No. 2

JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)

NATIONAL ELECTRIC POWER CO. (NEPCO)
THE HASHEMITE KINGDOM OF JORDAN

THE STUDY ON ELECTRIC POWER LOSS REDUCTION OF TRANSMISSION AND DISTRIBUTION NETWORKS IN THE HASHEMITE KINGDOM OF JORDAN

FINAL REPORT

MAY 1997

TOKYO ELECTRIC POWER SERVICES CO., LTD.

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PREFACE

In response to a request from the Government of the Hashemite Kingdom of Jordan, the Government of Japan decided to conduct the Master Plan Study on Electric Power Loss Reduction of Transmission and Distribution Networks in the Hashemite Kingdom of Jordan and entrusted the study to Japan International Cooperation Agency (JICA).

JICA sent a study team led by Mr. Kunio Okawara of Tokyo Electric Power Services Co., Ltd. to the Hashemite Kingdom of Jordan four times from February 1996 to March 1997.

The team held discussions with the officials concerned of the Government of the Hashemite Kingdom of Jordan, and conducted related field surveys. After returning to Japan, the team conducted further studies and compiled the final results in this report.

I hope this report will contribute to the promotion of the plan and to enhancement of friendly relations between our two countries.

I wish to express my sincere appreciation to the officials concerned of the Hashemite Kingdom of Jordan for their close cooperation throughout the study.

May 1997

Kimio Fujita

Kimio FUJITA
President
Japan International Cooperation Agency

May 1997

Mr. Kimio FUJITA
President
Japan International Cooperation Agency
Tokyo Japan

Dear Mr. FUJITA,

Letter of Transmittal

We are pleased to submit you the report on the Study on Electric Power Loss Reduction of Transmission and Distribution Networks in the Hashemite Kingdom of Jordan. The report contains the advice and suggestions of the authorities concerned of the Government of Japan and your Agency as well as the formation of above mentioned study. Also included are comments made by the Ministry of Planning and respective electric power companies in the Hashemite kingdom of Jordan during technical discussions on the draft report which were held in Amman and Irbid.

This report presents a 10-year master plan for electric power loss reduction in the transmission and distribution networks in the Hashemite Kingdom of Jordan. A consecutive implementation of feasibility study is required for the implementation of this plan. We trust that realization of the plan will much contribute to reduce power loss.

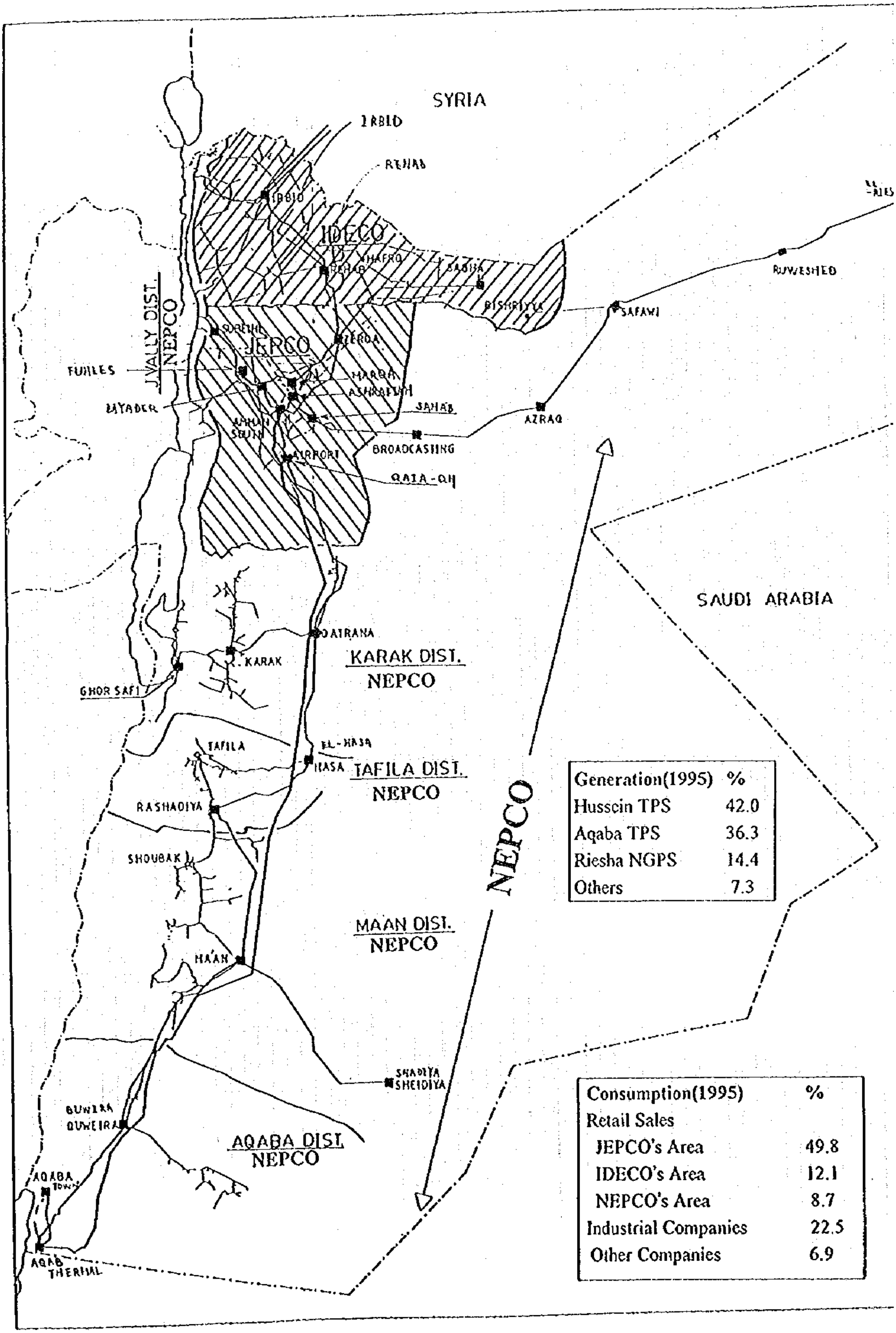
In view of the urgency to improve energy efficiency by power loss reduction in the transmission and distribution networks and of the need for socio-economic development of Jordan as a whole, we recommend that the Government of Jordan implement this plan as a top priority.

We wish to take this opportunity to express our sincere gratitude to your Agency, the Ministry of Foreign Affairs, and Ministry of International Trade and Industry. We also wish to express our deep gratitude to the Ministry of Planning and other organizations concerned of the Hashemite Kingdom of Jordan for the close cooperation and assistance extended to us during our investigations and study.

Very truly yours,

K. Okawara

Kunio OKAWARA
Team Leader
The Study on Electric Power Loss Reduction of
Transmission and Distribution Networks in
the Hashemite Kingdom of Jordan



Generation(1995)	%
Hussein TPS	42.0
Aqaba TPS	36.3
Riesha NGPS	14.4
Others	7.3

Consumption(1995)	%
Retail Sales	
JEPCO's Area	49.8
IDECO's Area	12.1
NEPCO's Area	8.7
Industrial Companies	22.5
Other Companies	6.9

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OUTLINE OF THE FORMULATION OF TRANSMISSION AND DISTRIBUTION POWER LOSS REDUCTION PLAN

1 Flow of the Study

(1) Present situations of transmission and distribution loss throughout Jordan

The transmission loss rate and distribution loss rate in 1995 was 2.0 % and 7.4% respectively and the total network loss was 9.4%, according to the annual report of NEPCO. The measurement and calculation of representative LV(Low Voltage) feeders were implemented under this study for the purpose of sorting out the distribution loss into the LV loss and the MV(Medium Voltage) loss. The result showed that MV loss rate and LV loss rate were as 2.2% and 5.2% respectively. These facts indicate that a large portion of the transmission and distribution loss as the objective of reduction is taking place in the distribution systems especially in the LV distribution systems.

(2) The systems chosen as objective of the studied

The JICA Study Team narrowed the study down to the power loss reduction in the LV and MV distribution systems and proposed as a master plan, basing itself on the assumption that any power loss reduction countermeasure should bring about justifiable economic benefits.

(3) The approach to the optimum power loss reduction plan

Since there are nearly 20,000 LV feeders in Jordan, it is entirely impossible to study all of the individual feeders. A sample study method was selected, therefore, for estimating the potential of loss reduction in entire power system.

Firstly, 81 feeders from the LV system and 14 feeders from the MV system were selected as "Sample-1" system. Then they were minutely analyzed by means of software provided by the JICA Study Team. The relation between the feeder current, and cost of power loss reduction were converted into a mathematical model based on the result of the above analysis. Secondly, this mathematical model had to be applied to the entire power systems of Jordan. Two percent (2%) of the entire distribution substations in Jordan was selected by a random sampling method. The LV feeders which were connected to those substations, and all feeders in the 33 kV system were chosen as sample-2". Then the potential of feasible countermeasures (wherein the benefit exceeds the cost) has been estimated regarding the entire relevant systems, based on the mathematical models.

(4) The priority order of the power loss reduction countermeasures

The three kinds of loss reduction countermeasures are implemented according to the priority order as shown below:

1) The reduction of the unbalanced current in the LV feeder is implemented as the top priority, as it is effective in the loss reduction and does not require any investment.

2) The power factor improvement in the system by installation of capacitors brings about high investment efficiency (high B/C value). The installation is promoted within the limit of not causing over-compensation at the time of light load.

3) As the above two methods will not yield big enough volume of loss reduction, the plans of new line construction should be considered in addition to these two methods. Such plans should be chosen, in principle, from those with bigger value of B/C.

(5) Target fiscal years and annual allocation of the power loss reduction plans

The target year was set to start from 1999 and to end in 2008, allowing two years of preparatory period after 1997 when this study will come to an end.
The work execution period was formulated based on the load conditions in 2008 and annually allocated along with the priority order of Item (4) above and taking into account the scale of benefits, averaging of work volumes and other conditions.

(6) Setting of alternative countermeasure plans

With regard to the potential of the overall power systems in 2008 obtained in Item (3) above, 94.1 MW of power loss is estimated to be reduced with the net cost of JD 6357 million, excluding price escalation and so forth. The alternative plans A, B, C, D and E were formulated on the basis of this potential.

2. Outline of the Plan

The outline of the five alternative plans are as listed below:

Alternative plan		A	B	C	D	E
Capacitor installation	Capacity(MVA)	191	191	191	191	191
LV new line construction	No. of feeder	1,533	1,989	2,599	3,881	6,248
MV new line construction	No. of feeder	0	7	15	22	40
Total cost(1000 JD) for 10 years		20,000	30,000	40,000	50,000	63,570
Power loss reduction(MW) in 2009Y		48.0	61.0	73.5	84.8	99.0
Energy loss reduction rate to generation(%)		1.8	2.3	2.8	3.2	3.8
Estimated network loss rate to generation(%)	Without project 11.0%	9.2	8.7	8.2	7.8	7.2

Meanwhile, the estimated network loss rate of 7.2 % of the plan E is deemed to be the virtually optimum power loss rate.

3. Economic Evaluation and Financial Analysis

According to the results of economic and financial analysis, all the Alternative works are feasible both in the economic and financial viewpoints.

Evaluation values of five alternative plans are listed below.

Summary of Results of Economic and Financial Analyses

Alternative Plan		A	B	C	D	E
Economic Evaluation	EIRR	24.91	20.08	17.80	16.45	15.04
	B/C	1.99	1.63	1.45	1.34	1.23
	B-C (1000JD)	11,155	10,687	10,195	9,604	8,142
Financial Evaluation	FIRR	15.73	12.80	11.36	10.33	9.27
	Net surplus (1000JD)	98,820	117,271	134,097	145,068	154,896

4. Recommendations

The alternative plans proposed in this Study are highly significant in eliminating the waste of valuable natural resources and reducing environmental pollution from a global point of view. Also from economical and financial point of view, these plans are so excellent as to contribute significantly in improving the economical structure of the nation and financial situation of the respective companies.

Out of the five alternative plans, the Plan E is recommended to be adopted by Jordan power sector, since this plan certainly makes it possible to realize an optimum power loss rate in Jordan, and will bring the largest net benefit among the five plans.

The following items should be considered for execution of loss reduction project.

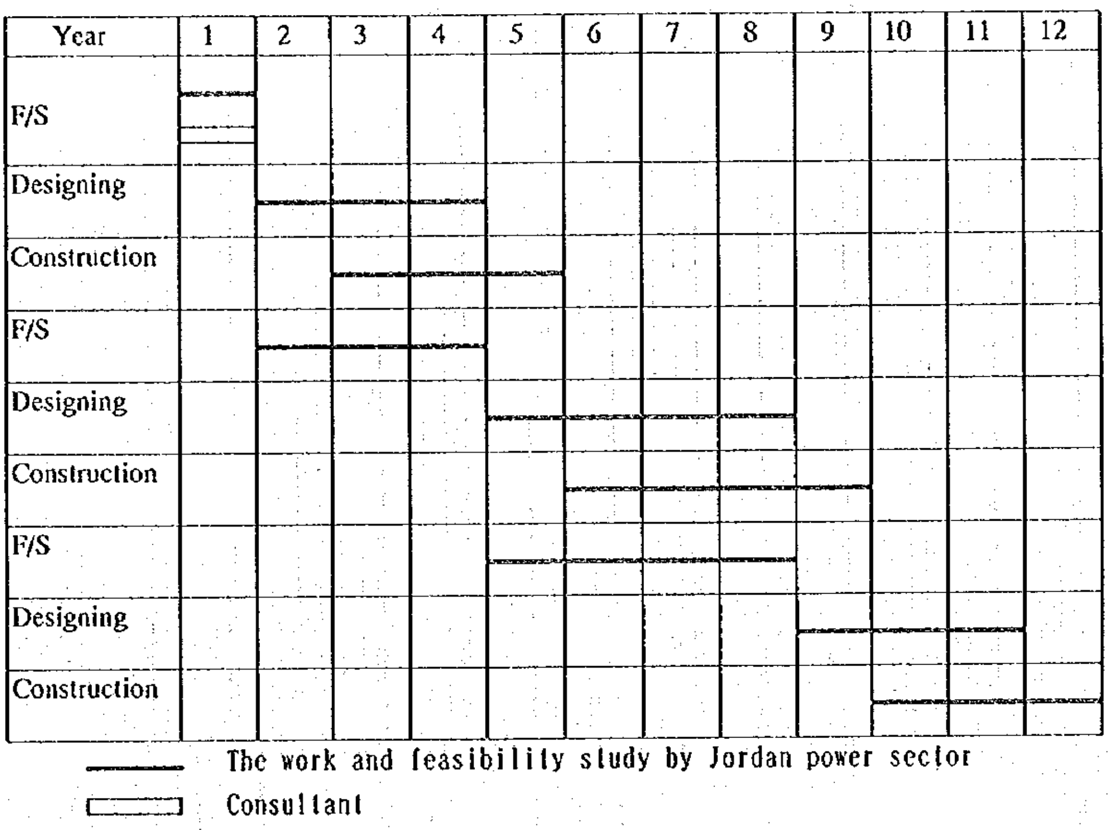
(1) The improvement of the three phase unbalanced current is recommended to be executed at the very beginning, regardless of financing from outside, as it does not require any investment.

(2) In the second place, the improvement of power factor by installing capacitors in the LV system is recommended to be executed by self-financing or local bank loan, because it is executable with a low investment of less than one million JD.

(3) The quantity of loss reduction by improvement of the three-phase unbalance current and improvement of power factor is not sufficient. The loss rate in 2009 will certainly increase by the load growth, if no additional countermeasures are adopted. New line construction countermeasure is recommended to be executed, because it is indispensable to realize loss reduction throughout Jordan.

A large amount of investment and a large volume of work for feasibility study are required for execution of this countermeasure. Besides, efforts to obtain loans from foreign countries may also be required. The outline of schedule of feasibility study and construction work is proposed as the table shown below.

Outline of Schedule for the Program



(4) For smooth and efficient execution of loss reduction program, development of small capacity LV capacitor and study for high conductance line such as multi circuit line, big size conductor line or multi conductor line are recommended.

CHAPTER 1

INTRODUCTION

CHAPTER 1 INTRODUCTION

1.1 Background of the Study

In the Hashemite Kingdom of Jordan, the majority of power generation and transmission is undertaken by the National Electric Power Co. (hereinafter referred to as "NEPCO") [which was renamed and reorganized from the Jordan Electricity Authority (JEA) on September 1, 1996], and power distribution in the areas other than the supply areas of NEPCO are undertaken by two private electric power companies [Jordanian Electric Power Co. (hereinafter referred to as "JEPCO") and Irbid District Electricity Co. (hereinafter referred to as "IDECO"). Both of the private power companies purchase electric power from NEPCO and supply it to their respective consumers. The supply areas of JEPCO are Amman, the capital city, Zarqa and Balqa Governorates (districts), while those of IDECO are both the Irbid and Mafraq Governorates (districts).

The total installed capacity of power sources in Jordan as of the end of 1995, is 1,167.3 MW, of which 1,048.8 MW or roughly 90% is shared by NEPCO. This is followed by 112.5 MW of non-utility and municipality, and 6 MW of IDECO. In view of the power source configurations, 60% is occupied by oil-fired thermal (steam) power source, followed by 31% of gas turbine power source and 9% of diesel power source. The share of hydro-electric power source does not reach even 1% of the total. Moreover, a very small scale wind power generator (300 kVA) is also in operation.

The peak load recorded throughout the country in 1995 was 894 MW (The peak load in the NEPCO's power system increased by 8.6% to 862 MW from the previous year).

The power consumption has consistently shown steady increase, and marked 4,778 GWh in 1995 roughly doubling the figure in 1986, at a high annual average growth of 8.3% during these ten years' period, although the increase rate of electric power demand in the country slowed down to even as low as 1.7% from the previous year reflecting mainly the effect of the Gulf War in 1991.

The ten years' average rate of transmission and distribution loss in Jordan between 1996 and 1995 has been 9.4% . When viewed in blocks of five years, the average loss was 8.8% during the first five years with the help of a one-time record low of 7% level. However, the average loss increased to 10.5% during the latter five years, reflecting the demand increase.

When the present transmission and distribution loss rate of 10% is compared with that of other countries, this rate is found higher than that of some countries but also lower than that of other countries as well. If the level of the power loss is classified into three groups, that of Jordan can be said to belong the intermediate group. It cannot necessarily be said that the transmission and distribution loss in Jordan is remarkably high, considering that the density of power demand in Jordan is roughly one-fiftieth (1/50) of that in Japan. However, it may rather be said that a more serious problem lies in the fact that the rate of transmission and distribution loss is recorded more or less 10 % every year since 1989. Which is a constant increase by nearly three point from the past good result of 7% level before 1989. This trend of increase is assumed to prevail in the future as well.

The reduction of power loss is a very important task which leads both to the future improvement of the efficiency of energy consumption, and saving of construction cost of power plants and also development of power sources in Jordan. The Government of Jordan has made an official request for the implementation of this Study from necessity of clarifying the causes of such power losses, receiving recommendation of the method of its improvement, and acquiring relevant technical knowledge and know-how of Japan through the training of the staff of power utilities in Jordan.

In response to this request, the Government of Japan, through the Japan International Cooperation Agency (JICA), has determined the implementation plan of this Project, after dispatching a preliminary study team in July 1995, discussing with relevant local authorities regarding implementation of this project, carrying out field survey and collect data and information.

On August 5, 1995, the JICA Preliminary Study Team and JEA reached an agreement on "the Minutes of the Meeting (M/M) pertaining to Reduction of Electric Power Losses in Jordan".

Further in November 1995, JICA dispached a pre-study team to the site to confirm the terms of reference, the scope of work and the schedule of main Study and to review the methodology of the Study through discussions with the local authorities concerned. On November 26, 1995 the JICA Pre-Study Team and JEA reached an agreement on "the Scope of Works (S/W) and Minutes of the Meeting (M/M) concerning the Reduction of Electric Power Losses in the Transmission and Distribution Networks in Jordan".

The Government of Japan has decided, basing on these S/W and M/M, the full-scale implementation of this plan and entrusted this study work to the JICA.

