THE FEASIBILITY STUDY
ON
THE LOSS REDUCTION PROJECT
OF
DISTRIBUTION NETWORK
IN
THE HASHEMITE KINGDOM OF JORDAN

FINAL REPORT

(Summary)

DECEMBER 2000

JAPAN INTERNATIONAL COOPERATION AGENCY

TOKYO ELECTRIC POWER CO., INC.
TOKYO ELECTRIC POWER SERVICES CO., LTD.

Preface

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

JICA sent a study team led by Mr. Takahashi of Tokyo Electric Power Company, Inc. and organized by Tokyo Electric Power Company Inc. and Tokyo Electric Power Service Company Ltd. to the Hashemite Kingdom four times from September 1999 to October 2000.

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

I hope this report will contribute to the rehabilitation of distribution network for power loss reduction and to the promotion of amity between our two countries.

I also express my sincere appreciation to the officials concerned of the Government of Hashemite Kindom of Jordan for their close cooperation throughout the study.

December 2000

Kunihiko SAITO
President
Japan International Cooperation Agency

December 2000

Mr. Kunihiko Saito
President
Japan International Cooperation Agency
Tokyo, Japan

Letter of Transmittal

We are pleased to submit you the report of Feasibility Study on Electric Power Loss Reduction of Distribution Network in the Hashemite Kingdom of Jordan.

This study was conducted by the joint venture of Tokyo Electric Power Company Inc. and Tokyo Electric Power Service Company Ltd., under a contract to JICA, during the period of from September 6, 1999 to December 21, 2000. The major contents of the report are the technically and economically feasible rehabilitation plans of target distribution networks for power loss reduction in the Hashemite Kingdom of Jordan.

We trust that realization of the study will much contribute to enhance the power losses in the distribution network and to improve system efficiency. In view of urgency to enhance electric system efficiency by power loss reduction, we recommend that the Government of Hashemite Kingdom of Jordan take this study as a highest priority.

We wish to take this opportunity to express our sincere gratitude to the officials concerned of JICA, Ministry of Foreign Affairs and Ministry of International Trade and Industry. We would also like to express our gratitude to the officials concerned of Ministry of Planning, Ministry of Energy and Mineral Resources, NEPCO, JICA Jordan Office and Embassy of Japan in the Hashemite Kingdom of Jordan for their cooperation and assistance throughout our field survey.

December 21, 2000

Akira Takahashi

Akira TAKAHASHI
Leader of Feasibility Study on the Loss Reduction Project of Distribution Network in the Hashemite Kingdom of Jordan

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ABBREVIATIONS

ACSR	:	Aluminum Conductor Steel Reinforced
b/d	:	barrel per day
boe/d	:	barrel oil equivalent per day
CEGCO	:	Central Electricity Generation Company
CIF	:	Cost-Insurance & Freight
DSM	:	Demand Side Management
ECU	:	Euro Currency Unit
EDCO	:	Electricity Distribution Company
EIRR	:	Economic Internal Rate of Return
EU	:	European Union
FIRR	:	Financial Internal Rate of Return
FOB	:	Free on Board
GDP	:	Gross Domestic Product
GEF	:	Global Environmental Facility
GIS	:	Gas Insulated Switchgear
GWh	:	Giga Watt-hour (10^6 kWh)
HV	:	High Voltage (400 kV, 230 kV, 132kV and 66kV in Jordan)
HAL	:	Hard-drawn Aluminum Conductors
IDECO	:	Irbid District Electricity Company
IEC	:	International Electro-technical Committee
IRR	:	Internal Rate of Return
ISO	:	International Standards Organization
JD	:	Jordan Dinar
JEA	:	Jordan Electricity Authority
JEPCO	:	Jordan Electric Power Company
JICA	:	Japan International Cooperation Agency
LF	:	Load Factor
LOLP	:	Loss of Load Probability
LRAIC	:	Long Run Average Incremental Cost

LRMC	:	Long Run Marginal Cost
LV	:	Low Voltage (415/240 V in Jordan)
MCC	:	Marginal Capacitor Cost
MEC	:	Marginal Energy Cost
MEMR	:	Ministry of Energy and Mineral Resources
mteo	:	million tons of equivalent oil
MV	:	Medium Voltage (33 kV, 11kV and 6.6kV in Jordan)
MVA	:	Mega Volt Ampere
MVar	:	Mega Volt Ampere (Reactive Power)
MW	:	Mega Watt
NEPCO	:	National Electric Power Company
NPV	:	Net Present Value
O & M	:	Operation and Maintenance
PLC	:	Power Line Carrier
PSS/E	:	Power System Simulator for Engineering (published by PTI, USA)
RCC	:	Regional Control Center
RTU	:	Remote Terminal Unit
SCADA	:	Supervisory Control and Data Acquisition
T & D	:	Transmission and Distribution
VHF	:	Very High Frequency

1. Background of the Study

The total amount of generation capacity of the Hashemite Kingdom of Jordan (hereinafter referred to as Jordan) in 1995 and 1998 was 1167.3 MW and 1670.4MW respectively. Peak demands were 894MW in 1995 and 1060MW in 1998, growing rapidly at an average annual growth rate of 9.3%. Thermal power is the main source of energy in Jordan with the ratio of generation capacity being close to 100%. As a country heavily dependant on imported fuels, reduction in generation fuel consumption costs as well as conservation of natural resources and prevention of environmental pollution are all urgent issues which need to be addressed.

As a solution, the Government of Jordan is paying close attention to the power loss reduction project and promoting it's implementation. Considering these factors and in response to the request of the Government of Jordan, the Government of Japan dispatched a study team from the Japan International Cooperation Agency (hereafter referred to as JICA) from 1996 to 1997 to conduct "The Study on Electric Power Loss Reduction of Transmission and Distribution Networks in the Hashemite Kingdom of Jordan : Master Plan (M/S)."

The results of the study indicated that as transmission and substation loss reduction could expect few economic merits, a detailed study on loss reduction in middle and low voltage distribution networks was required with the following three loss reduction plans proposed:

(1) Improvement of 3-phase unbalanced currents
(2) Power factor correction by installing capacitors in low voltage distribution networks
(3) Installation of new feeders based on the aforementioned study

JICA experts were dispatched from 1997 to 1998 to provide the distribution system improvement plans on the following two measures:

(1) Improvement of 3-phase unbalanced currents
(2) Power factor correction by installing capacitors in low voltage distribution networks

Detailed improvement measures were proposed and the technology transfer was performed (these two measures could be implemented at relatively low cost).

Based on the above mentioned, the government of Jordan requested that the government of Japan formulate technically and economically feasible plans for conducting the third remaining power loss reduction measure on first stage feeders for electric power loss reduction. The government of Japan, through JICA, then determined the implementation of this Project after dispatching a preliminary study team in December 1998; discussing with relevant local authorities it's implementation as well as carrying out field surveys and

collection of data and information.

On December 17, 1998, the JICA Preliminary Study Team and NEPCO reached an agreement on the "Scope of Works (S/W) and Minutes of Meeting (M/M) for the Feasibility Study on Electric Power Loss Reduction of Distribution Networks in the Hashemite Kingdom of Jordan" in confirmation of the terms of reference, the scope of work and the schedule of the main study through discussions with the local authorities concerned. The government of Japan then decided, based on the S/W and M/M, to carry out the full-scale implementation of this plan entrusting the study to JICA. The study area covers the whole area of Jordan. The number of target feeders for the first stage is approximately 400. The study also includes the transfer of technical knowledge on the feasibility study methodology in order to execute the study for improvement and reinforcement of the networks in the second and third phases by Jordanian engineers.

2. Contents of the Study

2.1 Objectives of the Study

As a country heavily dependant on imported fuels, Jordan is focusing on measures for power loss reduction from the viewpoint of reduction of fuel related costs, conservation of energy and prevention of environmental pollution. Jordan views the energy loss reduction plan as important in these terms and from 1996 to 1997 “The Study on Loss Reduction of Transmission and Distribution Networks in the Hashemite Kingdom of Jordan : M/S” was carried out on the nationwide power system.

The objectives of this study were to formulate technically and economically feasible plans to improve and reinforce the distribution network at the first stage for electric power loss reduction based on the recommendations of the M/S. At the same time, the study also serves to transfer technical knowledge intended for succeeding studies and enables Jordanian engineers to achieve independently the improvement and reinforcement of the distribution networks for the second and third phases.

2.2 Items of the Study

It was decided to hold two seminars during the field investigation period in Jordan for a wider range of senior executives in order to recognize the methodology of the study and importance of executing the project. Manual compilation on F/S study methodology was also taken up as a significant item of importance for enabling local counterparts to incorporate the method of study.

The study items are as presented below:

(a) Data acquisition for power supply facilities in the study area including 33kV, 11kV, 6.6kV, 415V feeders and 33kV/415V substations (data in 132kV feeders and 132/33kV substations also necessary in view of introduction of higher voltage system.)

(b) Estimation of energy sales in the study area including review of existing data

(c) Establishment of plural plans and their standardization for energy loss reduction

(d) Establishment of fundamental policy and philosophy for distribution network improvement and reinforcement

(e) Establishment of the optimal improvement and reinforcement plans for the target distribution networks

(f) Comprehensive design of facilities concerned

(g) Estimation on feasibility of the optimal plan (economic and financial analysis, estimation on environmental impacts)

(h) Establishment of practical plan (construction and investment plans, etc.)

(i) Manual compilation on F/S study methodology

3. Profile of Jordan

The capital city of Jordan is Amman. The population of the whole nation of Jordan is approximately 4.8 million. The area is 89,342 km^2 of which 80 % is desert and 557 km^2 incorporates the Dead Sea and Jordan Valley's Eastern bank area bounded by the Jordan river. There are two mountainous ranges which reach a height of approximately 600 to 1,000m high running down along the Jordan River. The area between these two mountainous ranges form one of the world's most famous green belts called the Jordan Valley with an elevation range of 200 to 340m below sea level. The Jordan River flows into the Dead Sea which marks the world's lowest point with its surface at 390m below sea level. The Capital Amman is located in eastern hilly land in the undulations ranging from approximately 900 to 1,100m above sea level. Amman has a clearly defined dry and rainy season. The dry season (May～October) falls in the summer and rainy season falls in autumn, winter and spring. In a dry season (summer), the highest temperature often exceeds 40 degrees in Amman, however the humidity is low. On the other hand, it rains in winter. Jordan has only one seaport in Aqaba. Aqaba is the city in the basin surrounded by rocky mountains located in the most southern end of Jordan, 340 km from Amman to the south and is the only point of contact with the sea for

Jordan. Under His Majesty the King with the Vice of King, there lies the Royal Court, the Council for the King, the House of Parliament, and the Cabinet. Several ministries come under the Cabinet which is headed by the Prime Minister. As of the year 2000, there are 26 ministries. The National Electric Power Company (NEPCO), a state owned electric enterprise, belongs to the Ministry of Energy and Mineral Resources.

Jordan is divided into twelve regional governates, or "muhafathat", each of which is divided into smaller administrative sub-regions. Each governate is headed by a governor, who is appointed by the king through the Ministry of the Interior. The district government acts as the executive organ for carrying out cabinet decisions on the local level. These district governments are thus essentially an extension of the central government, and are supervised by the Ministry of the Interior.

4. Current Situation of Power Sector

The government has continued to adopt several measures which have lead to the improvement of economic performance by implementing privatization programs for principal infrastructure projects in order to improve performance and increase efficiency and production levels.

There used to be three electricity enterprises operating in Jordan, one of them being the National Electric Power Co. (NEPCO) and the other two being private enterprises, the Jordanian Electric Power Co. (JEPCO) in Amman and the Irbid District Electricity Co. (IDECO) in northern Jordan. In January 1999, NEPCO was divided into three companies, that is; NEPCO as a transmission company, CEGCO as a generation company and EDCO, as a distribution company. The function and relationships of each are described hereunder.

CEGCO and IDECO have generation facilities while JEPCO is a distributing firm responsible for the distribution of electric power in Amman, Zarqa and Balqa regions. EDCO distributes electricity to the previous NEPCO concession area. These three distribution companies purchase electricity from NEPCO.

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

The structure of power sectors in Jordan, along with their functions and relationships are illustrated in Fig. 4-1.

CEGCO is a large scale power generation enterprise in Jordan. It owns the 11 main power stations; Hussein Thermal Power Station, Aqaba Thermal Power Station, Risha Power Station, Marka Power Station, Karak

Power station, Aqaba Central Power Station, Amman South Gas Turbine Power Station, Rehab Power Station, King Tolal Dam and Wind Energy Generation Station. Energy production of CEGCO (NEPCO) in 1998 was 6,300 GWh with an annual growth rate of 6.7% (1998/1997). The average annual growth rate of the five years from 1993 was 7.4%.

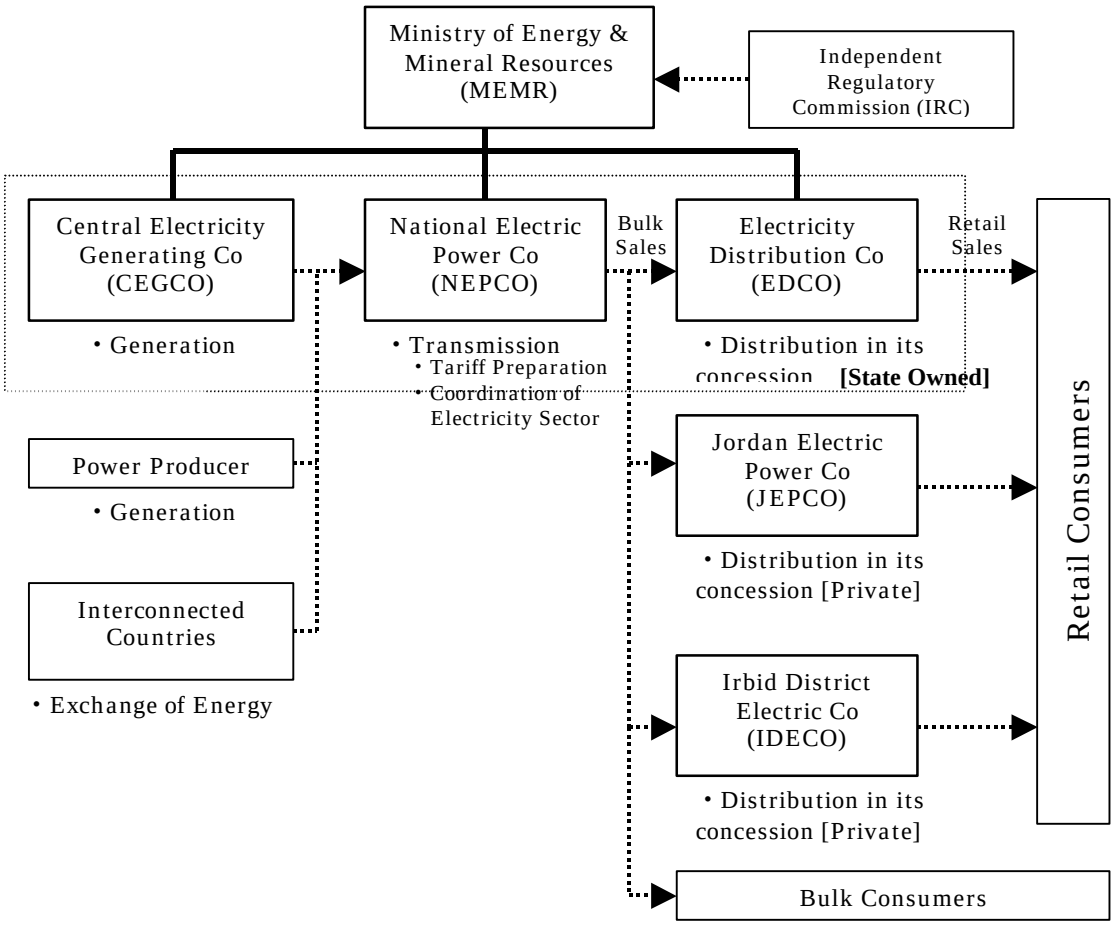


Fig. 4-1 Structure of the Power Sector in Jordan

NEPCO sells electricity to distribution companies and large consumers. The electricity generated by CEGCO is sold to EDCO, JEPCO, IDECO and other large-scale industries such as refinery companies, cement factories etc. in bulk, using NEPCO's power transmission lines. NEPCO's interconnecting system network covers the whole area of Jordan. As of 1999, EDCO covers NEPCO's distribution concession area, the areas of Aqaba, Ma'an, Shoubak, Karak, Tafila, Jordan Valley, the eastern area and a part of the Amman area for retail sales. In 1998, the total energy consumption for the whole area of Jordan was 5,634 GWh. The energy sold by NEPCO to JEPCO and IDECO amounted to 3,262 GWh and 857 GWh, respectively. However, the retail sales of NEPCO were 540GWh, less than that compared with sales to the two private enterprises.

