Republic of the Philippines

National Electrification Administration (NEA)

The Project on System Loss Reduction for Philippine Electric Cooperatives (ECs)

Project Completion Report

March 2013

Japan International Cooperation Agency

Tokyo Electric Power Company

Contents

Figure and Table List

Abbreviations

ADB	Asian Development Bank
AMDT	Amorphous Transformer
C/P	Counterpart
CAPEX	Capital Expenditures
DT	Distribution Transformer
DOE	Department of Energy
EC	Electric Cooperative
ERC	Energy Regulatory Commission
EU	European Union
JETRO	Japan External Trade Organization
JICA	Japan International Cooperation Agency
kV	Kilo Voltage
LV	Low Voltage
MERALCO	Manila Electric Company
MV	Medium Voltage
NEA	National Electrification Administration
NEDA	National Economic Development Authority
NGO	Non-Government Organization
PDP	Philippines Development Plan
PSALM	Power Sector Assets and Liabilities Management Corporation
TA Team	Technical Assistance Team
TEPCO	Tokyo Electric Power Company, Inc.

<Targeted ECs>

ISELCO I	Isabela I Electric Cooperative, Inc.
PELCO II	Pampanga II Electric Cooperative, Inc.
FLECO	First Laguna Electric Cooperative, Inc.
CASURECO II	Camarines Sur II Electric Cooperative, Inc.
CASURECO IV	Camarines Sur IV Electric Cooperative, Inc.
SORECO I	Sorsogon I Electric Cooperative, Inc.
LEYECO III	Leyte III Electric Cooperative, Inc.

Chapter 1 Outline of the Project

1.1. Outline

1.1.1. Title of the Project

The Project on System Loss Reduction for Philippine Electric Cooperatives

1.1.2. Project Term

From March 2011 to March 2013

1.1.3. Counterpart

- National Electrification Administration (NEA)

1.1.4. Targeted Groups

- ISELCO I (Isabela I Electric Cooperative, Inc)
- PELCO II (Pampanga II Electric Cooperative, Inc.)
- FLECO (First Laguna Electric Cooperative, Inc.)
- CASURECO II (Camarines Sur II Electric Cooperative, Inc.)
- CASURECO IV (Camarines Sur IV Electric Cooperative, Inc.)
- SORECO I (Sorsogon I Electric Cooperative, Inc.)
- LEYCO III (Leyte III Electric Cooperative, Inc.)

The seven targeted ECs was selected in consideration of local balance from EC of medium rank in five-step evaluation to which the performance improvement effect was accepted among 119 EC. The seven targeted ECs are shown in Fig. 2-3.

1.2. Purpose of Technical Assistance

In order to develop the technical capacity and planning abilities of the National Electrification Administration (hereinafter referred to as NEA) and Electric Cooperatives (hereinafter referred to as ECs) to reduce distribution system losses, the Technical Assistance Team (hereinafter referred to as the TA Team) will provide the necessary support to improve the management and technology of NEA and selected ECs. Specifically, the TA Team will conduct activities to achieve the following:

- Preparations and practices in accordance with the System loss reduction manual are implemented.(Output 1)
- Establish a support system for the quantitative evaluation of system losses. (Output 2)
- Establish a support system for upgrading the present medium voltage and technical design standards. (Output 3)

1.3. Technical Assistance Team Structure

The TA Team members were slightly replaced over the course of the Project. By having considering assignment, there was no trouble to the project implementation by change. Figure 1.1 shows the structure of TA Team for this operation.

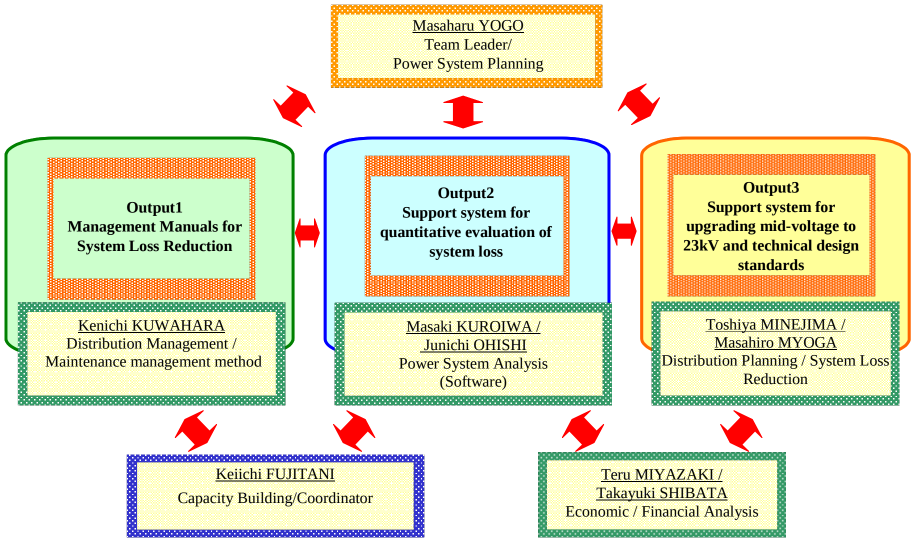

Figure 1-1 Technical Assistance Team Structure

1.4. Project Design Matrix (PDM)

The Project Design Matrix (PDM) has been revised three times over the course of Project execution as mentioned below. The narrative summary of the current PDM is as follows:

(1) Overall Goal

Losses of ECs' power distribution systems are reduced and the power supply capability is enhanced in an efficient and economic fashion.

(2) Project Purpose

The engineering and planning capacity to reduce the distribution system losses by the EC’s and NEA are enhanced.

(3) Output

1. Prepare the System Loss Reduction Manual and put it into practice.
2. Establish a support system for the quantitative evaluation of system losses.
3. Establish a support system for upgrading the mid-voltage to 23kV as well as the technical design standards.

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(4) Activities

1 System Loss Reduction Manual is prepared and put into practice

1-1 Survey the best existing practices of the system loss reductions, including the non-technical losses at the leading EC's;

1-2 Prepare draft manuals for system loss reduction based on Japanese experience;

1-3 Case studies to solve the issue for application of manuals into selected EC's are conducted;

1-4 Finalizing manuals based on the above activities with NEA, including the compilation of EC's best non-technical practices;

1-5 Propose an appropriate mechanism to transfer the manual contents to other EC's with NEA;

2 Support system for a quantitative evaluation of system losses is established

2-1 Survey current usage of software for power flow analysis in the selected EC's;

2-2 Propose appropriate methods for evaluating the system loss reduction for the selected EC's;

2-3 Develop appropriate methods based on 2-1, 2-2 for the selected EC's;

2-4 Train NEA and EC staff in electric power transmission and distribution via the methods established above;

3 Establish a support system to upgrade the present mid-voltage to 23kV and the technical design standards

3-1 Survey the existing facilities, facility configuration and the distribution development plan;

3-2 Discuss proper design standards and guidelines for a 23 kV distribution line in the Philippines with NEA;

3-3 Preparation work for a full scale F/S;

The final PDM including the indicators/targets means of verification and important assumptions are shown in Appendix 1.

Chapter 2 Background of Technical Assistance

2.1. Background of Technical Assistance

The self-sufficiency rate of energy in the Philippines is low[1] compared with other Asian countries, and the focus is on improving energy independence as one of the most important parts of energy policy. A considerable amount of energy depends on oil and coal from foreign countries. Therefore, recent skyrocketing oil prices are having adverse effects on the economic and industrial activities of the Philippines.

Current energy policies assert the importance of energy efficiency to improve the self-sufficiency of energy in the Philippines in the “Philippine Energy Plan 2012-2030” , and demand is expected be reduced by 10 % by 2030.

The electric power sector accounts for a large proportion of energy demand in the Philippines, and improvement of energy efficiency in the electricity sector can contribute to the comprehensive reduction of energy demand.