1.2 Contents of the Study

1.2.1 Objectives of the Study

The objectives of this Study are:

1) to provide countermeasures and recommendations for reducing the power loss in the transmission and distribution network down to a level reasonably attainable for the purpose of improving the energy efficiency of Jordan and sparing electric power equipment in the long run.

2) to carry out the transfer of technology to the Jordanian counterparts concerning the formulation of transmission and distribution power loss reduction plan during the scheduled period of this study.

1.2.2 Scope of the Study

The areas relevant to this study are the electric power supply areas of the NEPCO, JEPCO and IDECO. The power losses to be studied are the following technical power losses, excluding the auxiliary consumption in the power stations:

(1) Power loss in transmission line (132 kV)
(2) Power loss in substations (132/33 kV, 33/11 , 6.6 kV; 33, 11, 6.6/0.415 kV)
(3) Power loss in distribution system (including 33, 11, 6.6 and 0.415 kV lines)

The kind of this study are those that have been carried out to reduce the power losses in the transmission and distribution networks in the relevant study areas to a reasonably attainable level within a target period of the coming ten years.

1.2.3 Items of the Study

The contents of the study are those as described in the Scope of Work and featured by formulation of a ten-year plan for reducing the power losses in the transmission and distribution networks of the NEPCO, JEPCO and IDECO.

Seminars have been held three times during the field investigation period in Jordan for the porpoise of transferring technology for a wider range of the senior executives of Jordan to recognize the methodology of this study and the importance of executing this project.

In response to the request of the engineers of NEPCO scheduled to visit Japan to follow up the power loss reduction plan, the items deemed important for technology transfer to local counterpart have further been incorporated into the study items.

The study items are as presented below:

(a) Collection, analysis and study of data and information
(b) Site survey
(c) Investigation of the situations of electric power industry in Jordan
(d) Analysis of the present situations of power system
(e) Execution of power measurement work
(f) Clarification of power losses and analysis of the causes thereof
(g) Estimation of transmission and distribution costs and equivalent cost of power losses
(h) Development of power loss reduction model
(i) Formulation of optimum power loss reduction plan
(j) Economic and financial analysis
(k) Study of fund-raising method
(l) Technology transfer

1.3 Activities of the Study Team and Relevant Personnel in Jordan

1.3.1 Activities of the Study Team in Jordan

In February 1996 through to March 1997, the JICA Study Team has executed the following activities:

The first field investigation: February 24, 1996 ~ March 27, 1996

- Explanation of the Inception Report
- Investigation of the situations of electric power industry
- Collection of basic data and information for estimating electric power supply
- Study of the method of clarifying the causes of power losses
- Preparation of the measurement work schedule

- Study of the specifications, quantity and procurement methods of equipment and materials to be procured

The second field investigation : June 17, 1996 ~ October 15, 1996

- Meeting prior to the measurement work
- Execution of the measurement work
- Clarification of power loss
- Analysis of the causes of power loss
- Estimation of the cost for implementing countermeasures
- Calculation of long run marginal cost of power generation
- Estimation of the benefit of loss reduction countermeasures
- Formulation of the benefit and cost model
- Development of loss reduction model
- Prediction of power loss rate
- Holding of seminars

The third field investigation : November 22, 1996 ~ December 20, 1996

- Explanation and discussion on the Interim Report
- Review of the reasonable rate of power loss
- Formulation of optimum power loss reduction plan
- Economic and financial analysis
- Method of fund procurement
- Holding of seminar

The fourth field investigation : March 3, 1997 ~ March 17, 1997

- Explanation and discussion on the Draft Final Report
- Preparation of the Minutes of Meeting
- Holding of seminar

1.3.2 List of Participants

The members of NEPCO, JEPCO, and IDECO and the JICA Study Team involved in this study are as listed below:

Ministry of Planning

Mr. SALEM O. GHAWI	Assistant Secretary General
Mr. NAEL J.H. AL HAJAJ Ph. D	Head Officer- Bilateral Division

NEPCO

Mr. M. S. ARAFEH	Director General
Mr. MOHAMAD AZZAM	Chief Engineer
	Technical & Corporate Planning
Mr. NIAZI MUSA	Technical Planning Manager
Mr. MAJED QAWASEMEH	Chief Engineer
	Distribution Division
* Mr. ALI. Y. AL-ZUBI	Load Research & Management Section Head
* Mr. FALAH ABABNAH	Electric Planning Engineer
* Mrs. REEM HAMDAN	Distribution Department Electrical Engineer
* Mrs. SUHA QOUSSOUS	Electric Planning Engineer
* Mr. KHALIL BADER	Electric Planning Engineer
Mr. ABV ZEID NABIL	National Control Center

JEPCO

Mr. MARWAN BUSHNAQ	Director General
Mr. JUDEH	Assistant Director General
Mr. REYAD KALIDY	Technical Department Manager
* Mr. ANWAR ELLAYAN	Electric Planning Engineer

IDECO

Mr. ABDEL RA'UF M. SHEIKH	Director General
Mr. S. OJAILAT	Planning Manager
Mr. AHMAD THAINAT	Area Manager
Mr. ABDULIAH JABER	Construction Manager
* Mr. JEHAD ROUSAN	Head of Planning Section
Mr. MAZEN MARJI	Head of Design Section
Mr. WALEID BATAYNEH	Head of Studies
Mr. ALI SHAMALI	Head of Meters

The marks * are shown Jordanian counterparts.

JICA Study Team

Mr. KUNIO OKAWARA	Team leader/Power Loss Reduction Plan
Mr. TAKAO NAKAMURA	Optimization Model
Mr. KATSUHIRO MUKAI	Transmission and Distribution Equipment
Mr. TATSUHIKO MURAKAMI	Power Measuring
Mr. YOSHIAKI ISHIZUKA	Economic and Financial Analysis

JICA Head Office

Mr. AKIHIKO HOSHINO	Administrator

1.4 Grant of Equipment and Materials

The Study Team procured the load analyzers and clamp CTs during the Second Site Survey in Jordan, and used these instruments for power measurement. At the same time, the Study Team purchased personal computers and used them effectively for calculation of power losses, technology transfer and other purposes. Meanwhile, all the measurement instruments and computers procured then were granted by JICA to the Jordanian side when the Forth field investigation ended.

1.5 Preparation of Software

The Study Team used the power loss calculation software and the analysis software developed by Tokyo Electric Power Services Co., Ltd. (TEPSCO). This enables easy calculation for analyzing the power loss and preparing the power loss reduction countermeasures.
The Team granted the end-user's licence of this software to the Jordanian parties so that the local counterparts can use it also after completion of this Study.

1.6 Training of the Counterparts

In order for the NEPCO counterparts to follow up the power loss reduction plan during this study period, the training of the counterparts was carried out in Japan as follows, mainly letting them participate in the joint work for preparation of the Interim Report:

Participants : Mr. Ali Yousif Moh'd Al-Zubi
Mr. Falah Qasem Ahmad Ababnah
Period : October 20 ~ November 17, 1996 (29 days)

1.7 Seminars

The Study Team held three times of seminars in Jordan for the purpose of promoting technology transfer to the relevant parties during this study period as follows:

(1) The first seminar
The first seminar was held at the NEPCO's head office on August 20th, 1996 and at the IDECO's head office on August 21, 1996.

Mainly for the purpose of explaining the outline of this study, electric power loss analysis model and economic evaluation as well as for introducing the outline of the power facilities of the Tokyo Electric Power Co., Inc. (TEPCO) and actual examples of the trend of power loss reduction of the TEPCO.

(2) The second seminar
The second seminar was held at the NEPCO's head office on December 14, 1996.
The main theme of the seminar was the outline of this study and the contents of the Interim Report as well as a case study of economic and financial evaluation.

(3) The third seminar
The third seminar was held at the NEPCO's head office on March 12, 1997.
The main theme of the seminar was the outline of this study and the contents of the Draft Final Report.

CHAPTER 2

SOCIO-ECONOMIC SCENES OF JORDAN

CHAPTER 2 SOCIO-ECONOMIC SCENES OF JORDAN

2.1 General

2.1.1 Geographical Features and Location of Study Area

The official name of the nation is the Hashemite Kingdom of Jordan in English (hereinafter referred to as "Jordan"). The capital city of Jordan is Amman. The area of whole nation of Jordan is 89,342 km^2 including the desert of about 80 %, the Jordan valley area and the its Eastern bank area bounded by the Jordan river including the Dead Sea of the area of 557 km^2. There are 2 mountainous ranges from about 600 m to 1,000 m high laying down along the Jordan river. The area between these 2 mountainous ranges form the greatest rift valley in the world named the Jordan valley which elevation range from 200 m to 340 m below the sea level. The capital city Amman is located in the eastern hilly land, elevated ranging from about 700 m to 1,100 m above sea level. The mountainous area continues to the Eastern desert located in its hinterland. Jordan has only one sea port of Aqaba (al Aqaba).

2.1.2 Governmental Organization and Administration Situation

Under His Majesty the King with the Vice of King, there are the Royal Court, the Council for the King, the Parliament House, and the Cabinet of the Government. The Cabinet of the Government headed by the Prime Minister organizes several ministries. As of 1994, there are 26 ministries as shown in Appendix 2.1. A state owned electric enterprise named as the National Electric Power Company (NEPCO) (former called as the Jordan Electricity Authority (JEA) is belonging to the Ministry of Energy and Mineral Resources.

Jordan has 12 governorates as Amman, Zarqa, Balqa, Madaba, Mafraq, Irbid, Ajlun, Jarash, Karak, Tafiela, Ma'an, and Aqaba. Under these Governorates, there are 20 Districts which have 36 Sub-districts. The name of administrative unit, Nahias (52 Nahias in total) are belonging to these Sub-districts. Under these Nahias, there are 1,241 smallest administrative units called as the city, the town and the villages.

2.1.3 Fiscal Year

The Government of Jordan is using a fiscal year ending 31st of December. Therefore, years indicated in this study are from 1st of January in a calendar year to 31st of December in the same calendar year unless otherwise mentioned.

2.2 Population and Labor Force

2.2.1 Population

Jordan has conducted a Population and Housing Census in 1994. The report is not finalized yet as of August 1996, but there is a temporary report on it. According to statistical data and information from the Department of Statistics on that Census, the total population of Jordan was 4,134.5 thousand with its population density of 46 persons per km^2 as summarized below.

Table 2.2-1 Area and Population by Governorate

As of 1994

Governorate	Area (km^2)	Population (persons)	Households (HHs) Nos. of HH (households)	Households (HHs) HHs' size (persons/HH)	Population density (persons/km^2)
Amman	8,231	1,574,809	279,701	5.63	191
Balqa	1,076	280,537	43,618	6.43	261
Zarqa	4,080	640,094	100,713	6.36	157
Mabada	2,008	103,183	16,400	6.29	51
Irbid	1,621	747,179	118,472	6.31	461
Mafraq	26,435	178,856	24,974	7.16	7
Ajlun	412	94,548	14,853	6.37	229
Jarash	402	123,190	18,721	6.58	306
Karak	3,217	169,770	26,333	6.45	53
Tafiela	2,114	62,783	9,585	6.55	30
Ma'an	33,163	79,670	12,149	6.56	2
Aqaba	6,583	79,839	13,740	5.81	12
Total	89,342	4,134,458	679,259	6.09	46

Source : Statistical Year Book 1994 and information by Department of Statistics.

Total number of households were around 679,000 and the average family size was 6.1 persons per household as shown in the above Table. Detail is shown in Appendix 2.2. Here, the population in 1980 was around 2,215 thousand, so a population growth rate was quite high as 4.49 % per annum as shown in Appendix 2.3.

2.2.2 Labor Force

Present labor force was amounted as 859 thousand persons with around 51 % of share rate engaged in social and administration services in terms of economic activities. Among the other share rates in productive activities, the highest one was trading activities as 15 % to the total labor force, the second one : mining and manufacturing as 11 %, the third one : construction as 7 %.

The share rate for the agricultural activities was as low as only 6 % to the total labor force, the 5th one, which seems to be reflected a nation's geographical characteristics. About 80 % of the nation's land area is the desert as mentioned in previous sub-clause, and the arable land is only in Jordan valley area.

A situation of labor force in Jordan by major economic activities and by occupation groups is shown in Appendix 2.4.

2.3 General Economic Features

2.3.1 Gross Regional Domestic Products

Gross domestic product (GDP) in Jordan is shown in Appendix 2.5 by current price level, and 1985 constant price level for last 5 years since 1989, and they are summarized in Table 2.3-1

Table 2.3-1 Summary of GDP

As of 1993 (Million JDs.)

No.	Economic activity	At current prices GDP	Share rate (%)	Annual growth rate(%)	At 1985 constant prices GDP	Share rate (%)	Annual growth rate(%)
A	Industry of origin						
1	Agriculture, hunting, forestry and fishery	193.3	5.07%	8.44%	154.3	6.46%	5.53%
2	Mining and quarrying	106.9	2.80%	-8.80%	47.4	1.99%	-11.54%
3	Manufacturing	427.3	11.21%	13.81%	261.9	10.97%	6.39%
4	Electricity and water	78.7	2.06%	10.55%	67.1	2.81%	-0.84%
5	Construction	283.7	7.44%	29.30%	174.1	7.29%	19.25%
6	Wholesale and retail trade, restaurants and hotels	317.2	8.32%	15.10%	82.4	3.45%	1.68%
7	Transport, storage and communications	487.1	12.78%	7.92%	289.9	12.14%	0.88%
8	Finance, insurance, real estate and business services	622.7	16.34%	10.76%	440.9	18.47%	4.92%
9	Community, social and personal services	88.8	2.33%	18.13%	50.6	2.12%	14.15%
10	Non monetary terms	675.3	17.72%	11.13%	486.4	20.37%	5.72%
	Total	3,281.0	86.08%	10.95%	2,055.0	86.08%	4.48%
-	Less : Imputed bank service charge	-66.4	-1.74%	4.68%	-41.6	-1.74%	-1.45%
	GDP at factor cost	3,214.6	84.34%	11.10%	2,013.4	84.34%	4.62%
+	Indirect taxes less subsidies	596.8	15.66%	22.79%	373.8	15.66%	15.63%
	GDP at producers prices	3,811.4	100.00%	12.59%	2,387.2	100.00%	6.02%

Source:Statistical Yearbook 1994, Department of Statistics of the Hashemite Kingdom of Jordan, October 1995.

According to the above mentioned Table, an economic activity group of finance, insurance, real estate and business services is the highest contribution factor to the GDP as 16.3 % in share rate in current price level and 18.5 % in 1985 constant price level as of 1993, while the second contribution factor is the group of transport, storage and communication as 12.8 % in current price level and 12.1 % in 1985 constant price level. The manufacturing group is the 3rd one, and the construction group is the 4th one both in current price level and in 1985 constant price level.

2.3.2 Government Finance

In 1990 and 1994, the Government finances of Jordan amounted to JDs. 938 million and JDs. 2,099 million in revenue and JDs. 1,033 million and JDs. 1,437 million in expenditure with their rise rates of 22.30 % and 8.61 % per annum respectively as shown in Appendix 2.6, and summarized in Table 2.3-2. Comparing with the growth rate of expenditure, that of revenue was quite high for these 4 years since 1990. A factor for this high rise in revenue was indirect tax revenues, especially the fees for licenses according to the said Appendix 2.6.

Table 2.3-2 Government Finance

(Million JDs)

Revenue/expenditure	1990	1994	Average annual growth rate (%)
Revenue	938.2	2,098.7	22.30
Expenditure	1,032.6	1,437.1	8.61
Surplus/deficit	-94.4	661.6	-

Source : Statistical Year Book 1994, Department of Statistics.

2.3.3 External Trade and International Balance of Payment

In 1967 and 1994, the trading amount of Jordan amounted to JDs. 11,327 thousand and JDs. 995,181 thousand in export and JDs. 55,048 thousand and JDs. 2,362,583 thousand in import as shown in Appendix 2.7. In Jordan, the balance of external trading was constantly minus side since 1967. It means that the amount of import was larger than that of export.

The capital account was decreased during 4 years since 1991 which shows the highest amount of it. So that the overall balance was fluctuated between credit side and debit side during these 5 years from 1990 as shown in Appendix 2.8. A summary of the international balance of payment in cash basis is shown in Table 2.3-3 below.

Table 2.3-3 International Balance of Payment in Cash Basis

(Million JDs)

Item of	1990		1991		1992		1993		1994	
account	Credit	Debit	Credit	Debit	Credit	Debit	Credit	Debit	Credit	Debit
Net current Acc.		148.2		269.0		520.6		325.0		176.2
Net capital Acc.	353.9		733.2		483.7		106.6		204.6	
Overall balance	205.7		464.2			36.9		218.4	28.4	

Source : Monthly Statistical Bulletin Vol.31 No.12, Central Bank of Jordan.

The total exports and imports by broad economic category is shown in Appendix 2.9, and summarized as shown in the following Table 2.3-4.

Among the exports, chemicals were the highest amount exported as over 26 % in every years since 1990, and the second ones were crude materials, inedible except fuels as around 21 % in the same period. And the third ones were food and live animals as around 9 % or more during the same period also. The main export commodities were phosphates, potash belonging to the crude materials and, medicaments and fertilizers belonging to the chemicals which they indicated their share of around 9 % respectively to the total export amount as of 1994 as shown in Appendix 2.9.

Table 2.3-4 Exports and Imports in Jordan

(Million JDs)

Exports and imports	1990	1991	1992	1993	1994	Annual growth rate (%)
Exports	706	768	830	864	994	8.93
Imports	1,726	1,712	2,215	2,456	2,364	8.18
Balance	-1,020	-944	-1,385	-1,592	-1,370	-

Source : Monthly Statistical Bulletin Vol.31 No.12, Central Bank of Jordan

On the other hand, machinery and transport equipment were the highest imported amount as 25 % or more to the total imported amount as of 1994. The second ones were manufactured goods with sharing as around 18 % in 1994. Furthermore, the third ones were the food and live animals as 17 % or more as the share rate to the total import amount in 1994. The main import commodities were electrical and non-electrical machinery, and transport equipment and spare-parts belonging to the machinery and transport equipment which they indicated their share of around 15 % and 10 % respectively to the total import amount as of 1994 as shown in Appendix 2.9.

2.4 Industrial Perspective

2.4.1 Socio Economic Features

As mentioned in aforementioned clauses, 50 % or more of people engaged as workers and they were working for social and administration services in Jordan, and Jordan has GDP with a high share rate of producers as around 19 %, finance and insurance, real estate and business services as 18 %, transport, storage and communications as 12 % and manufacturing as 11 % in terms of industry of origin as of 1993 at 1985 constant price as shown in Appendix 2.5.

At the viewpoint of the international trading, chemicals representing as medicaments and fertilizers is the highest exported amount as 26 % or more, and crude materials representing as phosphates and potash is the second exported amount as 21 %. Both of these two industrial categories have shared almost half to the total export amount.

On the other hand, both of two industrial categories as machinery and transport equipment and manufactured goods have shared around 40 % or more to the total import amount. And, during these 27 years since 1967, the import amount exceeds the export amount with no exception as mentioned in previous sub-clause.

Furthermore, the arable area in Jordan is only in Jordan valley. Considering these situation, almost all of the people in Jordan depend on mining, quarrying and manufacturing industries for their economic activities at the present.

2.4.2 Industrial Production

As shown in Appendix 2.10, phosphate and potash belonging to the mining and quarrying were produced at 4,461 thousand tons and 1,364 thousand tons in 1991, and 4,984 thousand tons and 1,780 thousand tons in 1995 with annual growth rates of 2.81 % and 6.88 % respectively.

In manufacturing, textiles were produced at 1,084 thousand yards in 1991 and 1,745 thousand yards in 1995 showing the highest growth rate of 12.64 %. Among the other manufacturing activities, petroleum products show a high production comparing with the others as 2,307 thousand tons in 1991 and 3,101 thousand tons in 1995 with annual growth rate of 7.67 %. Cement has also shown rather high production as 2,752 thousand tons in 1991 and 3,162 thousand tons in 1995 with growth rate of 3.45 % per annum. Fertilizers show too a high growth rate of 4.90 % per annum from 602 thousand tons in 1991 and 729 thousand tons in 1995.