The number of total consumers in Jordan as of 1998 was approximately 793,000. This demonstrates an annual average growth rate of 5.41% since 1990. JEPCO covers 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 covers the area of Irbid Governorate including the cities of Irbid, Al-Ramtha, Al-Mafrak, Ajlun and Jarash by their network.

The number of consumers or subscribers of the three enterprises in 1998 was 792,714 in total and is summarized by type of consumption as shown in Table 4-1.

Table 4-1 Number of Consumers by Type of Consumption in 1998

	NEPCO	JEPCO	IDECO	Others	Total
Domestic	86,379	406,727	150,383	220	643,709
Industrial	1,097	8,120	2,836	0	12,053
Commercial	11,957	79,328	19,514	10	110,809
Water pumping	968	660	892	0	2,520
Governmental	2,502	6,227	3,638	0	12,367
Others	2,115	8,998	143	0	13,406
Total	105,018	510,060	177,406	230	792,714

Source : Annual Report 1998.National Electric Power Company.

According to the Annual Report of NEPCO, as of 1998, the number of customers receiving energy supply was 4.745 million at an electrification ratio of 99.8% to the total population.

NEPCO, JEPCO and IDECO have carried out rural electrification schemes since 1984 and in 1992 the Ministry of Energy and Mineral Resources started to manage the rural electrification of the whole Kingdom. In 1998, 120 villages were electrified and the remaining 142 villages were to be electrified in 1999.

5. Demand Forecast

Table 5-1 shows the summary of electricity demand forecast. The following is an overview of the tables;

Net generation required in 2005 is forecasted to be 9,710 GWh at an average annual growth rate of 6.4% from 1995, and that of 2010 is forecasted at 13,667 GWh at an average annual growth rate of 3.5% for the succeeding 10 years. The required generation in 2010 and 2015 is equivalent to about 1.9 and 2.6 times of that in 1995.

Peak Load in 2005 and 2015 are forecasted to be 1,542 MW and 2174 MW with average growth rates of 6.0% and 3.5%, respectively. Morning Peak load is estimated to exceed Evening Peak Load in the year 2005 due to increases in air-conditioning load.

Table 5-1 Demand and Energy Forecast for Whole Country (Scenario-Medium)

(unit: MW, GWh)

	1995	2000	2005	2010	2015	Ave. Annual Growth (%)
Energy Generated (GWh)	5,201	7,390	9,710	11,999	13,667	6.4 (3.5)
・NEPCO	5,201	7,151	9,487	11,791	13,459	6.2 (3.6)
Peak Load (MW)	862	1,179	1,542	1,901	2,174	6.0 (3.5)
・Morn. Peak	842	1,163	1,553	1,927	2,207	6.3 (3.6)
・Even. Peak	862	1,179	1,531	1,874	2,140	5.9 (3.4)
Load Factor (%)	71.0	71.6	71.9	72.1	71.8	----

Note: Ave. Annual growth (%) …… from 1995 to 2005 (from 2005 to 2015)

Peak Load is the load which is most probable and is estimated as an average of morning and evening peak load.

Table 5-2 and Table 5-3 show the forecast of the peak load and total electrical energy sold to respective sectors. The total energy sales in 1999 are expected to be 5529GWh with an annual growth rate of 5.9%. In the former and later five years in the first decade in 21st century, annual average growth rate is 4.5 and 2.6%, respectively. In the period from 2011 to 2015, the average annual growth is 2.6%.

Table 5-2 Peak Load Forecast for Whole Country (Scenario-Medium)

(unit: MW)

	1995	2000	2005	2010	2015	Ave. Annual Growth (%)
Domestic	267	363	465	554	644	5.7 (3.3)
Commercial	86	127	170	294	236	7.1 (3.3)
Retail Industry	61	105	151	194	230	9.5 (4.3)
Retail W-Pumping	109	119	147	173	191	3.0 (2.7)
Services	25	37	47	58	66	6.5 (3.5)
Street Lighting	27	37	45	55	66	5.2 (3.9)
Total	576	788	1016	1232	1427	5.8 (3.5)
Sent Out	682	946	1223	1480	1713	6.0 (3.4)
KW Loss Rate (%)	15.5	16.7	16.9	16.8	16.7	----

note: Ave. Annual growth (%) …… from 1995 to 2005 (from 2005 to 2015)

Table 5-3 Energy Sales Forecast for Whole Country (Scenario-Medium)

(unit: GWh)

Scenario-Medium	1995	2000	2005	2010	2015	Ave. Annual Growth (%)
Domestic	1265	1757	2263	2701	3140	6.0 (3.3)
Commercial	481	715	960	1152	1339	7.2 (3.4)
Retail Industry	605	1009	1487	1958	2349	9.4 (4.7)
Retail W-Pumping	612	681	838	991	1091	3.2 (2.7)
Services	303	415	538	656	751	5.9 (3.4)
Street Lighting	119	161	197	240	290	5.2 (3.9)
Total	3384	4738	6283	7699	8959	6.4 (3.6)
Sent Out	3883	5471	7222	8850	10298	6.4 (3.6)
Energy Loss	499	733	939	1151	1342	---
Loss Rate (%)	12.9	13.4	13.0	13.0	13.3	---

note: Ave. Annual growth (%) ····· from 1995 to 2005 (from 2005 to 2015)

6. The Present Situation of Distribution Systems on the Investigation Target Areas

Existing distribution systems and facilities in Jordan are briefly summarized as follows.

6.1 Distribution Network of EDCO

EDCO distributes power to all governorates except the Amman areas covered by JEPCO and the Irbid areas covered by IDECO. There are six districts in the EDCO area, which are; Jordan Valley, Karak, Tafila, Ma'an, Aqaba and the Eastern districts. Approximately 100,000 consumers are supplied energy and in comparison to the other two companies, EDCO covers a wide area with relatively small demand. The peak demand is approximately 150MW corresponding to 14% of the whole Jordan. Power is commonly distributed with 33kV overhead distribution lines supplied from the nine HV/MV bulk substations (132/33kV). An 11kV underground distribution system is also used for power distribution to the towns within the four districts of Karak, Tafila, Ma'an and Aqaba and 6.6kV distribution lines are usually only applied for supply to water pumps. The 6.6kV lines used for distribution purposes fall under the old system and will be replaced with 11kV lines. The number of MV/LV distribution transformers amount to more than 1,000 using a common 415V LV system of overhead distribution lines, with the exception of the limited area in the new town in Aqaba district where underground cables are used for LV systems. Overhead distribution lines are configured in the radial form and the sectionalizers are installed in the MV systems.

The sectionalizer is also installed on the far end of the feeder as a normally open switch, which is closed to interconnect with the adjacent feeder when necessary.

6.2 Distribution Network of JEPCO

JEPCO covers the capital city Amman and has the largest demand among three distribution companies. Its customers number half a million, occupying 60% of the whole Jordan area. The peak demand was 540MW in 1998, which was 50% of the peak load of Jordan in 1998. The average demand growth rate of JEPCO is 6～7% in recent years. The service areas cover the Amman, Madaba and Balqa governorates with ten bulk substations (132/33kV) where the power is distributed from. Power supply to the cities is distributed with 11kV underground distribution lines and supply to the suburban areas is distributed with the 33kV overhead distribution lines as with the other two distribution companies. There are 4,000 distribution transformers (MV/LV) and the 415V overhead distribution lines are used as the low voltage distribution systems both in cities and suburbs characterized by the high demand and short length of distribution lines.

6.3 Distribution Network of IDECO

IDECO's distribution area covers the four governorates of Irbid, Ajulun, Jarash and Mafrak with 180,000 customers and supply to 20% of the whole Jordan area with a peak demand of 170MW. There are three bulk substations (132/33kV) in the area the power is distributed from. The number of MV/LV distribution transformers amounts to approximately 1,500. The system configuration is the same as those of EDCO and JEPCO where the 33kV overhead distribution lines are common for power distribution to the suburbs, the 11kV underground distribution lines to the cities and 415V overhead lines for low voltage distribution system are common for the distribution system. There are, however, 6.6kV underground distribution lines in Jarash and Mafraq, which are to be replaced with 11kV lines due to limited capacity and aging. Overhead covered-bundled conductors are also frequently adopted mainly for security reasons.

7. System Improvement Plan in the Study Area

7.1 Community Development and Industrialization Plan

The development of tourism and industry such as construction of hotels and industrial complexes are under way in the Dead Sea eastern coast and Karak areas. These development plans should be taken into account in the feasibility study.

7.2 Plan for Power System Development

Concrete plans for installation of the 132/33kV substation and 33kV MV feeders in the target area are as follows:

7.2.1 Plan for 132/33kV Substation

To meet growing demand in the respective area, the following transmission substations and lines are planned or under construction;

(1) 132/33kV Abdoon and Seima Substation

In the Amman area, construction of the Abdoon substation is planned in addition to the Tareq substation in 1998. In the Dead Sea eastern area, a 132kV/33kV Seima substation and 132kV double circuit transmission line from QAIA substation are under construction aiming at commercial operations in the first quarter of the year 2000.

(2) 132/33kV Waqas and Shtafina Substation

In the western section of the Irbid area, commissioning of Waqas substation is expected in 2001 to meet growing demands due to area development and increasing pumping demands in the Irbid area. A 132kV double circuit transmission line from Subeihy substation is also planned as a power source of Waqas substation.

MV feeders for target feeders of the Emrawa and Samma lines and the Jordan Valley area are also planned as secondary networks of the Waqas substation. One feeder for the Emrawa line and two feeders for the Samma line are planned. One of the other two feeders for Jordan Valley area is expected to reduce load on the MV target feeder of the JV2 line.

In the southern area of Waqas substation, the 132kV/33kV Shtafina substation is expected to be put into commercial operation in the early stage of 2000s with one feeder for the target feeder for the Samma line.

(3) Plan for 132/33kV Substation Reinforcement

The Ghor Safi, Karak and Ma'an substations will also be reinforced in 2001 and 2002 to meet electricity demand growth of the magnesium factory and industrial complex, respectively.

For reactive power compensation, total capacity of 105MVA capacitors will be installed in Abdoon (45MVA), Seima (30MVA) and Waqas (30MVA).

7.2.2 Plan for Distribution (33kV and below) Network

In accordance with the transmission substation reinforcement plan, 33kV distribution lines are planned with reinforcement. Distribution companies, EDCO, JEPCO and IDECO will carry out the studies for 33kV and below networks reinforcement plan. Respective plans related to this study have been corrected and reviewed in the second site investigation period. Existing 6.6kV distribution systems are planned to be upgraded to 11kV in the future, installing 11kV facilities and cables on existing 6.6kV distribution systems to meet demand growth.

(1) MV Feeders from 132/33kV Waqas Substation

MV feeders for target feeders of Emrawa and Samma lines along with the Jordan Valley area are also planned as a secondary network for Waqas substation. One feeder for the Emrawa line and two feeders for the Samma line are planned. One of the other two feeders for Jordan Valley area is expected to reduce load on the MV target feeder of JV2 line.

(2) MV Feeders from Shtafina Substation

The 132/33kV Shtafina substation is expected to be put into commercial operation in the early stage of 2000s with one feeder for the target feeder of the Samma line.

(3) Reinforcement of MV Feeder from Irbid Substation

The underground cable portion of the MV feeder for the Samma line of the target feeder from the existing 132/33kV Irbid substation has been completed to date. This system will be utilized to reduce the load on the Samma line.

Studies on target feeders of Emrawa and Samma lines of IDECO and JV2 lines of EDCO have been carried out based on the afore-mentioned reinforcement plan. Their respective study has been conducted on system configuration reflecting the reinforcement plans.

8. Basic Policy on Loss Reduction in Distribution System

8.1 Target Feeders

Target feeders in low (415V) and medium voltage (33kV) systems are selected in cooperation with the Jordanian counterparts . Outlines and situation of respective MV and LV target feeders are shown below;

(1) MV Target Feeder

Outlines of respective MV target feeders are shown in Table8-1.

Table 8-1 MV Target Feeder (1999yr)

Distribution Company	Name of Line	Main Substation	Total Line Length (km)	Capacity (MVA) [A]	Load (A)	Power Factor
EDCO	Wadi Musa	Ma'an	156	15.5 (271)	157	0.84
	Tafila	Rashada	28	15.5 (271)	92	0.82
	JV2	Subeih	125	15.9 (278)	194	0.80
JEPCO	Duleel	Zarka	48	19.4 (340)	167	0.80
	Madaba	QAIA	156	19.4 (340)	283	0.88
IDECO	Jarash	Rihab	155	15.5 (271)	246	0.83
	Emrawa	Irbid	163	20.0 (350)	250	0.82
	Samma	Irbid	182	20.0 (350)	367	0.84

(2) LV Target Feeder

Table 8-2 shows currents, lengths and power factors of LV target feeders. Current distribution of LV feeders is shown in Figure 8-1.

Table 8-2 Currents, Lengths and Power factors of LV target feeders (1999)

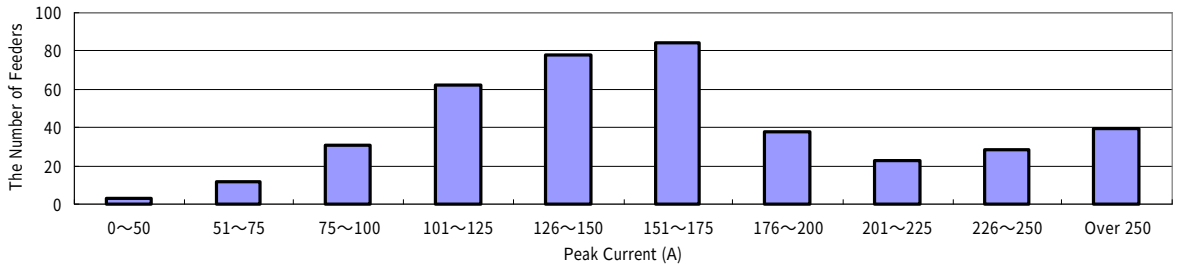
	The Numbers of LV Target Feeders in Peak Current									Tot.	Ave. Curr.	Ave. Len.	Ave. pf
	～75 (A)	～100 (A)	～125 (A)	～150 (A)	～175 (A)	～200 (A)	～225 (A)	～250 (A)	250～ (A)		(A)	(km)	
EDCO	1	5	31	39	32	13	5	11	11	148	163	1.77	0.817
JEPCO	3	10	9	18	15	12	9	4	20	100	185	1.06	0.820
IDECO	11	16	22	21	37	13	9	13	8	150	155	2.09	0.820
Total	15	31	62	78	84	38	23	28	39	398	166	1.71	0.819

Ave. Curr.: Average Current

Ave. Len.: Average Line Length (Total of main and branch portion of feeder)

Ave. pf: Average Power Factor

Figure 8-1 Feeder Current Distribution of LV Target Feeders



8.2 Methodology for Loss Reduction in the Distribution System

Low loss reduction levels in the distribution system result in higher distribution efficiency. However, system efficiency improvement must be evaluated in economic terms taking into account the investment required and the benefits. It would be almost impossible to establish just how far loss reduction in the system should be achieved due to the large number of facilities. Studies on system loss reduction in practice are usually carried out only on the respective target heavy load feeders. The optimum plans for loss reduction are established and put into practice to improve efficiency of the networks. In this project, the study on optimization of respective measures for loss reduction shall be examined in the same manner as the previous Master Plan Study on Electric Power Loss Reduction of Transmission and Distribution Network in the Hashemite Kingdom of Jordan. Studies have been carried on respective target feeders selected through the study in cooperation with Jordanian counterparts in the first site investigation. The target feeders consist of 8 MV feeders and 400 low voltage feeders. Suitability of the countermeasures on these target feeders shall be studied mainly in economic terms. The concrete reinforcement plan for respective target feeders has been established based on the studies on technical standards required and viable measures for loss reduction.

8.3 Measures for Loss Reduction

In addition to measures to be studied in this project such as construction of same voltage feeders and the introduction of higher voltage system, power factor correction by installation of capacitors has been taken into account as one of the measures for loss reduction in accordance with the strong request by the Jordanian counterparts. Power factor correction with capacitors is one of the most economical and viable measures for low power factor systems due to low cost with superior measures to other facility measures such as reinforcement of the distribution line itself. The study on reinforcement such as construction of same voltage feeders and introduction of higher voltage system has been carried out under given conditions of power factor correction with capacitors. Reduction in loss due to power factor correction does not necessarily result in significant reduction compared with other measures, however it only requires minimal investment. Thus, the power factor correction is deemed to be a superior measure. Re-conductoring with larger size conductors without needing to replace existing poles and structures is also one of the economical measures for loss reduction adopted in the study.