The National Electrification Administration (hereinafter referred to as “NEA”), counterpart of the project, is a governmental organization managing and supervising 119 Electric Cooperatives (hereinafter referred to as “ECs”). Since its establishment in the 1970s, NEA has provided ECs with technical and financial support. However, many ECs cannot conduct appropriate maintenance and are short of investments.

According to the statistical data from NEA in 2010, the average of the system loss reductions (distribution system) for ECs is 12.29%. These losses consist of technical losses, non-technical losses and administrative losses. Mainly, the resistance of equipment such as power lines and transformers causes technical losses in the distribution systems. On the other hand, non-technical losses are defined as meter reading errors and energy thefts, and administrative losses are due to energy consumed in substations and electric power companies.

The Electricity Regulatory Committee requests that each EC report technical losses and non-technical losses respectively to grasp the electricity consumption patterns of each customer and clarify the business management practices of each EC. However, many ECs are not able to grasp system losses accurately because appropriate measures to evaluate losses have not been established. Thus, many ECs have not yet taken measures to reduce system losses and improve business management practices, which results in inefficiency of distribution losses.

In addition, the transmission and distribution loss rate of the Philippines in 2009 was 12.1%. On the other hand, the loss rate of Asian nations is 4.8% in Japan, 4.9 in China, 5.6% in Thailand, 9.6% in Vietnam, 9.9% in Indonesia, 15.7% in Myanmar and 18.3% in Cambodia. The loss rate of the Philippines needs to improve by the loss rate level of Thailand, Vietnam, and Indonesia that are neighboring countries.

[1] The energy self-sufficiency rates of Indonesia, Malaysia, and Vietnam are 174%, 134%, and 120%, respectively. On the other hand, the energy self-sufficiency rates of China, Cambodia, Thailand, and the Philippines are 90%, 71%, 60%, and 60%, respectively. (Energy Balances of OECD / non-OECD Countries 2009)

2.2. Current Situation of Electricity and Energy Sector

2.2.1. Institutional Arrangement and Sector Overview

(1) Outline

Since 1936, the generation and transmission business had been operated by the monopoly National Power Corporation (hereinafter referred to as "NPC"), and the electricity generated by owned power stations was supplied to distribution cooperatives.

Since the late 1980's, an Independent Power Producer (hereinafter referred to as "IPP") is allowed to enter the market, and NPC began to sell the electricity from its own power plants as well as that from IPP.

In June 2001, the Electric Power Industry Restructuring Act (hereinafter referred to as "EPIRA") was enacted; the transmission department of NPC became the National Transmission Corporation (hereinafter referred to as "TRASNCO") as a split-off. As a result, the generation business is operated by NPC and IPP, while the transmission business is run by TRANSCO. The assets of NPC have been sold, and the transmission business license was knocked down by NGCP, which is joint business venture include State Grid Corporation of China, in an open bid, and has been operated by NGCP. Moreover, the Wholesale Electricity Spot Market (hereinafter referred to as "WESM") was founded in June 2006 and has been operated in the Luzon area.

The distribution businesses in the Philippines are owned by private distribution cooperatives and public ECs. The distribution cooperatives exclusively supply electricity via a cross trade transaction with NPC or IPP, or the new WESM market.

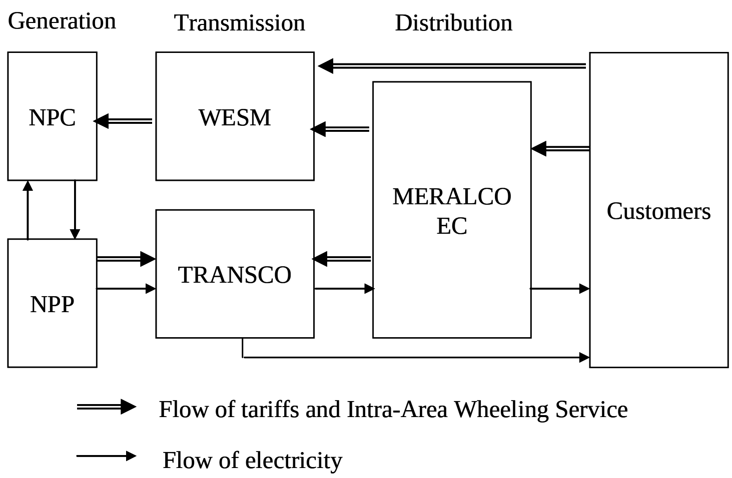

Figure 2-1 Institutional arrangement of electricity sector in the Philippines

（Source：PSALM、MERALCO）

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(2) Related Organizations of Electricity Sector

(a) Department of Energy（DOE）

The Department of Energy (hereinafter referred to as “DOE”) was founded in 1976, and was entitled to supervise the development and usage of energy. After the enforcement of EPIRA, the DOE is also in charge of the power development plan as well as energy planning.

(b) National Electrification Administration（NEA）

The NEA was founded in 1969 to promote electrification in the Philippines. The NEA is the counterpart of this project, and declares the electrification of all areas by 2020. Its mission is to assist ECs financially, systematically, and technically in implementing electrification and quality services.

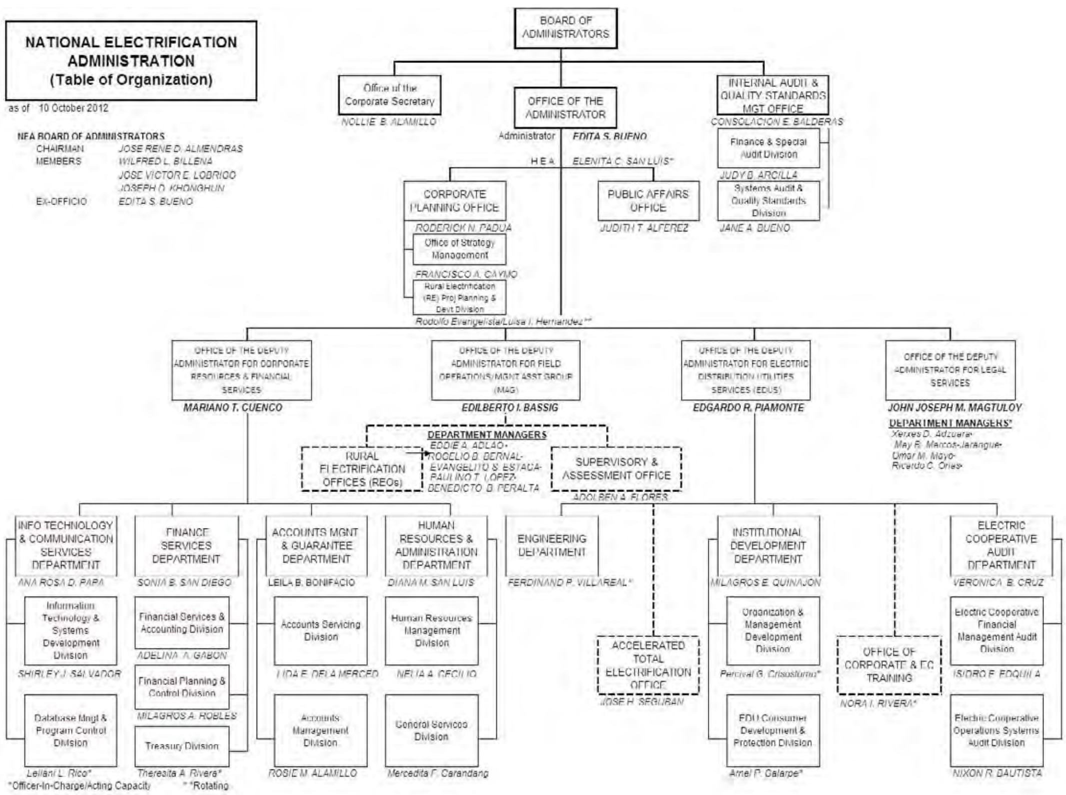

Figure 2-2 Organization of NEA

（Source：NEA home page）

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2.2.2. Distribution Sector

(1) Outline

There are 16 Private Investor-Owned Utilities (hereinafter referred to as "PIOU") including the Manila Electric Company (hereinafter referred to as "MERALCO", 199 ECs, and 8 Local Government Unit-Owned Utilities (hereinafter referred to as "LGUOU"). In 2008, the total number of customers was 4,570,647, and electricity sales were 26,800GWh. The number of consumers in 2011 was 4,847,238 houses in MERALCO and 8,027,939 houses in 119 ECs. The sales electric energy in 2010 was 55,266GWh in the Philippines whole country. The distribution utilities map of the Philippines, which made an extract from the JICA expert report, is shown in Fig. 2-3. The private distribution utility area is shown in red and the EC area is shown in yellow. There are 119 ECs in the Philippines in 2011 and there is no big change from this figure. Some EC, such as PELCOII, is due to be privatized in the near future.