2.4.3 Agricultural Production

Arable area in Jordan is only the Jordan valley as mentioned in previous clause. Using this area, people cultivate several kind of plants as field crops, vegetables, and fruits. During past 6 years, however, their production were drastically decreasing, especially field crops included wheat as they use as main cereal food material.

Production volume of wheat, barley, tobacco and lentils were 78.8 thousand tons, 44.9 thousand tons, 3.7 thousand tons and 6.5 thousand tons in 1988 and, 46.9 thousand tons, 27.4 thousand tons, 1.5 thousand tons and 1.4 thousand tons in 1994 with rates of -12.17 %, -11.62 %, -20.21 % and -31.88 % respectively decreased annually.

Among the vegetables, tomatoes, cauliflower and cabbages, and melons were increased from 218.7 thousand tons, 33.6 thousand tons and 87.0 thousand tons in 1988 to 438.7 thousand tons, 51.8 thousand tons and 145.2 thousand tons in 1994 with annual growth rates of 19.01 %, 11.43 % and 13.66 % respectively. However, eggplant and cucumbers were decreased from 72.9 thousand tons and 68.0 thousand tons in 1988 to 37.9 thousand tons and 35.1 thousand tons in 1994 with the annual rate of -15.09 % and -15.24 % respectively.

On the other hand, among four fruit trees, only banana was decreased from 33.3 thousand tons in 1988 to 24.7 thousand tons in 1994 with the annual rate of -7.20 % per annum. Other three fruits as olives, grapes and citrus fruits were increased from to.70.8 thousand tons, 21.5 thousand tons and 101.3 thousand tons in 1988 to 94.1 thousand tons, 26.4 thousand tons and 150.7 thousand tons in 1994 with annual growth rates of 7.37 %, 5.27 % and 10.44 % respectively.

On livestock production, all of four commodities as red meat, poultry meat, milk and eggs were increased during the same period as red meat : from 8.3 thousand tons (in 1988) to 16.1 thousand tons (in 1994) with the annual growth rate of 18.01 %, poultry meat : from 68.0 thousand tons (in 1988) to 94.0 thousand tons with 8.43 % per annum, milk : 66.4 thousand tons (in 1988) to 151.4 thousand tons (in 1994) with 22.88 %, and eggs : 380 million eggs (in 1988) to 871 million eggs (in 1994) with 23.04 %.

2.4.4 General Industrial Aspects as a Whole

Appendix 2.12 shows a number of registered total establishments and permanent employees, and some figures concerned by industrial origin in Jordan. As shown in this table, industrial group consists of 25 kinds of economic activities as mining/quarrying, food manufacturing, beverage industries, tobacco manufacturing, manufacture of textiles, manufacture of wearing apparel except footwear, manufacture of leather/leather products, manufacture of footwear except vulcanized or molded rubber or plastic footwear, furniture/wood products, paper/paper products, printing/publishing/allied industries, chemical/chemical products, petroleum refineries, manufacture of rubber products, manufacture of plastic products (NEC), manufacture of non-metallic mineral products, basic metal products, manufacture of fabricated metal products except machinery/equipment, machinery other than electrical, manufacture of electrical machinery apparatus/appliances/supplies, manufacture of transport equipment, manufacture of professional scientific, measuring/controlling equipment not NEC, other manufacturing industries, electricity, and industrial services. Following Table 2.4-1 is its summary.

Table 2.4-1 Industrial Situation in Jordan

As of 1993

Number of employees			Number of enterprises (firms)	Gross value added (1,000 JDs)	Intermediate consumption (1,000 JDs)	Gross output (1,000 JDs)
Female (persons)	Male (persons)	Total (persons)				
5,747	102,599	108,346	18,980	766,817	1,523,475	2,290,292

Source : Statistical Year Book 1994, Department of Statistics.

A rate of female who engaged in industrial field was only 5.3 % to the total employees in 1993 according to the above mentioned Table.

The Appendix 2.12 indicates industrial origin that has a number of enterprises were food manufacturing (2,172 firms), manufacture of wearing apparel except footwear (1,536 firms), furniture and wood products (2,808 firms), manufacture of non-metallic mineral products (1,740 firms), manufacture of fabricated metal products except machinery and equipment (2,299 firms), and industrial services (6,997 firms).

However, the number of enterprises does not reflect the economic capability. At the viewpoint of gross output assuming as a factor of economic capability, the enterprises whose gross output were over JDs.100 million were mining and quarrying (125 firms, JDs.241 million), food manufacturing (2,172 firms, JDs.218 million), chemical and chemical products (115 firms, JDs.401 million), petroleum refineries (1 firm, JDs.374 million), manufacture of non-metallic mineral products (1,740 firms, JDs.218 million), and electricity (3 firms, 135 million).

The GDP as mentioned in previous clause clearly reflects these economic activities, especially mining and quarrying, and manufacturing are the major industries in Jordan. Here, in the field of petroleum refineries, one firm which produced the second highest gross output is the state enterprise.

Three firms of electricity as mentioned above consist of the National Electric Power Company (NEPCO) (former called as the Electricity Authority (JEA)), the Irbid District Electricity Company Ltd. (IDECO) and the Jordanian Electric Power Co. Ltd. (JEPCO). Among them, NEPCO is a state enterprise. They also produced rather high gross output as mentioned above. Details of their activities are described in the next clause.

2.4.5 Infrastructure in Jordan

In Jordan as of 1994, there are 6,856 km of road in total consisting of highway : 2,820 km, secondary road : 1,899 km and village road : 2,137 km according to the statistical data (see Appendix 2.13).

Jordan has only one sea port in Aqaba. The total handled goods and number of vessels were 10,572 thousand tons and 2,486 ships respectively as of 1994.

Jordan has 1 international airports in Amman, and 2 local airport in Aqaba and Amman. The passengers, and volume of freights are 1,222 thousand persons and 54,584 tons respectively as of 1994 by Jordanian Airlines.

Number of facilities for postage services and telephone services was 946 in total in whole Jordan as of 1994 consisting of postal agency : 424, post office counter : 12, telephone office : 3, rural post office : 42, post office : 430, and subscribers office : 35.

Hotels in Jordan are classified into two categories as (1) classified hotels and (2) non-classified hotels. Classified and non-classified hotels were 129 and 133 in total as of 1994, and they had 13,719 beds for the former ones and 3,670 beds for the latter ones. Almost these hotels concentrate in Amman, the capital city of the Nation, but some hotels located in other several cities because that Jordan has a lot of archaeological places.

2.5 Development Policies and Target

Jordan is now in on-going situation of the Economic and Social Development Plan 1993-1997. The various policies and projects in this Plan have aimed at achieving the following economic and social objectives :

1. Creating conditions conductive to sustainable growth;
2. Ensuring fiscal and monetary stability, eliminating production and price distortions, mobilizing and increasing domestic savings, and securing a proper climate for private sector investment;

3. Attaining a high level of self-sufficiency and self-reliance through narrowing the gaps in the economy, particularly in the general budget and the balance of payment;
4. Expanding and diversifying the income and employment-generating production base and developing a highly competitive export sector;
5. Reducing disparities among social groups and geographical regions, ensuring equality of opportunity, combating poverty, and providing all citizens with basic services;
6. Enhancing the capabilities of all citizens and instilling in them a spirit of initiative and the work ethnic through updating educational and training systems and expanding technical and vocational education;
7. Creating the proper conditions that would encourage citizens to invest in projects based on individual initiative and self-employment;
8. Conserving the environment and preventing the deterioration of its component elements through regulating economic and human activities in such a way to secure a healthy environment for people as well as for faun and flora, to ensure the non-depletion of exhaustible resources and to check soil erosion, desertification and pollution;
9. Ensuring wider participation and accountability in decision-making.

To achieve the above mentioned objectives, the Plan had set the following framework :

1. On the viewpoint of realization of sustainable growth in excess of population growth rate, the plan aims at realizing a GDP growth rate of 6 % per annum at 1991 constant price. This would raise real per capita GDP by about 3 %.
2. On the viewpoint of correcting structural imbalances and achieving fiscal and monetary stability;

    (a) Gradual reduction in the budget deficit to GDP ratio, excluding grants, to no more than 3 % by 1997.
    (b) Elimination of the balance of payments current account deficit by 1997.
    (c) Reduction of the external debt to GDP ratio to a level not exceeding 100 % by 1997.
    (d) Reduction of the external debt service as a percentage of exports of goods and services to a level not exceeding 25 % by 1997.
    (e) Reduction of the ratio of consumption to GDP to a level not exceeding 89 % by the end of the planned period.
    (f) Maintenance of the annual rate of inflation at 4 % to 5 %.

3. On the viewpoint of realization of balanced social development

The social dimension is vital for the success of economic development, the Plan said that, hence the importance attached to solving the problems of poverty and unemployment, improving the quality and raising the standard of social services, and reducing disparities between the regions. The social objectives include:

(a) Lowering the unemployment rate to 9.6 % by realizing sustainable growth rates that would create 224,100 new job opportunities.

(b) Concentrating the public sector investment program in the field of social services, and securing the delivery of these services to the various regions in a way that would ensure balanced geographical distribution and access by low income groups.

(c) Raising the level of educational, health, housing, and other social services during the planned period through appropriate fiscal and monetary policies aimed at providing incentives for private sector investment in these vital areas. The overall objective would be to raise life expectancy from 67 to 69 years, lower infant mortality rates to 25 per 1,000, and infant mortality under 5 years to 30 per 1,000, and raise the percentage of population with access to electricity and drinking water from 98 % to 100 % by 1997 and to sanitation facilities from 55 % to 65 % during the same period.

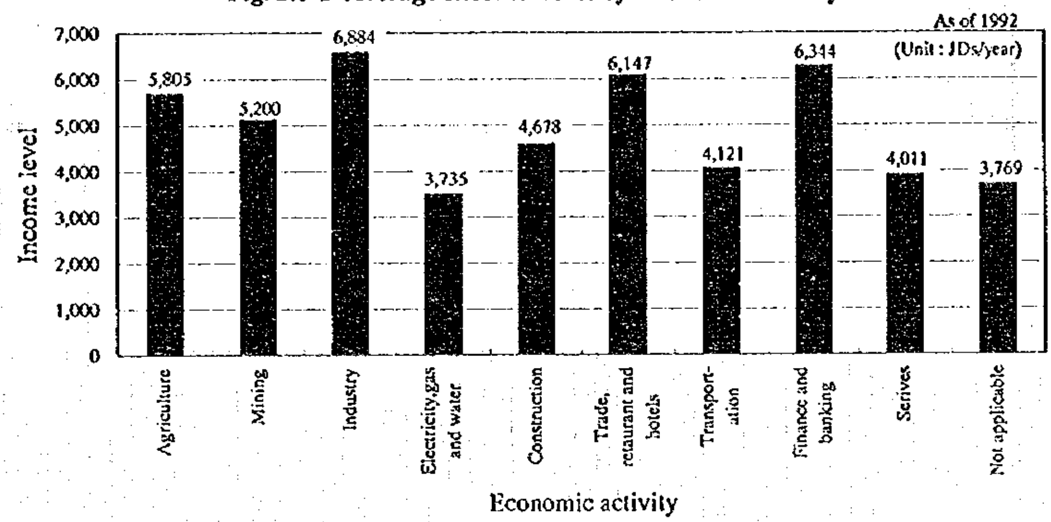
(d) Reducing poverty in the short run through the adoption of policies designed to promote the establishment of income-generating small projects for low income groups, particularly in the less developed regions, and raising per capita consumption at 1991 constant prices to JDs.787 in 1997.

(e) Training and rehabilitating 72,800 trainees to help them acquire the skills needed for the jobs created by economic growth and to reduce dependence on non-Jordanian labor, and increasing vocational education enrollment to 40 % of total secondary school enrollment by 1997.

2.6 Family Economy

Appendix 2.14 shows a situation of household income by economic activities as of 1992 based on the Household Expenditure and Income Survey 1992 by Department of Statistics. According to this data, the income level of household in Jordan is illustrated as follows:

Fig. 2.6-1 Average Income Level by Economic Activity



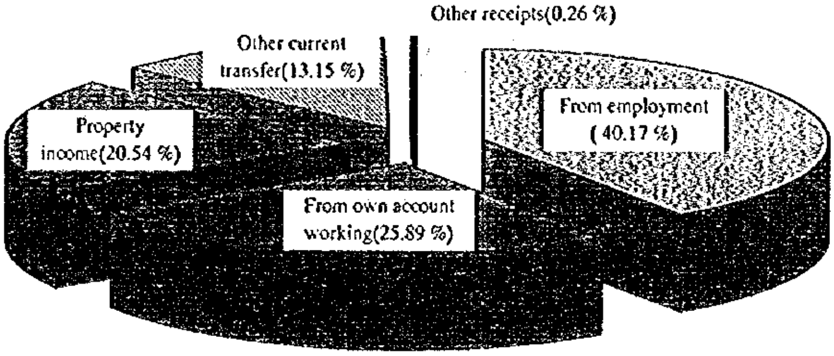
Source : Household Expenditure and Income Survey 1992, Department of Statistics.

As shown in the above figure, the highest income level was the household engaged in industrial activity, the second : in finance and banking, third : trade, restaurant and hotels with the amount of JDs.6,884, JDs.6,344 and JDs.6,147 respectively. It seems that the said income situation reflects the industrial condition as mentioned previous clause. The average annual income per household may be calculated at an amount of JDs.4,607 in 1992.

According to the said survey, the income mentioned above consists of (1) income from employment, (2) own account working income, (3) property income, (4) other current transfer, and (5) other receipts. The income from employment also consists of income in cash and in kind as food, housing allowance, cloths and so on.

For the average income of JDs.4,607, the share rate of those component may be illustrated as following Fig.2.6-2.

Fig. 2.6-2 Share Rate of Income by Source



Source : Household Expenditure and Income Survey 1992, Department of Statistics.

In monetary terms, the amounts of income from employment, income from own account working, property income, other current transfer, and other receipts were JDs.1,851, JDs.1,193, JDs.946, JDs.606 and JDs.12 respectively. Among the income from employment, cash income was JDs.1,828 (98.8 %). Remaining income from employment was in kind as food, housing allowance, cloths and others.

On the viewpoint by rural and urban, the said average annual household income of JDs.4,607 consists of rural : JDs.3,532 and Urban : JDs.4,898. By governorate, it consists of JDs.5,795 in Amman, JDs.3,966 in Irbid, JDs.4,003 in Zarqa, JDs.4,203 in Balqa, Jds.2,997 in Mafrak, JDs.2,648 in Karak, JDs.4,355 in Ma'an, and JDs.2,899 in Tafiela.

The situation of household expenditure is shown in Appendix 2.15 which is also based on the said Survey. The survey for household expenditure was made by itemization in 16 kinds of food, beverage and tobacco as cereals products, meats and poultry, fish and sea products, dairy products and eggs, oils and fats, fruits, vegetables, dry and canned legumes, spices, nuts, sugar and confectioneries, tea/coffee and cacao, beverages, alcohol, and tobacco and cigarettes.

The expenditure for the other commodities and services are also itemized in 17 kinds of expenditure items as ready made men's cloths, ready made women's cloths, children's cloths, clothing and tailoring expense, footwear, housing and related expenses, fuels/electricity/water, house furnishings, household appliances, utensils, cleaning materials, transportation, education, medical care, personal care, recreation, and other expenses. Following Table 2.6-1 is its summary.

Table 2.6-1 Average Annual Household Expenditure and Its Share Rate by Item

As of 1992

Expenditure Item by expenditure group	Food, beverage and tobacco	Cloth-ing	Hous-ing & related expce.	Fuel/ electri-city water	Furni-shings	Trans-portat-ion	Edu-cation	Medi-cal care	Mis-cella-neous	Total
Amount of expenditure(JDs)	1,856	373	72	229	278	510	160	102	342	3,920
Share rate in percentage (%)	47.35%	9.52%	1.84%	5.84%	7.09%	13.01%	4.08%	2.60%	8.72%	100%

Source : Household Expenditure and Income Survey 1992, Department of Statistics.
Note 1 : The item of food, beverage and tobacco includes all 16 expenditure items.
2 : The item of clothing includes all items of clothing and footwear.
3 : The item of furnishing includes house furnishings, household appliances, utensils and cleaning materials.
4 : The item of miscellaneous includes personal care, recreation and other expenses.

The balance between amounts of income (JDs.4,607) and expenditure (JDs.3,920) amounting at JDs.687 seems to be reserved for foods, or medical care or others, or saved if remained.

As shown in the above Table, the share rate of expenditure for foods was 47 % or more in 1992. Considering the standard share rate (called as the Engel's coefficient) of around 30 % in developed countries, this figure is quite high.

The share rate of expenditure for fuel, electricity and water was 5.84 % as shown in the said Table. The expenditure for the electricity may be calculated based on the data from NEPCO (former JEA) at the amount of around JDs.160 as the average annual amount in 1992 which is 4.08 % among the said total expenditure for fuel, electricity and water.

Details for average annual expenditure situation is shown in Appendix 2.15 by rural and urban, and by Governorate.

2.7 Price

2.7.1 Consumer Price

Appendix 2.16 (A) shows a cost of living index in Jordan since 1991 and summarized below:

Table 2.7-1 Cost of Living Index in Jordan

Year	General	Food	Clothing/footwear	Housing	Other goods/services
1991	96.2	97.1	92.1	96.2	96.7
1992	100.0	100.0	100.0	100.0	100.0
1993	103.3	101.9	105.8	106.3	101.5
1994	107.0	107.9	109.9	108.6	102.6
1995	109.5	110.4	117.9	111.4	102.9
Average annual growth rate (%)	3.29 %	3.26 %	6.37 %	3.74 %	1.57 %

Source : Monthly Statistical Bulletin Vol.32 No.6, Central Bank of Jordan.

The average annual growth rate living index was 3.29 % since 1991 up to 1995 for the general index according to the above Table. And, that for the other index is not so much far from the general index except that for clothing and footwear.

The Government of Jordan has controlled that prices of bread produced from Jordanian wheat is Fils.85 per kg, that from mixture Jordanian and imported wheat is Fils.120 and that from wholly imported wheat is Fils.150 during last 10 years. On August 13, 1996, the Government announced increases in prices of bread as Fils.180, Fils.220 and Fils.250 respectively. The increasing rate of prices for bread is around 2 times as a whole. The main cereals for living in Jordan is wheat, and people in Jordan live on bread. The Government has subsidized to their people for expenditure for bread. Even if the people received such subsidy from the Government, the increase of prices for bread should influence the prices for the other commodities, and this should press people's livelihood in the future.

2.7.2 Exchange Rate

The fluctuation of exchange rates with US Dollars and Japanese Yen during the period from 1991 to 1995 is shown in Appendix 2.16 (B) and summarized below:

Table 2.7-2 Exchange Rates with US Dollars and Japanese Yen

(J.Fils, middle rate)

Year	1 US Dollar	100 Japanese Yen
1991	680.9	506.4
1992	679.8	537.4
1993	692.9	625.0
1994	698.8	684.5
1995	700.8	749.1
June 1996	709.0	651.0
Annual average decreasing ratio (%)	0.72 %	10.28 %

Source : Monthly Statistical Bulletin Vol.32 No.6, Central Bank of Jordan.

