.9		1,920		9,543.6	
2004/2005	1,101	7.5	5,850.0	7.1	1,260	7.0	5,909.9	1.1	2,072	7.9	9,979.9	4.6
2005/2006	1,186	7.7	6,305.0	7.8	1,335	6.0	6,305.2	6.7	2,207	6.5	10,833.0	8.5
2006/2007	1,279	7.9	6,750.0	7.1	1,417	6.1	6,769.4	7.4	2,334	5.8	11,739.7	8.4
2007/2008	1,341	4.8	7,172.4	6.3	1,505	6.2	7,845.3	15.9	2,550	9.3	12,919.2	10.0
2008/2009	1,430	6.6	7,716.9	7.6	1,624	7.9	8,401.9	7.1	2,747	7.7	13,659.9	5.7

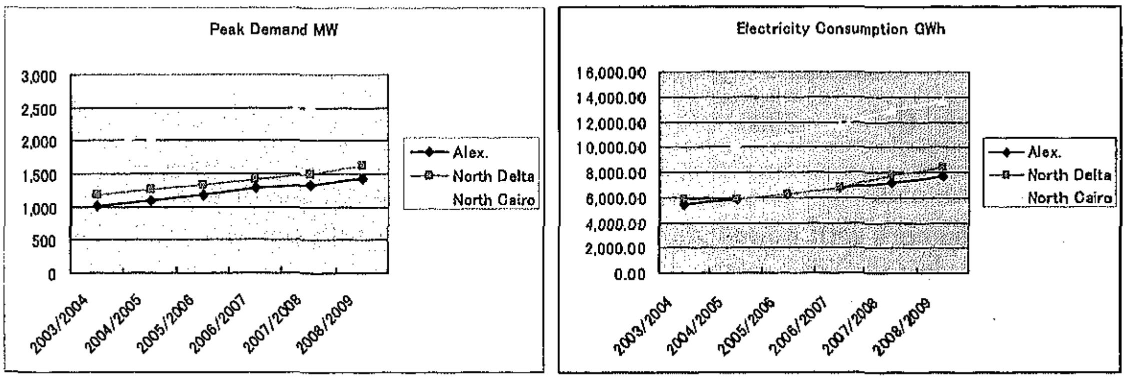


Fig. 4-1-1-3 Peak Demand and Electricity Consumption

5) Revenue and expenditure
Both Revenue and expenditure is growing 10.0 to 19.1% per year, except North Cairo 2005. Revenue exceeds expenditure by 0.4 to 2.7% or (1 to 2.7 expect North Cairo). Revenue and expenditure are shown in Table 4-1-1-3.

Table 4-1-1-3 Revenue and Expenditure

Year	Alex.			North Delta			North Cairo		
	Exp. 1000 LE	Rev. 1000LE	BP	Exp. 1000 LE	Rev. 1000LE	BP	Exp. 1000 LE	Rev. 1000LE	BP
2004/2005	934,234	943,439	9,205	1,107,328	1,125,319	17,991	1,084,174	1,095,749	11,575
2005/2006	1,028,046	1,041,264	13,218	1,242,288	1,264,140	21,852	1,934,777	1,952,069	17,292
2006/2007	1,208,617	1,224,371	15,754	1,455,013	1,474,795	19,782	2,173,258	2,203,108	29,850
2007/2008	1,346,516	1,363,912	17,396	1,678,008	1,700,557	22,549	2,589,306	2,620,435	31,129
2008/2009	1,513,411	1,552,581	39,170	1,869,271	1,919,188	49,917	3,011,026	3,021,957	77,650

6) Electricity sales revenue by tariff category
49 to 58% of electricity sales are by households. 9% to 28% are by consumers with power of more than 500 KW. 17 to 23% are by consumers with power of less than or equal to 500 KW.

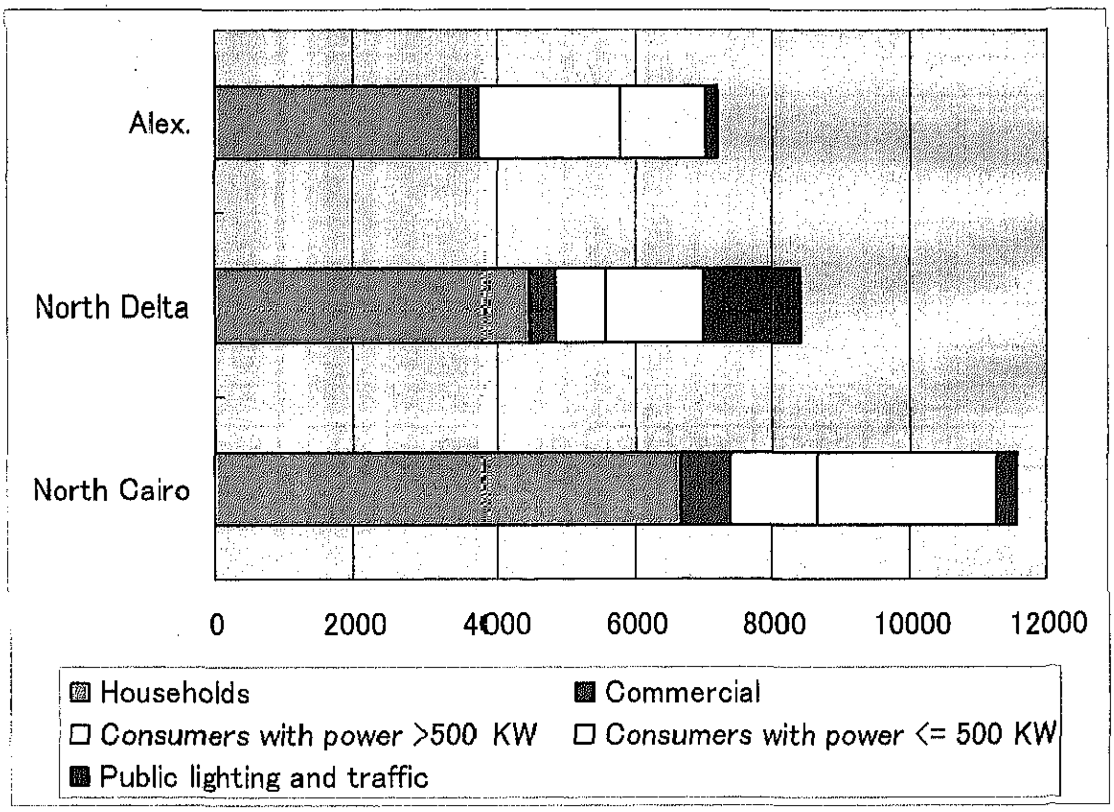


Fig. 4-1-1-4 Electricity Sales Revenue by Customer

Table 4-1-1-4 Electricity Sales Revenue by Tariff Category

Tariff Category (KWh/month)		Electricity Sales (Million KWh)		
		Alex. (2008/2009)	North Delta (2008/2009)	North Cairo (2008/2009)
Households	50 kwh	1,286.9	1,153.804	1,869.445
	51 – 200	1,471.4	2,236.051	2,532.600
	201 -350	445.5	695.493	1,040.949
	351-650	201.4	298.306	628.117
	651-1000	61	48.113	285.100
	>1000	69.6	23.728	290.268
	Total households	**3,535.8**	**4,465.495**	**6,676.479**
Commercial	100	76.9	289.215	242.758
	101-250	49.8	38.014	142.920
	251-600	47.4	22.848	133.812
	601- 1000	22.3	7.952	71.086
	>1000	61.9	15.423	103.601
	Total commercial	**258.3**	**373.452**	**694.177**
Consumers with power >500 KW	Industry	1,333	201.351	2,041.3
	Agriculture	22.9	180.504	-
	Public utilities	300.8	241.871	627.162
	Government	134	102.201	658.336
	others	191.7		
Total consumers (power >500 KW)		**1,982.4**	**725.926**	**3,326.798**
Consumers with power <= 500 KW	Agriculture	8.7	61.389	59.052
	Industry	407	442.184	2,121.458
	Public utilities	38.9	232.562	45.018
	Government	166.6	422.285	387.459
	others	603.1	259.79	6.061
Total (power < =500 KW)		**1,224.3**	**1,427.439**	**2,619.048**
Public lighting and traffic		**171.8**	**1,409.505**	**297.391**
Total electricity sales of the distribution company		7,172.5	8,401.86	93.272

7) Average purchase price of electricity by customers
Below are the average purchase prices of electricity.