(2) Manila Electric Company (MERALCO)

MERALCO is the largest private distribution company in the Philippines, and Manila is one of its franchise areas. Its electricity sales account for more than about 55 % of all sales in 2010.

(3) Electric Cooperatives (ECs)

Private distribution companies operate the lucrative distribution lines in city areas, while ECs are in charge of areas that are not profitable under the supervision of NEA. All coverage areas of ECs account for approximately 90 % of all of the Philippines. In 2010, about 90 % of all customers were classified under resident usage, and the system losses were 11.9 %.

NEA has provided ECs with technical assistance and loans for the expansion of facilities, and supported the ECs financially.

ECs are non-profit electricity utilities, and have promoted electrification as a national policy. Thus, some ECs' income statements are not stable. NEA evaluates the ECs in terms of finance and technology, and divides the ECs into 6 levels to facilitate improvements.

The amount of loan in the 2011 is 1,395,000,000 PHP, and the detail is shown below.

Table 2-1 Amount of loan for EC

Type of Loan	Actual (M PHP)	No. of ECs
STCF*	464 (average per month)	19
Capital Projects	712	33
Working Capital	219	12
TOTAL	1,395	

*Short Term Credit Finance
(Source: NEA Annual Report 2011)

Table 2-2 Ranking of ECs based on management in 2011

Rank	Score	Num. of ECs	Ratio (%)
A+ (outstanding)	90~	58	49
A (very satisfactory)	75 ~ 89	24	20
B (satisfactory)	65 ~ 74	10	9
C (fair)	55 ~ 64	4	3
D (poor)	30 ~ 54	4	3
E (no improvement)	~29	6	5
No evaluation		13	11
Total		119	100

(Source: NEA data)

2.2.3. Current Method to Reduce System Losses

In the Philippines, distribution loss is relatively high. The loss of the distribution system owned by the ECs was 11.9 % in 2011. The system losses are limited to 12 % by the government in 2011, and this regulation makes some ECs' non-profitable.

(1) Examples of Loss Reduction by MERALCO

The system loss of the MERALCO facilities is 7.35 % in 2011 due to the installation and improvement of distribution systems.

Methods to reduce losses implemented by MERALCO are shown below.

- Technical loss reduction
  - Install substations and a capacitor bank
  - Use appropriate capacity distribution transformers
  - Adopt appropriate supply voltage
  - Manage distribution line capacity and load
  - Revise route of distribution systems
  - Upgrade supply voltage for the large load and basic tariff discount
  - Install generators in the distribution systems
  - Reduce operated transformers at off-peak times (ex. 1 bank operation)
  - Recommend peak-shifts and set special tariff price
  - Estimate technical losses using the analysis system

- Non-technical loss reductions
  - Install a large number of meters at the upper part of poles and conduct meter readings with cameras
  - Install meters in iron boxes
  - Removal of illegal branch lines
  - Prevent power thefts by excluding unauthorized residents

(2) Examples of Loss Reduction by ECs

EC distribution systems are broadly extended, and system losses vary according to ECs. Methods to reduce losses implemented by the ECs are shown below.

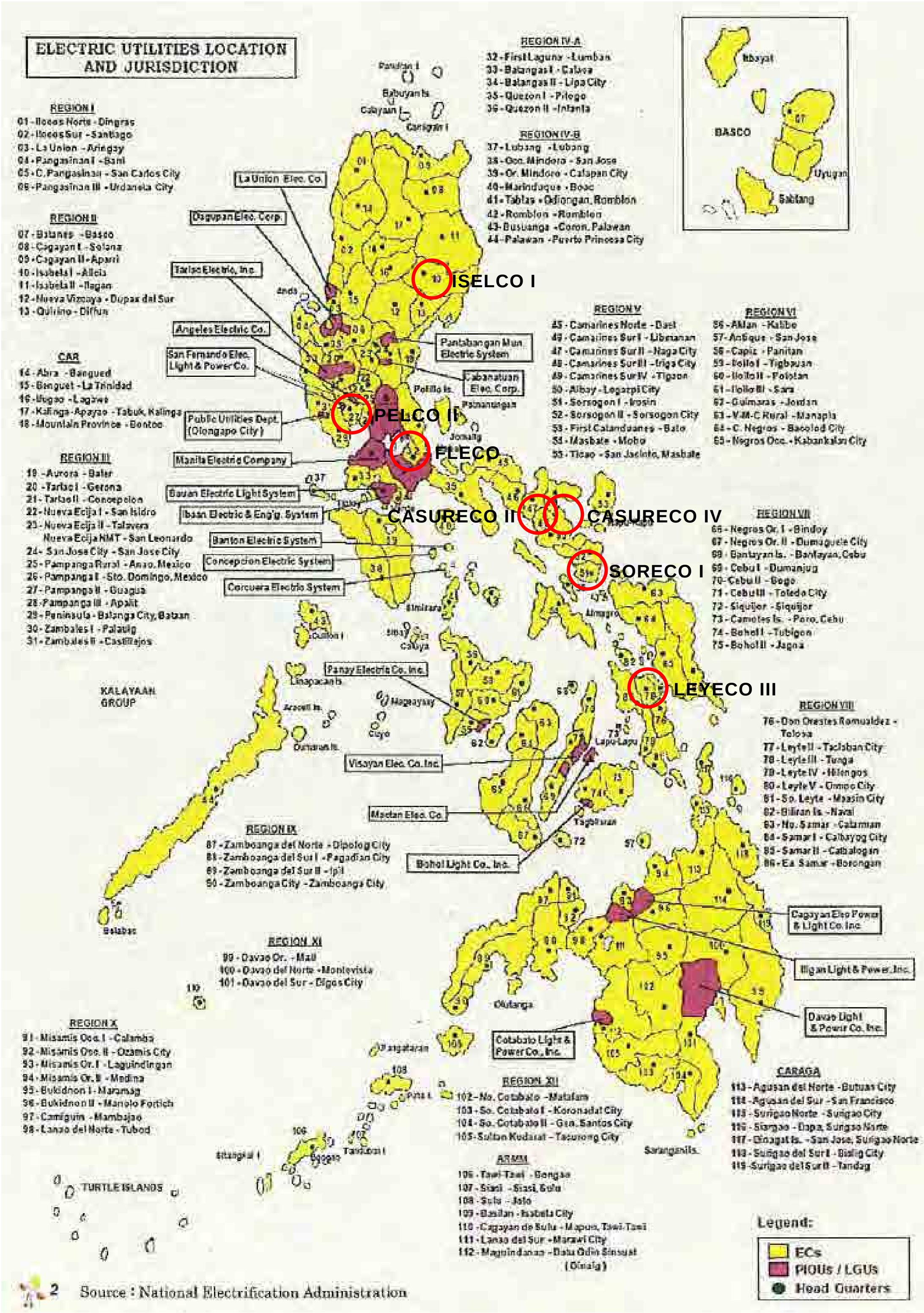
- Technical loss reduction
  - Install a 5MVA substation to prevent the overload of a transformer, or reduce the distribution current
  - Improve overload and heating
  - Replace distribution transformers
  - Improve the long single-phase lines (medium-voltage and low-voltage)
  - Install capacitors to the improve voltage and power factor
  - Deforestation around lines
  - Manage voltage using analysis software

- Non-technical loss reduction
  - Secure 100 % bill collection
  - Prevent power theft
  - Install a large number of meters at the upper part of the poles
  - Replace, adjust, and repair defective meters

Load loss, which is generated from the conductor by flowing the current of a power line, and no-load loss, which is generated with the distribution transformer, exists in a technical loss. The most effect measure for technical loss reduction is as follows.