CHAPTER 3

ELECTRICITY IN JORDAN

CHAPTER 3 ELECTRICITY IN JORDAN

3.1 Electricity Enterprises in Jordan

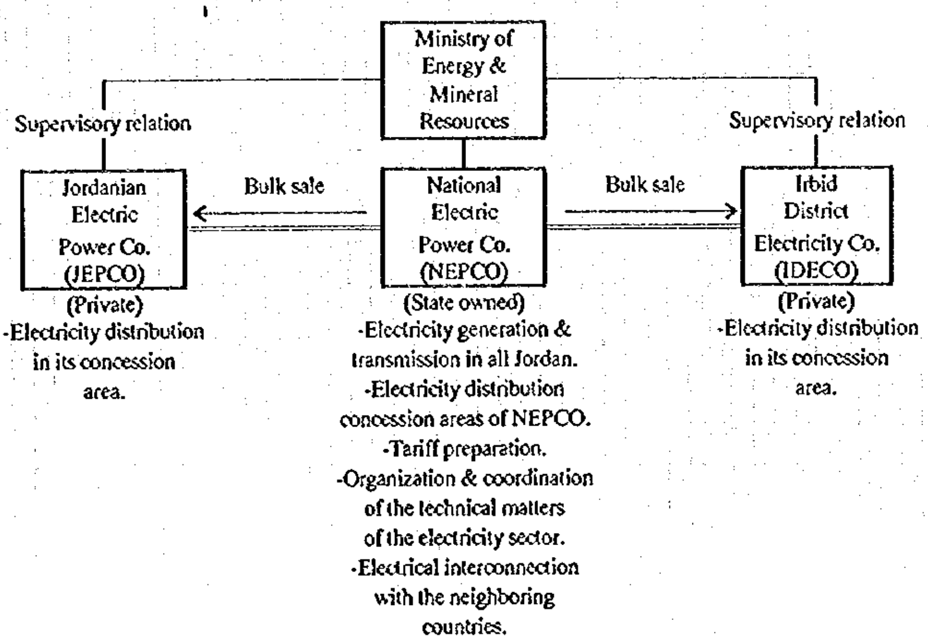
There are three electricity enterprises in Jordan. The one is a state owned enterprise belonging to the Ministry of Energy and Mineral Resources named "the National Electric Power Co. (NEPCO) (former called as Jordan Electricity Authority = JEA)". The other two are private enterprises named as the Jordanian Electric Power Co. (JEPCO) and the Irbid District Electricity Co. (IDECO). The function and relationships among them are as described hereunder. Among them, JEA and IDECO have generation facilities. JEPCO is a distributing firm buying electricity from JEA.

Other than those three enterprises, the Jordan Potash Co. Ltd. and the Jordan Cement Factories Co. Ltd. are also producing electric power for their own use.

3.1.1 Function and Relationships among Electricity Enterprises in Jordan

The Ministry of Energy and Mineral Resources is one of ministries in Jordan. NEPCO belongs to this ministry as shown in Appendix 2.1. The organization of NEPCO is shown in Appendix 3.1 and function and relationships among the three enterprises are as shown in the following Fig.3.1-1.

Fig.3.1-1 Electricity Enterprises in Jordan



NEPCO is a large scale power generation enterprise in Jordan. Its power stations counts at 11 stations as Hussein Thermal Power Station, Aqaba Thermal Power Station, Risha Power Station, Marka Power Station, Karak Power station, Remote Villages Power Station, Aqaba Central Power Station, Amman South Gas Turbine Power Station, Rehab Power Station, King Tolal Dam & Fertilizer Co., and Wind Energy Generation Station. Energy production of NEPCO in 1995 was 5,201 GWh with annual growth rate of 9.80 % from 3,258 GWh produced in 1990 as shown in Appendix 3.2 (A).

NEPCO is a energy distributing enterprise too. The energy was sold to JEPCO and IDECO, and other large scale industries as Refinery Co., Cement Factories Co., etc. by NEPCO as bulk sales. NEPCO's interconnecting system network covers Aqaba area, Ma'an and Shoubak areas, Karak area, Tafila area, Jordan Valley area, eastern area, and a part of Amman area for retail sales. As of 1995, the total energy consumption in whole Jordan was 4,778 GWh as shown in Appendix 3.2 (B). The energy volume sold by NEPCO shares 4,665 GWh against the said total energy consumption with with share rate of 97.6 % including sold volume at 2,606 GWh to JEPCO and 654 GWh to IDECO. However, the sold volume as retail sales was not so high as 397 GWh only, comparing with other two private enterprises.

Number of consumers in Jordan in 1995 was 674,000 in total with developing by average annual growth rate of 5.34 % since 1990. Among them, NEPCO shares only 90,000 of consumers with share rate of 13.4 %.

At present, NEPCO has a plan to separate its energy distribution section as a independent private enterprise. A restructuring for this plan was already started since July 1996. Even the energy distribution section will become a private enterprise, the function to sell energy to JEPCO, IDECO and to others as for bulk sales and retail sales seems to be kept as same as the present situation.

JEPCO and IDECO are energy distributing enterprises who are buying energy from NEPCO as mentioned above. Among them, IDECO has its own generating station.

JEPCO has covered the areas of a large part of Amman Governorate and Balqa Governorate including the cities of Amman, Al-Zarqa, Al-Salt, Madaba and Al-Baq'ah, and IDECO has covered the area of Irbid Governorate including the cities of Irbid, Al-Ramtha, Al-Mafrak and Jarash by their network.

Appendix 3.2 (D) shows number of consumers or subscribers the three enterprises connect to in 1995 amounting to 674,484 in total and is summarized by type of consumption as shown in the following Table 3.1-1.

Table 3.1-1 Number of Consumers by Type of Consumption in 1995

	NEPCO	JEPCO	IDECO	Others	Total
Domestic	75,381	348,078	129,816	212	553,487
Industrial	895	7,179	2,487	0	10,561
Commercial	9,867	67,282	17,034	8	94,191
Water pumping	723	487	761	0	1,971
Governmental	2,642	2,124	1,376	0	6,142
Others	967	4,883	2,279	3	8,132
Total	90,475	430,033	153,753	223	674,484

Source : Annual Report 1995, Jordan Electricity Authority (JEA) (now named as NEPCO).

According to the data from NEPCO, energy services population in 1995 was 4,254 thousand with electrification rate of 99.2 % to the total population as of 1995.

3.1.2 Finance of Energy Enterprises

All of three electricity enterprises have made balance sheets and statements of their incomes and expenses as of at the end of each fiscal year, and they have made their annual account reports. The available annual account reports from them were those for 1994 fiscal year except NEPCO's one. From NEPCO, the account report for 1995 fiscal year was available too.

Appendix 3.3 shows the situation of income and expenses for NEPCO, and JEPCO and IDECO, and summarized below.

Table 3.1-2 Summary Statements of Income and Expenses of Enterprises

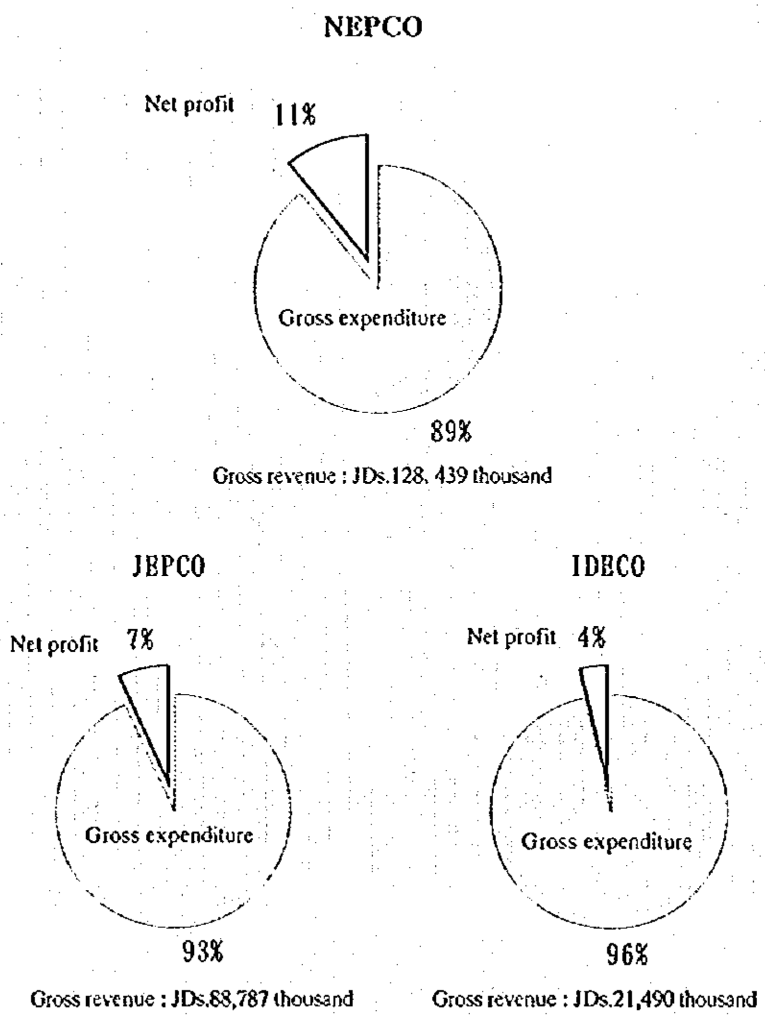
(JDs)

	NEPCO		JEPCO	IDECO
	in 1994	in 1995	in 1994	in 1994
REVENUE	128,439,585	138,901,013	88,787,004	21,490,002
Electricity sales	119,242,838	132,012,477	84,567,035	16,887,571
Other income	9,196,747	6,888,536	4,219,969	4,602,431
GROSS EXPENDITURE	114,466694	126,229731	82,828,241	20,726,338
Operation/purchase	70,366,464	77,763,510	65,925,198	18,536,513
Other expenditure	44,100,230	48,466,221	16,903,043	2,189,825
NET PROFIT	13,972,891	12,671,282	5,958,763	763,664

Source : Annual Account Reports from JEA(NEPCO), JEPCO and IDECO.
Note : The item of purchase means the electricity purchase of JEPCO/IDECO from NEPCO.

According to the above Table, all of three electricity enterprises have resulted to get positive incomes in each fiscal year. The rate of net profit to the gross revenue may be illustrated as shown below:

Fig. 3.1-2 Net Profit Rate to Gross Revenue of Each Electricity Enterprises in 1994



As of 1994, NEPCO get its net profit at amount of JDs.13,973 thousand with a share rate of 11 % to the gross revenue. The NEPCO's net profit rate is rather high comparing with that of other two enterprises as JDs.5,959 thousand with 7 % of JEPCO and JDs.764 thousand with 4 % of IDECO, and this seems to reflect its scale merit.

However, NEPCO has brought a huge amount of accumulated losses from previous years as shown in Appendix 3.3, so NEPCO's final account was negative in 1994 and 1995 too.

This accumulated losses of NEPCO seems to mainly be caused by its investing activities according to NEPCO Annual Report 1995 such mainly as:

- Risha Gas Turbine Project
- Aqaba Steam Plant Project - Phase II
- Risha Gas Turbine Transfer Project
- Jordanian-Egyptian Interconnection Project and Expansion Project
- South Amman Gas Turbine Project
- Transfer Station Construction Project and Expansion Project
- Other payments on consultant services and research, and to contractors.

Scale of enterprises are usually indicated by balance sheets. Appendix 3.4 are the balance sheets of JEA, JEPCO and IDECO and summarized as follows:

Table 3.1-3 Summary of Balance Sheet of Electricity Enterprises

For 1994 Fiscal Year (JDs.)

Credit	NEPCO	JEPCO	IDECO	Debit	NEPCO	JEPCO	IDECO
Current assets	81,932,582	39,082,061	12,450,935	Current liabilities	71,472,257	54,792,383	14,649,965
Fixed assets	285,570,186	94,916,008	31,157,105	Equity	115,470,630	80,011,365	4,156,160
Others	5,801,487	805,679	207,553	Others	186,361,368	0	25,009,468
Total	373,304,255	134,803,748	43,815,593	Total	373,304,255	134,803,748	43,815,593

Source : Annual Account Reports of JEA (NEPCO), JEPCO and IDECO.

Among the equities indicated in the above Table, capitals of NEPCO, JEPCO and IDECO were JDs.80,734 thousand, JDs.15,000 thousand and JDs.3,000 thousand respectively in 1994. The amount of capital of NEPCO has become at JDs.82,720 thousand in 1995.

3.1.3 Electricity Tariff

As mentioned above, the electricity tariff is set by NEPCO. The existing tariff system at the end of 1995 is as follows according to the Annual Report of NEPCO:

1. Bulk Supply Tariff
   a. Electricity enterprises

Peak load	2.4 (JDs/kW/Month)
Day energy	23.5 (Fils/kWh)
Night energy	14.5 (Fils/kWh)

b. Large industries

Peak load	2.4 (JDs/kW/Month)
Day energy	45 (Fils/kWh)
Night energy	23 (Fils/kWh)

2. Retail Tariff

a. Domestic (Fils/kWh)

First block : From 1 - 160 kWh/Month	28 (Fils/kWh)
Second block : From 161 - 300 kWh/Month	52 (Fils/kWh)
Third block : From 301 - 500 kWh/Month	55 (Fils/kWh)
Fourth block : More than 501 kWh/Month	70 (Fils/kWh)
b. Flat rate tariff for TV and broadcasting	45 (Fils/kWh)
c. Commercial	50 (Fils/kWh)
d. Medium industries	
Peak load	3.05 (JDs/kW/Month)
Day energy	25 (Fils/kWh)
Night energy	20 (Fils/kWh)
e. Small industries	30 (Fils/kWh)
f. Water pumping	30 (Fils/kWh)
g. Hotels	50 (Fils/kWh)
h. Agriculture	21 (Fils/kWh)
i. Street lighting	13 (Fils/kWh)*

(Note) Monthly minimum charge is:

1. JDs.1.00 per month for domestic.
2. JDs.1.25 per month for other consumers.
3. * 13 Fils/kWh is applied for consumption which exceed the average level of 1988 consumption. Here, JDs.1 = Fils.1,000.

Based on the financial statistics of NEPCO, the actual average tariff may be calculated at a sum of Fils.37 per kWh in average as shown in the following Table 3.1-4:

Table 3.1-4 Actual Average Electricity Tariff in NEPCO

Sector	Domestic and public building	Bulk industry	Medium and small industries	Commercial	Agriculture & Water. pumping	Others	Total
Share of consumption(%)	32.35	16.54	13.74	10.96	20.32	6.09	100.00
Share of revenues(%)	36.64	17.26	10.80	14.87	15.63	4.80	100.00
Average tariff (Fils/kWh)	41.67	38.49	29.00	50.00	28.36	29.09	36.88

Source : Annual Report 1995, JEA (NEPCO).

3.1.4 Meter Reading, Claim and Collection of Electricity Charge

Electricity meter reading is made once a month for general subscribers, and bills of electricity charges are sent based on the meter reading to subscribers within 2 months after the meter reading. When the subscribers do not pay within a specified period (usually 1 or 2 months) after sending the said bill, electricity distribution is cut without any warning.

For bulk sales, measuring equipment (meters) is equipped at the point of just behind of transmission lines to IDECO and JEPCO directly branching off from high voltage lines at their sub-stations, and measuring attendants of each interconnected electricity enterprise read the meter at the end of every month with attendants from NEPCO. Both the interconnected electricity enterprises make 2 copies of a report based on the meter reading, and one of them are sent to NEPCO. NEPCO issues bills based on this reports within one month after receiving the report. IDECO and JEPCO shall pay the electricity charges according to these bills.

3.2 Equipment and Facilities in Power Plant, Transmission Lines, Substations and Distribution Lines in Jordan

In principle, the several power plants owned by NEPCO are interconnected to the power systems in the country through 132 kV transmission lines, and after stepping down to 33, 11 and 6.6 kV at main substations and further to 415 V at distribution substations located at the respective load centers, the power is distributed to consumers by 415 V 3-phase 4-wire system.

3.2.1 Power Plant Equipment

As at the end of 1995, the total installed capacity is 1,167 MW. Out of this total, 1,049 MW is interconnected to the power systems throughout the country. The various types of power plants in Jordan as at the end of 1995 are Presented in Table 3.2-1.

The fuel used in both the Aqaba and Hussein Thermal Power Stations owned by NEPCO is heavy oil. Although the Aqaba Thermal Power Station faces the Red Sea, sea transportation of fuel is impossible particularly due to the political situations in the Middle East. All the required heavy oil is land-transported by tank lorries from the refineries near Amman or from Iraq. For transportation of heavy oil to the Aqaba Thermal Power Station, thirty 50-ton tank lorries a day are required at present. In the case of the Hussein Thermal Power Station located in the desert zone where acquisition of cooling water is difficult, moreover, the condensers are cooled with air fans. Meanwhile, a gas turbine generator (100 MW x 1) has been added at the Rehab Thermal Power Station in 1996.

Table 3.2-1 Power Stations and Capacities in Jordan (MW)

Power Stations	Steam	Gas Turbines		Diesel	Wind	Hydro	Total
		Diesel	N. Gas				
1. NEPCO	623	242	120	56.5	0.3	7	1,048.8
Hussein Thermal P.S.	3 × 33 4 × 66	1×14 1×18	- -	- -	- -	- -	395 -
Aqaba Thermal P.S.	2 ×130	-	-	-	-	3	263
Aqaba Central P.S.	-	-	-	2×3.5 3×5	-	-	22
Marka P.S.	-	4×18	-	30	-	-	102
Al-Risha P.S.	-	-	4×30	-	-	-	120
Am'man South G.T.	-	2×30	-	-	-	-	60
Karak P.S.	-	1×18	-	3×1.5	-	-	22.5
King Talal Dam	-	-	-	-	-	4	4
Wind Energy	-	-	-	-	0.3	-	0.3
Rehab P.S.	-	2×30	-	-	-	-	60
2. Other Organizations	73	-	-	45.5	-	-	118.5
IDECO	-	-	-	6	-	-	6
Cement Factory	-	-	-	9	-	-	9
Refinery Co.	14	-	-	2	-	-	16
Arab Potash Co.	15	-	-	8	-	-	23
Fertilizer Co.	44	-	-	-	-	-	44
El-Hasa Phosphate Co	-	-	-	12	-	-	12
Municipalities & Others	-	-	-	8.5	-	-	8.5
Total	696	242	120	102	0.3	7	1,167.3

3.2.2 Transmission Facilities

In Jordan, the transmission line voltages are divided into the four 400, 230, 132 and 66 kV classes. Among these classes, the 400 kV 2-ckt transmission line has been provided between the Aqaba Thermal Power Station and Amman South Substation. This transmission line is now operated at 132 kV. Meanwhile, this transmission line is being designed for boosting the voltage to 400 kV by the end of 1997.

Moreover, the 230 kV transmission line, which had been constructed for interconnection with the power system in Syria through the Irbid Substation for power supply to Syria, has so far not been operated.

The other hand a 66 kV transmission line was connected between Irbid Substation and Syria, however, the line has been shut down and used as a 33 kV distribution line. The length of the transmission lines of NEPCO as at the end of 1995 is listed below:

Transmission Line (kV)	66	132	230	400
Line Length (ckt-km)	17	2,106	17	670

3.2.3 Substation Facilities

The installed capacity of the substations for the power systems owned by NEPCO as at the end of 1995 is as listed below:

Substation (kV)	33/11	66/33	132/6	132/33	230/123
Capacity (MVA)	150	10	75	1,989	200

Meanwhile, the SF_6 gas insulation system has been adopted partly among the 132 kV class substations. Both the manned and unmanned control systems are applied for operation of the substations in the country. To reinforce the power supply capacity to Amman and Irbid, the Abdali Substation (3 x 40 MVA, 132/33 kV) was completed by NEPCO in 1995. In addition, the Tareq Substation (3 x 40 MVA, 132/33 kV) and Abdoun Substation are scheduled to be constructed in the Amman district.

3.2.4 Distribution Facilities

According to the definition of the power companies in Jordan, the 33 kV or lower voltage facilities are all referred to as the distribution facilities. In the case of the respective power companies: NEPCO, JEPCO and IDECO, the distribution voltages are divided into 2 groups, MV (medium voltage) and LV (low voltage). The 33, 11 and 6.6 kV are called MV, while the 415 V (3-phase 4-wire system) is called LV.

In principle, the 11 kV underground cable is used for the primary distribution lines in densely populated residential areas. Whereas, the 33 and 11 kV overhead distribution lines are used in rural area and on the outskirts of city areas. Meanwhile, the 6 kV distribution lines which observed to be in service in partial areas tend to be dismantled successively in the future.

Although the 415 V or lower voltage distribution lines are mainly of an overhead system, the underground cable is used in the area of Aqaba City. The distribution facilities and installed capacity of the distribution substations of NEPCO, JEPCO and IDECO are as presented in Tables 3.2-2 and 3.2-3.