Concrete measures for studies on power loss reduction in this project are summarized as shown below:

- Power factor correction with capacitors
- Re-conduct ring of the existing lines
- Construction of same voltage lines
- Introduction of higher voltage system

For re-conductoring of existing distribution lines, capability of supply during the re-conductoring work

period should be sufficient. Feasibility of re-conductoring especially for the regional trunk MV system should be carefully studied in terms of supply capability during re-conductoring work so as not to cause long term interruption of electricity supply due to shortage of capability of the remaining system in cooperation with Jordanian counter parts.

8.4 Policy of Improvement of Target Feeder

8.4.1 Policy of Improvement of LV Target Feeder

(1) Policy on Study

Measures such as re-conductoring and new line installation for LV target feeders were studied in combination with power factor correction with capacitors because of its cost efficiency as mentioned before. For measures of MV introduction, the same type of facilities (type of the transformer and MV line) as existing facility was examined considering actual site condition under the condition that MV feeder is introduced along with the existing LV target feeder. Respective sections in both main and branch feeders examine MV introduction for loss reduction. Taking into account of difficulty in siting of facilities, number of new LV feeder is confined to one circuit.

(2) Policy of Selection of Measures

Objective of this project is to obtain maximum net-benefit by improving distribution network in terms of loss reduction. However, to maintain system voltage within approximate range is also essential from the viewpoint of quality. Based on the discussion with Jordanian counterpart and IEC standard 'Standard Voltage', the criteria for selection of alternative for loss reduction was determined as:

- The most net-beneficial case among net-beneficial alternatives that can maintain system voltage in the initial year within 10% should be selected.

(3) Conditions of the Study

Facilities for improvement of the LV system are adopted from those widely applied on the existing LV system in Jordan. WASP (aluminum bare conductor of cross-section of 100mm^2) or smaller size aluminum bare conductors are studied for new LV line construction and/or LV line re-conductoring. In the study of MV introduction, the same type facilities as existing ones is examined to reflect site conditions. The commissioning year and the evaluation period of the measures of LV feeders shall be set in the year 2001 and for ten years (from 2001 to 2010), respectively. Respective phase load currents were averaged in the study, for correction of unbalanced phase current is underway in Jordan. Equivalent power factor and reduced load current due to power factor correction are applied.

8.4.2 Fundamental Policy of Loss Reduction on MV System

(1) Policy of Improvement of MV Target Feeders

As discussed in the previous section, measures for loss reduction on eight MV target feeders have been studied on power factor correction by LV capacitors and on other measures in combination with the LV capacitor installation as a base case. In addition, measures combined with MV capacitor have been examined.

Measures for loss reduction to be examined comprise of re-conductoring of existing feeders, new line installation, and 132/33kV substation installation. The re-conductoring may result in difficulties in construction work due to insufficient supply capability of the remaining system during the work since the MV feeder covers a wide area and a relatively large load. This makes it necessary to examine the capability of interconnection to the adjacent system or its source 132/33kV substation, as well as the feasibility of the construction.

The combined criteria of alternative selection were determined as follows;

- The most net-beneficial case among alternatives that can maintain system voltage in initial year within 10% regulated by IEC standard should be selected.

- As measures of MV system require larger investment than that of LV system, if the net benefit of the two alternatives differs by less than several percent, the alternative with larger I.E. should be selected taking into account its swift recovery period of investment.

Among those target feeders, two of IDECO's and one of EDCO's target feeders relate to the existing new 132/33kV substation installation plan under bidding procedures. This study has been carried out to take existing plans into account. In addition, on one of IDECO's target feeders, a removal plan of the line from private land to public land is in progress, where the existing line is removed and a new line is installed. This is here after referred to as "re-routing" in this study. In accordance with this re-routing plan, installation of a new line with a larger size conductor was also analyzed in this study for loss reduction.

(2) Method for Improvement of MV Target Feeders

Optimization software extracted beneficial measures of net benefit such as reinforcement plans combined with capacitors. After initial software analysis of a beneficial improvement plan on the target feeder, a solution was selected in accordance with the criteria of measure selection in paragraph 8.4.2 (1) followed by engineering brush-up.

9. Overview of Optimization Study on Loss Reduction

This chapter describes the summary of results of study based on the condition in section 8. A study on the capacity of capacitor to be installed and other reinforcement measures of three- hundred ninety-eight LV target feeders has been completed. A study on reinforcement measures of eight MV target feeders has also been completed.

9.1 Study Result on LV Target Feeders

Table 9-1 shows the summary of study result on all LV target feeders.

Table 9-1 Summary of Study Result on LV Target Feeders

		EDCO	JEPCO	IDECO	Total
Countermeasure	Capacitor Inst. & MV Introduction	43	14	37	94
	Capacitor Inst. & LV Reinforcement	96	78	92	266
	Capacitor Installation	9	8	21	38
	Total	148	100	150	398
Initial Investment (×1,000JD)	On Capacitor Installation	20	15	19	55
	On Network Reinforcement	1,029	500	876	2,405
	Total	1,049	515	895	2,460
Energy Loss Reduction (MWh/10yr.)	From Capacitor Installation	39,204	16,296	26,130	81,630
	From Network Reinforcement	66,494	30,851	44,514	141,859
	Total	105,698	47,147	70,644	223,489
Net Benefit (×1,000JD/10yr.)	From Capacitor Installation	1,099	451	728	2,278
	From Network Reinforcement	1,071	480	568	2,120
	Total	2,170	931	1,297	4,398
I.E. Factor	Capacitor Installation	54.7	29.7	37.8	41.8
	Network Reinforcement	1.04	0.96	0.65	0.88
	Total	2.07	1.81	1.45	1.79

9.2 Study Result on MV Target Feeders

The summary of the study on MV target lines is tabulated in Table9-2 and Table 9-3.

Table 9-2 Summary of Loss Reduction on MV Target Feeders (2001)

Co.	MV Lines		Loss Before			Loss After			Reduced Loss	
			Load a (MW)	Loss b (kW)	Loss Rate c (%)	Load d (MW)	Loss e (kW)	Loss Rate f (%)	Loss b-e (kW)	Loss Rate c-f (%)
EDCO	Wadi Musa		8.66	726	8.4	8.35	419	5.0	307	3.4
	Tafila		4.86	202	4.2	4.82	158	3.3	44	0.9
	JV2	A	4.78	209	4.4	4.70	132	2.8	77	1.6
		B	4.76	230	4.8	4.68	151	3.2	79	1.6
	Sub Total		23.06	1,367	5.9	22.55	860	3.8	507	2.1
JEPCO	Duleel		10.57	343	3.2	10.48	254	2.4	89	0.8
	Madaba		16.31	1,490	9.1	15.52	695	4.5	795	4.7
	Sub Total		26.88	1,833	6.8	26.00	949	3.7	884	3.2
IDECO	Jerash		13.29	1,655	12.5	12.45	811	6.5	844	5.9
	Emrawa & Samma	A	6.79	300	4.4	6.70	205	3.1	95	1.4
		B	7.69	241	3.1	7.64	190	2.5	51	0.6
		C	2.18	71	3.3	2.17	60	2.8	11	0.5
	Sub Total		29.95	2,267	7.6	28.95	1,266	4.4	1,001	3.2
TOTAL			79.89	5,467	6.8	77.50	3,075	4.0	2,392	2.9

Table 9-3 Summary of Economy on MV Target Feeders

Company	Target Feeder		Investment (JD) a	Loss Reduction (kW)	Loss Reduction (GWh/10yr)	Net Benefit (JD/10yr) b	I.E. b/a
EDCO	Wadi Musa		113,790	307.4	24.18	637,506	5.6
	Tafila		7,000	44.0	3.46	98,680	14.1
	JV2	A	70,037	76.6	6.03	125,512	1.8
		B	49,369	79.0	6.21	147,735	3.0
	Sub Total		240,196	507.0	39.88	1,009,433	4.2
JEPCO	Duleel		18,000	89.0	7.00	196,530	10.9
	Madaba		386,600	795.2	62.56	1,575,344	4.1
	Sub Total		404,600	884.2	69.56	1,771,874	4.4
IDECO	Jerash		435,400	844.1	66.40	1,652,197	3.8
	Emrawa & Samma	A	34,285	95.4	7.50	198,670	5.8
		B	10,000	51.0	4.01	112,870	11.3
		C	3,000	11.0	0.87	23,670	7.9
	Sub Total		482,685	1,001.5	78.78	1,987,407	4.1
Total			1,127,481	2,392.7	188.22	4,768,714	4.2

9.3 Priority of Investment of Countermeasures on LV Feeders

Table 9-4 shows composition of numbers of target feeders, investment and net-benefit of counter-measures on target feeders such LV line construction, re-conductoring and MV introduction combined with capacitor installation by respective investment recovery period.

Table 9-4 Numbers, Investment and Net-benefit of Target Feeders by Investment Recovery Period

		Investment Recovery Period		
		5 yr. or less	5～10 yr.	More than 10 yr.
Composition Ratio	Number of Feeders	12%	50%	38%
	Investment	11%	48%	41%
	Net Benefit	40%	49%	11%

This table shows that the target feeders shall be implemented based on the recovery period of respective counter-measures on target feeders taking into account of efficiency of investment.

9.4 Reduction in Emission Gases

Based on the annual allocation of the construction work, reduction in emission gases such as green house effect gas is evaluated.

9.4.1 Power Loss Reduction due to Improvement of Distribution System

Based on the following values of annual trends of power loss reduction, reduction in emission of environment-effective gasses were estimated.

Table 9-5 Power Loss Reduction by Year (excluding effect of capacitor: MWh)

Year	Whole Project		EDCO		JEPCO		IDECO	
	LV	MV	LV	MV	LV	MV	LV	MV
2001	0	0	0	0	0	0	0	0
2002	0	0	0	0	0	0	0	0
2003	3,601	0	1,688	0	783	0	1,130	0
2004	7,946	1,305	3,725	1,170	1,728	0	2,493	135
2005	13,260	7,762	6,215	1,301	2,884	3,715	4,161	2,746
2006	14,689	8,599	6,885	1,442	3,195	4,115	4,609	3,042
2007	16,097	9,424	7,545	1,580	3,501	4,510	5,051	3,334
2008	17,589	10,297	8,245	1,726	3,825	4,928	5,519	3,643
2009	18,942	11,089	8,879	1,859	4,119	5,307	5,944	3,923
2010	20,153	11,798	9,446	1,978	4,383	5,646	6,324	4,174
2011	21,358	12,503	10,011	2,096	4,645	5,983	6,702	4,424
2012	22,597	13,229	10,592	2,218	4,914	6,331	7,091	4,680
2013	23,431	13,962	10,983	2,341	5,096	6,681	7,352	4,940
2014	24,013	14,792	11,256	2,341	5,222	7,170	7,535	5,281
Total	203,676	114,760	95,470	20,052	44,295	54,386	63,911	40,322
	Sub-Total：318,436		Sub-Total：115,522		Sub-Total：98,681		Sub-Total：107,233	

9.4.2 Reduction in Emission of Gasses

Reduction in emission of gasses such as carbon dioxide (CO_2), sulfur oxide (SO_X), and nitrogen oxide (NO_X) was estimated based on the CEGCO's actual result of fuel consumption and emission intensity of emitted gases per kWh in 1999.

The fuel consumption per kWh generated of CEGCO in 1999:250g/kWh

The fundamental data for estimation of emission of gasses such as metric ton per fuel tons and intensity of gas emission are tabulated as shown in Table 9-6.

Table 9-6 Intensity of Gas Emission

	Emission Metric ton per Fuel ton	Intensity of Emission per kWh
CO2	3.11668 ton/fuel-ton	779.17g/kWh
SOX	0.080 ton/fuel-ton	20.0g/kWh
NOX	0.0038 ton/fuel-ton	0.95g/kWh

Reduction in emission of gasses such as CO_2 and SO_X due to execution of project are estimated by multiplying intensity of emission of gasses. Results are shown in Table 9-7.

Table 9-7 Volume of Gasses to be Reduced due to Project (ton)（without Capacitor）

	Whole Project			EDCO's Work			JEPCO's Work			IDECO's Work		
Year	CO2	Sox	Nox	CO2	SOx	NOx	CO2	SOx	NOx	CO2	SOx	NOx
2001	0	0	0	0	0	0	0	0	0	0	0	0
2002	0	0	0	0	0	0	0	0	0	0	0	0
2003	2,806	72	3	1,315	34	2	610	16	1	880	23	1
2004	7,208	185	9	3,814	98	5	1,346	35	2	2,048	53	2
2005	16,380	420	20	5,856	150	7	5,142	132	6	5,382	138	7
2006	18,145	466	22	6,488	167	8	5,696	146	7	5,961	153	7
2007	19,885	510	24	7,110	183	9	6,242	160	8	6,533	168	8
2008	21,728	558	26	7,769	199	9	6,820	175	8	7,139	183	9
2009	23,399	601	29	8,367	215	10	7,344	189	9	7,688	197	9
2010	24,895	639	30	8,901	228	11	7,814	201	10	8,180	210	10
2011	26,383	677	32	9,433	242	12	8,281	213	10	8,669	223	11
2012	27,915	717	34	9,981	256	12	8,762	225	11	9,172	235	11
2013	29,136	748	36	10,382	266	13	9,176	236	11	9,578	246	12
2014	30,236	776	37	10,594	272	13	9,655	248	12	9,986	256	12

10. Economic and Financial Analysis

Economic and financial evaluations of the Project as a base case are made in case of excluding an effect due to installation of capacitors. So that the cost for installation of capacitors in this case were also excluded from the Project cost in total.

The economic and financial costs and benefits including the installation of capacitors have also been

identified as a reference as well as repayability analyses in the case of with-capacitor.

10.1 Identification of Cost

Based on the result of cost estimation for the Project taking technical and economical optimized countermeasure for electricity distribution loss reduction into account, the cost by each distribution company including, for reference, and excluding the cost for installation of capacitors are estimated as in Tables 10-1 and 10-2.

Table 10-1 Annual Cost Allocation with Capacitors

(JDs.)

By Distribution companies		2001	2002	2003	2004	Total
Whole Project	Financial cost[1)]	49,700	1,161,579	1,696,069	1,575,698	4,483,046
	Financial cost[2)]	47,333	1,074,032	1,507,946	1,346,689	3,976,000
	Economic cost[3)]	42,735	1,002,712	1,407,419	1,256,853	3,709,718
EDCO's Works	Financial cost[1)]	17,872	554,949	577,178	452,109	1,602,108
	Financial cost[2)]	17,021	513,167	513,167	386,374	1,429,728
	Economic cost[3)]	15,367	479,015	479,015	360,696	1,334,093
JEPCO's Works	Financial cost[1)]	12,739	219,320	457,587	464,868	1,154,514
	Financial cost[2)]	12,133	202,787	406,864	397,362	1,019,146
	Economic cost[3)]	10,954	189,449	379,790	370,881	951,074
IDECO's Works	Financial cost[1)]	19,089	387,311	661,303	658,720	1,726,423
	Financial cost[2)]	18,180	358,078	587,914	562,953	1,527,126
	Economic cost[3)]	16,414	334,248	548,614	525,276	1,424,552

(Note) *1) Incl. price contingency for execution of the Project*
2) Excl. price contingency for financial evaluation
3) *Excl. price contingency for economic evaluation*

Table 10-2 Annual Cost Allocation without Capacitors

(JDs.)

By Distribution companies		2001	2002	2003	2004	Total
Whole Project	Financial cost[1)]	47,393	1,096,260	1,605,649	1,527,252	4,276,554
	Financial cost[2)]	45,136	1,013,586	1,427,440	1,305,246	3,791,408
	Economic cost[3)]	40,750	946,113	1,332,012	1,218,072	3,536,948
EDCO's Works	Financial cost[1)]	17,136	527,739	548,892	443,019	1,536,786
	Financial cost[2)]	16,320	487,983	487,983	378,609	1,370,895
	Economic cost[3)]	14,735	455,426	455,426	353,440	1,279,027
JEPCO's Works	Financial cost[1)]	12,030	202,534	429,471	446,720	1,090,755
	Financial cost[2)]	11,457	187,256	381,831	381,831	962,375
	Economic cost[3)]	10,344	174,910	356,342	356,342	897,938
IDECO's Works	Financial cost[1)]	18,227	186,442	627,285	637,514	1,649,013
	Financial cost[2)]	17,359	169,108	557,626	544,806	1,458,138
	Economic cost[3)]	15,672	146,538	520,244	508,290	1,359,982

(Note) *1) Incl. price contingency for execution of the Project*
2) Excl. price contingency for financial evaluation
3) *Excl. price contingency for economic evaluation*

10.2 Identification of Economic Benefit

10.2.1 Economic Benefit Derived from Electricity Loss Reduction

The economic benefit of the Project can be estimated as a difference between the electricity loss "with the project" and that "without the project." In other words, it may be called as the volume of "electricity loss reduction". In this case, the electricity losses are derived as power value or capacity value and energy value as mentioned below. The electricity loss counting as economic benefits should be considered in total of those values.