- Install a substation to prevent the overload of a transformer, or reduce the distribution current
- Improve overload and heating
- Improve the long single-phase lines
- Replace distribution transformers
- Install capacitors to the improve voltage and power factor

Moreover, the most effect measure for non-technical loss reduction is Install a large number of meters at the upper part of the poles, which is the system currently widely held to the electric power supply to the small colony in the Philippines including MERALCO.



○: Targeted EC

Figure 2-3 Map of distribution utilities in the Philippines

(Source: JICA experts report "Demand and power development plan")

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Chapter 3 Basic Policy of Technical Assistance

3.1. Issues on technical loss reduction Projects

(1) Technical Matters

- Technical Losses
  - Specific technical loss calculation methods are not established
  - The load factor of pole transformers are low and iron losses might be high
  - Customer loads, which are used to calculate technical losses by software, are estimated based on meter readings. However, the calculated technical losses are not accurate since these loads include non-technical losses.
  - Need to unify the temperatures of the conductor resistance on technical loss calculations.
- Software (PowerSolve)
  - As low voltage loss calculations are bundled, it does not identify the exact location of the loss.
  - Without a mapping function, it is not easy to know the measurements such as a load allocation.
- Non-Technical Losses
  - Metering data are not validated by the system
- Economics evaluation
  - There is no economical index to compare both the facilities investment and loss reduction effects.
  - The investment plans are not determined from a long-term viewpoint.
  - The proper timing for the facilities replacement are not understood

Among these matters, establishment of specific technical loss calculation methods, the grasp of a loss generating part using the power distribution analysis software equipped with the mapping function, and the analysis of the proposed measures serve as an important subject especially. Moreover, as a cause of loss, the situation that the load factor of pole transformers are low and iron losses might be high is not suitable. The creation of guideline for the selection method of transformer capacity is important. Moreover, it is required to enable it to conduct economic evaluation appropriately quickly from the stage of planning of the draft of loss reduction.

(2) Financial Matters

- As ECs spend their budget to first repair the facilities, capital investment for loss reduction is not enough
- Project selection and prioritization by ERC is as follows,

1. Power Quality with Safety and Capacity
2. Rural electrification
3. Reliability improvements
4. System loss reduction

Loss reduction projects are the least priority of the ECs to invest in.

- Update the software fees for loss calculations are relatively expensive

The standard of project implementation of ERC which priority is given to safety or electric supply reliability is appropriate. On the other hand, technical loss reduction cannot be achieved depending on the minimum investment only for supply capability. The TA team recommends the implementation of the project that considered loss reduction as suitable grasp of the effect because the effect continues to a long period.

(3) Management Matters

- Lack of engineers in charge of management of electrical power facilities
- Lack of engineers in charge of using SynerGEE software
- Lack of efficiency and purchasing power because each EC is too small to order the equipment

3.2. Project Strategy and Approach

3.2.1. Basic Policy on Technical Aspect

The main tasks are set as follows to achieve this technical assistance’s target.

【Common Tasks】

- Grasp the current situation and the issues on technical and organizational aspects of NEA and selected the ECs
- Examine the overall plan of NEA
- Examine the existing facilities and plans of selected ECs

【Output 1】

- Study the existing best practices of selected ECs on loss reduction
- Manuals and checklist preparation for system loss reductions
- Carry out studies utilizing manuals to solve problems of selected ECs
- Manual completion based on the above activities including the integration of best practices for the non-technical loss reduction of selected ECs through cooperation with NEA
- Recommend appropriate methods that supersede other manuals currently used through cooperation with NEA

- Create a system loss reduction manual

【Output 2】

- Examine and suggest an appropriate method of evaluating system loss reduction
- Examine the necessity of analytical software
- Collect data for carrying out an electric power system analysis
- Conduct a preliminary analysis of power distribution losses
- Develop methods of evaluating system loss reduction
- Create a system loss reduction manual which includes technical loss evaluation
- Train staff of selected EC's on technical loss evaluations

【Output 3】

- Examine the standard design and guidelines for 23 kV or 34.5 kV power lines
- Establish the standard design and guidelines for 23 kV or 34.5 kV power lines
- Create a system loss reduction manual which includes the basic design and technological standards for 23 kV or 34.5 kV distribution lines
- Work preparation to support the planning of full-scale F/S (confirmation and analysis of a power distribution development plan)

3.2.2. Detailed Approach to solving Issues

The SynerGEE basic and advance training implemented for the engineer's capacity development in using SynerGEE software. In addition, the implementation of AMDT pilot projects and 23kV upgrading studies are recommended to aid in coming up with proper measures in finding the best solution for technical problems. An abstract of the pilot project is as follows.

(1) Purpose

- To create useful and efficient manuals on system loss reduction. A numerical analysis on the chosen distribution network owned by selected ECs would be conducted. The results of the analysis should be fully reflected in the manual wherein the method of finding the proper measure for system loss reduction and in estimating the individual measures would be described.
- To transfer the planning technique for network loss reduction to NEA Staff and concerned ECs
- To verify the effects of the AMDT after introducing AMDT in three ECs
- To nominate the candidate sites for the planning and conduct of system loss reduction projects in the future.

(2) Outputs

- Manuals on the system loss reduction are released and utilized.
- Distribution professionals belonging to the counterpart organizations are trained to make plans for the loss reduction utilizing software.
- Understand the effects of AMDT to reduce losses and its easy O&M
- Information on candidate sites for the future project is shared particularly with those concerned with JICA's technical cooperation.

(3) Procedures

1). Estimation of economical value created by reducing the system losses, which would be equivalent to the costs of the construction work that would be implemented to diminish losses.

2). Grasping the costs of each measure for loss reduction such as expanding the LV network or installing new DTs and so on.

3). Surveying the distribution network

- Listing up the overloaded DTs by checking the DSL data or by detecting the load currents of some DTs.
- Showing the expectation of reduced non-load losses of DTs by replacing the conventional DTs to AMDTs.

4). Draft manuals on distribution network loss reduction

- The selection of proper facilities such as wires or DTs from the perspective of reducing technical losses
- Guidance in choosing between two alternatives, multiplying the number of wires or installing big conductors
- Showing sample cases like upgrading the system voltage is expected to be a better choice.
- A comparison between the two methods, by expanding the LV line or MV line, which means that a new DT would be installed.
- Connecting the two distribution MV feeders, the load of one feeder is much bigger than the other. The loads of the two feeders shall be well balanced to reduce the total losses of the two MV lines.
- The relocation of some of the DTs that would diminish the losses from the LV lines.
- The suppression of the non-load losses from the DTs by replacing the existing transformers to the AMDTs, whose iron-losses would be much less than that of the conventional ones.

5). Simulations

- The simulation models of some distribution system for SynerGEE would be created. Power flow, network losses and the voltage profile of the simulated distribution feeders shall be checked.
- The proposed methods for loss reduction described in the draft manuals would be studied in computer simulations. The effectiveness of the recommended measures to improve the system losses of the listed DTs shall be confirmed via the SynerGEE simulations.
- Know-how on making plans to reduce the system losses by software aids shall be transferred to the distribution technicians of the counterpart organizations.
- To confirm the effects to introduce AMDT as the pilot project and to measure the loss reduction by the ECs

6). Efficient methods shall be included in the planning manual on loss reduction.