Table 3.2-2 Distribution Facilities in Jordan

Distribution Line	Company	33kV	11kV	6.6kV	0.4kV
Overhead Lines(km)	NEPCO	1,413.4	306.8	5.2	2,324.1
	JEPCO & IDECO	2,975.1	309.7	264.4	12,799.3
	Subtotal	4,388.5	616.5	269.6	15,123.4
Underground Cable(km)	NEPCO	17.5	102.2	5.8	261.4
	JEPCO & IDECO	399.5	794.7	656.7	1,057.4
	Subtotal	417	896.9	662.5	1,318.8
	Ground Total	4,805.5	1,513.4	932.1	16,442.2

Table 3.2-3 Distribution Substation Capacities in Jordan

Substation	Company	33,11,6.6/0.4kV	33/11,6.6kV	11/6.6kV
Capacities(MVA)	NEPCO	379.9	145.5	2.5
	JEPCO & IDECO	847.4	493.7	1,509.5
	Total	1,227.3	639.2	1,512

3.3 Power Demand

3.3.1 Production and Consumption of Electrical Energy

(1) Production of electrical energy

In Jordan, the electrical energy producers are largely classified into the electric utilities and non-utility industrial enterprises. The enterprises undertaking electrical energy production are the NEPCO, IDECO, municipalities and so forth. Moreover, the industrial power plants are owned by five companies including cement and steel makers. In Jordan, the electrical energy is produced nearly totally by the NEPCO. As the electrical energy produced by industry owned power plants is consumed almost entirely by the industrial plants.

The share of the electrical energy production by NEPCO to the total production, which was about 93% in 1995, has been remaining nearly unchanged for the past six years since then.

Breakdown in Table 3.3-1 is the electrical energy production by electric utilities and non-utility sectors in Fiscal 1995. Presented further in Fig. 3.3-1 is the trend of the electrical energy production in Jordan and that of NEPCO.

Table 3.3-1 Electrical energy production and its share by sectors in 1995

	Electrical Energy (GWh)	Share (%)
1. Electricity Sector	5,215	92.8
NEPCO	5,201	92.6
IDECO	12	0.2
Municipalities & Others	2	0.0
2. Industrial Sector	401	7.2
Refinery	65	1.2
Cement Factory	39	0.7
Potash Co.	113	2.0
Fertilizer Co.	166	3.0
H. Iron Factory	18	0.3
Total	5,616	100

As the breakdown and trend of electrical energy production by generator types in Jordan are presented in Fig. 3.3-2, the generators driven by steam turbines share as much as about 78.5% of the total energy production in the country as in 1995. This is followed by 20% of gas turbine power plants. The development gas turbine and other high efficiency power sources is predicted to be promoted further in the future.

The yearly rainfall is scarce so there is no river to make effective use of water resource in the country. Thus, the energy production by hydro-power source is limited to only 0.3%. Consequently, the electrical energy production in Jordan depends nearly totally on thermal power source.

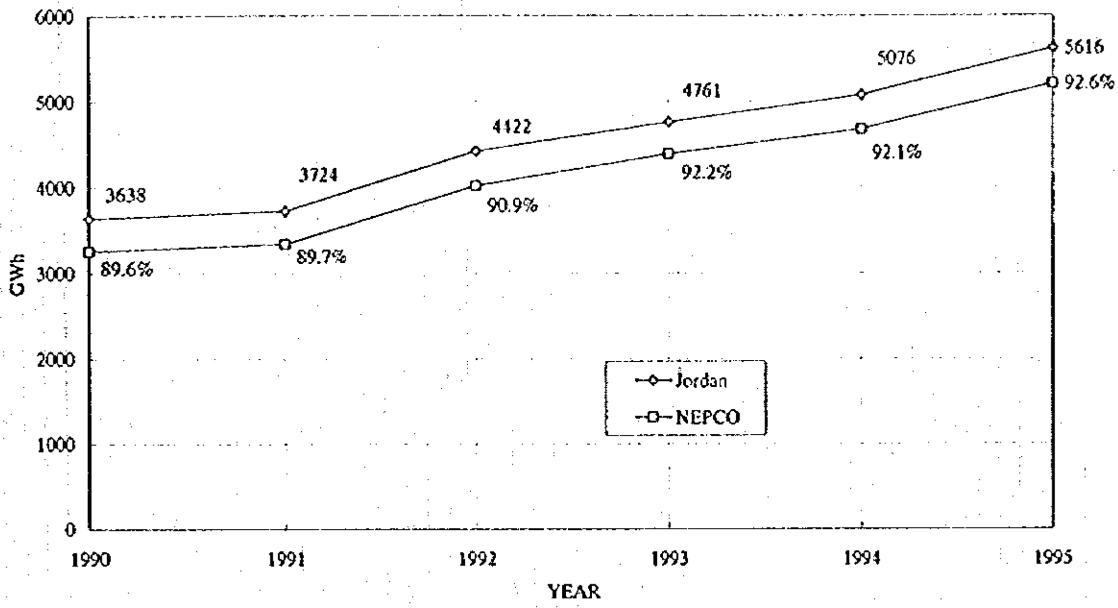


Fig. 3.3-1 Electrical energy production by type of generation in Jordan

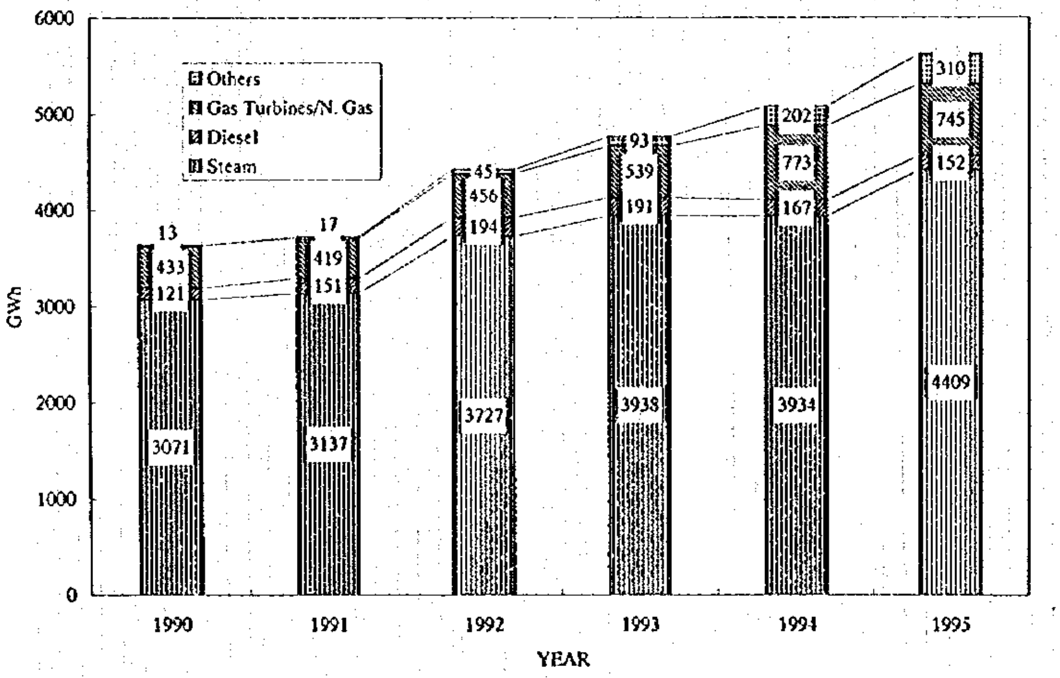


Fig. 3.3-2 Electrical energy production and share by type of generation in Jordan

(2) Sold electrical energy

The total electrical energy sold throughout Jordan in 1995 is 3,373 GWh. Out of which, 2,382 GWh, 576 GWh and 415 GWh was sold respectively by the JEPCO, IDECO and NEPCO in terms of the categories of electric utilities, and about 70% of the total was shared by the JEPCO with its supply area in Amman, the capital city, followed by about 17% of IDECO and about 15% of NEPCO.

As about 71%, 16% and 13% was shared respectively by the JEPCO, IDECO and NEPCO as in 1986, the share of electrical energy sold by the respective suppliers has undergone little changes. Moreover, the electric power demand has grown nearly equally throughout Jordan.

Although the growth rate of sold electrical energy was more or less than 10% in late 1980s, the growth rate dropped sharply reflecting the impacts of the invasion of Iraq to Kuwait in 1990 and the Gulf War in 1991. After undergoing rapid recovery since then, the growth rate has been growing at more or less than 10% ever since 1992.

When viewed from the growth rate of the respective suppliers, the JEPCO and IDECO have been undergoing a roughly similar trend. This is because the two companies have supply areas with high population density and similar power demand structures.

The trend of electrical energy sold by the respective electric utilities in Jordan is presented in Fig. 3.3-3. And the growth rate of electrical energy sold by the respective electric utilities in Jordan is presented in Fig. 3.3-4

The shares of electric power demand for the respective categories of consumption in 1995 are respectively about 30% for residential consumption, about 11% for commercial consumption, 30% for l industrial consumption, 19% for water pumping, 3% for public street lighting and about 8% for government agencies, news media, transportation, education, medical and other service sectors. The trend of the configuration ratios of electrical energy sold by the categories of consumption in Jordan is presented in Fig. 3.3-5.

According to the trend of configurations for the past one decade, there have been no major changes in the residential and commercial demand. Although the overall industrial demand has remained nearly unchanged, the demand for small industrial consumers has increased by three (3) points in contrast to three point decrease in that for big industrial consumers. Moreover, the water pumping demand has been undergoing steady increase.

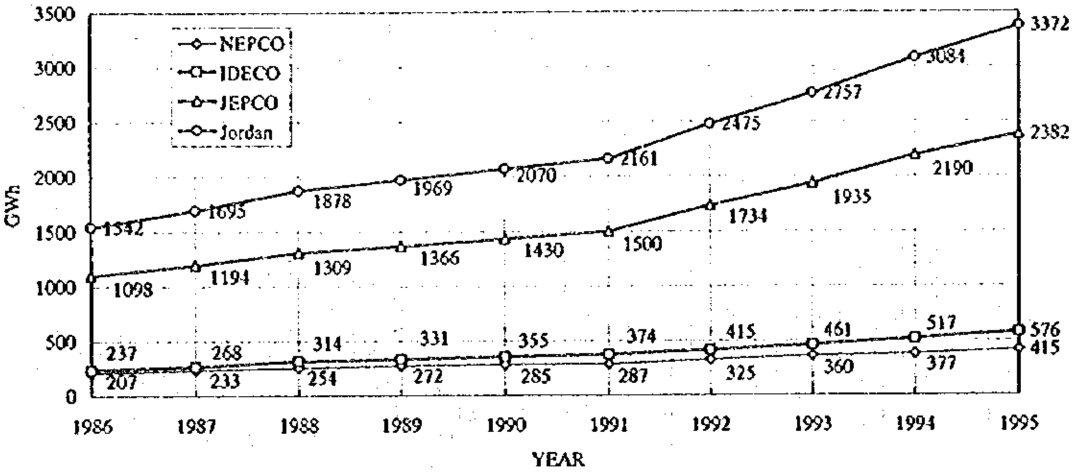


Fig. 3.3-3 Trend of electrical energy sold by the respective electric utilities in Jordan

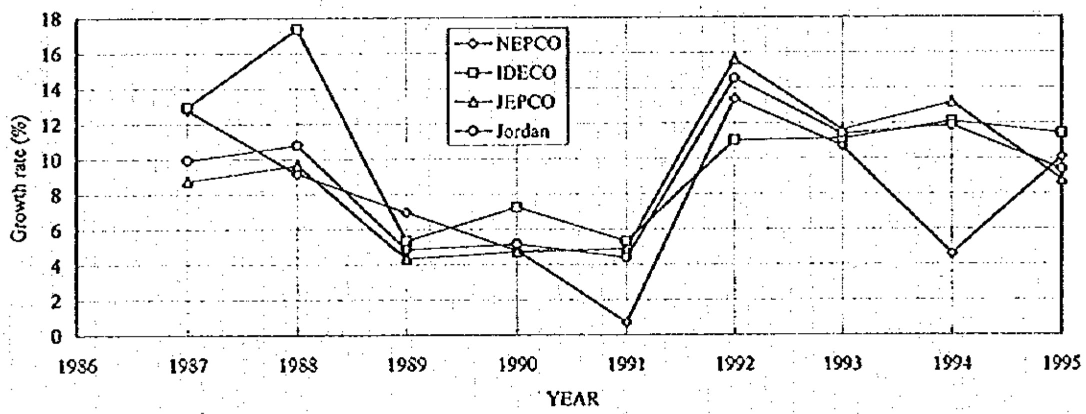


Fig. 3.3-4 Growth rate of electrical energy sold by the respective electric utilities in Jordan

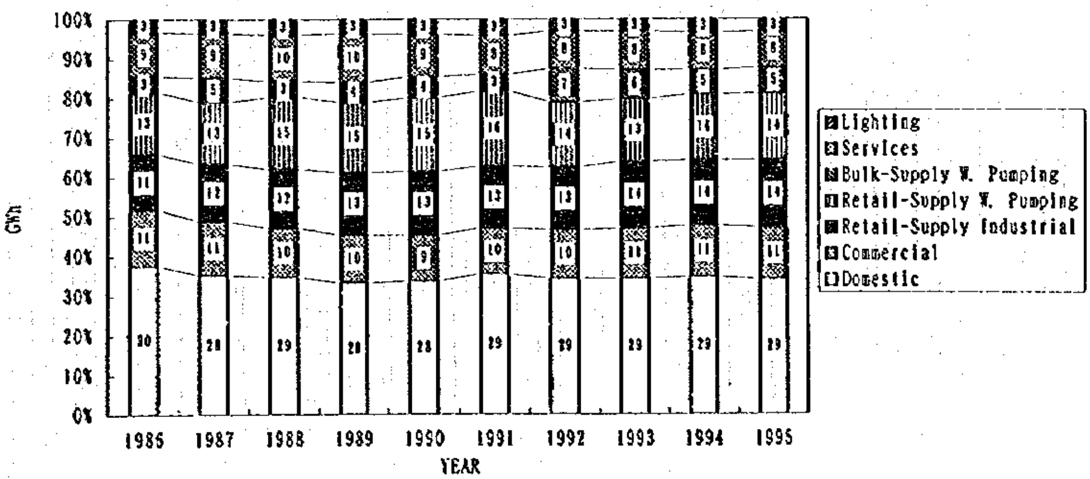


Fig. 3.3-5 Trend of the configuration ratios of sold electrical energy by consumption categories

3.3.2 Characteristics of Power Demand

(1) Daily and yearly load curves

The daily and yearly load curves in Jordan are presented in Figs. 3.3-6 and 3.3-7. In Jordan, the daily peak load arises in the evening when lighting is turned on. Whereas, the yearly peak load takes during summer in August and September.

(2) Trend of peak load and yearly load factor

The trend of peak load and yearly load factors in Jordan are presented in Fig. 3.3-8. For the past nine years, the peak load has increased to about 1.8 times at an annual average rate of as high as 7.4%. Moreover, the annual average growth rate reached 10% during the period from 1991 through 1995 after the end of the Gulf War.

Although the annual load factor did not undergo so substantial change for the past nine years, the factor was improved to more or less than 70% during the latter half period of four years from an order of 60% during the earlier half period of five years.

(3) Marginal supply capability (kW)

The trend of capability marginal (kW) is presented in Fig. 3.3-9 This kW capability margin is calculated from the ratio of the available capacity of power units to the peak load. Since any power plant has not been constructed by 1993 since 1990, the ratio of the capability margin to peak load decreased substantially to 17% in 1993 from 35% in 1990.

Although each one 60 MW unit was commissioned respectively 1994 and 1995, the kW capability margin has been on the decrease reflecting the rapid growth of electric power demand.

To cope with such situations as mentioned above, the NEPCO is promoting the projects to install two 130 MW steam turbine power units at the Aqaba Thermal Power Station. Thereby, the installed capacity of the power stations throughout Jordan is scheduled to be increased to 1,527 MW by 2000 to cope with the growth of power demand in the future.