Table 4-1-1-5 Residential Tariff 2009 (North Cairo)

Category (kWh)	LE/ kWh
0-50	0.05
51-200	0.108
201-350	0.155
351-650	0.228
651-1000	0.361
> 1000	0.442

Table 4-1-1-6 Commercial Tariff 2009 (North Cairo)

Category (kWh)	Commercial Tariff 2009 (LE/ kWh)	
	Alexandria, North Delta	North Cairo
0-100	0.236	0.234
101-250	0.351	0.347
251-600	0.447	0.449
601-1000	0.558	0.562
> 1000	0.578	0.587

Table 4-1-1-7 Other Tariff (North Cairo)

Item	Other Tariff (LE/ kWh)	
	Alexandria, North Delta	North Cairo
Contracted power ≥ 500 kw	0.235	0.237
Contracted power ≤ 500 kw	0.243	0.238
Agricultural	0.109	
Street light	0.405	0.402

8) Number of employees
The number of employees is increasing around 7% per year.

Table 4-1-1-8 Number of Employee

Year	Number of Employees		
	Alex.	North Delta	North Cairo
June 2005 (04/05)	NA	7,170	9,316
June 2006 (05/06)	NA	7,260	10,082
June 2007 (06/07)	12,558	7,385	10,809
June 2008 (07/08)	12,561	7,989	11,204
June 2009 (08/09)	12,737	8,618	11,812

9) Number of costumers by tariff category
82 to 86% of customers are residential and 6 to 13% are commercial.

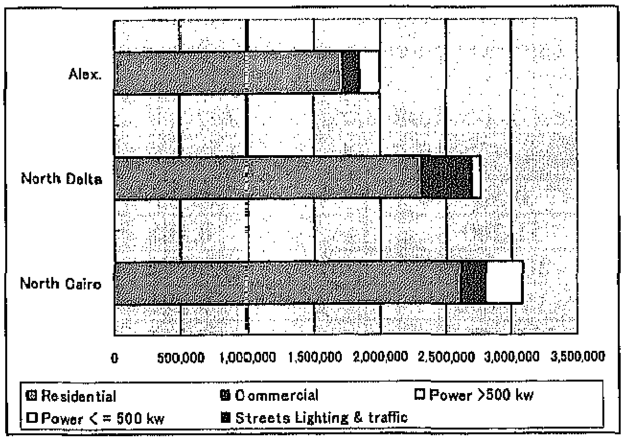


Fig. 4-1-1-5 Numbers of Customers by Tariff Category

Table 4-1-1-9 Numbers of Costumers by Tariff Category

Category of consumers	No. of consumers		
	Alexandria (2008/2009)	North Delta (2008/2009)	North Cairo (2008/2009)
Residential	1,717,850	2,326,712	2,607,714
Commercial	124,548	365,481	197,971
Power >500 kw	771	131	797
Power <= 500 kw	147,650	68,077	274,658
Streets Lighting & traffic	2,734	269	2,927
Total	1,993,332	2,835,754	3,084,067

10) Bill collection efficiency

The range of bill collection efficiency is between 91.6% and 97.9%.

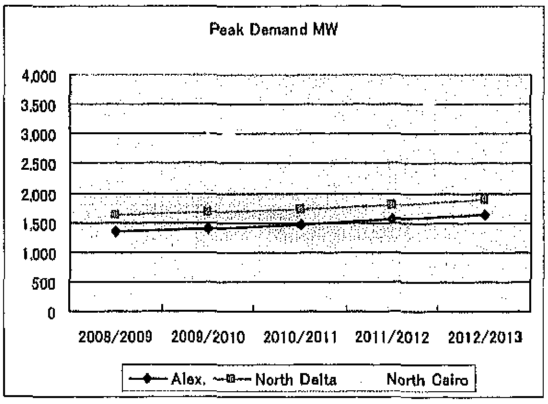
Table 4-1-1-10 Bill Collection Efficiency

Year	Percentage of Consumers*		
	Alexandria	North Delta	North Cairo
(2006/2007)	97.9%	96.2%	97.2%
(2007/2008)	97.2%	97.0%	91.6%

These figures are confirmed electricity fee which excluding non-technical loss.

11) Forecasts for peak demand and electricity consumption

Expected annual growth rates of peak demand are from 2.2% to 7.8%. Expected annual growth rates of electricity consumption are from 5.0% to 7.1%.



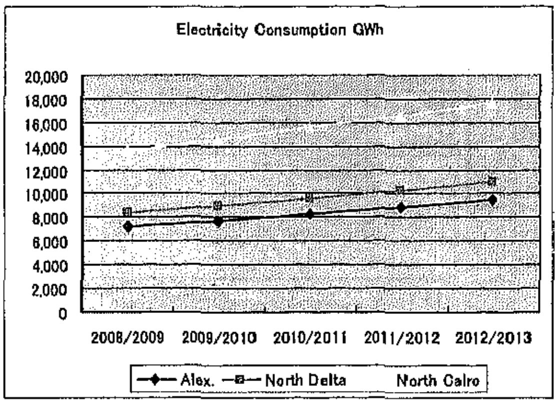


Fig. 4-1-1-6 Forecasts for Peak Demand and Electricity Consumption

Table 4-1-1-11 Forecasts for Peak Demand and Electricity Consumption

	Alexandria.				North Delta				North Cairo			
	Peak Demand		Electricity Consumption		Peak Demand		Electricity Consumption		Peak Demand		Electricity Consumption	
	MW	Growth (%)	GWh	Growth (%)	MW	Growth (%)	GWh	Growth (%)	MW	Growth (%)	GWh	Growth (%)
2008/2009	1,430	-	7,716.9	-	1,624	-	8,402	-	2,748	-	13,660	-
2009/2010	1,407	-1.5	7,578	-1.2	1,684	3.7	8,992	7.0	2,954	7.5	14,614	7.0
2010/2011	1,478	5.0	7,957	5.0	1,721	2.2	9,629	7.1	3,163	7.1	15,598	6.7
2011/2012	1,552	5.0	8,355	5.0	1,804	4.8	10,297	6.9	3,410	7.8	16,611	6.5
2012/2013	1,630	5.0	8,773	5.0	1,887	4.6	11,020	7.0	3,635	6.6	17,653	6.3

(2) Model areas

1) Selection of model areas (sectors) in 3 Distribution companies

Three model areas (sectors) are selected from three model distribution companies. The selected model areas are West Alex (Alexandria), North Dakhalia (North Delta), and Helmya (North Cairo). The main reason of the selection is percentage of technical loss. Technical loss of the selected model area is higher than the other sector. The technical loss of West Alex, North Dakhalia, and Helmya is 8.38%, 6.70%, and 12.20% (See Table 4-1-1-12).

Table 4-1-1-12 Distribution loss of each sector

EDC	Sector	Tec. Loss	Non Tec. Loss	Total	Selected reasons of model area
Alexandria	Central Alex	8.05	5.49	13.54	- The technical loss of West Alex sector is highest in 5 sectors. - There are many important industries in West Alex area. - West Alex area is a new town which has new and planned residences/ commercial buildings, so that a lot of peoples have moved to this area from old town in Alexandria.
	East Alex	7.97	5.32	13.29	
	El Sahel	7.97	5.23	13.20	
	Montaza	8.14	5.27	13.41	
	West Alex*	**8.38**	**5.38**	**13.76**	
	Total	8.15	5.39	13.54	
North Delta	Damietta	4.10	1.90	6.00	- The technical loss of North Dakhalia sector is highest in four sectors. - Potentials of technical loss reduction in North Dakhalia sector is large due to high ratio of OH feeder, long distribution lines and growing demands. - North Dakhalia sector is important due to concentration of industries, commercial activities and growing new residences.
	Kafr El Shikh	4.90	3.10	8.00	
	North Dakhalia*	**6.70**	**5.30**	**12.00**	
	South Dakahlia	3.50	2.70	6.20	
	Total	4.80	3.25	8.05	
North Cairo	East	5.61	2.58	8.19	- The technical loss in Helmya sector is highest in four sectors. - Helmya sector is important due to governmental buildings, hospitals and concentration of industries/ commercial activities/ residences. - Outage duration in Helmya sector is relatively longer.
	Helmya*	**12.20**	**5.60**	**17.80**	
	Heliopies	9.37	4.31	13.70	
	North	7.09	3.26	10.40	
	Total	6.08	5.57	11.65	