In order to evaluate the economic benefits, a power value or a capacity value described as "kW-value" and an energy value described as "kWh-value" are calculated. kW-value represents the construction and fixed O/M costs of power plant for unit kW volume for a year, and is called as "power benefit." kWh-value represents fuel and variable O/M costs of the power plant, and is called as "energy benefits." Unit kW-value and unit kWh-value are calculated based on "the Long Run Marginal Cost Method."

The economic benefit can be obtained by using the unit kW-value and unit kWh-value multiplying the volume of electricity loss reduction as shown in Tables 10-3 and 10-4 hereunder.

Table 10-3 Annual Electricity Loss Reduction Due to Completion of Project (with Capacitor)

Year	Whole project				EDCO's Works				JEPCO's Works				IDECO's Works			
	Low voltage system		Medium voltage system		Low voltage system		Medium voltage system		Low voltage system		Medium voltage system		Low voltage system		Medium voltage system	
	Power (kW)	Enegy (MWh)	Power (kW)	Enegy (MWh)	Power (kW)	Enegy (MWh)	Power (kW)	Enegy (MWh)	Power (kW)	Enegy (MWh)	Power (kW)	Enegy (MWh)	Power (kW)	Enegy (MWh)	Power (kW)	Enegy (MWh)
2001	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2002	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2003	1,186	5,673	0	0	561	2,683	0	0	250	1,197	0	0	375	1,793	0	0
2004	2,616	12,519	1,041	4,980	1,237	5,921	700	3,351	552	2,641	123	588	827	3,957	217	1,041
2005	4,365	20,889	3,676	17,593	2,065	9,879	779	3,727	921	4,407	1,359	6,502	1,380	6,603	1,539	7,364
2006	4,836	23,141	4,073	19,490	2,287	10,944	863	4,130	1,020	4,882	1,505	7,202	1,529	7,315	1,705	8,158
2007	5,299	25,360	4,463	21,359	2,506	11,994	946	4,526	1,118	5,350	1,649	7,893	1,675	8,016	1,868	8,940
2008	5,790	27,711	4,877	23,338	2,739	13,106	1,033	4,945	1,222	5,846	1,802	8,625	1,830	8,759	2,041	9,768
2009	6,236	29,842	5,252	25,132	2,949	14,114	1,113	5,325	1,316	6,295	1,941	9,288	1,971	9,433	2,198	10,519
2010	6,634	31,749	5,587	26,739	3,138	15,015	1,184	5,666	1,400	6,698	2,065	9,881	2,097	10,036	2,339	11,192
2011	7,031	33,647	5,922	28,338	3,325	15,913	1,255	6,004	1,483	7,098	2,188	10,472	2,222	10,636	2,479	11,862
2012	7,439	35,600	6,265	29,982	3,518	16,837	1,328	6,353	1,569	7,510	2,315	11,080	2,352	11,253	2,622	12,549
2013	7,714	36,914	6,612	31,643	3,648	17,458	1,401	6,705	1,627	7,788	2,444	11,693	2,438	11,668	2,768	13,245
2014	7,905	37,830	6,944	33,230	3,739	17,892	1,401	6,705	1,668	7,980	2,605	12,463	2,499	11,958	2,938	14,062

Table 10-4 Annual Electricity Loss Reduction Due to Completion of Project (without Capacitor)

Year	Whole project				EDCO's Works				JEPCO's Works				IDECO's Works			
	Low voltage system		Medium voltage system		Low voltage system		Medium voltage system		Low voltage system		Medium voltage system		Low voltage system		Medium voltage system	
	Power (kW)	Enegy (MWh)	Power (kW)	Enegy (MWh)	Power (kW)	Enegy (MWh)	Power (kW)	Enegy (MWh)	Power (kW)	Enegy (MWh)	Power (kW)	Enegy (MWh)	Power (kW)	Enegy (MWh)	Power (kW)	Enegy (MWh)
2001	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2002	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2003	753	3,601	0	0	353	1,688	0	0	164	783	0	0	236	1,130	0	0
2004	1,660	7,946	273	1,305	778	3,725	245	1,170	361	1,728	0	0	521	2,493	28	135
2005	2,771	13,260	1,622	7,762	1,299	6,215	272	1,301	603	2,884	776	3,715	870	4,161	574	2,746
2006	3,070	14,689	1,797	8,599	1,439	6,885	301	1,442	668	3,195	860	4,115	963	4,609	636	3,042
2007	3,364	16,097	1,969	9,424	1,577	7,545	330	1,580	732	3,501	942	4,510	1,056	5,051	697	3,334
2008	3,675	17,589	2,152	10,297	1,723	8,245	361	1,726	799	3,825	1,030	4,928	1,153	5,519	761	3,643
2009	3,958	18,942	2,317	11,089	1,855	8,879	389	1,859	861	4,119	1,109	5,307	1,242	5,944	820	3,923
2010	4,211	20,153	2,465	11,798	1,974	9,446	413	1,978	916	4,383	1,180	5,646	1,321	6,324	872	4,174
2011	4,463	21,358	2,613	12,503	2,092	10,011	438	2,096	971	4,645	1,250	5,983	1,400	6,702	924	4,424
2012	4,722	22,597	2,764	13,229	2,213	10,592	464	2,218	1,027	4,914	1,323	6,331	1,482	7,091	978	4,680
2013	4,896	23,431	2,917	13,962	2,295	10,983	489	2,341	1,065	5,096	1,396	6,681	1,536	7,352	1,032	4,940
2014	5,018	24,013	3,091	14,792	2,352	11,256	489	2,341	1,091	5,222	1,498	7,170	1,575	7,535	1,104	5,281

Estimated results including and excluding the cost for installation of capacitors are summarized as below in Tables 10-5 and 10-6.

Table 10-5 Amount of Electricity Loss Reduction by Year (with Capacitor)

(JDs.1,000)

Year	Whole Project	EDCO's Works	JEPCO's Works	IDECO's Works
2001	0	0	0	0
2002	0	0	0	0
2003	255	121	54	81
2004	752	393	141	217
2005	1,607	586	445	576
2006	1,780	649	493	638
2007	1,951	711	540	700
2008	2,132	777	590	765
2009	2,296	837	635	823
2010	2,442	890	676	876
2011	2,588	943	717	928
2012	2,739	998	758	982
2013	2,861	1,040	794	1,027
2014	2,962	1,059	832	1,071

Table 10-6 Amount of Electricity Loss Reduction by Year (without Capacitor)

(JDs.1,000)

Year	Whole Project	EDCO's Works	JEPCO's Works	IDECO's Works
2001	0	0	0	0
2002	0	0	0	0
2003	162	76	35	51
2004	407	212	78	117
2005	891	329	271	291
2006	987	364	300	323
2007	1,081	399	329	354
2008	1,182	436	359	386
2009	1,273	470	387	416
2010	1,354	500	411	443
2011	1,435	530	436	469
2012	1,518	561	461	496
2013	1,584	583	483	518
2014	1,641	595	507	539

10.2.2 Economic Benefit Derived from External Cost Saving

The external cost burdened by the people caused by air pollution due to emission of CO_2, Sox and NOx should also be considered in this kind of project. When the emitted volume of CO_2, SOx and NOx will be decreased in the case of the execution of the proposed countermeasures in the Project, the Project will get an additional economic benefit from an environmental viewpoint as an external cost saving.

In this Project, the electricity loss reduction will make decrease the fuel consumption. Therefore, those gasses to be emitted will also be controlled as shown in Table 10-7.

Table 10-7 The Volume of Emitted Gases per GWh

Kind of gas	Unit volume of gases to be controlled (ton/GWh)
CO_2	779.17
SO_x	20.00
NO_x	0.95

Based on the information reported in "Incorporating Environmental Concerns into Power Sector Decision-making" issued by the World Bank (WB) as a World Bank Environment Paper No.6, unit costs of CO_2, SO_x and NO_x are estimated as follows: CO_2 : 20.3(US$/ton), SO_x : 605.5 (US$/ton)and NO_x : 244.6 (US$/ton)(as of 2000).

Volume of emitted gases to be controlled for estimation of the external cost saving can be calculated by applying the said intensity of gasses to be emitted multiplying the volume of the electricity loss reduction (GWh) as shown in the following Table 10-8:

Table 10-8 Volume of Gasses to be Controlled Due to Project (without Capacitor)

Year	Whole Project			EDCO's Works			JEPCO's Works			IDECO's Works		
	CO_2	SO_x	NO_x	CO_2	SO_x	NO_x	CO_2	SO_x	NO_x	CO_2	SO_x	NO_x
2001	0	0	0	0	0	0	0	0	0	0	0	0
2002	0	0	0	0	0	0	0	0	0	0	0	0
2003	2,806	72	3	1,315	34	2	610	16	1	880	23	1
2004	7,208	185	9	3,814	98	5	1,346	35	2	2,048	53	2
2005	16,380	420	20	5,856	150	7	5,142	132	6	5,382	138	7
2006	18,145	466	22	6,488	167	8	5,696	146	7	5,961	153	7
2007	19,885	510	24	7,110	183	9	6,242	160	8	6,533	168	8
2008	21,728	558	26	7,769	199	9	6,820	175	8	7,139	183	9
2009	23,399	601	29	8,367	215	10	7,344	189	9	7,688	197	9
2010	24,895	639	30	8,901	228	11	7,814	201	10	8,180	210	10
2011	26,383	677	32	9,433	242	12	8,281	213	10	8,669	223	11
2012	27,915	717	34	9,981	256	12	8,762	225	11	9,172	235	11
2013	29,136	748	36	10,382	266	13	9,176	236	11	9,578	246	12
2014	30,236	776	37	10,594	272	13	9,655	248	12	9,986	256	12

Amounts of the external cost savings are resulted as shown in Tables 10-9 hereunder.

Table 10-9 Amount of External Cost Saving by Year (without Capacitor)

(JDs.1,000)

Year	Whole Project			EDCO's Works			JEPCO's Works			IDECO's Works		
	CO_2	SO_x	NO_x	CO_2	SO_x	NO_x	CO_2	SO_x	NO_x	CO_2	SO_x	NO_x
2001	0	0	0	0	0	0	0	0	0	0	0	0
2002	0	0	0	0	0	0	0	0	0	0	0	0
2003	40	31	1	19	14	0	9	7	0	13	10	0
2004	104	79	2	55	42	1	19	15	0	30	23	0
2005	236	180	3	84	65	1	74	57	1	78	59	1
2006	262	200	4	94	71	1	82	63	1	86	66	1
2007	287	219	4	103	78	2	90	69	1	94	72	1
2008	313	239	5	112	86	2	98	75	1	103	79	2
2009	337	258	5	121	92	2	106	81	2	111	85	2
2010	359	274	5	128	98	2	113	86	2	118	90	2
2011	380	291	6	136	104	2	119	91	2	125	96	2
2012	402	308	6	144	110	2	126	97	2	132	101	2
2013	420	321	6	150	114	2	132	101	2	138	106	2
2014	436	333	6	153	117	2	139	106	2	144	110	2

10.3 Identification of Financial Benefit

Financial benefit in these kind of project can be obtained as "operating expenses to be saved due to completion of the project."

Based of past financial report of each electricity distribution company, envisaged unit operating expense per kWh as of 2000 in each distribution company were estimated by means of extrapolation as:

For EDCO: 40.19 Fils/kWh
For JEPCO: 40.58 Fils/kWh
For IDECO: 42.46 Fils/kWh

Using the said unit-operating-expense, the following financial benefits including and excluding the cost for installation of capacitors were estimated as Tables 10-10 and 10-11.

Table 10-10 Amount of Probable Revenue by Year (with Capacitor)

(JDs.1,000)

Year	Whole Project	EDCO's Works	JEPCO's Works	IDECO's Works
2001	0	0	0	0
2002	0	0	0	0
2003	233	108	49	76
2004	716	373	131	212
2005	1,583	547	443	593
2006	1,753	606	490	657
2007	1,921	664	537	720
2008	2,099	725	587	787
2009	2,261	781	632	847
2010	2,405	831	673	901
2011	2,549	881	713	955
2012	2,697	932	754	1,011
2013	2,819	971	791	1,058
2014	2,923	989	830	1,105

Table 10-11 Amount of Probable Revenue by Year (without Capacitor)

(JDs.1,000)

Year	Whole Project	EDCO's Works	JEPCO's Works	IDECO's Works
2001	0	0	0	0
2002	0	0	0	0
2003	148	68	32	48
2004	378	197	70	112
2005	863	302	268	293
2006	956	335	297	325
2007	1,048	367	325	356
2008	1,145	401	355	389
2009	1,233	432	383	419
2010	1,312	459	407	446
2011	1,390	487	431	472
2012	1,471	515	456	500
2013	1,535	535	478	522
2014	1,593	546	503	544

10.4 Result of Economic and Financial Evaluation of the Project

Table 10-12 shows a summary of the evaluation results. In this case, B/C rates are comparison of benefit and cost in present value of them, and NPV (B – C) means net cash balance between benefits and costs also expressed by their present value. For calculation of present value, a discount rate of 10 % is applied as same as in similar projects in Jordan. The Project life is set at 25 years after completion of the works.

Table 10-12 Result of Economic and Financial Evaluation of the Project

Whole Project/ by companies	Economic evaluation			Financial evaluation		
	NPV(JDs.10^3)	EIRR(%)	B/C	NPV(JDs.10^3)	FIRR(%)	B/C
Whole Project	7,161	32.99	3.42	4,604	24.83	2.45
EDCO's works	2,076	29.19	2.91	1,584	24.27	2.36
JEPCO's works	2,615	40.92	4.52	1,596	29.18	3.00
IDECO's works	2,470	31.18	3.18	1,423	22.34	2.17

Both the resulted EIRR and FIRR in all cases seem to be too much high comparing with those in the other projects in electricity sector. But from the viewpoint of design criteria, only the most economical countermeasures in terms of cost performance are adopted for the Project. So, the said results are quite logical and the Project is sound economically and financially.

10.5 Result of Sensitivity Analysis of EIRR and FIRR

There is constant fluctuation in prices of construction materials for these kind of projects as a reflection of economy in the state.

It also gives an impact to the economic benefit because that the economic benefit has estimated LRMC consisting of kW-value and kWh-value. Main component of the kW-value is construction cost of the power plant, and that of kWh-value consists mainly fuel cost.

The financial benefit consists of operating expenses for electricity sales. All three distribution companies purchase their electricity to be sold from a power company, CEGCO through NEPCO. The purchase prices are also subject to the generation price, so the financial benefits are also influenced by the said prices.

Furthermore, demand also may be fluctuated in the future. NEPCO has forecasted that the peak demand in Jordan will be increased at an annual average rate of 5.5 % per annum for 5 years from 2000, and 4.6 % per annum for 10 years from 2000 too. Here, if the said annual increasing rate in the peak demand will be decreased by 3.7 % for 10 years, the economic and the financial benefit will also be decreased by 10 % corresponding to the decrease in the peak demand. Furthermore, if the said annual increasing rate in the peak demand will be decreased to 2.6 % for 10 years, the economic and the financial benefit will also be decreased by 20 % also corresponding to the decrease in the peak demand.

Considering these situation, a sensitivity analysis is made for eight combined cases in addition to the base case under the conditions that the benefit will be decreased by -10 % and -20%, and the cost will be increased by +10 and +20%. The result of this sensitivity analysis is summarized as Table 10-13.