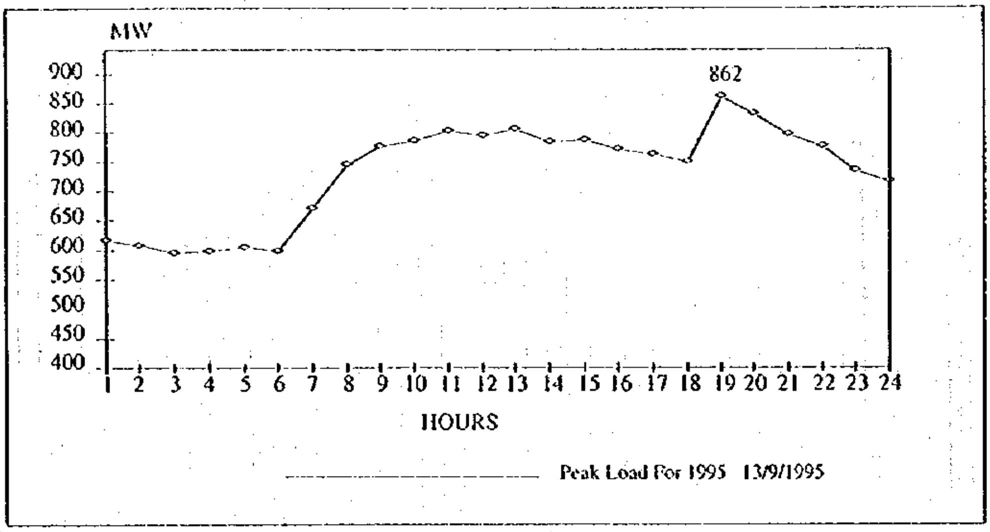


Fig. 3.3-6 Daily load curve in Jordan

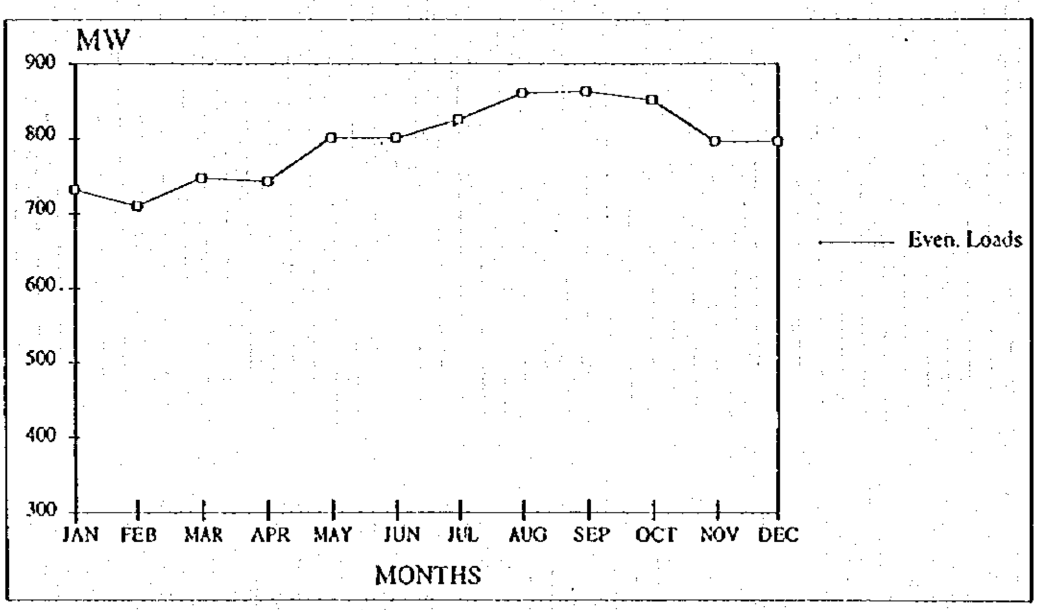


Fig. 3.3-7 Yearly load curve in Jordan

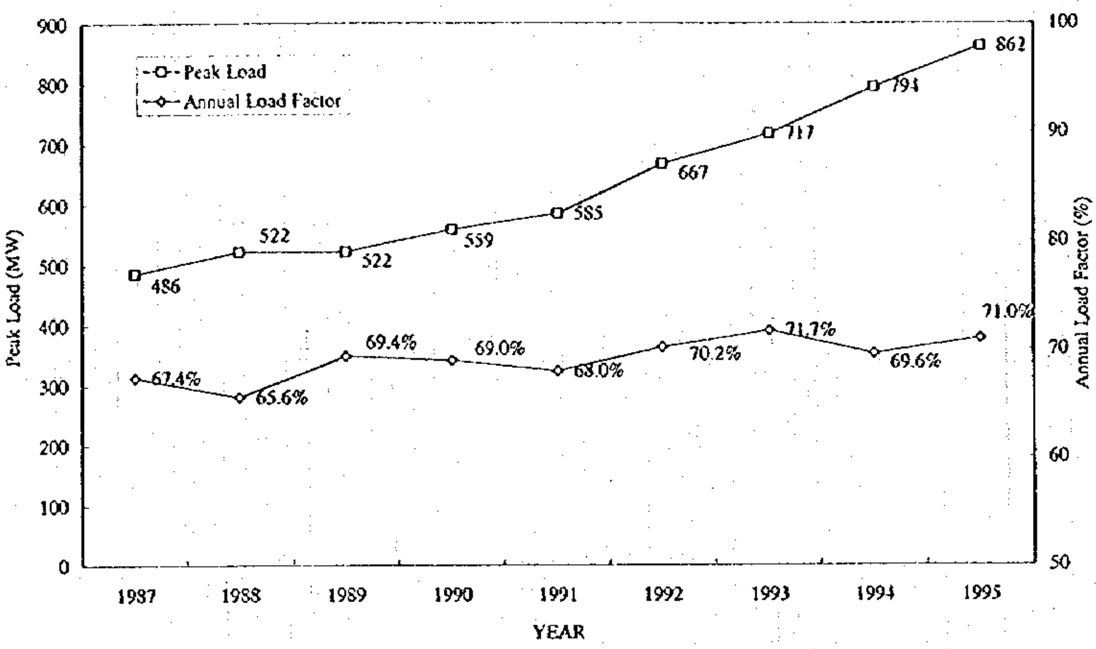


Fig. 3.3-8 Trend of peak load and annual load factor

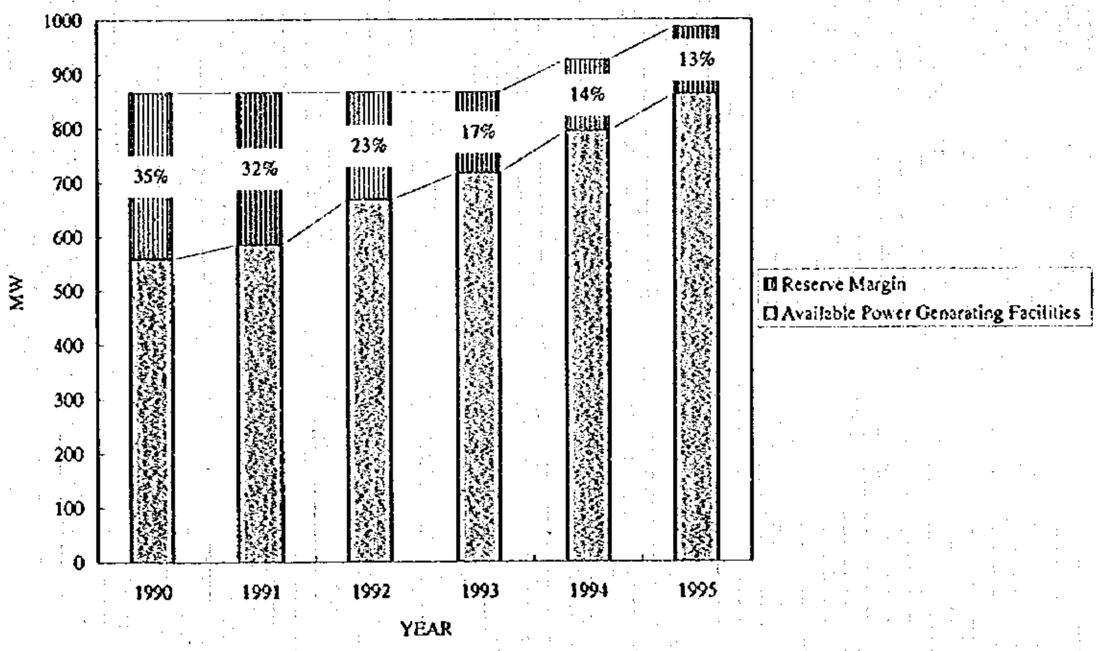


Fig. 3.3-9 Trend of capability marginal (kW)

3.3.3 Electric Power Demand Forecast

In Jordan, all the electric power demand forecast including analysis and evaluation of social situations, economic statistics and trend, technological innovation and other dimensions is undertaken by the NEPCO based on the know-how of its planning staff. Such electric power demand forecast values are used for its long term development plan and long term financial plan (study of electricity tariff), business strategies and other purposes.

The long term electric power demand forecast consists of three kinds of high, medium and low scenarios incorporating the future development of electric power consumption as much as possible. The medium scenario is prepared on the assumption that the economy is continues to undergo not so substantial or moderate growth, while the high and low scenarios are prepared where the economy continues to grow at higher or lower rate than that in the medium scenario.

(1) Demand forecast method

According to the NEPCO, the electric power demand is forecast by classified the electric power demand into similar kinds of consumption patterns. Namely, the demand is classified into the residential, commercial, industrial, water pumping and public street lighting demand groups similarly as in the case of classifying the electricity tariff.

The forecast method of the NEPCO is divided into the following three kinds:

- Marketing method
- Economic approach method
- GOMPERTZ estimation method

(a) Marketing research method

According to this method, hearing survey is carried out by the planning staff through hearing directly from enterprises or Water Resource Authority about the future operation and development plans including marketing strategies. This method is applied for forecasting the big industrial and large scale water pumping power demand.

(b) Economic approach method

According to this method, the relation between the trend in the past data of sold electrical energy and associated economic indicators is converted into a formula and used for forecasting the future electric power demand. This method is applied for forecasting the residential, commercial, service, small scale industrial and water pumping power demand.

(c) GOMPERTZ estimation method

According to this method, the electric power demand is forecast where the growth of demand is predicted to be saturated in future, and the growth rate until reaching saturation is expressed by the following exponential function equation:

$$D = \alpha * \exp[\beta * \exp(\gamma * t)]$$

where D: Energy demand in year t

α : Stationary or saturation value of D at $t = \infty$

β, γ: Constants, both < 0

This method is applied for forecasting the public street lighting.

(2) Conditions assumed for electric power demand forecast

In Jordan, this electric power demand has been forecast by JEA (NEPCO) since June 1995 based on the following conditions assumed for demand forecast:

(a) The load management and effective utilization of energy will be continued in the future as well.

(b) The annual average population increase rate in Jordan will remain within 2 ~ 2.9% by 2010 with the population reaching 6.1 ~ 6.9 million in 2010. Due to return of Jordanian immigrants from overseas countries after the end of the Gulf War, the annual population increase rate is estimated to be 10.3% in 1990 and 6.5% in 1991.

(c) The economic trend should be reflecting in setting the electricity tariff.

(d) The annual average economic growth rate will remain within a range from 2% to 6.5%.

(3) Electric power demand forecast values

The overall electric power demand forecast values (MW and GWh) and growth rate thereof throughout the country are presented in Figs. 3.3-10 and 3.3-11. However, any portion of electric power sent to Syria is not included in these diagrams:

The electric power demand forecast values (GWh) by the categories of consumption are presented in Fig. 3.3-12.

(a) Residential demand

The residential power demand is forecast to grow at an annual average rate of 6.1% in 1995 through 2000 and 4.5% in 2000 through 2005.

Since the increase rate in the number of residential consumers will become lower as closer to 2010, the growth rate of residential demand will also become lower. This reflects the completion of regional electrification projects and slowdown of population increase rate.

(b) Commercial power demand

The commercial power demand is forecast to grow at an annual average rate of 8.0% in 1995 through 2000 and 4.8% in 2000 through 2005.

(c) Industrial demand

The industrial power demand is divided into big and small consumers. The big industrial demand is forecast to grow at an annual average rate of 8.2% in 1995 through 2000 and 3.0% in 2000 through 2005, while the small industrial demand is forecast to grow at an annual average rate of 8.2% in 1995 through 2000 and 4.3% in 2000 through 2005.

(d) Water pumping demand

The water pumping demand is divided into big and small consumers. The big water pumping demand is forecast to grow at an annual average rate of 10.0% in 1995 through 2000 and 10.4% in 2000 through 2005, while the small water pumping demand is forecast to grow at an annual average rate of 4.2% in 1995 through 2000 and 2.0% in 2000 through 2005.

(e) Service demand

The service power demand is forecast to grow at an annual average rate of 5.1% in 1995 through 2000 and 3.0% in 2000 through 2005.

(f) Public street lighting demand

The public road (street) lighting power demand is forecast to grow at an annual average rate of 5.7% in 1995 through 2000 and 3.9% in 2000 through 2005.

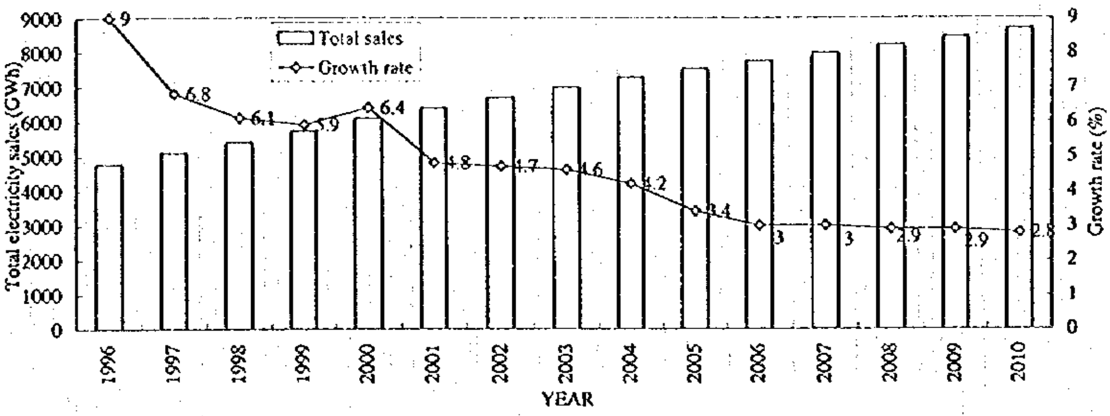


Fig. 3.3-10 Overall electric power demand forecast values throughout Jordan

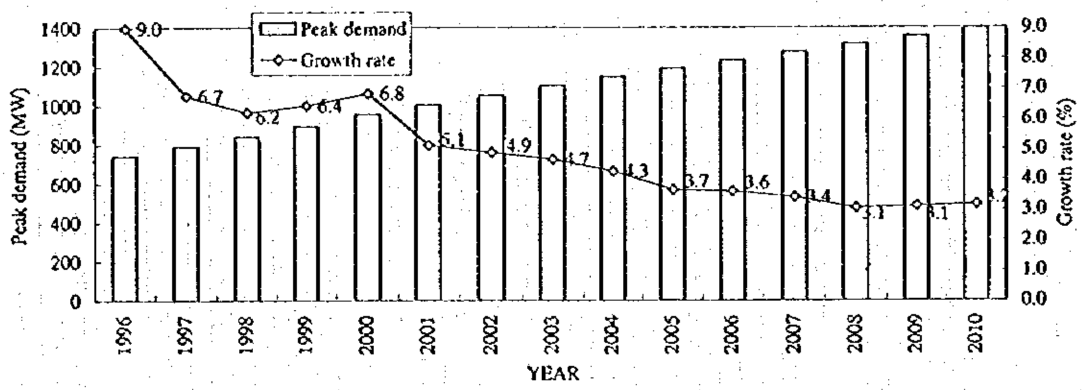


Fig. 3.3-11 Overall peak load forecast values throughout Jordan

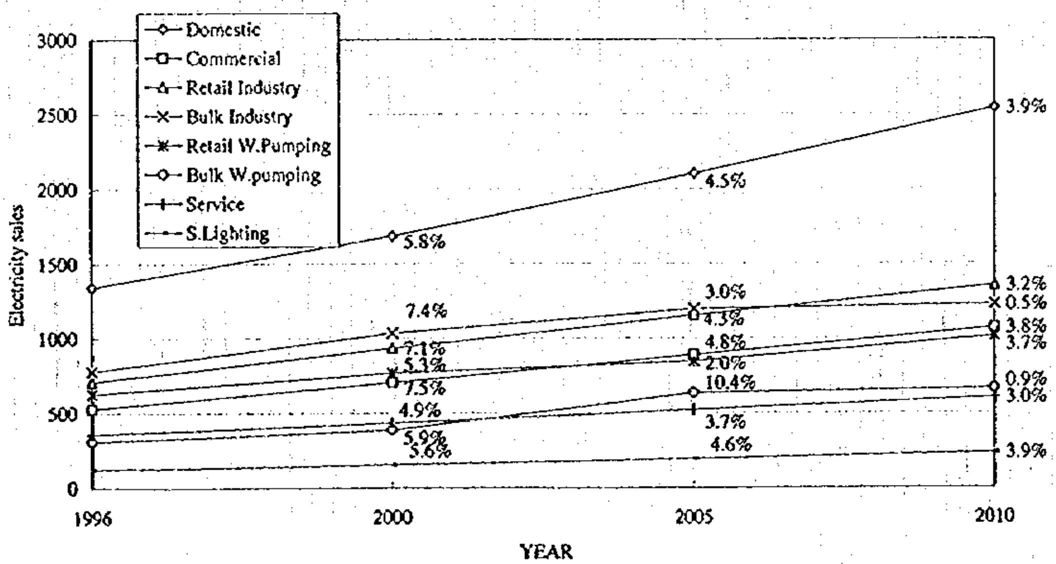


Fig. 3.3-12 Electric power demand by consumption categories

3.4 Electric Power System

3.4.1 Present Situations of the Power Systems and Extension Projects thereof

(1) Present situations of the power systems

The trunk power systems in Jordan are mutually interconnected to the 132 kV transmission lines through the power stations and substations owned by NEPCO throughout the country. Out of a total line length of 2,776 ckt-km, 670 ckt-km is used for interconnection between the Aqaba Thermal Power Station and Amman South Substation through the transmission line with a design voltage of 400 kV. Meanwhile, this transmission line is scheduled to be boosted to 400 kV by the end of 1997. The trunk power systems in Jordan are presented in Fig. 3.4-1.

(2) Power system extension projects

A project has been promoted for interconnecting mutually between Jordan, Egypt, Iran, Syria and Turkey through 400 kV transmission lines in the future. Thereby, the power systems in Jordan are expected to be reinforced by realizing interconnection to Egypt at the southern part and Syria at the northern part of the country.

For the purpose of realizing interconnection between Jordan and Egypt in July 1997, the work for laying submarine cable (AC 400 kV, 300 MW single core 1,000 mm^2 OF cable) has been promoted over a distance of 13.6 km between the Aqaba Bay (water depth: 85 m) in Jordan and Taba on the Sinai Peninsula. To enable interconnection based on a DC system as well, four single core cables are scheduled to be laid.

For the purpose of realizing interconnection between Jordan and Syria by the end of 1997, on the other hand, the technical studies are being carried out by an overseas consultant.

3.4.2 Control System for Power Plants, Transmission Lines, substations and Distribution Lines

The 132 kV transmission lines, power stations, substations including the circuit breakers for 33 kV distribution lines of NEPCO are supervised and controlled from the Control Center installed concurrently within the Amman South Substation. Moreover, the load dispatching services including instruction for startup and shutdown of power stations, electrical energy production and so forth are also carried out from the Control Center.

In the case of JEPCO, the 33 kV, 11 kV and 6.6 kV circuit breakers are controlled from its own Control Center within its head office building. Since any control center is not owned by IDECO, the 33 kV distribution line circuit breakers for its 33 kV distribution lines are controlled from the Control Center of NEPCO.

3.4.3 Power Supply Reliability

The 132 kV power system in Jordan is of a double-circuit configuration, and each main substation is of two-bank configuration. Therefore, the power supply can be ensured even in the event of one circuit or one bank shutdown. Although the 33 kV or lower MV and LV distribution lines are of a one-circuit configuration, the adjacently located distribution lines have been designed respectively so as to enable switching over mutually to and from the other distribution line. Thus, it is possible to supply power from another distribution line in the event of shutdown of one distribution line.

On the other hand, the respective distribution substations are of a one-bank configuration. Thus, when one bank has been shut down, power supply from two or more LV distribution lines receiving power from the corresponding bank will be interrupted. However, in some cases it is possible to supply power from another distribution line by switching over to and from mutually interconnected distribution lines as mentioned above.

3.4.4 System Analysis Method

In the case of NEPCO, system analysis is carried out by using the analysis software, PSS/E developed by Power Technologies (Inc.) of the United States. The available analysis items are as follows:

a. Load flow
b. Balanced and unbalanced fault analysis
c. Network equipment construction
d. Dynamic simulation

3.4.5 Frequency of Power Outage

In Jordan, the frequency of power outage per consumer is 6 hours per year.

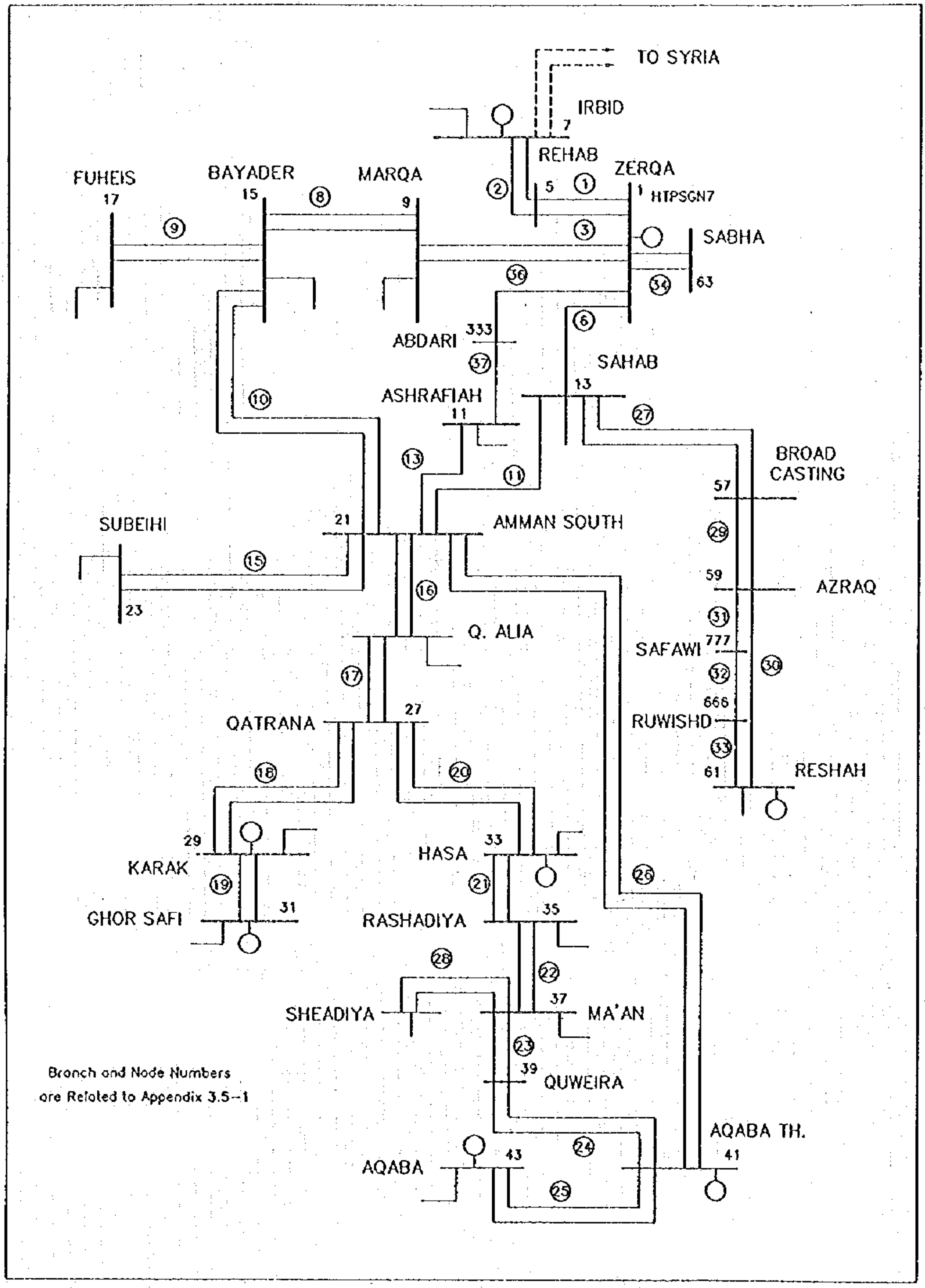


Fig. 3.4-1 Trunk Power System in Jordan

3.5 Transmission and Distribution Systems

3.5.1 Analysis of Power Systems in the Entire Transmission Network

By using the above-mentioned system analysis software PSS/E, system analysis including analysis of power flow is carried out by NEPCO for construction and extension of its power stations, modification of power systems and other purposes As in 1995, the system capacity in Jordan is about 1,000 MVA. The Study Team has carried out power flow analysis by using "CASTLE", a system analysis software, and confirmed the conditions of system stability at the same time. The power flow has been confirmed to become the same as the results of calculation carried out according to PSS/E. Moreover, the difference of the phase angles in the power system has been confirmed to be 17 deg. in maximum (HTPSGN7 and RESHAH) and ensure stable operation (Refer to Appendix 3.5-1).