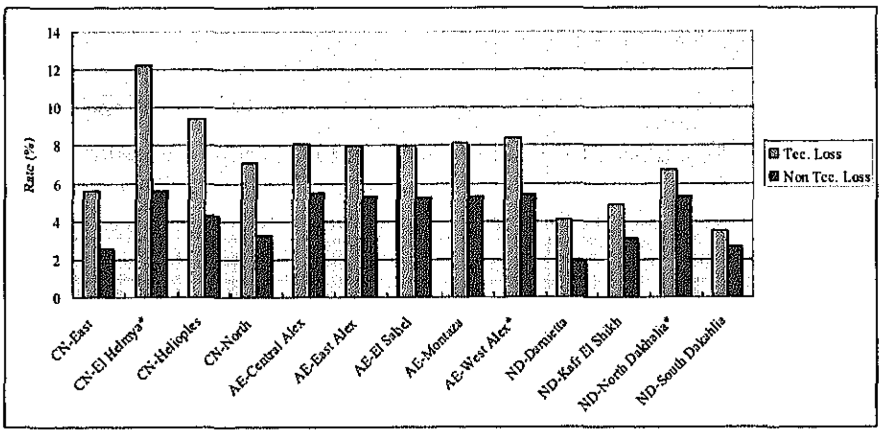


Fig. 4-1-1-7 Distribution loss by sector

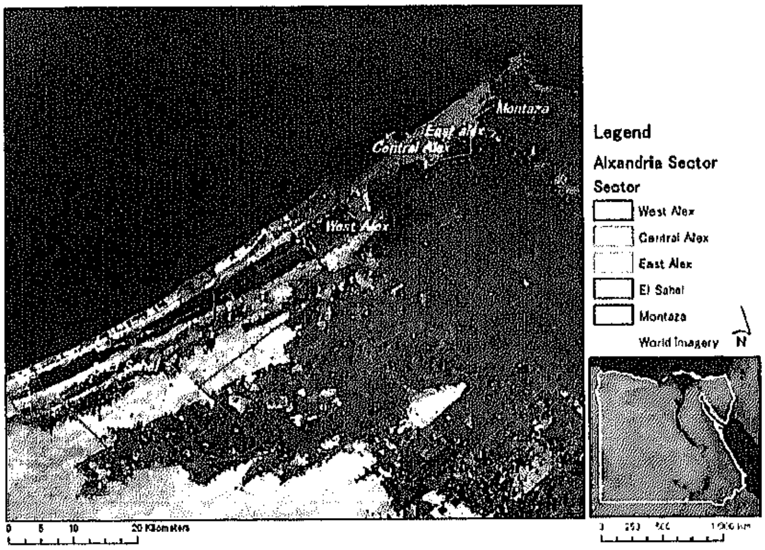


Fig. 4-1-1-8 Location of West Alex

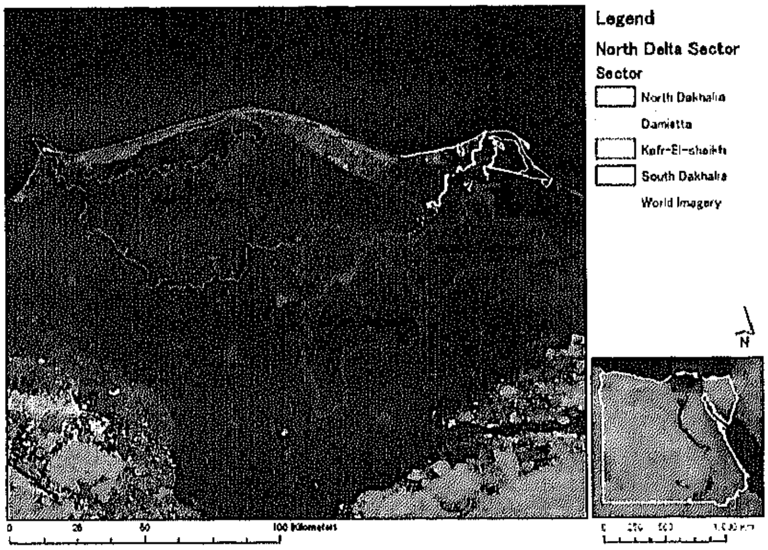


Fig. 4-1-1-9 Location of North Dakhalia

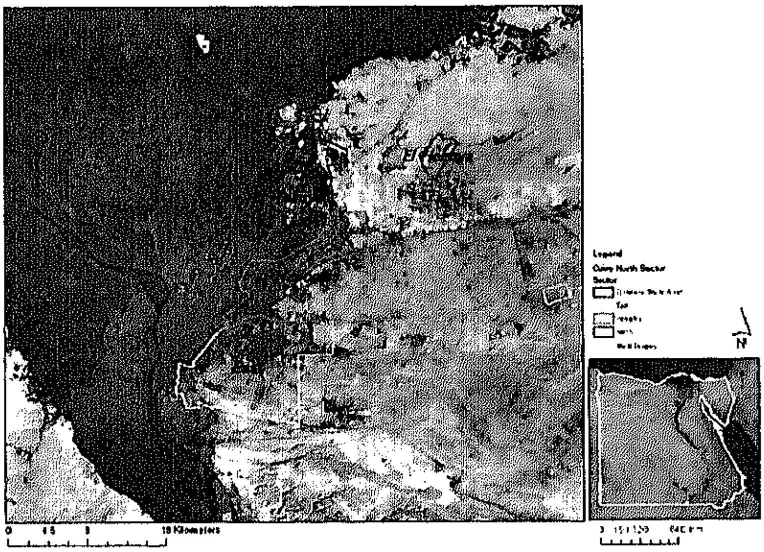
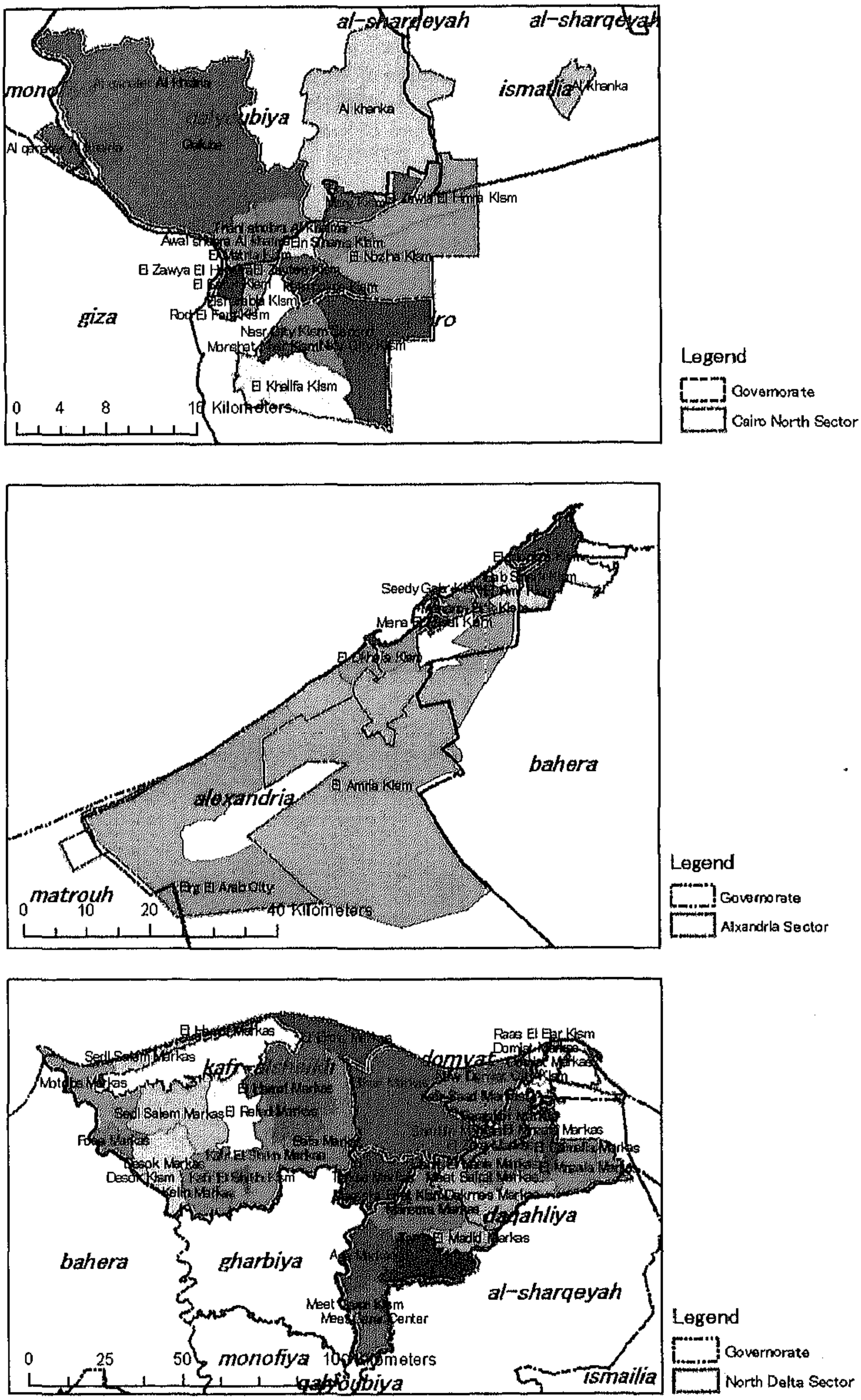


Fig. 4-1-1-10 Location of Helmya

2) Municipality boundary
The Cairo North EDC covers two governorates (22 Qisms), Alexandria covers one governorate (15 Qisms), and North Delta covers four governorates (40 Qisms). Some sector boundaries do not match the qism boundaries. Table 4-1-1-13 and Fig. 4-1-1-11 show the names and locations of the governorates and qisms.