Table 10-13 Result of Sensitivity Analysis of EIRR and FIRR

Whole Project (%)

		Benefit					
		EIRR			FIRR		
		Base	-10%	-20%	Base	-10%	-20%
Cost	Base	32.99	30.18	27.30	24.83	22.63	20.34
	+10%	30.44	27.83	25.14	22.83	20.77	18.62
	+20%	28.27	25.82	23.29	21.11	19.17	17.14

EDCO's Works (%)

		Benefit					
		EIRR			FIRR		
		Base	-10%	-20%	Base	-10%	-20%
Cost	Base	29.19	26.62	23.98	24.27	22.07	19.79
	+10%	26.86	24.47	22.00	22.27	20.21	18.08
	+20%	24.87	22.63	20.31	20.56	18.62	16.60

JEPCO's Works (%)

		Benefit					
		EIRR			FIRR		
		Base	-10%	-20%	Base	-10%	-20%
Cost	Base	40.92	37.57	34.13	29.18	26.72	24.17
	+10%	37.88	34.76	31.55	26.95	24.64	22.25
	+20%	35.29	32.37	29.35	25.03	22.85	20.59

IDECO's Works (%)

		Benefit					
		EIRR			FIRR		
		Base	-10%	-20%	Base	-10%	-20%
Cost	Base	31.18	28.51	25.75	22.34	20.31	18.20
	+10%	28.75	26.26	23.68	20.50	18.59	16.60
	+20%	26.68	24.33	21.91	18.91	17.11	15.22

As shown in the Table 10-13, even in the most pessimistic cases under the conditions of the costs increased

by 20 % and the benefits decreased by 20 %, both of EIRR and FIRR have resulted at high enough. It means that the Project under study is economically and financially sound in all cases.

10.6 Repayability Analysis

Repayability analyses are made in 3 cases as:

(1) financing by the Arab Fund for Economic and Social Development (hereinafter referred to "Arab Fund") by using 5.5 % of interest rate with 20 years of repayment period in addition to 6 years of grace period,

(2) financing by international commercial loan of public financing institution as the World Bank, the interest rate: 7.0 %, repayment period: 30 years including 5 years of grace period, and

(3) financing by international private commercial loan, the interest rate: 8.5 %, repayment period: 10 years including 2 years of grace period, by each distribution company.

In these cases, 15 % of the total cost are assumed to prepare by each distribution company its-self as their burdening capability.

And, those repayability analyses are also made in both the cases that the cost for the installation of capacitors and the amount of operating expanses to be saved due to the installation of capacitors (so called as financial benefit in financial evaluation) are excluded and included.

As a result, all companies have capabilities to execute their works by using any financing resources. However, there will register some deficits in all cases at an early stage after commencement of the works as shown in Tables 10-14 and 10-15 hereunder. These deficits are negligible small comparing with their surpluses. Nevertheless, from the viewpoint of deficit to be a minimum amount, the case using the Arab Fund is the best case for electricity enterprises.

Table 10-14 Deficits Appearing in Cash Flows of the Project (without Capacitor)

(JDs.)

Financing resource	Deficit-ridden year	Whole Project	EDCO's works	JEPCO's works	IDECO's works
In case of Arab Fund	2002	-2,998	-1,084	-761	-1,153
In case of international commercial loan of public financing institution such as IBRD	2002	-3,602	-1,302	-914	-1,385
In case of international private commercial loan	2002	-4,206	-1,521	-1,068	-1,618
	2004	-38,516		-22,690	-38,486
	2006				-12.987

Table 10-15 Deficits Appearing in Cash Flows of the Project (with Capacitor)

(JDs.)

Financing resource	Deficit-ridden year	Whole Project	EDCO's works	JEPCO's works	IDECO's works
In case of Arab Fund	2002	-3,144	-1,130	-806	-1,207
In case of international commercial loan of public financing institution such as IBRD	2002	-3,777	-1,358	-968	-1,451
In case of international private commercial loan	2002	-4,411	-1,586	-1,131	-1,694

11 Recommendation

Following are the recommendations based on the result of the study on target LV and MV feeders in terms of both technical and economic and financial analysis.

In this study, power factor correction with capacitor has been requested strongly by the Jordanian side and taken into account as the base means for distribution power loss reduction. As it is recommend in the Master Plan that power factor correction with capacitor should be propelled, installation of capacitors on LV and MV target distribution feeders should be conducted as the inexpensive and cost-effective measures.

It is also recommended that alternatives with shorter payback period of investment (with larger IE factor) have the priority of implementation. As the result of the study shows, the remedy with larger IE factor results in swift recovery of investment and larger benefit. The remedies for power loss reduction in distribution system should be implemented in accordance with the value of IE factor of the respective remedies.

Studies on respective remedies for LV feeders have been conducted by using the soft were PLOPT in order to seek optimal solutions for respective target feeders within the restricted of time, remedies for respective LV feeders may have some room for improvement by farther study or investigation such on actual distribution or location of existing facilities. Prior to implementation of respective measures, brush-up of remedies with human intelligence is recommended.

The FS manual for the study on power loss reduction has been compiled based on lectures or explanations in the site investigation period in Jordan as one of the important objectives for technology transfer. For the succeeding study of the second project of the power loss reduction by more Jordanian engineers, utilization of this manual is highly recommend as the instruction manual.

As results of economic and financial evaluation, both the resulted EIRR and FIRR in all cases seem to be too much high comparing with those in the other projects in electricity sector. But from the viewpoint of design criteria, only the most economical countermeasures in terms of cost performance are adopted for the Project.

So, the said results are quite logical and the Project is sound economically and financially.

And according to the results of repayability analyses, all companies have capabilities to execute their works by using any financing resources as (1) the Arab Fund, (2) international commercial loan of public financing institution as the World Bank, and (3) some international private commercial loan. However, there will register some deficits in all cases at an early stage after commencement of the works. These deficits are negligible small comparing with their probable revenue (saving amount of electricity sales). Nevertheless, from the viewpoint of deficit to be a minimum amount, the case using the Arab Fund is the best case for electricity enterprises.

The JICA Team would like to recommend starting procedures for commencement of the Project as soon as possible.

It is not originated from the result of this FS study but is on the issue of the electricity tariff system that discount rate of capacitor portion of electricity tariff should be taken into account. Recommendation of capacitor installation to relatively large customers can be taken into account to swiftly improve power factor of distribution system for power loss reduction as Japanese electric power companies have encouraged and propelled for many years. The study in the light of electricity tariff system should be suggested.

Appendix 1. Coefficient of Investment Efficiency

The term of recovery of initial investment on facilities for loss reduction has been studied. Using the coefficient of investment efficiency that is the ratio of the net benefit to the construction cost (investment for facilities), the term (recovering duration) has been estimated when the net benefit due to loss reduction exceeds the construction cost (initial investment for facilities). Relation between coefficient of investment efficiency and term of recovery of initial investment is summarized in Table A-1.

Table A-1 Coefficient of Investment Efficiency vs. Term of Recovery

Term of Recovery of Initial Investment	Coefficient of Investment Efficiency
The first year	10.43
2nd year	4.68
3rd year	2.80
4th year	1.86
5th year	1.30
6th year	0.93
7th year	0.66
8th year	0.47
9th year	0.32
10th year	0.20

・*Coefficient of Investment Efficiency = Net Benefit during the 10 years/ Investment on Facilities*

The above table shows that as coefficient of investment efficiency becomes larger, the term of recovery of initial investment becomes smaller. Using the coefficient of investment efficiency, measures for loss reduction can be ranked by respective feeders according to the value of investment efficiency. Further coefficients of investment efficiency can be used for determining the amount of investment and the selection of respective measures based on the order and/or term of recovery.

Appendix 2. Countermeasures on the LV Feeders

(1) EDCO

Feeder No.	Countermeasure			Invest.	Energy Loss (MWh/10yr.)				Cost & Benefit (JD/10yr.)			I.E.	Cap.	Remarks
	Cap. Inst.	MV Intro.	LV Reinf	(JD) A	Before B	After C	Reduct. D=B-C	Ratio E=D/B	Cost F	Benefit G	Net Ben. H=G-F	Factor I=H/A	Inst. (kVA)	
E001	●	●		24,499	3,081	358	2,723	0.884	19,510	77,438	57,928	2.365	55	(GM250)
E002	●		●	903	602	444	158	0.262	719	4,489	3,770	4.173	29	
E003	●	●		23,248	2,473	326	2,148	0.868	18,514	61,071	42,558	1.831	57	(GM250)
E004	●	●		17,370	1,683	308	1,375	0.817	13,833	39,096	25,263	1.454	34	* (PM150)
E005	●	●		16,169	1,505	330	1,174	0.780	12,876	33,393	20,517	1.269	33	(PM150)
E006	●		●	1,678	669	414	256	0.382	1,336	7,268	5,932	3.535	21	
E007	●		●	766	466	337	129	0.277	610	3,667	3,056	3.988	23	
E008	●		●	1,852	595	373	222	0.372	1,475	6,300	4,825	2.606	27	
E009	●	●		19,620	1,167	178	989	0.847	15,625	28,121	12,497	0.637	41	* (PM150)
E010	●		●	378	638	499	140	0.219	301	3,970	3,669	9.702	29	
E011	●	●		15,168	1,570	359	1,211	0.771	12,079	34,428	22,349	1.473	65	(PM150)
E012	●	●		20,390	1,753	277	1,476	0.842	16,238	41,963	25,725	1.262	42	(PM150)
E013	●		●	290	433	352	81	0.187	231	2,301	2,070	7.135	30	
E014	●		●	4,811	935	468	466	0.499	3,832	13,264	9,433	1.960	31	
E015	●		●	4,500	1,232	694	538	0.437	3,583	15,309	11,726	2.606	47	
E016	●	●		16,297	1,236	295	941	0.761	12,978	26,767	13,789	0.846	46	(GM250)
E017	●		●	224	617	535	82	0.133	179	2,338	2,159	9.626	28	
E018	●	●		15,645	1,133	255	879	0.775	12,459	24,985	12,526	0.801	35	(PM150)
E019	●		●	2,543	663	447	217	0.326	2,025	6,157	4,132	1.625	26	
E020	●		●	2,359	708	497	211	0.298	1,879	6,005	4,126	1.749	27	
E021	●		●	1,221	480	355	124	0.259	972	3,530	2,558	2.095	24	
E022	●		●	2,181	614	421	193	0.314	1,737	5,483	3,746	1.718	30	
E023	●		●	654	517	423	94	0.182	521	2,669	2,148	3.285	23	
E024	●		●	5,341	932	410	522	0.560	4,253	14,830	10,577	1.980	32	
E025	●		●	3,918	1,109	556	553	0.498	3,120	15,721	12,601	3.217	42	
E026	●		●	3,661	865	419	446	0.516	2,915	12,682	9,766	2.668	24	
E027	●		●	2,359	617	429	188	0.305	1,879	5,359	3,480	1.475	27	
E028	●		●	843	677	532	145	0.215	671	4,136	3,465	4.110	23	
E029	●		●	2,349	483	348	135	0.279	1,870	3,838	1,968	0.838	25	
E030	●		●	671	308	242	67	0.216	535	1,891	1,357	2.021	27	
E031	●		●	1,258	510	383	127	0.250	1,001	3,624	2,623	2.086	33	
E032	●		●	471	482	408	73	0.152	375	2,085	1,710	3.631	24	
E033	●		●	2,393	582	373	208	0.358	1,906	5,920	4,014	1.677	36	
E034	●		●	1,223	527	392	135	0.256	974	3,831	2,857	2.336	24	
E035	●		●	5,352	872	448	424	0.487	4,262	12,066	7,804	1.458	25	
E036	●		●	2,927	667	425	242	0.363	2,331	6,880	4,549	1.554	29	
E037	●			90	613	500	113	0.185	72	3,222	3,150	34.989	23	
E038	●	●		14,335	1,335	347	988	0.740	11,415	28,091	16,676	1.163	39	(PM150)
E039	●	●		14,316	1,262	452	810	0.642	11,401	23,038	11,638	0.813	35	* (PM150)
E040	●		●	1,815	513	380	133	0.259	1,445	3,776	2,331	1.284	32	
E041	●		●	2,437	952	522	430	0.451	1,941	12,223	10,282	4.220	46	
E042	●		●	3,899	863	476	387	0.448	3,105	11,009	7,904	2.027	37	
E043	●		●	3,537	584	327	257	0.440	2,817	7,305	4,489	1.269	38	
E044	●			121	465	382	83	0.179	96	2,363	2,266	18.728	30	
E045	●		●	3,792	530	257	273	0.515	3,019	7,769	4,750	1.253	48	
E046	●		●	1,220	377	269	108	0.287	971	3,072	2,100	1.722	24	
E047	●		●	5,186	982	541	441	0.449	4,130	12,543	8,413	1.622	31	
E048	●		●	180	529	443	87	0.164	144	2,472	2,328	12.905	42	
E049	●		●	3,333	908	516	391	0.431	2,654	11,122	8,468	2.541	36	
E050	●		●	7,622	944	396	548	0.581	6,070	15,585	9,515	1.248	30	

* :MV introduction measure is selected due to voltage criteria of over 10% in the initial year.
( ) : Recommended transformer type and capacity for MV introduction measure.

Feeder No.	Countermeasure			Invest. (JD)	Energy Loss (MWh/10yr.)				Cost & Benefit (JD/10yr.)			I.E. Factor	Cap. Inst. (kVA)	Remarks
	Cap. Inst.	MV Intro.	LV Reinf		Before	After	Reduct.	Ratio	Cost	Benefit	Net Ben.			
				A	B	C	D=B-C	E=D/B	F	G	H=G-F	I=H/A		
E051	●		●	2,383	670	428	242	0.361	1,897	6,871	4,973	2.087	33	
E052	●		●	1,793	476	349	127	0.267	1,427	3,613	2,185	1.219	26	
E053	●		●	1,230	477	334	143	0.300	979	4,072	3,093	2.516	26	
E054	●	●		16,293	950	213	737	0.776	12,975	20,962	7,988	0.490	31	* (PM150)
E055	●		●	3,474	614	409	205	0.334	2,766	5,829	3,063	0.882	25	
E056	●		●	1,227	736	559	176	0.240	977	5,015	4,038	3.292	25	
E057	●		●	5,540	831	456	375	0.451	4,411	10,652	6,240	1.126	25	
E058	●		●	4,478	1,391	448	943	0.678	3,566	26,804	23,239	5.190	41	
E059	●			127	446	371	76	0.170	101	2,156	2,055	16.208	32	
E060	●			108	263	238	25	0.095	86	713	627	5.781	27	
E061	●			99	497	394	103	0.207	79	2,930	2,851	28.874	25	
E062	●	●		18,932	1,189	209	980	0.824	15,076	27,871	12,795	0.676	26	* (PM150)
E063	●		●	1,591	576	291	285	0.494	1,267	8,101	6,834	4.295	23	
E064	●		●	4,873	778	362	416	0.535	3,880	11,820	7,940	1.629	32	
E065	●		●	2,469	684	463	221	0.323	1,967	6,278	4,312	1.746	27	
E066	●		●	6,553	938	429	509	0.543	5,218	14,486	9,268	1.414	30	
E067	●		●	2,889	670	407	263	0.392	2,300	7,479	5,179	1.793	33	
E068	●		●	3,690	588	336	252	0.428	2,939	7,156	4,217	1.143	27	
E069	●		●	2,187	473	306	168	0.354	1,742	4,765	3,023	1.382	27	
E070	●		●	2,358	653	439	214	0.328	1,878	6,082	4,204	1.783	27	
E071	●		●	5,132	751	412	339	0.451	4,087	9,629	5,542	1.080	45	
E072	●		●	1,937	503	257	246	0.489	1,542	6,989	5,447	2.812	15	
E073	●		●	1,485	792	595	197	0.249	1,182	5,613	4,431	2.985	34	
E074	●		●	1,118	711	579	132	0.185	890	3,743	2,853	2.553	26	
E075	●		●	1,334	354	239	115	0.324	1,062	3,265	2,203	1.651	24	
E076	●		●	1,321	436	265	172	0.394	1,052	4,888	3,836	2.904	16	
E077	●		●	2,102	668	430	238	0.356	1,674	6,768	5,094	2.424	33	
E078	●		●	4,371	925	517	408	0.441	3,481	11,610	8,129	1.860	38	
E079	●		●	615	344	267	77	0.223	490	2,182	1,692	2.749	27	
E080	●			98	305	249	56	0.184	78	1,598	1,520	15.548	24	
E081	●		●	1,677	603	432	171	0.283	1,335	4,857	3,522	2.101	25	
E082	●		●	3,130	824	442	382	0.464	2,492	10,870	8,378	2.677	32	
E083	●		●	3,312	636	351	285	0.448	2,637	8,092	5,455	1.647	31	
E084	●		●	2,043	490	275	215	0.439	1,627	6,116	4,489	2.197	23	
E085	●		●	1,335	470	335	135	0.287	1,063	3,831	2,768	2.074	24	
E086	●		●	2,271	661	387	274	0.414	1,808	7,788	5,980	2.633	33	
E087	●		●	1,579	507	289	218	0.429	1,258	6,195	4,937	3.127	29	
E088	●	●		16,741	1,001	256	745	0.744	13,331	21,185	7,854	0.469	26	* (PM150)
E089	●		●	233	336	260	76	0.226	185	2,156	1,970	8.465	24	
E090	●	●		14,702	1,954	419	1,536	0.786	11,708	43,670	31,961	2.174	65	(PM150)
E091	●	●		21,511	1,248	208	1,040	0.833	17,130	29,564	12,434	0.578	38	(GM250)
E092	●	●		20,880	4,046	799	3,247	0.803	16,627	92,347	75,719	3.626	63	(GM250)
E093	●	●		17,333	971	227	745	0.767	13,803	21,179	7,377	0.426	33	* (PM150)
E094	●		●	2,116	693	475	217	0.314	1,685	6,184	4,499	2.126	37	
E095	●	●		13,507	1,658	399	1,259	0.759	10,756	35,802	25,046	1.854	38	* (PM250)
E096	●	●		20,194	5,654	695	4,959	0.877	16,082	141,019	124,938	6.187	74	(GM250)
E097	●		●	4,674	1,588	488	1,100	0.693	3,722	31,278	27,556	5.896	34	
E098	●		●	4,843	1,430	442	988	0.691	3,856	28,108	24,252	5.008	34	
E099	●	●		21,213	1,885	343	1,542	0.818	16,893	43,859	26,967	1.271	47	* (GM250)
E100	●		●	5,371	920	414	506	0.550	4,277	14,377	10,100	1.880	35	

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( ) : Recommended transformer type and capacity for MV introduction measure.