3.3. Work Flow

The next figure shows the flow of the entire Technical Assistance.

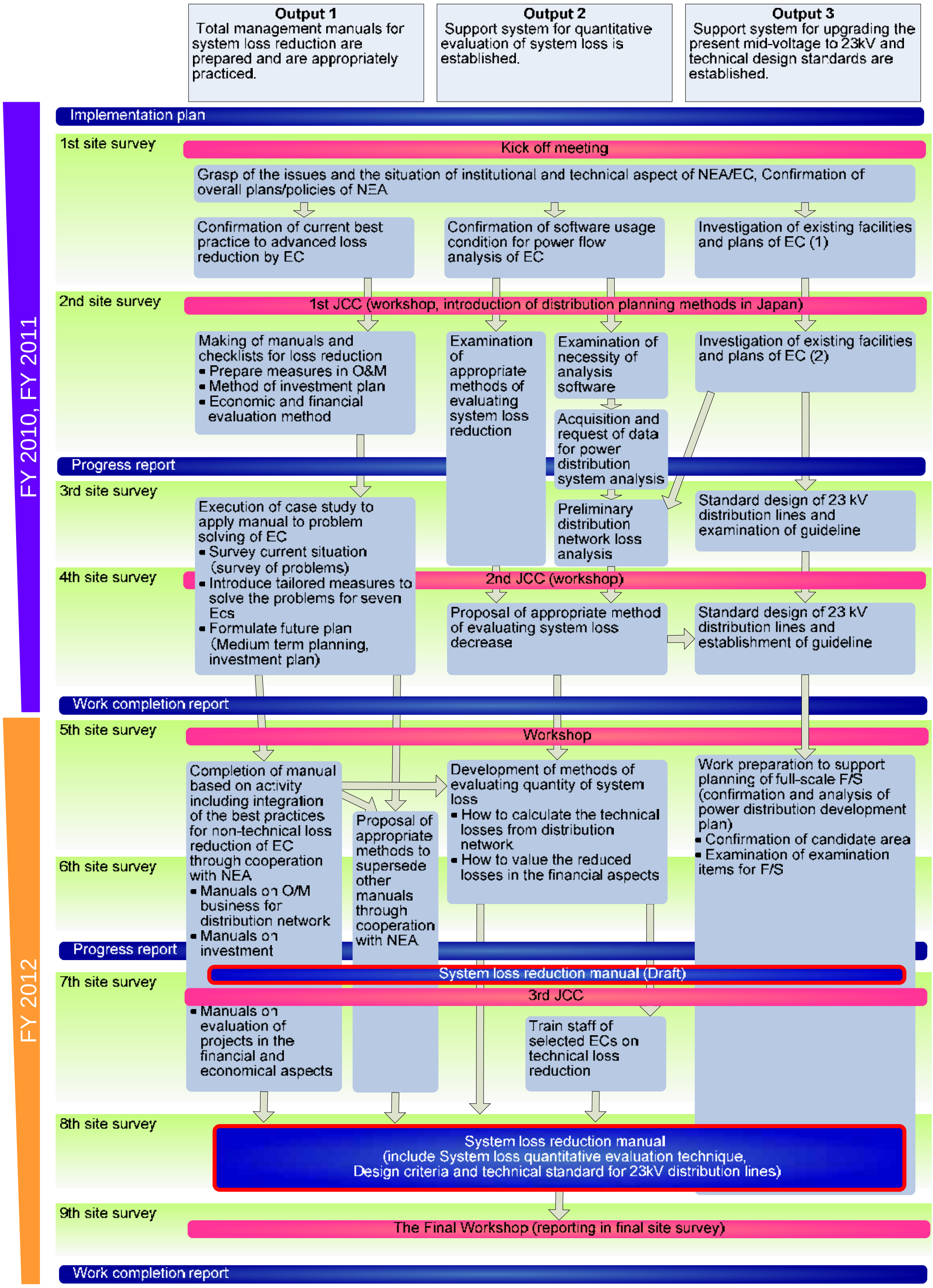


Figure 3-1 Flow of Overall Technical Assistance

3.4. Basic Policy of the Study Implementation

(1) Technology Transfer and Personnel Training

In this Technical Assistance, the TA Team worked with NEA and selected ECs to grasp and analyze the present situation in consideration of the organizational and technical aspects. Since the tasks were primarily conducted on-site (in the Philippines), the opportunity for the technology transfer and over-all human resource cultivation is deemed important.

The TA Team members provided technical assistance to counterparts for capacity enhancement in each field of specialization. Through one-on-one coaching, knowledge and skills were imparted to counterparts and priority issue solving activities were carried out. During the training, each expert explained the TA objectives, ways and methods of evaluating results. Moreover, the counterparts were encouraged to execute their tasks though OJT as much as possible.

(a) Management Manuals for System Loss Reduction are prepared and are appropriately practiced

The TA Team will tackle priority issue solving activities with selected ECs and propose workable countermeasures through introducing the Japanese best practices. In addition, the management system, which can share the best practices in all ECs, was developed in collaboration with NEA. Moreover, the trainers who can become a lecturer of priority issue solving activities were developed through participating counterpart training in Japan.

(b) Support system for quantitative evaluation of system loss is established

The TA Team developed the support system for quantitative evaluation of system loss in collaboration with NEA. When it is judged because of investigation that system analysis software needs to be introduced, the quantitative evaluation technique that used system analysis software is practiced, and the trainers who can become a lecturer was developed.

(c) Support system for upgrading the present mid-voltage to 23kV and technical design standards are established

The TA Team developed required guideline through considering standard specification in collaboration with a counterpart. Moreover, The TA Team will explain the necessary requirements for F/S based on the developed guideline. In addition, while having an on-site exploration of a power distribution development project area and explaining the point of an on-site exploration, it teaches so that the power distribution route and substation point investigation may be possible by a counterpart independent.

(2) Workshop

The Staff of NEA and around three participants from each selected EC participated in the workshop during the 2nd, 4th, 5th and 9th field survey. The purpose of the workshops is to share the best practices that would be introduced by the selected EC participants and to explain the progress of the system loss reduction manual, the support system for the quantitative evaluation of the system loss and support system to upgrade the present medium voltage to 23 kV or 34.5 kV including technical design standards. In the workshop, from the perspective of technology transfer, the counterpart staff made the presentation as much as possible. The participants in this workshop shall in turn be responsible to share the knowledge and skills acquired with their colleagues upon returning to their respective ECs.

(3) Counterpart Training in Japan

Maximum cooperation should be carried out to implement practical training on system loss reduction & efficient management technique among others to the counterpart training members.

The contents, trainees, time schedule and others of the counterpart training in Japan (FY2011 and FY2012) have been decided through mutual discussion among the TA Team, counterparts and JICA during field surveys. The appropriate steps for a successful technology transfer was planned as part of the counterpart training program to include study tours at Tokyo Electric Power Company, Shikoku Electric Power Company, quality control methods of the associated company and system loss reduction techniques.

Additionally, counterparts were able to understand the manufacturing process and maintenance procedures at the factory visit such as AMDT, meters and electric poles, and knowledge about quality control could be deepened. By touching an actual thing, since it has experience that is strongly impressive, it is expectable to practice to have learned by the counterpart training in Japan within each EC in future.

Chapter 4 Inputs

4.1. Inputs from Japanese Side

4.1.1. Experts

This project involved the dispatch of expert project teams and team leaders from Japan. The performance and achievement of the dispatch of these expert project leaders are outlined in Appendices 2 & 3. The table 4-1 shows the total dispatch Records of the project.