Table 4-1-1-13 Municipality Area by Sector Area

EDC	Sector	Governorate	Qism
Alexandria	Central Alex	Alexandria	Al Ibrahimia, El Gomrok-Moharam Bek
	East Alex	Alexandria	El souf (Sh. In Montaza), Abees (sh. In el raml), Bakoos (sh. In el raml)
	El Sahel	Alexandria	El Sahel, El Betash (Sh. In Dekhela), Borg el arab (Sh. In borg el arab), El hamam
	Montaza	Alexandria	Abu Kir (Sh.), Side bishr (Sh.), khorshed (Sh.), El mandara (Sh.)
	West Alex*	**Alexandria**	**El Kabari (Sh. In mina el basal), El Dekhela-Merghim (Sh. In New Borg El Arab city), El Amriya**
North Delta	Damietta	Domiat	Domiat First Kism, Domiat Markas, Faraskor Markas, Kafr Saad Markas, New Domiat City Kism, Raas El Bar Kism, El Zrka Markas, Domiat Second Kismd
	Kafr El Shikh	Kafr El Shikh	Kafr El Shikh Kism, Kafr El Shikh Markas, El Brols Markas, Bela Markas, Desok Kism, Desok Markas, Sedi Salem Markas, Foaa Markas, Kelin Markas, Motobs Markas, El Hamol Markas, El Reiad Markas
	North Dakhalia*	**Dakhlia**	**Mansora Markas, El Mataria Markas, Blkas Markas, Dekrnes Markas, Sherbin Markas, Menit El Nase Markas, El Gamalia Markas, Meet Selcil Markas, Mansora First Kism**
	South Dakahlia	Dakhlia	Aga Markas, El Senblawin, El Mnzala Markas, Talkha Markas, Meet Gamr Kism, Meet Gamr Center, Tamy El Madid Markas
North Cairo	East	Cairo	El Khalifa Kism, Nasr City Kism, Nasr City Kism Second, Badr city, Monshat Nasr Kism
	Helmya*	**Cairo**	**El Helmya, El Marg**
		Qalube	**Al khanka**
	Heliopoles	Cairo	Heliopolice Kism, El Nozha Kism, Ein Shams Kism, El Zawia El Hmra Kism
	North	Cairo	Elsharabia Kism, Shobra Kism, Rod El Farg Kism, El Sahel Kism, El Zawya El Hamera
		Qalube	Al qanater Al khairia, Awal shubra Al khaima, Thani shobra Al khaima, Qalube



Source: CNDC, ALDC, NDDC

Fig. 4-1-1-11 Governorate and Qisms in the Model EDC Coverage Area

3) Population

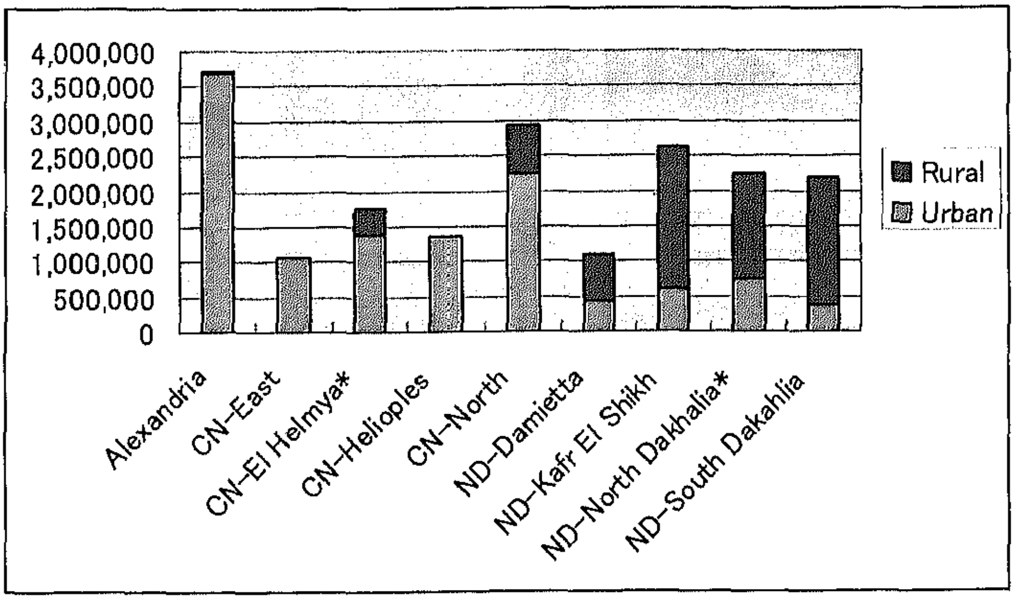
The population of Helmya (North Cairo) is 1,764,106 and that of North Dakhalia (North Delta) is 580,632. The population of West Alex cannot be divided into sectors, because the population census area is different from the sector area. The rural population rate is 21% for Helmya and 67% for North Dakhalia. Helmya is a high population density area.

Table 4-1-1-14 Population by Sector

Company	Sector	Population (Census 2006)			Number of Customers	Annual Electricity Consumption (GWh)
		Urban	Rural	Total		
Alex (08/09)	Central Alex	3,670,859	39,197	3,710,056	395,686	1,574
	East Alex				449,835	1,743
	West Alex*[1]				246,663	999
	Montaza				572,555	1,532
	El Sahel				328,592	1,266
North Delta (08/09)	North Dakhalia*	740,983	1,490,578	2,231,561	580,632	1,986
	South Dakahlia	388,150	1,806,349	2,194,499	1,028,876	2,920
	Kafr El- Sheikh	604,096	2,016,112	2,620,208	465,750	2,279
	Damietta	424,319	673,020	1,097,339	688,253	1,867
North Cairo (07/08)	Heliopies	1,349,049	0	1,349,049	373,190	2,514
	North	2,251,232	682,644	2,933,876	1,044,765	3,333
	Helmya*	1,388,624	375,482	1,764,106	1,353,839	4,538*[2]
	East	1,079,113	0	1,079,113	543,577	3,306