Feeder No.	Countermeasure			Invest. (JD)	Energy Loss (MWh/10yr.)				Cost & Benefit (JD/10yr.)			I.E. Factor	Cap. Inst. (kVA)	Remarks
	Cap. Inst.	MV Intro.	LV Reinf		Before	After	Reduct.	Ratio	Cost	Benefit	Net Ben.			
				A	B	C	D=B-C	E=D/B	F	G	H=G-F	I=H/A		
E101	●	●		15,426	2,278	462	1,816	0.797	12,284	51,633	39,349	2.551	46	* (PM150)
E102	●		●	1,716	478	219	259	0.542	1,366	7,374	6,008	3.501	16	
E103	●	●		18,422	1,406	311	1,095	0.779	14,670	31,134	16,464	0.894	46	(GM250)
E104	●		●	2,623	1,088	591	497	0.457	2,088	14,134	12,046	4.593	42	
E105	●	●		24,651	1,702	231	1,471	0.864	19,631	41,823	22,192	0.900	28	(PM150)
E106	●		●	3,018	721	435	286	0.396	2,403	8,124	5,721	1.896	23	
E107	●		●	4,013	969	574	395	0.408	3,196	11,243	8,048	2.005	24	
E108	●	●		17,171	3,880	614	3,266	0.842	13,674	92,859	79,185	4.611	51	(PM150)
E109	●	●		17,106	2,155	379	1,776	0.824	13,623	50,514	36,891	2.157	35	(PM150)
E110	●	●		15,346	2,787	308	2,479	0.889	12,221	70,496	58,275	3.797	43	(PM150)
E111	●			58	246	191	55	0.224	46	1,572	1,526	26.272	15	
E112	●		●	2,899	662	290	371	0.561	2,309	10,562	8,253	2.846	21	
E113	●	●		21,733	4,721	428	4,293	0.909	17,307	122,085	104,778	4.821	52	(PM250)
E114	●	●		22,798	7,564	1,265	6,298	0.833	18,155	179,103	160,948	7.060	72	(PM150X2
E115	●	●		21,461	4,180	673	3,507	0.839	17,090	99,721	82,630	3.850	67	(PM250)
E116	●	●		17,044	2,696	687	2,009	0.745	13,573	57,127	43,554	2.555	75	(PM250)
E117	●	●		21,926	5,396	667	4,730	0.876	17,461	134,497	117,036	5.338	89	(GM400)
E118	●	●		16,711	1,491	367	1,124	0.754	13,308	31,971	18,663	1.117	57	(GM250)
E119	●	●		18,130	1,880	500	1,380	0.734	14,437	39,236	24,798	1.368	56	(GM250)
E120	●	●		20,636	1,111	254	857	0.771	16,434	24,368	7,935	0.384	35	* (GM250)
E121	●		●	4,717	931	542	389	0.418	3,756	11,061	7,305	1.549	40	
E122	●	●		19,917	1,979	335	1,644	0.831	15,861	46,749	30,888	1.551	38	(GM250)
E123	●	●		24,148	3,182	420	2,762	0.868	19,230	78,549	59,319	2.456	35	(PM150)
E124	●	●		18,640	1,635	288	1,346	0.824	14,844	38,289	23,445	1.258	51	(GM250)
E125	●		●	3,076	836	523	313	0.375	2,450	8,901	6,451	2.097	38	
E126	●		●	2,836	948	589	358	0.378	2,259	10,193	7,934	2.797	34	
E127	●		●	1,587	549	401	148	0.269	1,264	4,207	2,943	1.855	31	
E128	●		●	2,392	681	417	264	0.388	1,905	7,502	5,597	2.340	36	
E129	●		●	887	519	387	132	0.255	706	3,762	3,056	3.446	25	
E130	●		●	3,738	631	378	253	0.401	2,976	7,202	4,225	1.130	25	
E131	●		●	4,100	1,043	368	675	0.648	3,265	19,202	15,937	3.887	27	
E132	●		●	4,391	840	496	344	0.410	3,497	9,788	6,292	1.433	29	
E133	●	●		18,810	1,425	249	1,176	0.825	14,979	33,437	18,458	0.981	29	(PM150)
E134	●	●		14,618	1,234	255	979	0.794	11,641	27,847	16,206	1.109	27	(PM150)
E135	●		●	2,336	503	295	208	0.414	1,860	5,925	4,065	1.740	31	
E136	●		●	2,032	606	426	180	0.296	1,618	5,105	3,487	1.716	30	
E137	●		●	3,842	824	452	371	0.451	3,059	10,555	7,495	1.951	32	
E138	●		●	3,034	554	339	214	0.387	2,416	6,091	3,674	1.211	27	
E139	●		●	2,701	639	438	201	0.314	2,151	5,708	3,556	1.317	28	
E140	●		●	3,532	1,000	376	625	0.625	2,813	17,766	14,954	4.234	30	
E141	●		●	1,627	517	347	170	0.330	1,296	4,846	3,551	2.183	31	
E142	●	●		15,764	810	180	630	0.778	12,553	17,924	5,371	0.341	31	* (PM150)
E143	●		●	5,301	777	473	304	0.391	4,221	8,649	4,427	0.835	31	
E144	●		●	739	518	420	98	0.189	589	2,781	2,192	2.966	30	
E145	●	●		15,249	865	239	626	0.724	12,144	17,795	5,651	0.371	27	(PM150)
E146	●			96	573	492	80	0.140	76	2,285	2,209	23.049	24	
E147	●	●		18,584	1,182	198	984	0.832	14,799	27,980	13,181	0.709	22	* (PM150)
E148	●			78	295	256	38	0.129	62	1,082	1,020	13.009	20	
Total				1,049,548	165,029	59,330	105,698		835,800	3,005,642	2,169,842			

* :MV introduction measure is selected due to voltage criteria of over 10% in the initial year.
( ) : Recommended transformer type and capacity for MV introduction measure.

(2) JEPCO

Feeder No.	Countermeasure			Invest. (JD)	Energy Loss (MWh/10yr.)				Cost & Benefit (JD/10yr.)			I.E. Factor	Cap. Inst. (kVA)	Remarks
	Cap. Inst.	MV Intro.	LV Reinf		Before	After	Reduct.	Ratio	Cost	Benefit	Net Ben.			
				A	B	C	D=B-C	E=D/B	F	G	H=G-F	I=H/A		
J001	●		●	3,851	1,022	599	423	0.414	3,067	12,039	8,972	2.330	35	
J002	●		●	1,679	568	437	131	0.230	1,337	3,718	2,381	1.419	26	
J003	●		●	1,701	417	300	117	0.280	1,354	3,323	1,969	1.158	31	
J004	●	●		25,099	1,607	357	1,250	0.778	19,987	35,548	15,561	0.620	45	(IN250)
J005	●	●		23,627	1,827	409	1,417	0.776	18,815	40,303	21,488	0.909	48	(IN250)
J006	●	●		19,271	972	293	679	0.698	15,346	19,300	3,954	0.205	39	(IN250)
J007	●	●		24,865	2,106	429	1,677	0.796	19,801	47,695	27,893	1.122	59	(IN400)
J008	●	●		23,231	1,792	541	1,250	0.698	18,500	35,550	17,050	0.734	55	(IN400)
J009	●	●		26,611	1,671	360	1,311	0.785	21,192	37,286	16,095	0.605	52	(IN250)
J010	●		●	1,371	537	355	182	0.339	1,092	5,177	4,085	2.980	24	
J011	●		●	1,927	897	608	289	0.322	1,535	8,213	6,678	3.465	50	
J012	●		●	2,980	1,164	529	635	0.546	2,373	18,066	15,693	5.267	42	
J013	●		●	5,023	1,143	440	703	0.615	4,000	19,995	15,995	3.184	83	
J014	●		●	1,944	545	323	222	0.407	1,548	6,309	4,761	2.450	40	
J015	●		●	1,426	538	335	203	0.377	1,135	5,770	4,634	3.250	47	
J016	●		●	1,537	599	440	159	0.266	1,224	4,529	3,305	2.150	28	
J017	●		●	1,363	752	445	308	0.409	1,086	8,745	7,659	5.618	27	
J018	●		●	1,509	358	208	150	0.419	1,201	4,265	3,063	2.031	26	
J019	●		●	1,777	656	423	234	0.356	1,415	6,649	5,234	2.945	22	
J020	●		●	5,387	1,583	589	994	0.628	4,290	28,253	23,963	4.448	39	
J021	●		●	3,531	1,454	657	797	0.548	2,812	22,669	19,857	5.623	43	
J022	●		●	1,788	623	382	241	0.387	1,424	6,853	5,429	3.036	44	
J023	●		●	2,485	544	360	184	0.338	1,979	5,225	3,246	1.306	30	
J024	●		●	1,962	538	344	194	0.360	1,563	5,515	3,952	2.014	27	
J025	●		●	986	444	363	81	0.183	785	2,307	1,522	1.543	22	
J026	●		●	1,748	716	414	302	0.422	1,392	8,591	7,199	4.117	57	
J027	●		●	1,852	750	256	494	0.659	1,475	14,051	12,576	6.791	46	
J028	●		●	213	275	227	48	0.174	170	1,359	1,189	5.575	21	
J029	●			61	323	293	31	0.095	49	876	828	13.573	15	
J030	●		●	2,870	800	434	366	0.457	2,285	10,398	8,113	2.827	33	
J031	●		●	2,185	490	298	192	0.392	1,740	5,462	3,722	1.704	26	
J032	●		●	1,024	328	177	151	0.462	815	4,305	3,490	3.410	26	
J033	●		●	2,213	557	223	335	0.600	1,763	9,516	7,753	3.503	28	
J034	●		●	1,115	477	213	264	0.554	888	7,514	6,626	5.941	35	
J035	●		●	2,620	605	364	241	0.398	2,086	6,844	4,758	1.816	31	
J036	●		●	2,433	664	370	294	0.443	1,937	8,362	6,424	2.641	32	
J037	●		●	2,850	731	406	325	0.445	2,270	9,253	6,984	2.450	37	
J038	●			77	290	257	32	0.112	62	919	858	11.074	19	
J039	●		●	401	256	219	37	0.144	320	1,050	730	1.819	21	
J040	●			83	278	249	29	0.104	66	825	758	9.111	21	
J041	●		●	2,780	659	380	279	0.423	2,214	7,930	5,716	2.056	29	
J042	●		●	1,461	485	292	192	0.397	1,164	5,470	4,306	2.946	28	
J043	●		●	995	303	216	86	0.285	793	2,452	1,660	1.668	29	
J044	●		●	3,155	909	455	454	0.500	2,512	12,917	10,405	3.298	34	
J045	●		●	2,616	557	343	214	0.385	2,083	6,098	4,015	1.535	26	
J046	●		●	3,897	782	390	392	0.501	3,103	11,137	8,033	2.061	46	
J047	●		●	4,826	997	469	528	0.529	3,844	15,004	11,160	2.312	34	
J048	●		●	4,567	1,212	558	654	0.540	3,637	18,601	14,964	3.277	49	
J049	●		●	720	610	490	119	0.195	573	3,388	2,815	3.911	39	
J050	●		●	1,449	643	487	157	0.243	1,154	4,453	3,300	2.278	34	

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( ) : Recommended transformer type and capacity for MV introduction measure.

Feeder No.	Countermeasure			Invest. (JD)	Energy Loss (MWh/10yr.)				Cost & Benefit (JD/10yr.)			I.E. Factor	Cap. Inst. (kVA)	Remarks
	Cap. Inst.	MV Intro.	LV Reinf		Before	After	Reduct.	Ratio	Cost	Benefit	Net Ben.			
				A	B	C	D=B-C	E=D/B	F	G	H=G-F	I=H/A		
J051	●		●	370	689	587	102	0.148	294	2,909	2,614	7.072	17	
J052	●		●	4,848	1,876	966	909	0.485	3,860	25,859	21,999	4.538	87	
J053	●			79	487	463	24	0.049	63	679	615	7.754	20	
J054	●		●	488	644	571	73	0.113	389	2,069	1,680	3.442	38	
J055	●		●	5,668	1,786	801	985	0.551	4,514	28,004	23,490	4.144	76	
J056	●			16	133	131	2	0.016	13	60	47	2.858	4	
J057	●		●	2,108	408	237	171	0.418	1,678	4,849	3,171	1.504	25	
J058	●		●	1,947	696	399	297	0.427	1,551	8,446	6,896	3.541	37	
J059	●		●	860	590	491	99	0.168	685	2,815	2,130	2.477	32	
J060	●		●	3,097	961	584	378	0.393	2,466	10,737	8,270	2.670	38	
J061	●		●	1,778	591	442	149	0.252	1,416	4,244	2,828	1.590	27	
J062	●		●	1,486	583	366	217	0.373	1,183	6,177	4,994	3.362	34	
J063	●		●	2,963	1,869	685	1,184	0.633	2,360	33,672	31,312	10.567	66	
J064	●	●		25,028	3,206	411	2,794	0.872	19,931	79,464	59,533	2.379	60	* (PU250)
J065	●		●	636	551	448	103	0.186	506	2,917	2,411	3.793	18	
J066	●		●	2,389	636	431	205	0.322	1,903	5,832	3,929	1.645	30	
J067	●		●	2,441	588	406	182	0.310	1,944	5,186	3,242	1.328	33	
J068	●		●	2,850	525	261	264	0.502	2,270	7,494	5,224	1.833	28	
J069	●		●	4,187	1,830	635	1,195	0.653	3,334	33,974	30,640	7.318	76	
J070	●		●	5,970	2,641	881	1,760	0.666	4,754	50,041	45,287	7.586	67	
J071	●		●	4,146	762	415	347	0.455	3,302	9,870	6,569	1.584	38	
J072	●		●	3,581	712	409	302	0.425	2,851	8,600	5,749	1.605	32	
J073	●		●	2,120	683	415	269	0.393	1,689	7,637	5,948	2.805	42	
J074	●		●	3,271	861	447	414	0.481	2,605	11,773	9,168	2.803	39	
J075	●		●	2,655	458	238	220	0.481	2,114	6,269	4,155	1.565	26	
J076	●		●	995	772	575	197	0.255	792	5,601	4,809	4.833	24	
J077	●		●	474	536	390	146	0.272	378	4,152	3,774	7.957	20	
J078	●		●	3,689	944	490	455	0.481	2,938	12,928	9,990	2.708	31	
J079	●		●	2,392	849	523	326	0.384	1,905	9,257	7,352	3.074	61	
J080	●		●	4,178	1,086	616	470	0.433	3,327	13,367	10,039	2.403	27	
J081	●		●	4,689	1,288	633	654	0.508	3,734	18,609	14,875	3.172	28	
J082	●		●	856	518	440	79	0.152	681	2,233	1,552	1.813	17	
J083	●		●	2,275	1,058	572	486	0.459	1,812	13,817	12,005	5.277	39	
J084	●	●		23,402	1,840	449	1,391	0.756	18,636	39,561	20,925	0.894	64	(IN400)
J085	●		●	1,076	1,167	959	209	0.179	857	5,940	5,082	4.721	65	
J086	●	●		24,935	2,603	490	2,113	0.812	19,857	60,094	40,237	1.614	76	(IN400)
J087	●	●		22,462	2,171	526	1,645	0.758	17,888	46,786	28,898	1.286	66	(IN400)
J088	●	●		21,566	1,776	483	1,293	0.728	17,174	36,779	19,605	0.909	61	(IN400)
J089	●			60	428	405	23	0.053	48	644	597	9.939	15	
J090	●		●	2,716	668	384	284	0.425	2,163	8,067	5,904	2.173	37	
J091	●		●	3,571	1,491	1,015	476	0.319	2,844	13,532	10,688	2.993	68	
J092	●		●	2,100	929	795	134	0.144	1,672	3,803	2,131	1.015	33	
J093	●	●		20,997	1,483	423	1,060	0.715	16,720	30,151	13,431	0.640	64	(PU250)
J094	●	●		20,427	1,234	368	866	0.702	16,267	24,639	8,371	0.410	57	(PU250)
J095	●	●		24,417	1,484	328	1,156	0.779	19,444	32,872	13,428	0.550	42	(PU250)
J096	●			78	801	775	26	0.032	62	730	668	8.517	20	
J097	●		●	2,648	1,050	546	504	0.480	2,109	14,333	12,224	4.616	43	
J098	●		●	3,310	733	428	305	0.417	2,636	8,686	6,050	1.828	30	
J099	●			76	562	541	21	0.037	60	584	524	6.941	19	
J100	●		●	1,245	478	342	136	0.284	991	3,866	2,875	2.309	30	
Total				514,759	91,771	44,624	47,147		409,924	1,340,682	930,758			

* :MV introduction measure is selected due to voltage criteria of over 10% in the initial year.
( ) : Recommended transformer type and capacity for MV introduction measure.