Table 4-1 Total dispatch Records of the project

Year	M/M (Site Survey)	M/M (Domestic Surver)	Total
2010	0.00	0.30	0.30
2011	11.58	5.48	17.06
2012	13.80	5.85	19.65
Total	25.38	11.63	37.01

4.1.2. Counterpart Training in Japan

Counterpart Training in Japan was held four times between FY2011 and FY2012. The C/P training consisted of lectures and study tours for about two weeks. The subjects of the C/P training were mainly on the “System loss reduction method”, “Data management” and “Quality control”. In total, 20 NEA and EC staff members had the opportunity to attend the series of the training in Japan.

The trainees’ lists of counterpart training in Japan can be found in Appendix 4.

4.1.3. Equipment

During the period of project implementation, SynerGEE software, which was given to 7 EC one license which is the number of minimum respectively, indicated as required at the very beginning of the project, and digital clip meters, which was given to 7 EC two sets which is the necessary requirement respectively, and amorphous transformers for pilot project shown to be necessary during the operation phase, were purchased. Appendix 5 lists all such equipment. This equipment will be required in future management activities at the relevant ECs; as such, the equipment has been gifted to them.

4.1.4. Others

JICA has shouldered local activity costs, such as travel expenses, pilot project costs, workshops and others.

4.2. Inputs from Philippine Side

4.2.1. Counterparts

Counterpart organizations are as shown in Chapter 1.1.3. and Chapter 1.1.4.

4.2.2. Spaces and facilities for project activities

NEA offered the office space for the Japanese experts at NEA, and the utilization costs of electricity and water in the project office.

Chapter 5 Project Activities

5.1. Outline of Project Activities

The project whose implementation was started in March 2011 is intended to provide technical assistance to enhance the capacity of NEA and related organizations. The site surveys were implemented six times.

- The 1st site survey: From April 3, 2011to April 16, 2011
- The 2nd site survey: From July 17, 2011 to August 5, 2011
- The 3rd site survey: From October 13, 2011 to October 28, 2011
- The 4th site survey: From January 29, 2012 to February 17, 2012
- The 5th site survey: From May 22, 2012 to June 6, 2012
- The 6th site survey: From August 15, 2012 to August 31, 2012
- The 7th site survey: From November 13, 2012 to December 21, 2012
- The 8th site survey: From January 6, 2013 to January 19, 2013
- The 9th site survey: From February 18, 2013 to March 5, 2013

The details are shown in appendix 2 and 3.

5.2. Detailed Activities

5.2.1. Outcome of the Study

- Preparation of the reports
  - Preparation of Implementation Plan
  - Progress Report (FY2011)
  - Completion Report for FY2011
  - Progress Report (FY2012)
  - Project Completion Report
- Study and prepare Technical Assistance
  - System Loss Reduction Manual

  (Include the "System Loss Quantitative Evaluation" and "Design Criteria and Technical Standards for the Upgraded Distribution Line Voltages")

5.2.2. Site Survey Implementation

- Accomplished tasks during the first site survey
  - Work plan explanation to the counterparts (held kick-off meeting)
  - Data collection and information review
  - Grasped issues and the situation concerning the institutional and technical aspects of NEA and ECs
  - Confirmed the overall plans/policies of NEA
  - Confirmed software usage conditions for power flow analysis of selected ECs
  - Examined existing facilities and plans of selected ECs
- Accomplished tasks during the second site survey

- Conducted the first Joint Coordination Committee meeting
- Carried out a workshop specifically for sharing best practices in system loss reduction.
- Introduced distribution planning methods in Japan
- Confirmed current best practices to advance the loss reduction by selected ECs
- Examined the appropriate methods of evaluating system loss reduction
- Examined the necessity of analysis software
- Acquisition and request of data for the power distribution system analysis
- Examined the existing facilities and plans of the selected ECs

■ Accomplished tasks during the third site survey

- Data collection and information review
- Confirmed the current best practices to advance the loss reduction by selected ECs
- Examined the appropriate methods of evaluating the system loss reduction
- Preparation of case studies for the application of the manuals into the selected ECs
- Acquisition and request of data for power distribution system analysis
- Examined existing facilities and plans of the selected ECs
- Examined proper design standards for a 23 kV distribution line

■ Accomplished tasks during the fourth site survey

- Conducted the second Joint Coordination Committee meeting
- Carried out a workshop specifically to share best practices in system loss reductions.
- Confirmed current best practices to advance loss reductions via selected ECs
- Propose appropriate methods to evaluate system loss reduction
- Acquisition and request of data for the power distribution system analysis
- Request of power distribution line modeling for the power distribution system analysis
- Preparation of case studies for the application of manuals into the selected ECs

■ Accomplished tasks during the fifth site survey

- Carried out a third workshop specifically for the presentation of power distribution line modeling for power distribution system analysis
- Carried out SynerGEE training
- Confirmed current best practices to advance loss reduction by selected ECs
- Assistance for the power distribution line modeling for power distribution system analysis
- Request of power distribution line modeling for power distribution system analysis

- Preparation of the System Loss Reduction Manual including the "System Loss Quantitative Evaluation" and "Design Criteria and Technical Standards for the Upgraded Distribution Line Voltages"

■ Accomplished tasks during the sixth site survey

- Preparation of the System Loss Reduction Manual including the "System Loss Quantitative Evaluation" and "Design Criteria and Technical Standards for Upgraded Distribution Line Voltages"
- Discussion of contents of the System Loss Reduction Manual
- Confirmed the pilot project of the amorphous transformers
- Preparation of the Total Ownership Cost (TOC) calculator

■ Accomplished tasks during the seventh site survey

- Conducted the third Joint Coordination Committee meeting
- Discussion of the contents of the System Loss Reduction Manual
- Introduction and explanation of the System Loss Reduction Manual for ECs
- Confirmed the pilot project of amorphous transformers
- Evaluation of the pilot project of amorphous transformers
- Preparation of the Total Ownership Cost (TOC) calculator
- 23kV upgrading candidate sites survey
- Modeling of the distribution system for 23kV upgrading candidate sites
- Simulation of the distribution system for 23kV upgrading candidate sites

■ Accomplished tasks during the eighth site survey

- Finalized System Loss Reduction Manual
- Evaluation of the pilot project of amorphous transformers
- Modeling of the distribution system for 23kV upgrading candidate sites
- Simulation of the distribution system for 23kV upgrading candidate sites
- Evaluation of the distribution system for 23kV upgrading candidate sites

■ Accomplished tasks during the ninth site survey

- Carried out a fourth workshop specifically to introduce the System Loss Reduction Manual to all ECs
- Submit the System Loss Reduction Manual to all ECs
- Submit the project completion report

Details are shown in Appendix 6, meeting minutes.

5.2.3. Cooperation on a Variety of Reports and Conferences

The TA Team explained the plan of the project and held discussion with NEA and related organizations on how to proceed with the survey. The first Joint Coordination Committee meeting was held on July 28. The second Joint Coordination Committee meeting was held on February 7 and the third Joint Coordination Committee meeting was held on November 27, and the first workshop was held on July 29, 2011, the second workshop was held on February

8, 2012, the third workshop was held on May 31, 2012 and the fourth workshop was held on February 28, 2013. The workshop materials can be found in Appendix 7.