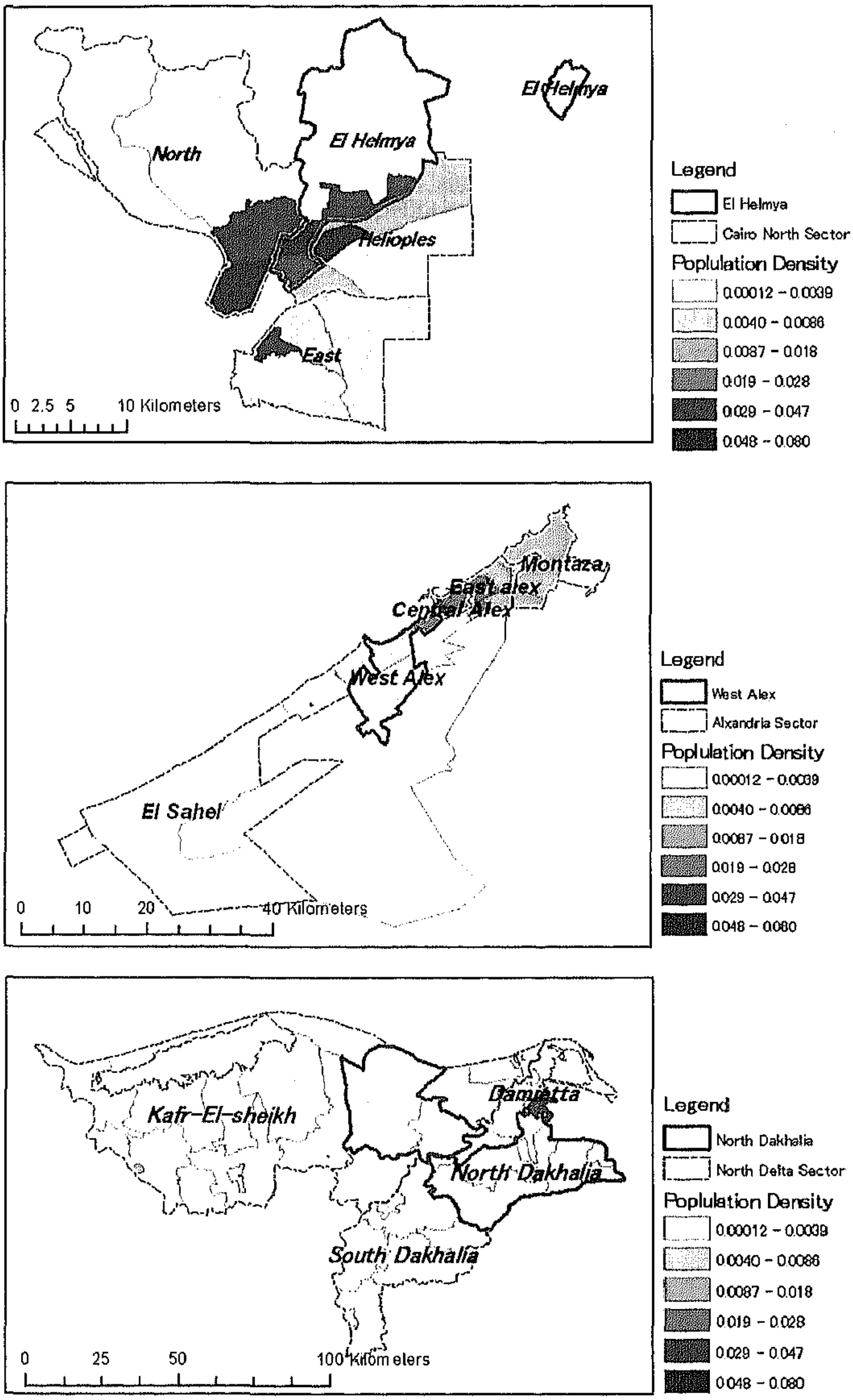
*Model area is marked with *[1]*

[2]: Consumption in Helmya is in 2008/09



(Source: Census 2006, CAPMAS)

Fig. 4-1-1-12 Population by Sector



(Source: Census 2006, CAPMAS)

Fig. 4-1-1-13 Population Density by Qism

Clause2 Existing distribution facilities in each Model Distribution Company and Model project area

(1) Outline of Model Distribution Company

There are nine distribution companies in Egypt and they have their own supply franchise area.

The JICA team nominated three potential candidates of distribution companies during first site visit confirming the agreement with EEHC.

These three companies are Alexandria Distribution Power Co., Cairo North Distribution Power Co. and Delta North Distribution Power Co. As these three candidates are the biggest distribution companies in Egypt, they have large potential of energy efficiency. And the JICA team discussed them to decide the project area and data collection during first site survey on July.

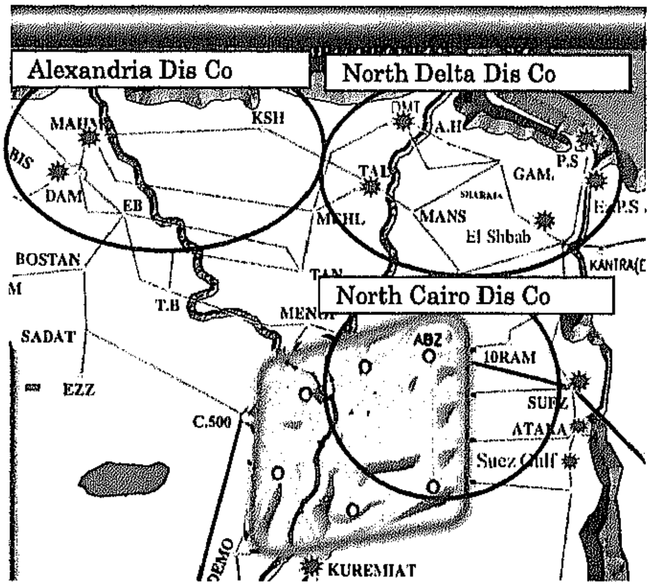


Fig. 4-1-2-1 Model companies and their supply area

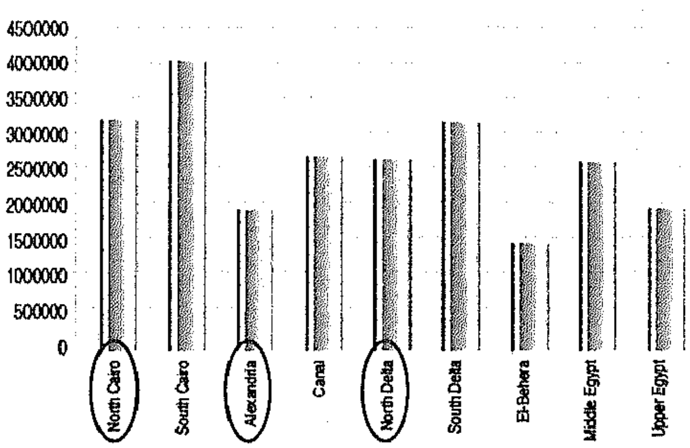


Fig. 4-1-2-2 No. of Customers of Model distribution Company

The basic information of Model Distribution Companies is follows,

Table 4-1-2-1 Quantity of Distribution Facility

	OH Feeder			Underground Feeder		
Distribution Co.	**NCEDC**	**NDEDC**	**AEDC**	**NCEDC**	**NDEDC**	**AEDC**
66/11kV SS (66/22kV)	42 (7)	45	30	-	-	-
66/11kV TR (66/22kV)	168 (26)	180	107	-	-	-
No. of 11kV Feeders	13	576	46	2,674	908	1,875
11kV Length[km]	288.8	9,556	579	1,220.1	4,799	9,157
No. of DT	272	5,550	100	13,932	8,749	6,716
LV Length[km]	16,010.7	21,565	2,584	651,022	2,589	5,430
11kV Capacitor [MVAR]	-	79.13	76.6	30	-	-
0.4kV Capacitor [MVAR]	-	224.5	0	510	-	-

(2) Regulation and Rule of Electric Power Supply

Power quality are regulated by the government ±5% in voltage and ±1% in frequency. Distribution companies install voltage regulator along the distribution line to keep the voltage level properly.

Table 4-1-2-2 Regulation of Electric power Supply

	Type	**Range**
Voltage	11 kV	within ± 5%
	400 V	within ± 5 %
Frequency	50 Hz	within ± 1%
Maximum Operation Level In Planning	Substation 11kV Feeder	80%
Overload Allowance	Substation 11kV Feeder	100%+10% (2 hours)

(3) Developing Planning of Distribution Facilities

These companies have their own developing plans to maintain distribution facilities in good condition. And they allocate their budget in each distribution facilites.

Table 4-1-2-3 Developing Planning of Distribution Facilities

Disco		NCEDC			NDEDC			AEDC		
Year		2009	2010	2011	2009	2010	2011	2009	2010	2011
OH [km]	MV 11kV	0	0	-	26	38	-	2	3	2
	LV 0.4kV	256	160	-	550	800	-	2	3	2
UG [km]	MV 11kV	12	25	-	52	40	-	143	150	200
	LV 0.4kV	136	185	-	10	10	50	50	50	-
DT	11/0.4 kV	366	220	-	72	84	-	150	150	150

(4) Features and Characteristics of Distribution Facilities

In Egypt, there are two environmental variations, one is city area that concentrated population and the other is outskirts area around the city.

Distribution facilities in city area, electric power are supplied by underground cables. These 11kV cables are relatively large capacity such as $3\times1\times400mm^2$ in 11kV XLPE cable and transformers which capacity is mostly 500KVA are located near each other because of high load density. 400V low voltage cable are installed underground or hanged along the wall of the building.

On the contrary, in outskirts area of the city, electric power is supplied by overhead line. The distribution facilities in this area are weak and do not have priority of investment compared with that of city area. Furthermore facilities strengthening schedule tend to delayed due to the international increase of the equipment cost such as copper, aluminum and cement Prices.

Among three project distribution companies, North Cairo and Alexandria distribution Company supply power mainly by underground cable and North delta supply by overhead line.