(3) IDECO

Feeder No.	Countermeasure			Invest. (JD)	Energy Loss (MWh/10yr.)				Cost & Benefit (JD/10yr.)			I.E. Factor	Cap. Inst. (kVA)	Remarks
	Cap. Inst.	MV Intro.	LV Reinf	A	Before B	After C	Reduct. D=B-C	Ratio E=D/B	Cost F	Benefit G	Net Ben. H=G-F	I=H/A		
I001	●			13	191	188	3	0.015	11	84	73	5.496	3	
I002	●		●	4,814	1,055	420	635	0.602	3,833	18,069	14,236	2.957	36	
I003	●			83	413	342	71	0.171	66	2,007	1,940	23.328	21	
I004	●		●	1,591	508	357	150	0.296	1,267	4,279	3,011	1.892	23	
I005	●	●		13,718	1,350	455	895	0.663	10,924	25,455	14,530	1.059	40	(GM250)
I006	●	●		16,805	1,528	299	1,228	0.804	13,383	34,932	21,549	1.282	48	(GM250)
I007	●	●		17,302	1,379	282	1,097	0.795	13,778	31,182	17,404	1.006	39	(GM250)
I008	●	●		17,099	1,811	347	1,464	0.808	13,617	41,643	28,026	1.639	55	(GM250)
I009	●	●		17,918	2,434	761	1,672	0.687	14,269	47,554	33,286	1.858	93	(GM250)
I010	●	●		16,698	1,863	247	1,616	0.867	13,297	45,942	32,644	1.955	47	(GM250)
I011	●	●		16,289	1,487	503	984	0.662	12,972	27,973	15,002	0.921	45	(GM250)
I012	●	●		17,674	1,260	302	958	0.760	14,075	27,233	13,158	0.744	36	(GM250)
I013	●	●		21,515	1,692	236	1,456	0.861	17,133	41,411	24,277	1.128	32	(GM250)
I014	●		●	5,342	998	622	376	0.377	4,254	10,691	6,437	1.205	50	
I015	●		●	2,099	768	521	247	0.321	1,671	7,023	5,351	2.550	46	
I016	●		●	4,997	1,113	619	493	0.443	3,980	14,030	10,051	2.011	35	
I017	●	●		22,851	2,387	340	2,047	0.858	18,197	58,207	40,010	1.751	41	(GM250)
I018	●		●	2,796	608	455	153	0.251	2,226	4,342	2,116	0.757	24	
I019	●		●	1,474	696	539	157	0.226	1,174	4,461	3,287	2.230	31	
I020	●	●		16,644	1,445	288	1,157	0.801	13,255	32,895	19,640	1.180	50	(GM250)
I021	●		●	6,273	1,292	702	590	0.457	4,996	16,786	11,790	1.879	50	
I022	●		●	3,670	1,051	632	419	0.398	2,923	11,902	8,979	2.446	50	
I023	●	●		13,995	1,520	475	1,045	0.687	11,145	29,718	18,573	1.327	43	(GM250)
I024	●	●		16,435	1,412	351	1,061	0.751	13,088	30,167	17,078	1.039	35	(GM250)
I025	●	●		18,862	2,549	459	2,090	0.820	15,021	59,436	44,415	2.355	50	(GM250)
I026	●		●	2,600	779	511	268	0.344	2,070	7,612	5,541	2.131	31	
I027	●		●	2,637	784	478	306	0.390	2,100	8,696	6,596	2.502	40	
I028	●		●	1,821	692	528	164	0.237	1,450	4,666	3,216	1.767	33	
I029	●		●	2,780	694	492	202	0.291	2,214	5,737	3,523	1.267	29	
I030	●		●	3,912	834	558	276	0.331	3,115	7,854	4,738	1.211	45	
I031	●		●	2,457	838	504	334	0.398	1,957	9,489	7,533	3.066	38	
I032	●		●	3,106	889	569	321	0.360	2,473	9,114	6,640	2.138	31	
I033	●			49	208	185	23	0.109	39	644	605	12.255	12	
I034	●			75	359	316	43	0.119	59	1,220	1,161	15.570	19	
I035	●	●		22,471	1,360	264	1,096	0.806	17,895	31,165	13,270	0.591	29	(GM250)
I036	●	●		17,035	873	241	632	0.724	13,566	17,984	4,418	0.259	29	* (GM250)
I037	●		●	4,332	670	308	362	0.540	3,450	10,286	6,836	1.578	31	
I038	●			44	190	153	37	0.197	35	1,065	1,031	23.659	11	
I039	●			21	80	76	5	0.060	17	137	121	5.658	5	
I040	●		●	349	374	316	58	0.155	278	1,653	1,375	3.938	22	
I041	●		●	369	509	409	100	0.196	294	2,836	2,542	6.897	33	
I042	●			77	375	321	54	0.144	62	1,529	1,468	18.950	19	
I043	●		●	2,698	619	364	256	0.413	2,149	7,272	5,124	1.899	28	
I044	●		●	4,271	969	489	480	0.496	3,401	13,651	10,250	2.400	36	
I045	●		●	1,978	683	375	307	0.450	1,575	8,742	7,167	3.624	25	
I046	●		●	2,466	1,197	617	580	0.485	1,964	16,503	14,539	5.896	54	
I047	●		●	3,423	1,729	642	1,087	0.629	2,726	30,904	28,178	8.232	54	
I048	●		●	3,656	611	372	239	0.391	2,911	6,789	3,877	1.061	23	
I049	●		●	5,812	1,179	594	585	0.496	4,628	16,644	12,016	2.067	46	
I050	●		●	1,267	477	322	155	0.325	1,009	4,408	3,399	2.683	45	

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( ) : Recommended transformer type and capacity for MV introduction measure.

Feeder No.	Countermeasure			Invest. (JD)	Energy Loss (MWh/10yr.)				Cost & Benefit (JD/10yr.)			I.E. Factor	Cap. Inst. (kVA)	Remarks
	Cap. Inst.	MV Intro.	LV Reinf		Before	After	Reduct.	Ratio	Cost	Benefit	Net Ben.			
				A	B	C	D=B-C	E=D/B	F	G	H=G-F	I=H/A		
I051	●			59	282	234	48	0.169	47	1,357	1,310	22.191	15	
I052	●			77	427	339	88	0.206	62	2,500	2,438	31.486	19	
I053	●			62	338	330	9	0.026	49	249	200	3.225	15	
I054	●			46	412	383	29	0.071	37	833	796	17.138	12	
I055	●		●	2,230	775	513	263	0.339	1,776	7,471	5,695	2.554	46	
I056	●			98	296	231	65	0.218	78	1,839	1,761	18.008	24	
I057	●		●	1,712	822	583	239	0.291	1,363	6,809	5,446	3.182	34	
I058	●		●	5,809	683	337	346	0.507	4,626	9,842	5,216	0.898	27	
I059	●		●	3,616	780	445	335	0.430	2,879	9,527	6,648	1.839	32	
I060	●	●		18,167	1,114	300	815	0.731	14,467	23,164	8,697	0.479	32	* (GM250)
I061	●		●	443	405	335	69	0.171	353	1,974	1,622	3.662	17	
I062	●			67	537	444	92	0.172	53	2,620	2,567	38.433	17	
I063	●	●		16,770	1,423	592	831	0.584	13,354	23,627	10,273	0.613	49	* (GM250)
I064	●	●		16,327	967	252	715	0.739	13,002	20,325	7,323	0.449	31	(GM250)
I065	●	●		17,732	3,171	378	2,793	0.881	14,121	79,416	65,295	3.682	67	(GM250)
I066	●		●	1,145	637	449	189	0.296	912	5,372	4,460	3.895	38	
I067	●		●	3,642	1,382	776	607	0.439	2,900	17,252	14,352	3.941	53	
I068	●		●	3,396	881	463	418	0.475	2,704	11,887	9,183	2.704	33	
I069	●		●	5,353	698	377	320	0.459	4,263	9,107	4,845	0.905	25	
I070	●		●	288	642	481	161	0.251	230	4,591	4,361	15.120	27	
I071	●		●	889	448	321	127	0.284	708	3,610	2,902	3.266	25	
I072	●			77	364	296	68	0.188	62	1,942	1,880	24.275	19	
I073	●	●		19,317	1,198	305	894	0.746	15,383	25,410	10,027	0.519	31	* (GM250)
I074	●	●		17,574	963	266	697	0.723	13,995	19,814	5,819	0.331	27	* (GM250)
I075	●		●	596	476	417	58	0.123	474	1,658	1,183	1.987	18	
I076	●		●	1,590	839	606	233	0.278	1,266	6,633	5,367	3.376	32	
I077	●		●	474	973	787	186	0.191	377	5,291	4,913	10.376	34	
I078	●			77	484	402	82	0.169	62	2,328	2,267	29.267	19	
I079	●		●	2,238	680	463	217	0.319	1,782	6,176	4,394	1.964	25	
I080	●		●	3,674	1,051	579	472	0.449	2,926	13,418	10,493	2.856	37	
I081	●		●	4,628	929	505	423	0.456	3,685	12,040	8,354	1.805	32	
I082	●		●	2,118	846	610	237	0.280	1,687	6,727	5,040	2.380	23	
I083	●		●	1,584	810	572	238	0.294	1,261	6,764	5,502	3.474	30	
I084	●	●		17,101	1,949	667	1,282	0.658	13,618	36,444	22,826	1.335	42	(GM250)
I085	●	●		16,642	923	236	687	0.744	13,252	19,534	6,281	0.377	26	(GM250)
I086	●			83	624	577	47	0.075	66	1,323	1,257	15.096	21	
I087	●	●		21,147	998	206	792	0.793	16,840	22,515	5,675	0.268	30	(GM250)
I088	●	●		18,909	1,674	433	1,241	0.742	15,058	35,304	20,246	1.071	49	(GM250)
I089	●		●	880	511	415	95	0.187	701	2,710	2,009	2.283	14	
I090	●		●	215	448	405	43	0.095	171	1,213	1,042	4.851	16	
I091	●		●	2,166	1,276	600	676	0.530	1,725	19,223	17,498	8.079	54	
I092	●		●	2,548	774	531	243	0.313	2,029	6,897	4,867	1.910	37	
I093	●		●	1,334	458	348	110	0.241	1,062	3,134	2,072	1.553	24	
I094	●		●	3,315	780	412	368	0.472	2,640	10,467	7,827	2.361	36	
I095	●		●	3,312	772	409	363	0.470	2,638	10,321	7,683	2.320	35	
I096	●		●	774	389	326	63	0.163	616	1,798	1,181	1.527	25	
I097	●		●	1,674	477	362	115	0.241	1,333	3,272	1,939	1.158	25	
I098	●		●	3,973	2,095	641	1,454	0.694	3,164	41,345	38,181	9.609	65	
I099	●		●	4,909	995	518	477	0.479	3,909	13,559	9,649	1.966	36	
I100	●	●		20,831	1,866	504	1,362	0.730	16,589	38,728	22,140	1.063	51	* (GM250)

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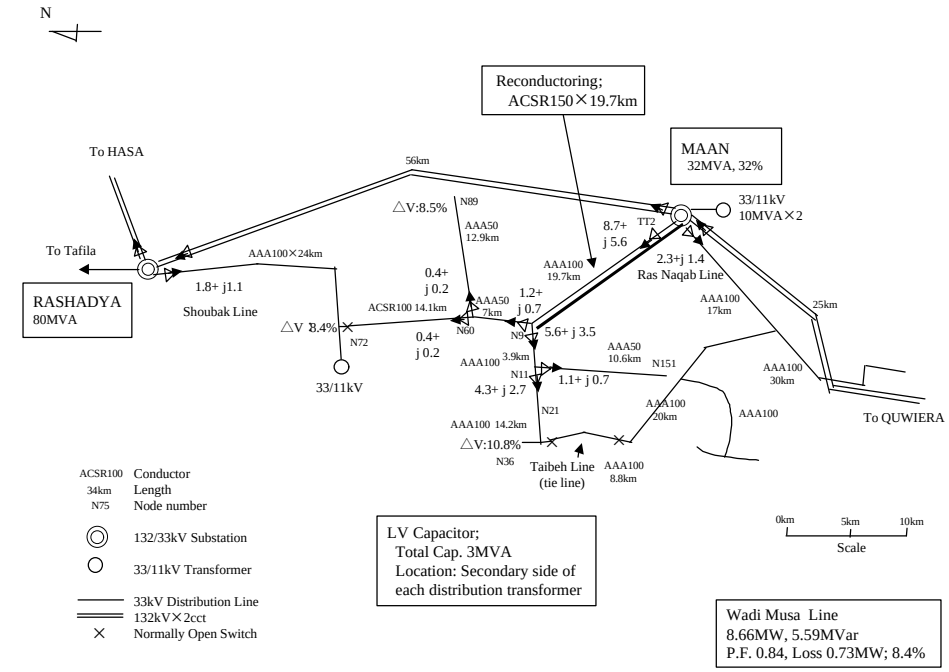
( ) : Recommended transformer type and capacity for MV introduction measure.