3.5.2 Operation, Maintenance and Management System

(1) Operation and management of generator (units)

For realizing economically optimum and highly reliable power supply through computer system analysis, the output of generator units and those to be standby are determined or selected from the Control Center of NEPCO in accordance with the load curves. In this case, the results of computer analysis are sent to the generator operation staff.

(2) Maintaining the frequency and voltage at appropriate levels

The frequency and voltage are controlled as follows to maintain the same at appropriate levels:

(a) Frequency

According to the under-frequency relay (UFR), the level of frequency drop is divided into nine stages from the first through the ninth step. In the case of the first step, 4.8% of the total load will be automatically interrupted when frequency drop to 49.1 Hz has continued for 0.4 seconds, and in the case of the ninth stage, 56.9% of the total load be automatically interrupted when frequency drop to 48 Hz has continued for 0.7 seconds.

(b) Voltage

For voltage control, the power capacitor is controlled based on the command from the Control

Center, but the transformer tap is controlled automatically.

(3) Monitoring and control of equipment

From the control center of NEPCO , the load conditions are monitored at 35 positions and circuit breakers for 33 kV or higher voltage substations including those of IDECO are remote-controlled. From the head office of NEPCO, it is also possible to monitor the voltage of 33 kV – 132 kV systems and load conditions (A, kW, and MVA). Meanwhile, the miscellaneous data mentioned above are recorded every 30 minutes and kept for one week.

In case any circuit breaker has been interrupted automatically due to the action of protective relay, the such information will be sent to the control center two seconds after such interruption. In case any 132 kV system has been interrupted automatically due to the action of main protective relay, then the circuit breaker will be reclosed automatically.

From control center of JEPCO, 15 substations are remote-controlled, and the load conditions of MV distribution lines and transformers are monitored.

(4) Maintenance of substation

Although the periodic maintenance of circuit breakers is carried out once a year, the visual inspection of other equipment is carried out once a month.

3.5.3 Load Management System

Similarly as in Japan, NEPCO has positively been promoting leveling of the load by shifting the load in the time zone when peak load arises to that when there is a margin in the generating capacity. According to this policy, many farming pumps are operated actually in the evening as recommended to operate such pumps during the off-peak time zone in the evening particularly in summer. The load has also been conducted to the off-peak load time zone according to the policy for electricity tariff as the consumption of electric power during the time zone when peak load arises is reduced by adopting the three-shift working system in industrial plants and so forth.

3.5.4 Peak Load in Major Substations

The peak load arising in major substations of NEPCO are as presented in Appendix 3.5-2. Although there is an allowance in the equipment capacity as a whole, some substations are overloaded at the time of one bank fault.

3.6 Present Situations of Voltage Drop and Future Tasks for Improvement

(1) Present Situations

According to the present situations in Jordan, it will be necessary to substantially improve the voltages in the low and medium voltage distribution lines. As a result of executing trial calculation of voltage in low voltage distribution line, the voltage is observed to have dropped by as much as 25% or over in some distribution lines.

(2) Future tasks

The common causes of substantial voltage drop in the low and medium voltage distribution lines deemed to be as follows:

- Overloading in long distance distribution lines
- Application of smaller size conductor
- Low power factor

Moreover, the load to low voltage distribution lines is deemed to be excessively unbalanced.

The improvement of voltage will not only be reflected directly to the improvement in the services to consumers but also lead to reduction of power loss. When the situations of voltage drop as mentioned above are taken into consideration, it will be of an urgent necessity to study the situations of voltage drop.

CHAPTER 4

PRESENT SITUATIONS OF ELECTRIC POWER LOSS

CHAPTER 4 PRESENT SITUATIONS OF ELECTRIC POWER LOSS

4.1 Present Situations of the Recorded Data of Power Loss

4.1.1 Actual Situations of Transmission and Distribution Loss Rates

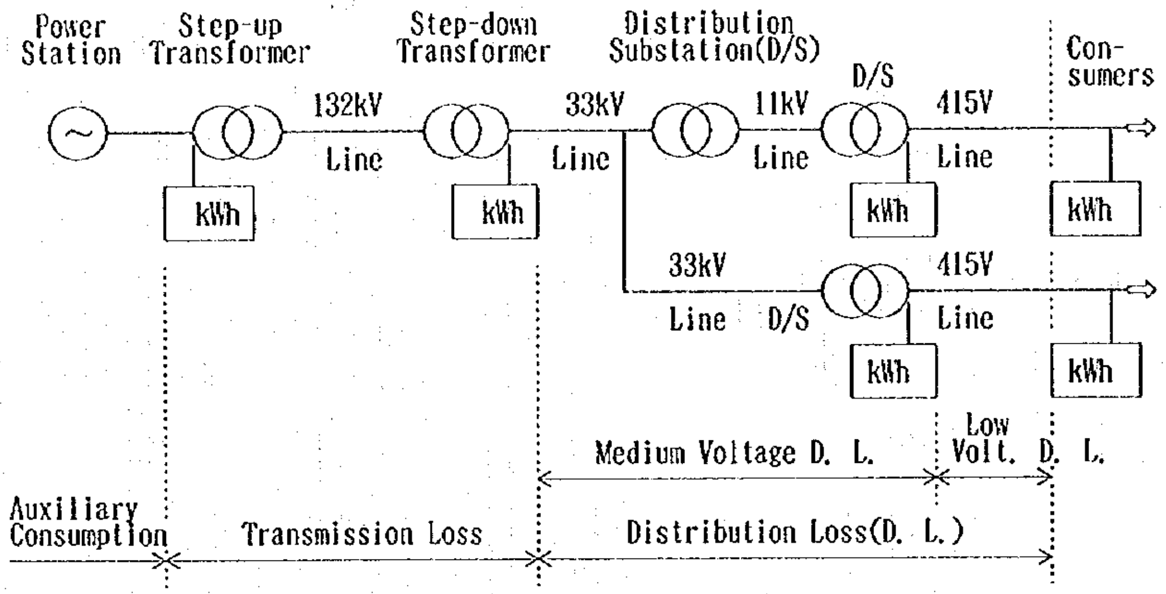
The power losses in the entire power systems throughout Jordan have been clarified by classifying it into:

- Energy lost as auxiliary energy consumption in power plant (Power plant loss);
- Energy lost in the transmission circuits ranging from the primary circuit of step up transformer in power plant to the secondary circuit of step-down transformer in the MV systems (transmission loss); and
- Energy lost between the secondary circuits of major substation and consumers in the LV systems (distribution loss).

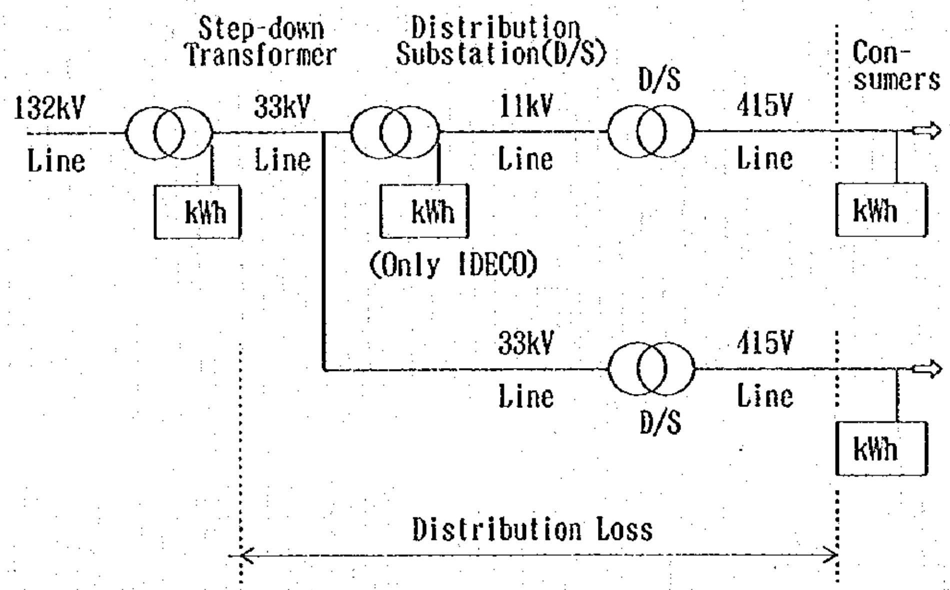
The loss rates expressed in terms of the ratios of energy lost in power plants, transmission and distribution systems to the total energy generated in 1995 are as given below:

Auxiliary energy consumption in PS	:	5.8%
Transmission loss	:	2.0%
Distribution loss	:	7.4%
(Transmission and distribution : network loss:		9.4%)

In Jordan, the voltage is classified into three classes: namely, high voltage (HV: 132 kV), medium voltage (MV: 33 kV, 11 kV and 6.6 kV), and low voltage (LV: 415 V). As the transmission loss refer to a HV loss, the distribution loss refer to a sum of MV and LV losses respectively according to the past records, it is difficult to identify the difference between the MV and LV losses. However, only the NEPCO has been metering the energy respectively in its MV and LV systems. Therefore, the distribution loss in NEPCO system is divided into those in the MV and LV systems. A conceptual diagram of metering the energy is presented in Fig. 4.1-1.



(NEPCO)



(JEPCO & IDECO)

Fig. 4.1-1 Measurement Point of Energy and Loss Classification

4.1.2 Metering Data Related to Power Loss and Analysis thereof

(1) Trend of the overall energy loss rate in the entire power systems in Jordan

The overall energy loss rate including auxiliary power consumption of power stations in the power systems of Jordan has been undergoing little changes at a rate of 15% or over for the past several years as presented in Table 4.1-1. Out of this total loss, the auxiliary energy consumption in power plants is roughly 6%, and the transmission loss is more or less than 2%. Therefore, the majority of network loss is estimated to occur on the distribution side.

When the energy loss on the distribution side is viewed by the respective power companies, the distribution loss of NEPCO is more or less than 14%, and that of IDECO is 13% or over, and tends to be on the increase in the case of both companies. Although the distribution energy loss of JEPCO reached as high as 16% two decades before, the energy loss has been lowered gradually and recently improved to 8% or over.

(2) Trend of the energy loss rate in MV and LV systems

In the case of NEPCO, the energy sent out to MV system and that sent out to the LV system are respectively metered. Consequently, the energy loss rate in the MV system and that in the LV system have been clarified individually. According to the metering data in fiscal 1995, the overall rate of energy loss in both the MV and LV systems is 15.05%. While the energy loss rate in the MV system is as low as 5.01%, that in the LV system is so high as even 10.57%.

The highest distribution loss rate among those in the respective supply areas of NEPCO is 20.73% in Jordan Valley followed by Ma'an(17.18%), Tafila(16.19%) as presented in Table 4.1-2. It can be said as a whole that the energy loss rate in the LV system tends to be higher than that in the MV system.

Judging from the actual situations of the distribution loss rate as mentioned above, the countermeasures for reducing the network loss will be studied preferentially for reducing the loss on the distribution system side under this Study. Therefore, the representative distribution systems have been selected as described later.

Table 4.1-1 TENDENCY OF LOSS RATE (%)

YEAR	DISTRIBUTION JEPCO	DISTRIBUTION IDECO	DISTRIBUTION JEA	DISTRIBUTION SUBTOTAL	TRANS MISSION	POWER STATION	TOTAL LOSS %
1975	15.97						
1976	14.93						
1977	13.33						
1978	9.70						
1979	11.06						
1980	8.55						
1981	10.48						
1982	9.76						
1983	10.11						
1984	9.71						
1985	8.33						
1986	9.92						
1987	9.36						
1988	9.40		12.96				
1989	9.45		14.35	10.30	1.66	6.62	15.85
1990	8.92		12.97	9.93	2.40	6.63	15.74
1991	10.93		13.89	10.77	2.14	6.60	16.27
1992	9.50	13.17	14.32	10.88	1.90	6.55	15.81
1993	9.83	13.30	13.08	11.19	1.81	6.48	15.79
1994	8.56	13.33	14.42	10.59	1.62	6.06	15.09
1995	8.55	13.53	15.05	10.48	2.36	5.82	15.65

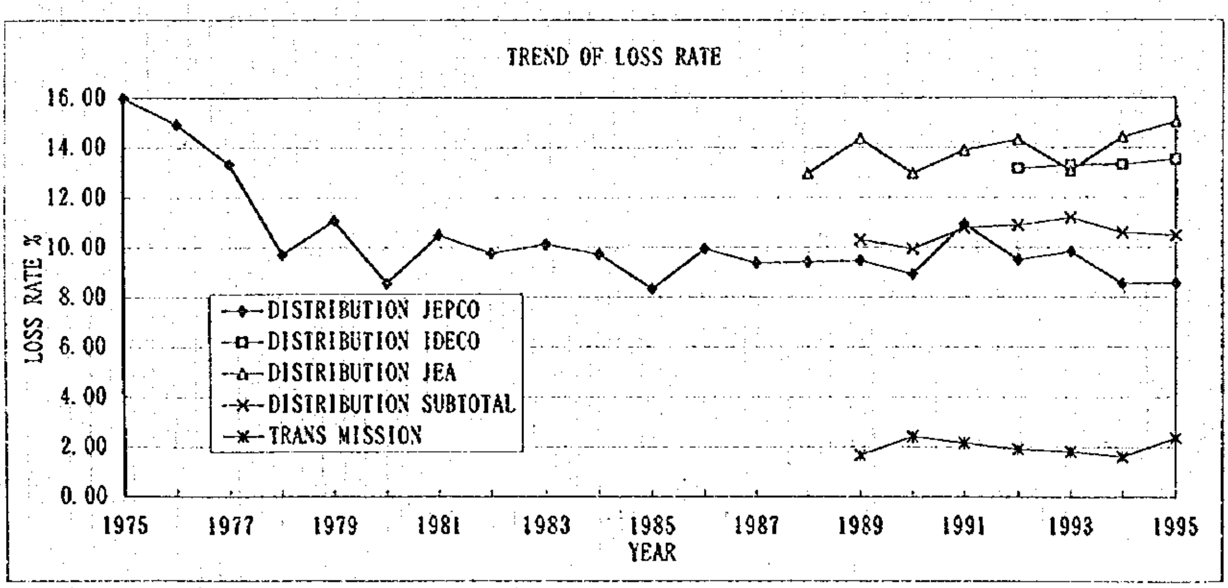
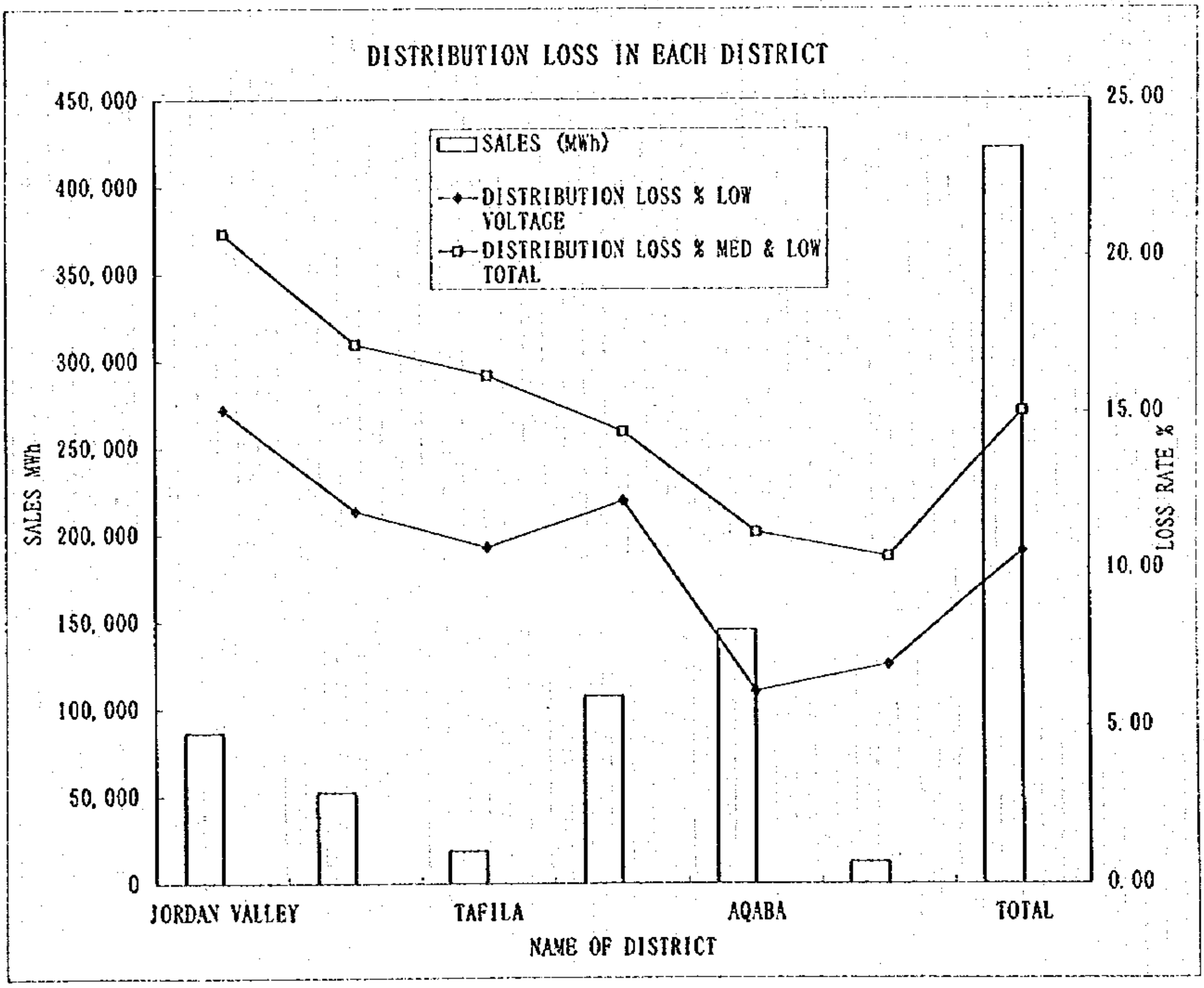


Table 4.1-2 ENERGY LOSS RATE OF EACH DISTRICT IN JEA IN 1995

DISTRICT	SENT OUT (MWh)	SALES (MWh)	DISTRIBUTION LOSS %		
			MEDIUM VOLTAGE	LOW VOLTAGE	MED & LOW TOTAL
JORDAN VALLEY	108,842	86,281	6.63	15.10	20.73
MAAN	62,965	52,146	6.05	11.85	17.18
TAFILA	22,398	18,771	6.14	10.71	16.19
KARAK	125,376	107,327	2.52	12.19	14.40
AQABA	163,580	145,268	5.40	6.12	11.19
EASTERN AREA	13,667	12,246	3.69	6.96	10.40
TOTAL	496,828	422,039	5.01	10.57	15.05



4.2 Measurement of Representative Power Systems for Analyzing the Prevailing Situations

4.2.1 Selection of the Representative Power Systems

In extending this study, it is important to clarify the location and rate of the network losses arising in the power systems in Jordan. Consequently, the distribution energy loss in the representative systems was measured preferentially to identify the locations of power loss, namely, to classify the energy loss into those arising in the MV and LV systems. At the same time, consideration has been given to make it possible to clarify the outline of the transformer loss in distribution substation included in the MV system and the service wire loss included in the LV system.