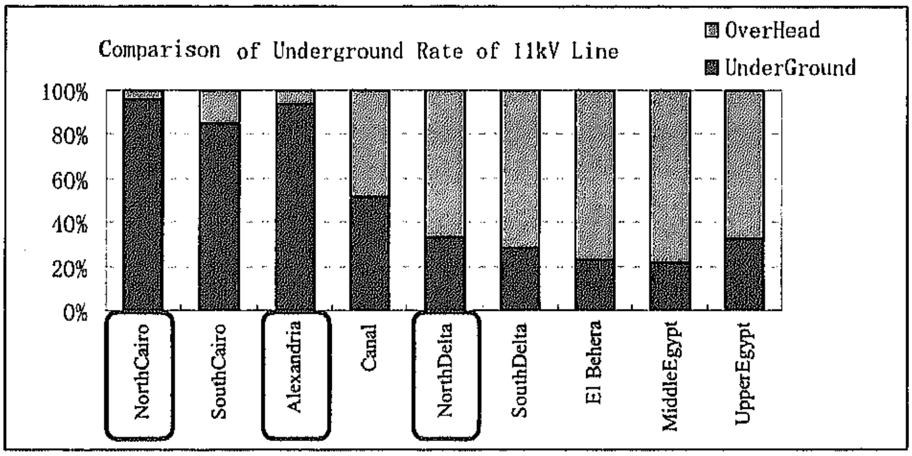


Fig. 4-1-2-3 Underground and overhead line in each distribution companies

In city area, the distribution facilities are strengthened properly to prevent over load and keep high quality of power supply.

Fig. 4-1-2-6 shows actual operation level of 11kV feeder. The rated load current of the most of the feeders are around 40-60% but during peak time some of the feeders become overloaded.

In these situations distribution losses are around 8-14% (about half of that is non technical loss) in general, the percentage losses are decreasing in decade, however, it is still higher than the values internationally acceptable. There are still potential to improve both technical and non-technical loss.

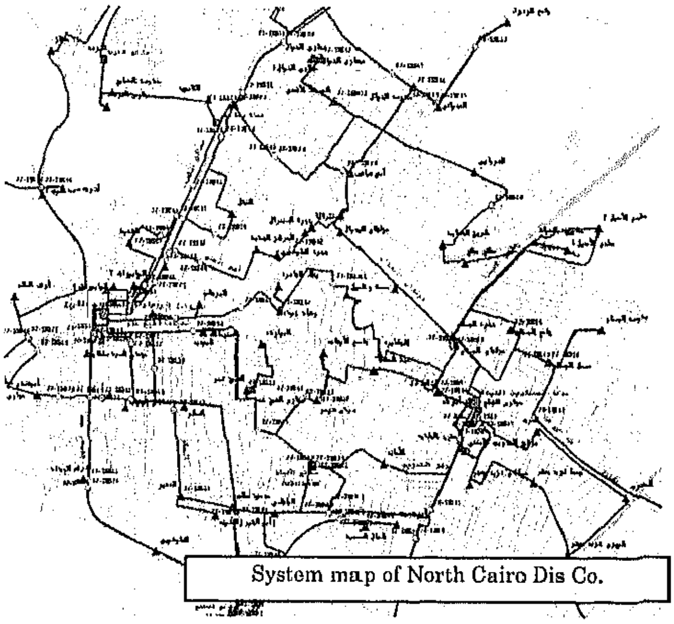


Fig. 4-1-2-4 Example of system map in the city center

(5) Problem in the outskirts area
High growth rate of demand which reached an average of 7% during the past five years, and nowadays rapid expansion of residence area and commercial and industry complex in outskirt of city leads higher growth of electric power consumption in that area. Furthermore, agricultural pumping motor and motor load of ceramic factories cause low power factor. Therefore big potential of energy efficiency located in rural area that facilities are overhead distribution line.

Table 4-1-2-4 Comparison of three Candidate company

Power Company	Distribution Loss	Power Factor
Alexandria Dis Co.	8.15%(Tech) 5.39%(Non-Tech)	0.85 average
North Delta Dis Co.	4.8%(Tech) 3.3%(Non-Tech)	from 0.86 to 0.95
Cairo North Dis Co.	6.08%(Tech) 5.57%(Non-Tech)	From 0.84 to 0.89

Clause3 Current distribution loss

Distribution Loss consists of technical loss and non-technical loss. The factor of non-technical loss mostly causes by human factor such as theft and miss reading of meter. In three model companies non-technical loss are around 6%, that has potential to improve and ideally it should be almost nothing. The solution is strengthening the customer management and prevents tampering the meter.
There is still potential to reduce the technical loss, that is, currently 6 to 7%.

Egyptian counter part and JICA team decided one project area in each three project distribution companies. Distribution loss in these project areas are high around 12 to 18% comparing with other area and these percentage will increase according to the high consumption growth rate.

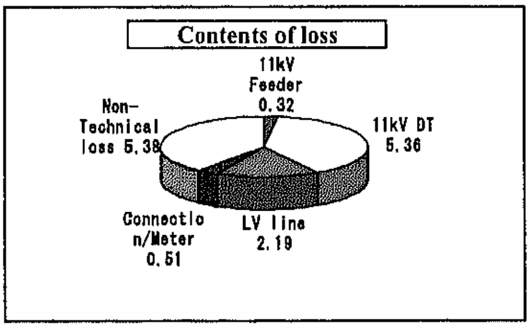
(1) Distribution Loss and consumption growth rate in project area

1) Alexandria Distribution Co.

Table 4-1-3-1 Comparison of contents of loss and growth rate (Alexandria)

Area		Montaza	East	Middle	West	North Coast	Total
Technical loss	11kV Feeder	0.33	0.33	0.34	0.32	0.33	0.34
	11kV DT	5.00	5.00	5.10	5.36	5.02	5.11
	LV line	2.00	2.00	2.10	2.19	2.05	2.09
	Connection/Meter	0.80	0.57	0.55	0.51	0.57	0.61
	Total	8.13	7.90	8.09	8.38	7.97	8.15
Non Technical loss		5.27	5.32	5.49	5.38	5.23	5.39
Total loss		13.4	13.22	13.58	13.76	13.20	13.54
Consumption Growth rate	2009	7.4	4.0	4.0	5.6	11.7	6.3
	2010	7.3	8.9	8.9	8.1	5.3	7.8
	2011	8.0	8.0	8.0	8.0	8.0	8.0
	2012	8.0	8.0	8.0	8.0	8.0	8.0
	2013						
	Average	7.7	7.2	7.2	7.4	8.3	7.5

Project area in Alexandria Distribution Company is **"West"** area one of which technical loss is bigger than any others supply area. There are new industrial parks and the wealthy people emigrate from downtown to West area.
The portion of DT loss has the obvious causes and could have much potential to improve it.



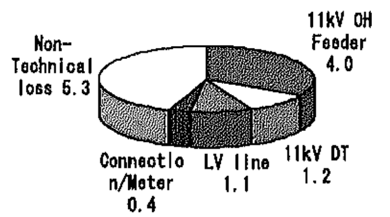
2) North Delta Distribution Co.

Table 4-1-3-2 Comparison of contents of loss and growth rate (North Delta)

Area		North dakhalia	South dakhalia	Kafr elsheikh	Domitta	Total
Technical loss	11kV Feeder	4.0	1.6	3.0	2.1	2.7
	11kV DT	1.2	0.8	1.0	1.1	1.0
	LV line	1.1	0.9	0.8	0.7	0.88
	Connection/Meter	0.4	0.2	0.1	0.2	0.22
	Total	6.7	3.5	4.9	4.1	4.8
Non Technical loss		5.3	2.7	3.1	1.9	3.3
Total loss		12.0	6.2	8.0	6.0	8.1
Consumption Growth rate	2009	8.6 (11.4)*	6.2	8.0	6.0	-
	2010	5.0 (11.4)*	6.3	8.1	6.1	-
	2011	5.0 (11.3)*	6.4	8.2	6.2	-
	2012	4.5 (11.2)*	6.5	8.3	6.3	-
	2013	4.5 (10.9)*	6.6	8.5	6.4	-
	Average	5.7 (11.2)*	6.4	8.22	6.2	-

*( ): percentage data is only for industrial area

Contents of loss



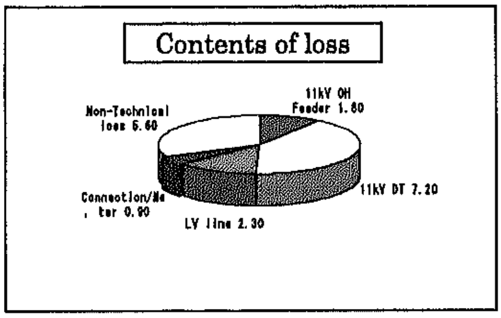
Project area in North Delta Distribution Company is **"North dakhalia"** area which technical loss and consumption growth rate are especially bigger than any others supply area.
This area is huge area and has some development project. Therefore, it could have much potential to improve distribution loss especially in 11kV distribution feeders.

3) Cairo North Distribution Co.