- The first Joint Coordination Committee meeting
  - The TA Team reported the status of the project, and discussed how to proceed with related organizations.
- The first workshop
  - The TA Team explained the outline of the project and the method to reduce system losses in Japan.
  - Selected seven ECs and introduced their best practices to reduce system losses.
- The second Joint Coordination Committee meeting
  - The TA Team reported the status of the project, the contents of the system loss reduction manual and discussed how to proceed with related organizations.
- The second workshop
  - The TA Team explained the contents of the system loss reduction manual, the appropriate methods for evaluating the system loss reduction and the effects of introducing AMDT.
  - Selected seven ECs and introduced their best practices to reduce system losses based on the sheet of “Good Practices for System Loss Reduction”.
- The third workshop
  - The TA Team explained the method of Loss Reduction for the Medium Voltage Line, the sample analysis of the Loss Reduction for the MV Line using SynerGEE, and propose an appropriate mechanism to transfer the loss reduction method to all ECs and the incentive system.
  - Selected seven ECs and introduced their sample analysis of the Loss Reduction for the MV Line using SynerGEE.
- The third Joint Coordination Committee meeting
  - The TA Team explained the contents of the system loss reduction manual, the appropriate methods for evaluating the system loss reduction and the effects to introduce AMDT and 23kV upgrades.
  - NEA and the TA Team agreed with the contents of the system loss reduction manual.
  - NEA and the TA Team confirmed the evaluation of the AMDT pilot project.
  - NEA and the TA Team confirmed the 23kV upgraded sites.
- The third workshop
  - The TA Team explained the system loss reduction manual to all ECs.
  - The TA Team reported the results of the AMDT pilot project.
  - The TA Team reported the results of the 23kV upgraded sites simulation using SynerGEE.

5.2.4. Record of installation and training of SynerGEE software

(1) Record of installation of SynerGEE software

Each EC uses the power system analysis software, PowerSolve and SynerGEE, in order to conduct a quantitative evaluation of system losses. Each of the software can calculate system loss. However, PowerSolve cannot visualize the source of loss outbreak in the LV line loss calculation. On the other hand, SynerGEE has a function of mapping and can display the source of loss outbreak by color according to the amount of loss. Because of this, we can easily grasp the source of loss outbreak. And we can also visually form countermeasures of loss reduction and confirm the effects. Moreover, by using switching function, which is an optional function of SynerGEE, SynerGEE can make the composition of the system of which system loss is the least. SynerGEE is a very powerful tool for loss analysis. The results of the comparison confirmed that SynerGEE is more useful than PowerSolve, therefore, the SynerGEE Electric Load Flow Core (SYNE) and Middlelink Electricity that is the option software is installed. The record of the installation of the SynerGEE software to each EC is shown in the following table.

Table 5-1 Record of installation of SynerGEE software

(License number)

EC	SynerGEE Electric Load Flow Core (SYNE)	Middlelink Electric (ML-E)	Remark (The past use record)
ISRECO I	1	1	New installation
PELCO II	1	1	Used old version
FLECO	1	1	Used old version
CASURECO II	1	1	Under training
CASURECO IV	1	1	New installation
SORECO I	1	1	New installation
LEYECO III	1	1	New installation
NEA	1	1	Used old version

(2) Record of training of SynerGEE software

The record of training of SynerGEE software for each EC is shown in the following table. Because of training, the engineers have reached to the level that can propose the system loss reduction project used SynerGEE at the workshop.

Table 5-2 Record of training of SynerGEE software

(Number)

EC	Number of attendance of basic trainig	Number of attendance of advance trainig	Total
ISRECO I	11	11	22
PELCO II	11	11	22
FLECO	13	12	25
CASURECO II	10	9	19
CASURECO IV	6	5	11
SORECO I	10	11	21
LEYECO III	5	8	13
Total	66	67	133

(3) Status of medium voltage feeder modeling using SynerGEE software

The status of modeling the medium voltage feeder, which was not modeled before project implementation, using SynerGEE software is shown in the following table. Modeling means the state that has finished to input the data of a power distribution system and to build a database, and can be performed the simulation.

Table 5-3 Status of distribution system modeling using SynerGEE software

(Feeder number)

EC	Number of medium voltage feeder which has been completed to model except for low voltage system	Number of medium voltage feeder which has been completed to model include low voltage system	Total Number of medium voltage feeder
ISRECO I	1	1	16
PELCO II	1	1	22
FLECO	8	0	8
CASURECO II	0	0	11
CASURECO IV	0	0	4
SORECO I	0	0	5
LEYECO III	0	0	4

5.2.5. System Loss Reduction Manual

The content of the System Loss Reduction Manual, which includes the "System Loss Quantitative Evaluation" and the "Design Criteria and Technical Standards for Upgraded Distribution Line Voltages" shows the following:

Table 5-4 Contents of the System Loss Reduction Manual

Contents
1 Introduction
1.1 Purpose of This Manual
1.2 Types of Distribution Technical Losses and Their Countermeasures
1.2.1 General
1.2.2 Countermeasures
1.2.3 Concept of Seeking an Appropriate Technical Loss Reduction
1.2.4 Example of Loss Occurrence of Conductors
1.3 Planning Procedures of Technical Loss Reduction
1.3.1 Medium Voltage (MV) Loss Reduction
1.3.2 Low Voltage (LV) Loss Reduction
1.4 Appropriate Methods for Manual Distribution
1.4.1 Method for Maximum Utilization of the Technical Loss Reduction Manual
1.4.2 Renewal of the Technical Loss Reduction Manual
1.4.3 Award of Good Practices for System Loss Reduction
2 Economical Evaluation for Technical Loss Reduction
2.1 Introduction
2.2 Methodology of Calculating Cost Savings from Loss Reduction
2.2.1 Outline
2.2.2 Process of Estimating Cost Saving
2.3 Countermeasure Cost
2.4 Benefits / Costs Analysis
2.4.1 Net Present Value (NPV)
2.4.2 Internal Rate of Return (IRR)
2.4.3 Practical Method to Estimate Total Cost Savings
3 Methodology of O&M for Data Arrangement of Loss Analysis
3.1 Network Data
3.2 Load Data
4 Identifying Countermeasures against Technical Losses for Low Voltage system
4.1 Calculation Methodology of the Operating Status of the Low Voltage System
4.1.1 Methodology based on the DSL data
4.1.2 Methodology of Confirming Operating Status of the Low Voltage System by Using SynerGEE
4.2 Countermeasure Options to Prevent Technical Losses Caused in the Low Voltage System
4.2.1 Line Thickening
4.2.2 Capacity Changing (Small → Big)
4.2.3 Capacity Changing (Big → Small)
4.2.4 Load Dividing
4.2.5 Load Centering
4.3 General Commentary for Taking Countermeasures against Technical Loss Reduction
4.3.1 Concept of the Low Voltage Technical Loss Reduction
4.3.2 Proper Installation of Pole Transformers
4.3.3 Proper Installation of Low Voltage Wire

TEPCO

The system loss reduction manual presents intelligibly the criteria or standard of the procedure of planning of the measure against the loss reduction so that the engineers in charge of loss reduction can carry out work smoothly.

(1) Economical Analysis for Technical Loss Reductions

There are many methods to reduce technical losses. A method to estimate loss reduction benefits easily from simulation results is necessary to verify the candidates. Therefore, the TA team proposed a simple method to estimate easily the loss reduction benefits and its procedures are described in the manual. Specifically, cost benefits are calculated based on the 1 kW loss reduction benefit during the peak time and the loss reduction (kW) using the simulation. Related knowledge such as NPV and IRR is also explained.

(2) Methodology of O&M for data arrangement of the loss analysis

The system losses are calculated by inputting the necessary information to the system model. The following figure shows the flow of loss calculation. Therefore, it is necessary to maintain the system model and properly input information in order to calculate the system losses correctly. The outline of each data arrangement is described as follows.

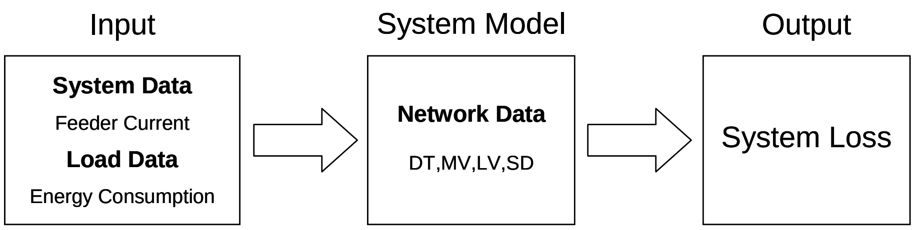


Figure 5-1 Flow of system loss calculation

➢ Network data

The system model is composed of such network data as the distribution transformer, the distribution line and so on. This network needs to be updated constantly because of the changing facilities such as the new customer connections and improvement work. Therefore, it is necessary to properly renew the system model, in case the distribution facilities undergo changes.