Substantially much time and enormous labor would generally be required where the energy loss is to be measured highly accurately for clarifying the location of distribution loss. For efficiently promoting this study, therefore, the power systems representing the entire systems were selected, and the measurement have been carried out to estimate the distribution of overall power losses.

For promoting clarification of the prevailing situations of network losses, the data available in Jordan were basically used. However, the data for the distribution loss have not sufficiently been available although the data for transmission loss are sufficient. To cover the shortage of such data, the measurement have been executed. In the light of the necessity to complete the measurement within the period of this study, the representative power systems were selected from among the entire power systems in Jordan, and the measurement have been carried out to clarify the locations of power losses.

In consideration that the distribution loss data by supply areas and voltage classes have already been owned by the NEPCO as described in Clause 4.1, the representative power systems were selected from the distribution systems of the IDECO and JEPCO. Meanwhile, distribution loss have been clarified in the case of both of the power companies, and since the loss in MV system can easily be identified where that in the LV system can be clarified, the representative systems have been selected only from the LV systems. Moreover, the representative system were selected taking into account the following requirements

- The distribution system selected should adequately represent the features of the entire systems in Jordan;

- It should be possible to measure the energy being sold to any consumer connected to the representative systems for measurement separately from any other system.
- Any representative system should never be switched over during the measurement period.

The system which would meet such conditions as mentioned above is extremely limited. As a result, it could not necessarily be said that any representative system truly represents the entire power systems in Jordan as initially intended. However, the following four systems recommended by the Jordanian counterpart have been selected as the representative systems.

The representative system of JEPCO	– West Thcheeba substation – Abu–Zeghan substation
The representative system of IDECO	– Juhfia substation – AL Rafeed substation

4.2.2 Method and Schedule of Measurement

With regard to the representative systems selected as mentioned previously, the power loss measurement was carried out by using the following two techniques for clarifying the causes and locations of power losses.

The first is a direct technique of directly measuring the energy sent out of the distribution substation in the representative system and the kWh readings of energy sold to the respective consumers connected to the representative system.

According to this method, the distribution loss rate is obtained from the following formula:

Distribution loss rate = [Ws – Wc]/Ws x 100 (%)

where Ws: Energy sent out of transformer

Wc: Sold electrical energy

By executing continuous measurement for one year, it is possible to minimize the errors that might be occurred by reading time difference between watt-hour meter of consumers and watt-hour meter of distributions. Since the measurement period was so limited that continuous measurement for one year was impossible under this study. For improving the measurement accuracy as much as possible, therefore, the measurement was started at the time of the first field investigation carried out continuously for five months.

The second is an analytical technique wherein the current, voltage and so forth are measured during specified time, and the power losses arising in the distribution line and transformer are obtained based on system analysis and other means by using the above miscellaneous measurement values.

Although the power loss at specified time was measured according to this analysis method, analysis was carried out after converting the current values measured based on the duration curve and other load characteristics into those at the time of peak load.

As a result, the energy loss (kW) at peak load is obtained according to this method. The coefficient for converting the kW loss at peak load into the kWh loss called a loss factor is calculated according to the following formula, from which the yearly energy loss can be obtained:

Yearly energy loss (kWh)

= [Energy loss (kW) at peak load] x [8,760 (hr.)] x P

where P: Loss factor

As a loss factor, the empirical formula of Buller-Woodrow

$P = 0.7f^2 + 0.3f$ (where f: Load factor) is used.

(1) Measurement method

Although the two direct and analysis techniques are available for clarifying the power losses as mentioned previously, the measurement method are also different depending upon the respective methods as described below:

(a) Measurement of loss in LV system

The power loss in LV system has been measured based on the direct method. As presented in Fig. 4.2-1, the energy in the secondary circuit (Point A) of distribution transformer and that sold to consumer (Point B) connected thereto have been measured during a same period, and the distribution loss in LV system including that in service wire has been obtained by calculating the difference between the energy at Point A and that at point B.

In the light of the necessity to perform continuous measurement for as long a period as possible including August when the peak of demand arose, this measurement had been carried out for five months from April through to August (1996). The metering instruments used for measurement were the watt-hour meters for the secondary circuit of distribution transformer and those installed at the respective consumers for calculating the electricity rate. In other words, the energy (kWh) in the secondary circuit of distribution transformer and that sold to the respective consumers were measured. As the sold electrical energy, the values read normally by meter-men were adopted. One of measurement system of representative power system is presented in Fig. 4.2-1.

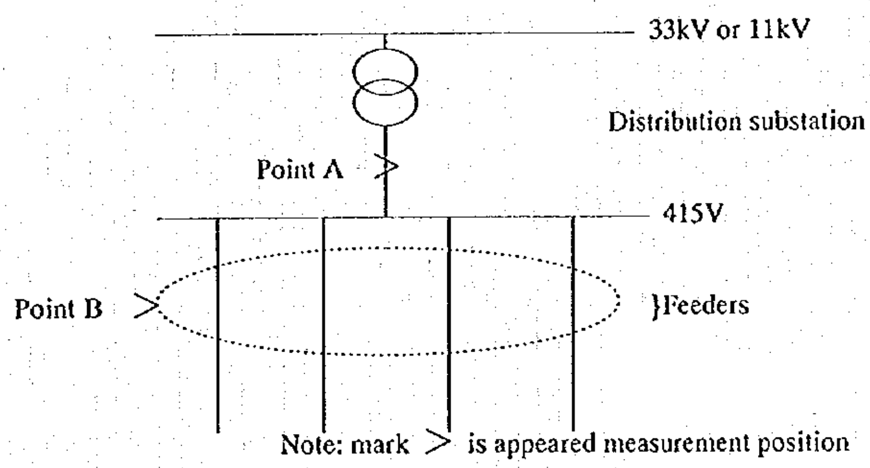


Fig. 4.2-1 Measurement system of representative power system (1)

(b) Measurement for estimating the transformer loss in distribution substation

The transformer loss in distribution substation has been estimated based on the analysis method. For this purpose, this measurement was carried out in August when peak load arose during the measurement period mentioned above according to the following method:

1) As presented in Fig. 4.2-2, the measurement was carried out by installing a load analyzer to the secondary circuit of transformer at Point C.
2) To clarify the changes of system conditions on weekday and holidays, the measurement was carried out just at every hour for a measurement period of three days including holiday (Friday) per system.

3) The load analyzer was used for the measurement.

4) The miscellaneous measurement quantities are the power (kW) sent out to the secondary circuit of transformer, bus voltage and the power factor in the secondary circuit of transformer.

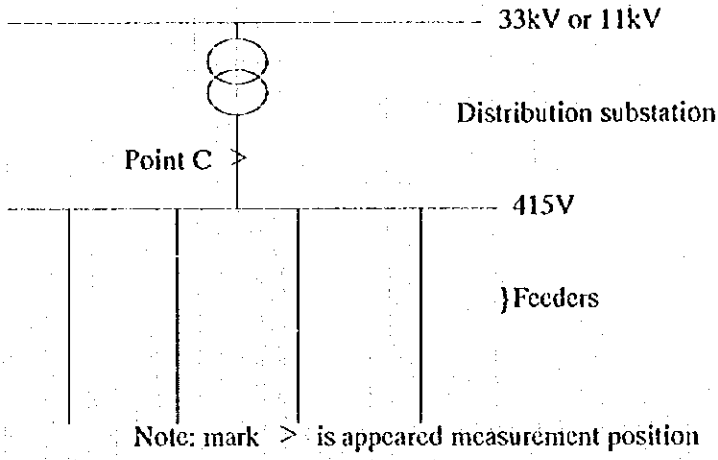


Fig. 4.2-2 Measurement system of representative power system (2)

(c) Measurement for estimating the service wire loss

For estimating the service wire loss, the measurement was carried out according to the analysis method.

1) The measurement was carried out by using a clip-on meter at Point D as presented in Fig. 4.2-3.

2) This measurement was carried out once per each service wire in August when peak load arose.

3) The miscellaneous measurement quantities are service wire current values, conductor size and distance of the service wire.

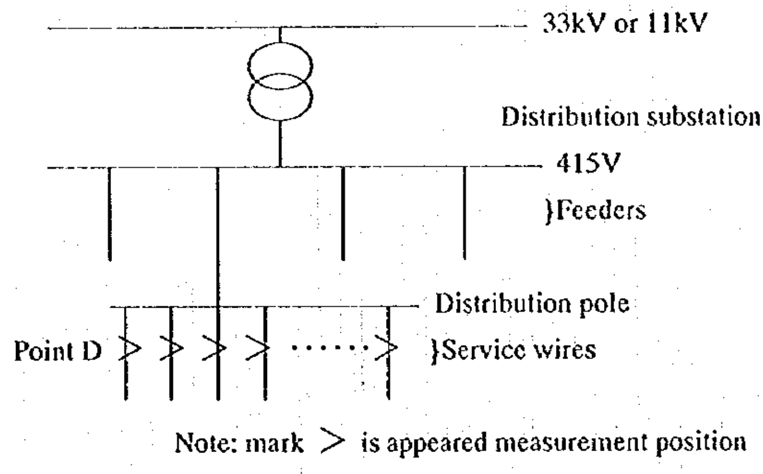


Fig. 4.2-3 Measurement system of representative power system (3)

4.2.3 Results of Measurement

(1) Distribution loss in LV system

Presented in Table 4.2-1 are the total values of the results of measuring the energy in the transformer secondary circuits of the representative power systems of IDECO and JEPCO for five months as well as those of measuring the energy sold to the respective consumers. However, the measurement results in the case of JEPCO (West Theheeba and Abu-Zeghan) are based on the four months' values.

Table 4.2-1 Results of measuring the energy of representative system

(1) Juhfia

Supplied energy from the transformer secondary circuits (A)	Sold energy to the consumers (B)	Energy loss (C=A-B)	Loss rate (C/A*100)
225,850 kWh	195,734 kWh	30,116 kWh	13.3 %

(2) Al-Rafeed

Supplied energy from the transformer secondary circuits (A)	Sold energy to the consumers (B)	Energy loss (C=A-B)	Loss rate (C/A*100)
242,062 kWh	227,534 kWh	14,528 kWh	6.0 %

(3) West Theheeba

Supplied energy from the transformer secondary circuits (A)	Sold energy to the consumers (B)	Energy loss (C=A-B)	Loss rate (C/A*100)
126,240 kWh	120,654 kWh	5,586 kWh	4.4 %

(4) Abu-Zeghan

Supplied energy from the transformer secondary circuits (A)	Sold energy to the consumers (B)	Energy loss (C=A-B)	Loss rate (C/A*100)
129,847 kWh	109,093 kWh	20,754 kWh	16.0 %

(2) Transformer loss in distribution substation

The results of measuring the power (electrical energy) and power factor, current and phase-to-phase voltage in the secondary circuits of distribution substations of the representative systems are as presented in Appendixes 4.2-1 ~ 4.2-4. These charts are presented Appendixes 4.2-6 ~ 4.2-9.

(a) Results of measurement

1) The difference of the fluctuation of demand in the LV system on weekdays and holidays is small. Moreover, the timely change of power factor is not large and remained at roughly constant values. However, the power factor is considerably inappropriate, as the average of those at three substations is not more than 0.8 with the lowest being 0.77 at the West Theheeba Substation.

2) The balance of the respective phase current values is generally large although the values vary depending on the areas. Therefore, the neutral line current was observed to be roughly equal to the main line current in some cases.
The smallest and largest unbalance factors of the respective phase currents at peak load are 0.11 for West Theheeba and 0.62 for Abu-Zeghan, while the smallest and largest neutral line currents are 41 (A) for West Theheeba and 85 (A) for Abu-Zeghan, respectively.

3) The line voltage is well balanced between the respective phases.

4) The voltage drops substantially during the time zone when the load is high in the evening. The largest voltage drop is 12% of the rated voltage of 415 V in the case of West Theheeba.

In the case of the representative power systems, the difference in the trend of load on weekday and holidays is not so large; the timely fluctuation of power factor is small; and the voltage drops substantially at peak load as mentioned previously.

Judging from these facts, the three-days' mean values at peak load are used for analysis. In consideration that these three-days mean values at peak load are based on the results of measurement on intensely hot days in August 1996, these values were used for analysis on the assumption that these are maximum values throughout a year. Presented in Table 4.2-2 are the respective mean values of the power demand, power factor, respective phase currents, and line voltage in the four representative power systems for three days during the measurement period.

Table 4.2-2 Results of measuring the representative power systems

	Juhfia	Al-Rafeed	W. Theheeba	Abu-Zeghan
Peak demand (kW)	129.33	134.03	137.13	76.42
Mean values of power factor	0.781	0.852	0.769	0.773
Current of phase A (A)	200.5	210.8	293.3	189.5
Current of Phase B (A)	246.3	273.7	264.0	156.1
Current of phase C (A)	84.7	245.7	263.3	98.5
Current of neutral (A)	76.9	47.1	41.0	84.5
Unbalance factor	0.345	0.258	0.110	0.615
Line voltage of phase A to B (V)	394.9	384.8	373.3	385.4
Line voltage of phase B to C (V)	392.5	381.3	377.4	386.8
Line voltage of phase C to A (V)	393.4	382.1	372.2	385.0

(b) Calculation of electrical power and energy losses in transformer

By using the above measurement data, the electrical power and energy losses in transformers have been calculated as presented in Table 4.2-3 below:

Table 4.2-3 Power loss in transformers of the representative power systems

	Juhfia	Al-Rafeed	W. Theheeba	Abu-Zeghan
Peak demand (kW)	129.33	134.03	137.13	76.42
(kVA)	165.60	157.32	178.33	98.86
Energy in secondary circuit of transformer (kWh)	805,532	834,806	854,114	475,953
Transformer Capacity (kVA)	250	250	250	200
Core loss (kW)	0.510	0.510	0.510	0.463
Copper loss (kW)	2.248	2.248	2.248	1.853
Yearly core loss(kWh)	4,467.6	4,467.6	4,467.6	4,055.9
Yearly copper loss (kWh)	4,900.9	4,422.9	5,683.1	2,249.5
Yearly transformer loss (kWh)	9,368.5	8,890.5	10,150.7	6,305.4
(%)	1.15	1.05	1.17	1.31

where,

[Energy in secondary circuit of transformer (kWh)] = (Peak load) x {Load factor (= 0.711)} x 8,760

[Yearly copper loss (kWh)] = [{Copper loss (kW) x A x A x {Loss factor (= 0.5672)} x 8,760]

A = [Peak load (kVA)]/[Transformer capacity (kVA)]

(3) Power loss in service wire

(a) Results of measuring the power loss in service wire

The results of measuring the distribution loss in service wire are presented in Appendix 4.2-5.

(b) Calculation of energy loss in service wire

By using the results of measuring the current in service wire, the energy loss per Wh of load energy (Wh/Wh) flowing in conductor has been calculated as follows:

[Energy loss] =(Current value)^2 x (Conductor resistance) x (Loss factor) x 8,760 (Wh)

[Energy load]=(Measured current) x (Line-to-ground voltage) x (Power factor) x (Yearly load factor) x 8,760 (Wh)

The calculated energy loss (Wh) per energy load (Wh) in service wire is as listed in Appendix 4.2-5 and the mean values in the respective substations are as presented in Table 4.2-4.

Table 4.2-4 Mean values of energy loss in service wires

Substation	Juhfia	Al-Rafeed	West-Theheeb
Energy loss per energy load %	0.03	0.059	0.155

The energy loss in service wire is quite small when compared with that in the LV system as clear from the above values. Therefore, this energy loss is judged to be negligible.

4.3 Distribution of energy Loss in the Representative Systems

(1) Energy loss in service wire

As indicated the values in Table 4.2-4, the energy loss in service wire is so small that it can be neglected.

(2) Energy loss in distribution line

As presented in Table 4.2-1, 4.4 ~ 16 % of the energy supplied through a distribution transformer is lost in the LV distribution line.

Juhia	13.3%
Al-Rafeed	6.0%
West Theheeba	4.4%
Abu-Zeghan	16.0%
Average	9.9%

(3) Energy loss in distribution transformer

As presented in Table 4.2-3, 1.1 ~ 1.3 % of the energy supplied to a distribution transformer from the MV system is lost in the distribution transformer.

Juhia	1.2%
Al-Rafeed	1.1%
West Theheeba	1.2%
Abu-Zeghan	1.3%
Average	1.2%

Therefore, roughly 1.2% is considered to constitute the energy loss in distribution transformer based on the received energy.

4.4 Distribution of Energy Loss in Jordan

The total energy generated throughout Jordan in 1995 was 5,365 GWh. Out of this total, 4,525 GWh was actually sold. The total energy loss was 840 GWh and corresponds to 15.65% of the total generated electrical energy. Meanwhile, the distribution of power loss in Jordan in 1995 is presented in Table 4.4-1.

(1) Energy loss in the transmission systems

Out of 4,612 GWh of energy transmitted through the 132 kV systems, 109 GWh or equivalent to 2.0 % of the total generated energy was lost in 1995.

(2) Energy loss in the distribution systems

The energy sent through the distribution systems in Jordan in 1995 was 3,768 GWh. Out of this total, the sold energy was 3,373 GWh and the network energy loss was 395 GWh or equivalent to 7.4% of the total generated electrical energy. Out of 395 GWh of energy loss, 117 GWh (2.2%) is estimated to have been lost in the MV systems. And 278 GWh (5.2%) is estimated to have been lost in the LV systems. Refer to Table 4.4-1 and Appendix 4.4-1.

Meanwhile, 1.2% of distribution transformer loss based on the received energy described in Section 4.3 corresponds to 0.8 % of that based on the total generated energy.
The figure can be obtained by following equation:

$$Tlossrate2=Tloss/Generation$$

$$Tlossrate1=Tloss/(Sales+LVloss+Tloss)$$

$$Tloss=Tlossrate1 \times (Sales+LVloss+Tloss)$$

$$Tloss(1-Tlossrate1)=(Sales+LVloss) \times Tlossrate1$$

$$Tloss=(Sales+LVloss) \times Tlossrate1/(1-Tlossrate1)$$

$$Tlossrate2=((3,373+278) \times 0.012)/(1-0.012))/5,365$$

$$=0.00827$$

where Tlossrate1 : Transformer loss rate based on the received energy
Tlossrate2 : Transformer loss rate based on the generated energy
Tloss : Transformer loss
LVloss : Loss in the LV system
Sales :Retail sales energy

Network energy losses in 1995 are summarized as follows:

Transmission loss			2.0%
Distribution loss	MV system	Line	1.4%
		Transformer	0.8%
	LV system		5.2%
Total network loss			7.4%

In the light of the above data of energy loss, it can be said that the loss rate in the LV systems tends to be high as a whole. In consideration of such actual situations of loss rate, it would be essential to place a priority on the countermeasures for reducing the power loss in the LV systems under this study.

Table 4.4-1 Estimation of Energy Flow

- Applying Results of Measuring the Electrical Energy of Representative System

Gene.	Aux. Cons.	Supplied to MV Systems	Sent out to Industrial & Others	Sold Energy to Industrial & Others	Sent Out to Retail Sale	Retail Sale	Loss Rate of Aux. (%)	Loss Rate of T/M (%)	Loss Rate of Line to Industrial & Others (%)	Loss Rate of Distribution %		Loss Rate Total (%)
										MV Part	LV Part	
*1	*1	*2	*2	*2	*1	*1	*1			*3	*3	
5,365	312	4,944	1,176 (Wmm)	1,152 (Wcm)	3,768 (Wml)	3,373 (Wcl)	5.8	2.0	0.4	2.2	5.2	15.66

Note *1 : JEA's 1995 Annual Report (P28) Note *2 : Estimated from JEA's 1995 Annual Report (P28) Note *3 : Estimated Value