Table 4-1-3-3 Comparison of contents of loss and growth rate (North Cairo)

Area		Heliopoles	North	Helmya	East	Total
Technical loss	11kV Feeder	1.38	1.04	1.80	0.82	-
	11kV DT	5.53	4.18	7.20	3.31	-
	LV line	1.76	1.33	2.30	1.05	-
	Connection/Meter	0.69	0.52	0.90	0.41	-
	Total	9.36	7.07	12.20	5.59	6.08
Non Technical loss		4.31	3.26	5.60	2.58	5.57
Total loss		13.70	10.33	17.80	8.17	11.65
Consumption Growth rate	2009					
	2010	2.5	2.5	2.5	2.5	8.3
	2011	3.0	3.0	3.0	3.0	7.8
	2012	3.5	3.5	3.5	3.5	7.8
	2013	4.0	4.0	4.0	4.0	7.8
	Average	3.25	3.25	3.25	3.25	7.9

Project area in Cairo North Distribution Company is **"Helmya"** area one of which technical loss is bigger than any others supply area. This area is big demand density and it is expected overload and load unbalance.
Therefore, it could have much potential to improve distribution loss especially in DT and LV distribution line.



(2) LV (Low Voltage) Feeder

Underground cables in three Distribution Company have sufficient capacity for load current at present. On the contrary, it is worth while to examine the possibilities to upgrade overhead cable in case of small conductor and long distance line.

Table 4-1-3-4 Length of LV feeder (unit : km)

Cable size		Alexandria (West Alex)		North Delta (North Dakhalia)		Cairo North (Helmya)	
OH	4*16mm2			450	9%	0	0
	4*35mm2			**2,001**	**40%**	0	0
	4*50mm2			1,200	24%	0	0
	4*70mm2			1,351	27%	0	0
	4*95mm2			0	0	0	0
	Total	401		5,002	100%	0	0
UG	3*70+35mm2			64	35%	3,884	47.8%
	3*120+70mm2			31	17%	0	0
	3*150+70mm2			46	25%	0	0
	3*185+95mm2			15	8%	4,248	52.2%
	3*240+120mm2			27	15%	0	0
	Others			0	0	0	0
	Total	844		182	100%	8,132	100.0%

(3) 11kV Feeder

In North Delta and Cairo North, there are around 40% overloaded 11kV feeders that load current exceeds more than 80% of rated capacity. It is necessary to upgrade and develop new 11kV feeders especially high demand increase area.

Table 4-1-3-5 Number of 11kV feeders

	West Alex		**North Dakhalia**		**Helmya**	
Number of OH feeders	3		**185**		0	0
Overloaded (more than 80%)	3*	0%	**68**	**37%**	0	0
Number of UG feeders	288		160		**565**	
Overloaded (more than 80%)	28	9.7%	59	37%	**91**	**16%**

**Three OH feeders in Alexandria are used during only summer vacation*

(4) DT (Distribution Transformer)

In Egypt, there are still many old types DT, which are high iron and cupper loss. They are carrying out to replace to new one when old DT is out of order. But replacement schedule is slow and takes long years.

In Alexandria and Cairo North, there are potentials to improve distribution loss to accelerate DT replacement plan.

Table 4-1-3-6 Number of Distribution Transformers

	West Alex		**North Dakhalia**		**Helmya**	
Number of new type DT	89	8.4%	714	23.8%	728	31.9%
Number of old type DT	**970**	**91.6%**	2289	76.2%	**1,555**	**68.1%**
Total	1,059		3,003		2,285	

(5) Capacitor

Power factor in three distribution companies are around 0.85. In order to improve power factor to 0.95, to install new capacitor in both 11kV feeders and LV feeders are best countermeasures.

Existing capacitors are fixed operated and to remote control according to system load condition can improve its power factors more efficiently.

Introducing LV capacitors need to examine parallel resonance trouble to prevent from facilities damages.

Table 4-1-3-7 Capacity of capacitor and power factor

	West Alex	**North Dakhalia**	**Helmya**
Capacity at 11kV (kVAR)	8,700	16,630	12,900
Number of capacitors at 11kV	29	55	42
Capacity at 400V (kVAR)	0	33,000	51,800
Number of capacitors at 400V	0	523	1,425
Power factor at daytime	**0.85**	**0.85**	0.89
Power factor at nighttime	**0.88**	**0.89**	0.84
Average power factor	0.86	0.86	0.86

Clause4 Improvement project to reduce the distribution loss

(1) Reduction of technical loss

Technical losses in distribution network primarily consist of 11kV distribution line loss and LV (400V) line loss.

The 11kV / 0.4kV distribution line loss can be improved by the following projects.

- ✓ Construction of new distribution feeders
- ✓ Avoiding voltage drop by Step Voltage Regulator (SVR)
- ✓ Shortening of distribution line distance
- ✓ Replacing to new DT with lower core loss
- ✓ Keeping load balance of feeders by Upgrading DMS (DAS)
- ✓ Improving power factor by Automatic device or Upgrading DMS (DAS)

The recommendable method is shown in Table 4-1-4-1.

Table 4-1-4-1 Recommendable method of technical loss reduction

Project	Current plan of Egypt	Effect for loss reduction	Invest ment	Recommendation as model project	Evaluation
Construction of new distribution feeders	Planned	○	△	Apply	Loss can be reduced and the investment is effective for load growth and loss reduction.
Avoiding Voltage drop	No	○	○	Apply for OH network	SVR can be easily installed in OH line and the loss can be reduced.
Shortening of distribution line distance	No	○	○	Apply (For LV line in OH network)	LV line can be shortened by transformer of small capacity, so that the loss can be reduced.
Replacing to new DT with lower core loss	On going	○	○	Apply	Technical loss can be reduced by replacing from old to new DT and the investment is effective by promoting with lower core loss and large capacity for avoiding overload operation.
Keeping load balance of feeders and improvement of LV phase unbalance by Upgrading DMS (DAS)	Planned (needs)	○	○	Apply	Technical loss can be reduced but the investment of Upgrading DMS (DAS) is large. The communication network of Upgrading DMS (DAS) can be useful for other projects such as AMR, DSM and future business, so that the investment is synthetically effective.
Improving power factor	Planned (needs)	○	○	Apply	Technical loss can be reduced and the investment is moderate.

Good ○ > △

Since the project for construction of new 11kV distribution feeders can reduce the load current, the technical loss can be improved. This project is common for providing power to new consumers with reasonable costs. Therefore, this project is recommended due to the reasonable investment and the improvement of technical loss.

Since the project for installing SVR to 11kV OH line of long distance can improve the voltage drop, the technical loss can be effectively reduced.
The installation work is easy and the investment is not so large, so that this project is recommended.

Since the shortening of distribution line is to install additional DT with small capacity, the distance of LV line can be shortened so that the technical loss can be improved. As for UG network, the distance of LV line has already shortened and the additional installation of DT is very difficult, so that this project is not recommended for UG network.
As for OH network, LV line is long and the additional installation of DT is easy, so that this project is recommended.

Since the project for replacing old DT with inferior loss to new DT with superior loss such as amorphous core can reduce technical loss and the replacement work is easy, this project is recommended.

Since the project for keeping load balance of feeders by Upgrading DMS (DAS) is averaging feeders load by control of automatic LBS, the feeders under overloaded condition can be improved and the load current and the technical loss can be reduced. The detail technical explanation is described in Appendix 4.1-6.
As for phase unbalance of LV line, Upgrading DMS (DAS) can monitor the phase unbalance through CTs installed in LV side of DT, RTU and the communication network. Upgrading DMS (DAS) can make the report for phase unbalance and recommend to change the connection of customer. These data can also be used for checking overload of DT and non-technical loss by theft.
Though the investment of this project is relatively large, the Upgrading DMS (DAS) project with communication network can be used for AMR for non-technical loss reduction, DSM for peak-cut and the improvement project of distribution reliability.
Therefore, this project is recommended.

The project for improving of power factor by Automatic device or Upgrading DMS (DAS) is useful to control capacitors installed in substations and 11kV distribution feeders by Automatic device or Upgrading DMS (DAS) function which can monitor the power factor in real time and control automatic LBS for the capacitor. As general, since low efficient power facilities like motors with power factor 0.55 to 0.6, are normally connected to 11kV distribution feeders, the technical loss ratio is become high level. This project is to install new controllable capacitors in 11kV distribution feeders and to control them by Automatic device or Upgrading DMS (DAS). Though the investment for this project is relatively large, the effect to improve the technical loss is high and this project can be used for keeping load balance project etc. Hence this project is recommended.
The detail technical explanation is described in Appendix 4.1-7.