Feeder No.	Countermeasure			Invest. (JD)	Energy Loss (MWh/10yr.)				Cost & Benefit (JD/10yr.)			I.E. Factor	Cap. Inst. (kVA)	Remarks
	Cap. Inst.	MV Intro.	LV Reinf		Before	After	Reduct.	Ratio	Cost	Benefit	Net Ben.			
				A	B	C	D=B-C	E=D/B	F	G	H=G-F	I=H/A		
I101	●		●	555	648	542	106	0.164	442	3,026	2,584	4.653	36	
I102	●		●	2,603	502	250	252	0.503	2,073	7,180	5,107	1.962	31	
I103	●	●		17,844	1,261	476	785	0.623	14,210	22,334	8,124	0.455	35	* (GM250)
I104	●		●	2,715	948	657	291	0.307	2,162	8,286	6,123	2.255	36	
I105	●		●	2,368	494	307	187	0.379	1,886	5,322	3,436	1.451	29	
I106	●		●	4,462	728	396	333	0.457	3,553	9,459	5,906	1.324	32	
I107	●		●	1,389	534	388	146	0.274	1,106	4,164	3,059	2.203	19	
I108	●			47	252	237	15	0.061	38	438	400	8.441	12	
I109	●		●	845	400	300	99	0.248	673	2,824	2,151	2.545	29	
I110	●			71	310	276	34	0.108	56	954	897	12.698	18	
I111	●		●	640	464	372	93	0.199	510	2,632	2,122	3.314	19	
I112	●		●	449	355	260	95	0.269	358	2,713	2,356	5.242	28	
I113	●	●		19,217	1,037	252	785	0.757	15,303	22,310	7,007	0.365	29	* (GM250)
I114	●	●		18,837	1,239	252	987	0.797	15,000	28,074	13,073	0.694	34	(GM250)
I115	●		●	2,752	1,046	717	330	0.315	2,192	9,373	7,181	2.609	36	
I116	●		●	2,177	484	290	194	0.401	1,734	5,516	3,782	1.737	29	
I117	●		●	3,076	599	340	259	0.432	2,450	7,368	4,919	1.599	23	
I118	●	●		24,508	2,166	356	1,810	0.836	19,517	51,469	31,953	1.304	40	(GM250)
I119	●	●		14,828	1,626	262	1,364	0.839	11,808	38,786	26,977	1.819	45	(GM250)
I120	●		●	3,583	872	377	495	0.567	2,853	14,074	11,220	3.132	38	
I121	●		●	376	388	306	82	0.211	299	2,332	2,033	5.413	19	
I122	●		●	1,294	496	347	149	0.300	1,030	4,238	3,208	2.479	23	
I123	●		●	392	512	387	125	0.244	312	3,553	3,240	8.259	28	
I124	●			46	211	176	34	0.164	37	979	942	20.282	12	
I125	●		●	318	386	338	48	0.124	253	1,365	1,112	3.495	14	
I126	●	●		17,180	1,876	537	1,338	0.713	13,681	38,051	24,370	1.419	68	(GM250)
I127	●	●		14,918	1,234	514	720	0.584	11,879	20,484	8,604	0.577	34	* (GM250)
I128	●			49	368	353	15	0.040	39	421	382	7.731	12	
I129	●		●	2,533	873	561	312	0.358	2,017	8,878	6,861	2.708	43	
I130	●		●	2,796	867	616	251	0.290	2,226	7,140	4,914	1.758	24	
I131	●	●		21,857	1,572	324	1,248	0.794	17,405	35,494	18,089	0.828	42	(GM250)
I132	●		●	1,780	714	474	240	0.336	1,417	6,813	5,396	3.032	32	
I133	●		●	2,040	785	456	329	0.419	1,624	9,356	7,732	3.790	32	
I134	●		●	3,208	632	354	278	0.440	2,554	7,895	5,340	1.665	25	
I135	●		●	6,572	1,076	536	539	0.501	5,234	15,338	10,104	1.537	35	
I136	●		●	665	716	530	186	0.260	529	5,296	4,767	7.173	25	
I137	●		●	5,212	958	509	450	0.469	4,151	12,786	8,635	1.657	37	
I138	●		●	1,590	842	545	296	0.352	1,266	8,431	7,165	4.507	32	
I139	●	●		14,538	1,052	394	658	0.626	11,577	18,719	7,142	0.491	39	* (GM250)
I140	●		●	1,474	570	416	154	0.270	1,174	4,385	3,212	2.179	31	
I141	●		●	1,683	635	457	177	0.280	1,341	5,045	3,705	2.201	27	
I142	●			77	417	384	33	0.078	62	928	866	11.185	19	
I143	●		●	3,957	881	472	409	0.464	3,151	11,623	8,473	2.141	33	
I144	●		●	2,573	769	481	288	0.375	2,049	8,192	6,143	2.387	29	
I145	●		●	1,964	573	320	253	0.442	1,564	7,201	5,637	2.869	27	
I146	●		●	5,290	749	448	300	0.401	4,213	8,544	4,331	0.819	29	
I147	●		●	1,849	647	451	196	0.303	1,473	5,577	4,105	2.220	22	
I148	●		●	1,171	628	415	213	0.339	933	6,046	5,114	4.367	30	
I149	●	●		14,642	970	262	707	0.729	11,660	20,118	8,458	0.578	25	(GM250)
I150	●		●	1,556	682	544	138	0.203	1,239	3,927	2,688	1.728	23	
Total				894,918	133,567	62,923	70,644		712,662	2,008,838	1,296,176			

* : MV introduction measure is selected due to voltage criteria of over 10% in the initial year.
( ) : Recommended transformer type and capacity for MV introduction measure.

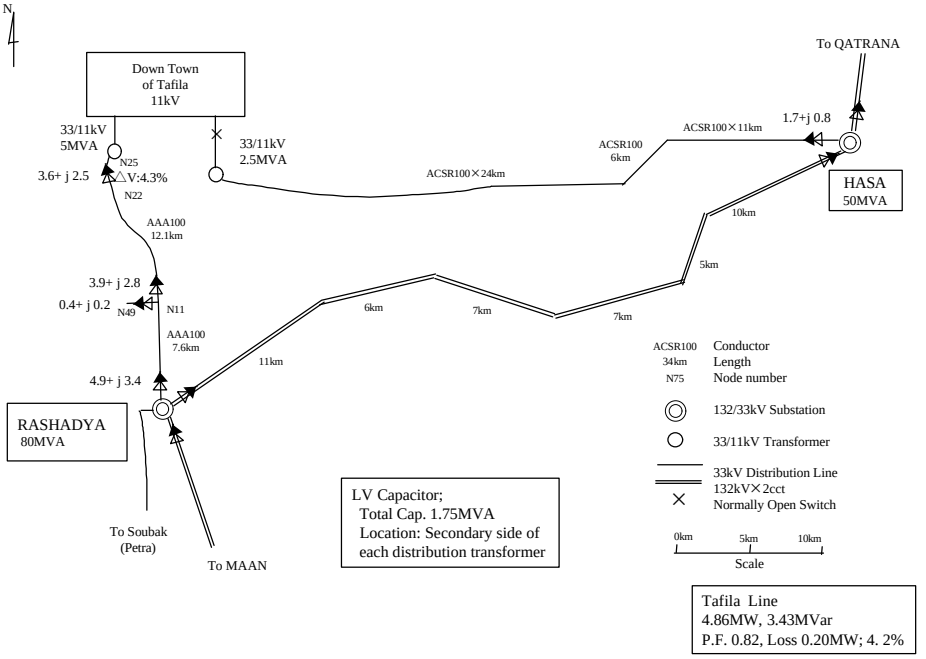
Appendix3. Outline of Result of Study on MV Target Feeders

[Unit: MW, Mvar, %V]

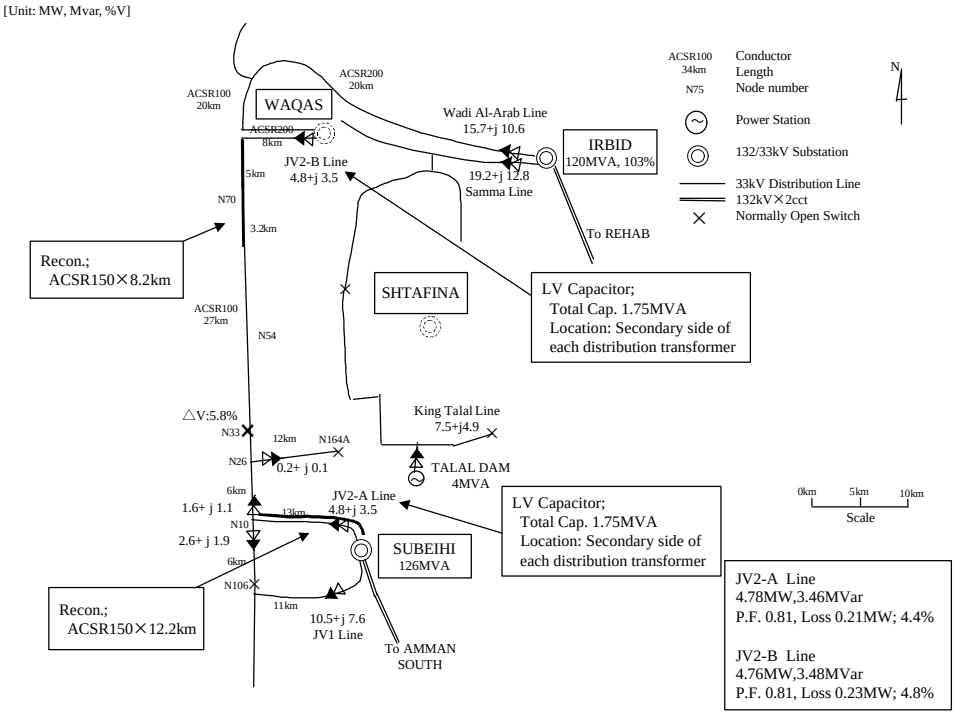


Wadi Musa Line

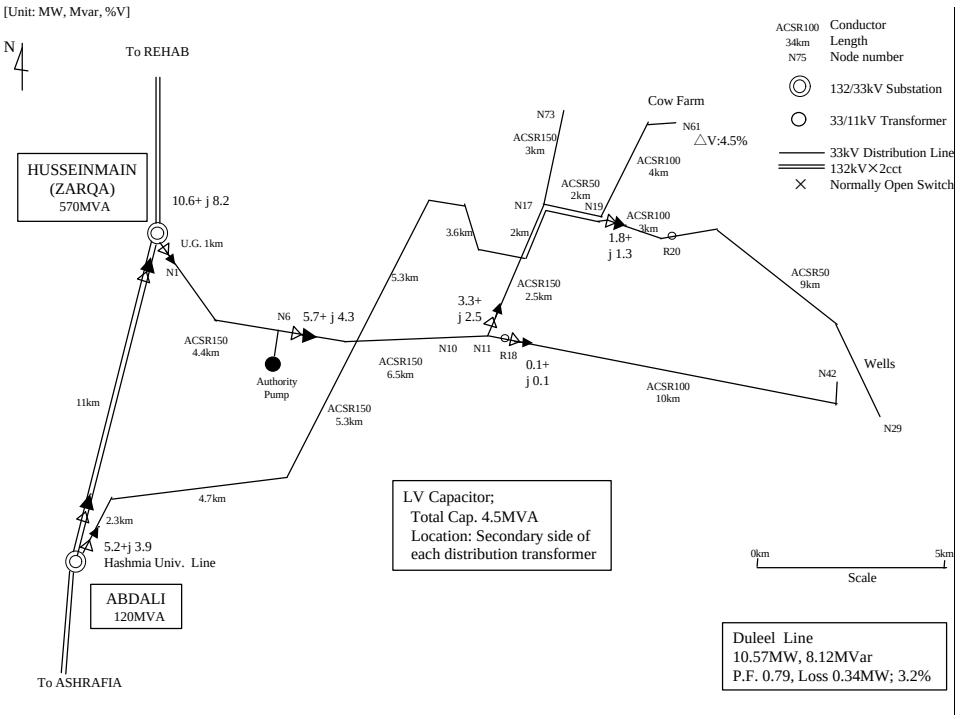
[Unit: MW, Mvar, %V]



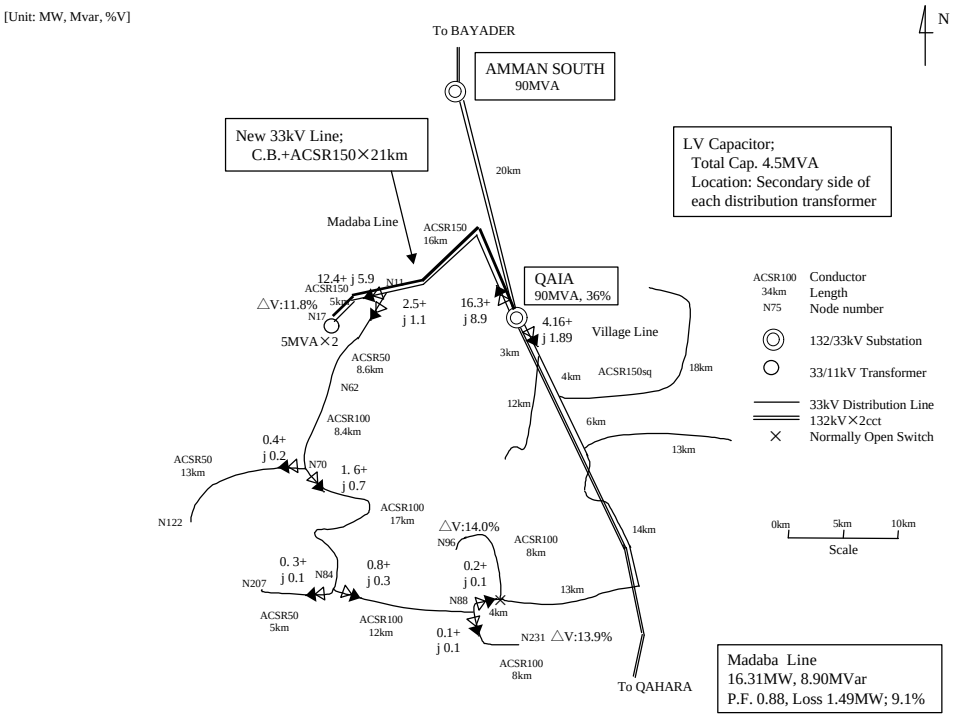
Tafila Line



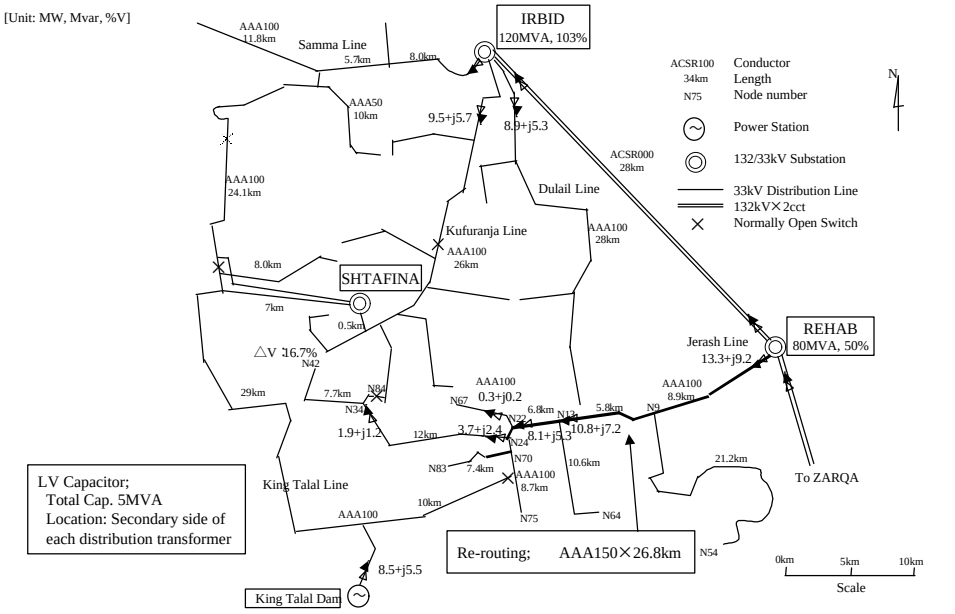
JV2 Line



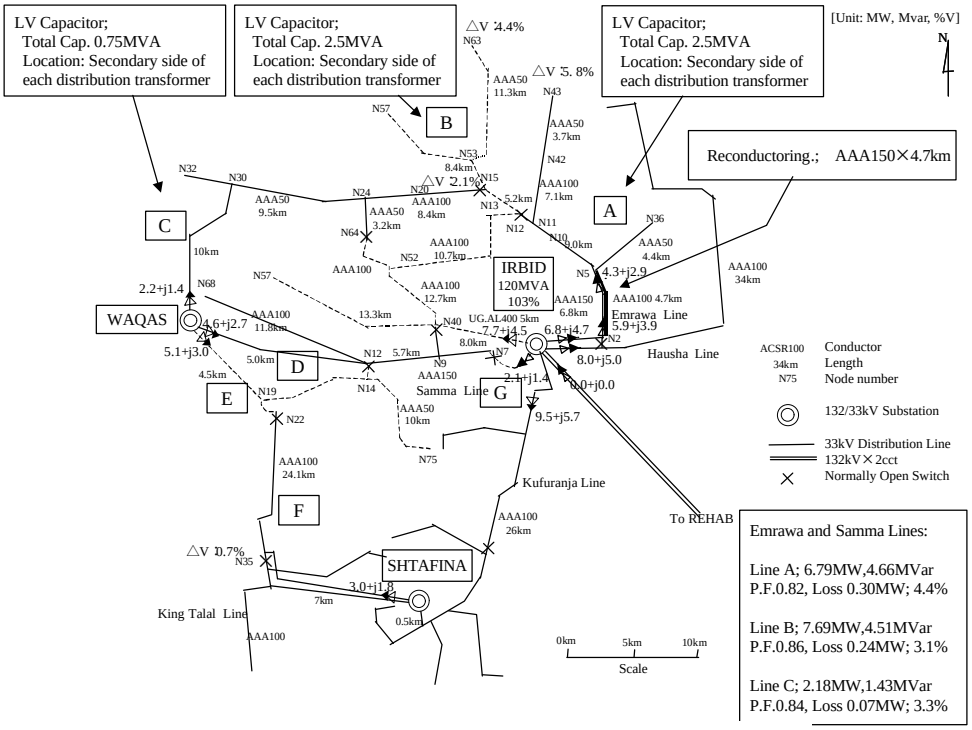
Duleel Line



Madaba Line



Jerash Line



Emrawa and Samma Line