(2) Reduction of non-technical loss
Non-technical losses (Commercial loss) are mainly due to low metering efficiency, theft and pilferages.
Non-technical losses can be eliminated by improving metering efficiency, proper energy accounting and improved billing & collection efficiency which can be gradually realized by the projects as shown in Table 4-1-4-2.

Table 4-1-4-2 Recommendable method of non-technical loss reduction

Projects	Current Plan of Egypt	Effect for loss reduction	Investment	Recommendation as model project	Evaluation
Metering with AMR	Planned (for model consumers)	◎	○	Apply	Effective for meter tampering, theft of energy including theft connection and wrong application of tariff category
Metering with pre-paid system	Planned	◎	△	Not apply (because AMR will be applied to whole area.)	Effective for meter tampering and theft of energy Not effective for theft connection
Measurement for feeder and Distribution Transformer (DT)	Not Planned	○	△	Apply (Future plan)	Upgrading DMS (DAS) can measure every feeder load and DT load in addition.
Meter of outside type	Not Planned	△	△	Not apply	Effective for meter tampering and theft of energy

As for reduction of non technical losses, recommended function as model project are of AMR and Upgrading DMS (DAS). AMR system can monitor consumers load and Upgrading DMS (DAS) can monitor feeder in real time, so that a pressure for theft can be made to the consumers. Besides, Advanced Watt Hour Meter (AWHM) can monitor the theft by tampering WHM and send the alarm to the center of AMR system, so that non technical loss can be reduced.

Function of pre-paid system is similar as AMR and useful for areas without AMR to need the communication network. However, pre-paid system is not needed because AMR is planned to apply to all of areas.

As Upgrading DMS (DAS) can measure all of DT load in order to improve LV phase unbalance, consumer of theft would be found more easily. As the investment become large, the measurement of DT will be recommended to apply when AMR will be expanded to whole consumers. RTU is required to accumulate a lot of data for whole consumers for AMR, so that the RTU will be recommended to install to every DT including Kiosks and Distributors.

Meter of inside type is not easy to modify in outdoor place but the reliability such as sealing is not so good and the investment is large in comparison with the effect of loss reduction.

Clause5 Distribution reliability in Model Distribution Company

(1) Distribution system reliabilities

System reliabilities in three distribution companies are improving for the past 10 years after introducing DCC. Index of reliabilities is as follows,

This shows that power distribution reliability in Egypt is inferior to the international standard, and there could be potential to raise distribution reliability by improving electric power supply facilities and their operation.

Table 4-1-5-1 SAIFI and SAIDI of each distribution company

Electricity Distribution Company (EDC)		SAIFI[times]	SAIDI[minutes]
Alexandria EDC.	Total	2.85	120.00
	West	3.62	146.21
North Delta EDC	Total	2.93	344.30
	North Dakhalia	3.90	428.50
Cairo North EDC	Total	1.56	110.19
	Helmya	1.20	462.00

System Average Interruption Frequency Index (SAIFI) is the average number of interruptions that a customer would experience
SAIFI [times] = Total Number of customer interruption / Total Number customer served

System Average Interruption Duration Index (SAIDI) is the average outage duration for each customer served
SAIDI [minutes] = Sum of all customer interruption duration / Total Number customer served

(2) Analysis of outage

The most of distribution facilities of Alexandria and Cairo North distribution companies are underground cable. That is the main reason the power reliabilities of these two companies are relatively good. Annual outage duration hours per customer is around 100 minutes.
Compare these companies with underground facilities. Delta North Distribution Company has mainly overhead line. SAIDI of this company are more than 300 minutes around three times.

The causes of the outage of 11kV facilities are as follows,
Fault of insulations is the biggest factor of the power outage. The reason is there are many old oil cables and its dielectric break down sometimes happen and it takes many hours to restore and fix it. Cairo North Distribution Company does not have the data of the outage causes but the most of the causes oriented on cable damages by earth works by drilling.

Table 4-1-5-2 Causes of faults in 11kV Feeder (%)

Causes	Alexandria	Cairo North	Delta North
Animal	2	-	-
Tree	3	-	7
Over load	2	-	15
Insulation	37	-	20
Switches	25	-	14
Lightning Surge	5	-	-
Others or Unknown	26	Most (Earth Works by drill)	44

(3) Countermeasures for improving power qualities

The following procedures have been taken to improve continuity of supply indices in the distribution company.

- ✓ The use of insulated conductors instead of un-insulated conductors.
- ✓ Analysis of the causes in case of increased un-planned interruptions and relate it to network renovation and rehabilitation plans.
- ✓ Follow-up the implementation of maintenance programs to insure optimizations of

interruption of supply time and at the same time implementation of the maintenance procedures with high quality.

- ✓ Insure high quality of the services provided by the call centers in case of interruptions.
- ✓ Intensive field inspections and data about interruptions collected, these data are *compared with the recorded data to check for accuracy.*
- ✓ The use of automatic restoration devices for overhead lines with high interruption rates, this system enable quick restoration for minor faults which result in reducing interruption rates also they help in locating the place of major fault resulting in reducing restoration time.

Setting annual plan for the rehabilitation and extension of system components in order to meet the growth of demand and reduce interruption rates.
In addition, introduction of Upgrading DMS (DAS), which can reduce outage durations caused by fault and maintenance work, can improve the power qualities.

Clause6 Current Tariff structure

Following is an abstract of Tariff System of Egypt taken from EEHC annual report.

Specification			***Pt****	***US Cent***	**Case of *TEPCO* US Cent***
Medium Voltage 500KW+	Demand Charge(/kW)		9.5	1.7	1638
	Energy Charge(/kWh)		21.4	3.9	13
Low Voltage Commercial	Energy Charge(/kWh)	0-100	24	4.3	16
		101-250	36	6.5	21
		252-600	46	8.3	22
		601-1000	58	10.5	22
		1000-	60	10.8	22
Low Voltage Residential	Energy Charge(/kWh)	0-50	5	0.9	13
		51-200	11	2.0	16
		201-350	16	2.9	21
		351-650	24	4.3	22
		651-1000	39	7.1	22
		1000-	48	8.7	22
Public Lighting	Energy Charge(/kWh)		41.2	7.5	20

** 1US Cent=5.5PT, 1USD=100JPY*
*** TEPCO's tariff is shown only as a reference for comparison purposes hence it is not accurate.*

From the tariff table, following characteristics are notable:

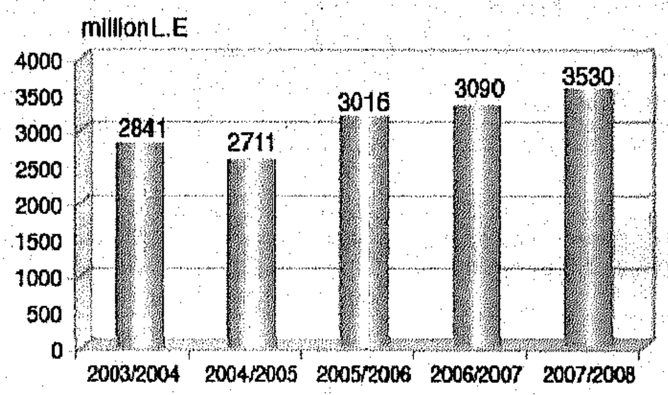
(1) Energy Tariff is generally very cheap, about 1/4 to 1/2 of that of TEPCO. Considering that the current average generation cost of thermal power unit comes around 4 US Cents to 8 US Cents, it is obvious that this tariff system does not enable independent and sustainable management of Power Company.

(2) Step-Up energy tariff system is applied. TEPCO has 3 steps while EEHC has 5 for commercial and 6 for residential. This suggests that EEHC intends to support the people in subsistence level by offering low tariffs. TEPCO's tariff is based on the same concept.

(3) Step-Up energy tariff also suggests that EEHC intends to apply deterrence to excessive consumption, or to encourage energy conservation, which is the same for TEPCO.

(4) Public Lighting is rather high, Since the public lighting fee is likely to be paid by government body, this high tariff could be the similar intension as the subsidy

(5) No consideration for Time of Use included. Suggesting that EEHC is not yet exercising peak shifting by setting different tariffs to peak/off-peak hours.



(Source: EEHC annual report)

Fig. 4-1-6-1 Subsidy provided to EEHC

According to EEHC annual report, electricity business is heavily subsidized as in the Fig.4-1-6-1 which is assumed to be the purpose of compensating the excessive cheap tariff levels. In order to promote Energy Conservation and Demand Side Management, it could be recommendable to abolish such subsidy and increase the tariff level so that the power business can be independent and higher tariff can deter excessive consumption. These Tariff amendment suggestions are further discussed in Section 4 of this Chapter.