It is easy to renew the system model to suit the contents of the construction, because SynerGEE has a mapping function. Also by using Middlelink, which is a function added to SynerGEE, it is easy to partially add and change new facilities to the system model. Therefore, the TA Team proposed the O&M methodology for the network data arrangement by using these SynerGEE functions.

➢ System data, Load data

● System data

The system data are the current, voltage, power factor etc of each distribution feeder. This data is recorded at the distribution substation in each EC. Given that this data is necessary for system loss calculation, the TA Team described the necessity of managing these data with a Microsoft Excel database.

● Load data

The load data is the energy consumption data of each customer. Given that this data is necessary to calculate electricity rates, each EC acquires and is properly managing this data properly. Furthermore, this data is easily available for the system loss calculation by using Middlelink. The TA Team described this methodology.

(3) Identifying countermeasures to prevent technical losses for the low voltage system

(a) Methodology of calculation of the operating status of the low voltage system

It is necessary to properly grasp the operating status of each of the distribution facilities in order to identify system loss countermeasures. In this part, we made a proposal on how to grasp the operating status of the distribution transformer and the low voltage line which is composed of the low voltage system. At that time, we described the methodologies by using not only the PowerSolve data but also SynerGEE. Furthermore, regarding the distribution transformer, we proposed a methodology to create the list classified by the operating status of the distribution transformer.

(b) Countermeasure options to prevent technical losses caused in the low voltage system

We proposed 5 items as countermeasure options to prevent technical losses caused in the low voltage system. Furthermore, we described the contents, target facilities and effects of the proposed items as follows;

- ➢ Thickening of the low voltage line
  - ✓ Change existing low voltage line to the upper size
  - ✓ Apply to the high-operated low voltage line
  - ✓ Reduce technical losses by lowering the operating ratio of the low voltage line
- ➢ Capacity changing of the distribution transformer small => large
  - ✓ Change the capacity of the transformer to a large size
  - ✓ Apply to high operated transformers
  - ✓ Reduce technical losses by lowering the load loss of transformer
- ➢ Capacity changing of the distribution transformer large => small
  - ✓ Change the capacity of the transformer to a small size
  - ✓ Apply to low operated transformers
  - ✓ Reduce technical losses by lowering the no load loss of the transformer
- ➢ Load dividing
  - ✓ Divide load by adding a new transformer
  - ✓ Apply to high operated transformers and the low voltage line
  - ✓ Reduce technical losses by lowering the load loss of the transformer and the operating ratio of the low voltage line
- ➢ Load centering
  - ✓ Move transformers at the center of load
  - ✓ Apply to the high operated low voltage line
  - ✓ Reduce technical losses by lowering the operating ratio of the low voltage line

Furthermore, we show the specific examples of these options, and describe the confirmation of the effect of each countermeasure.

(c) Criteria for implementing countermeasures of the low voltage system

The position of the low voltage system is the end terminal of the electric power system and its power flow counts high values, because its currency is flowing through the various facilities such as generators, transmission lines and the high voltage/medium voltage lines. This means that the loss reductions in the low voltage system are valuable compared with that of the high voltage/medium voltage lines.

The losses consist of the resistance loss from the line and iron/copper losses from the pole transformers. The criteria of the low voltage system operation to reduce losses are as follows,

- **Dividing system by installing the pole transformers**

Although the low voltage line losses are one of the line's resistance losses, this loss reduction should be considered with the installation span of the pole transformers.

That is becouse the installation span are related to the cross section size of the conductors.

This means it is very important to install pole transformers (new additions and replacements) in consideration of the demand density in this area and its demand increasing rate.

The loss reduction manual should instruct on the appropriate load dividing measurement by installing new transformers

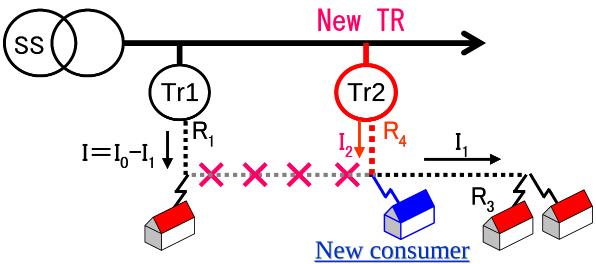


Figure 5-2 Dividing load by transformer

- **Strengthening or replacing low voltage feeders**

The low voltage system losses are proportional to the square of the line current and to the line resistance. It is not affected by the power factor and frequency. For this reason, it is possible to reduce the system losses to thicken the cross section of the conductors per the results of the analysis of the load density and the load dispersions in the supply area. But the real onsite situation is not dependent on these methods. The criteria of the low voltage line strengthening are not conducted using loss reduction measures but with a voltage drop limitation.

The TA team discussed the countermeasures against the voltage drop regulation with ECs and created the manual to include the apropriate contents in these subjects.

➢ **Replacing / relocation of pole transformers**

The apropriate location of the pole transformers are mentioned in the previous section, to reduce the losses of the transformer itself (Iron/Cupper loss), it is important to manage the transformers which are of the overload and old type and if the conditions are not suitable, they should be replaced.

The transformers are the most important parts of the low voltage distribution facilities. Therefore the criteria of replacements are closely related to the economical operation of the distibution facilities. It is vital to be very careful during the decsion-making process and conduct operations properly.

To create the new replacement rules, the TA team discussed this rule including the quantitative evaluation with the NEA and ECs in consideration of the operational limitations of the transformer that is mentioned in the next section

(d) Appropriate capacities of pole transformers and sizes of conductors

The appropriate capacity of the pole transformers shall be selectied to meet its real load. However, in a real situation it is very difficult to monitor the realtime load in each transformer and it is more practical to estimate the proper capacity from the customer facility and the unequal rate of the load.

The TA team discussed this operational limit with NEA and the ECs and described the calculation methods of the capacity in the manual.

Additionally, as the maximum peak load time of the residential load curve of the Philippines is just a few hours, it is an economical way to accept the short time overload operation to consider the temperature limitation of the core of the transformer.

The limitation of the tempratures should be carefully decided depending on its specifications because the overload is closely related to the decrease of the lifetime of the transformers.

In this study, the TA team held a discussion with the Philippine members on the tolerable amount of temperature. As a result of the discussion, the TA team proposed the IEEE index and the transformer size up methodology.   They are described in the manual.

(e) Installation of amorphous transformers

In recent years, non-load transformer losses expect to be dramatically reduced due to technical innovation to introduce the amoulphas material to its iron care.

There are many past failures and it makes sense to be apprehensive of the quality of the amoulphas transformers made in India, because there has been much trouble with them in the past. But for the past three years Philec, transformer manufactures, has been producing the amoulphas transformers and shipped them to MERALCO. MERALCO has a plan to replace the existing silicon transformer to amoulphas in order.

In this study the TA team are considering the fact that Philec company are using the Japanese amoulphas technology for their materials, and the TA Team gave a presentation concerning these technologies at the workshop. As a result of the workshop presentations, there are more reactions from the ECs than we expected and the TA team implemented the amoulphas pilot project with ISELCO I, PELCO II and FELCO.

Consultation should be held with NEA on the contents of the manual such as on the effects of there being no special tools and know-how for their maintenance. However it is expected that there will be a lot of loss reductions with quantitative values. Furthermore, the TA team tried to encourage the ECs to introduce amoulphas transformers to reduce their losses.

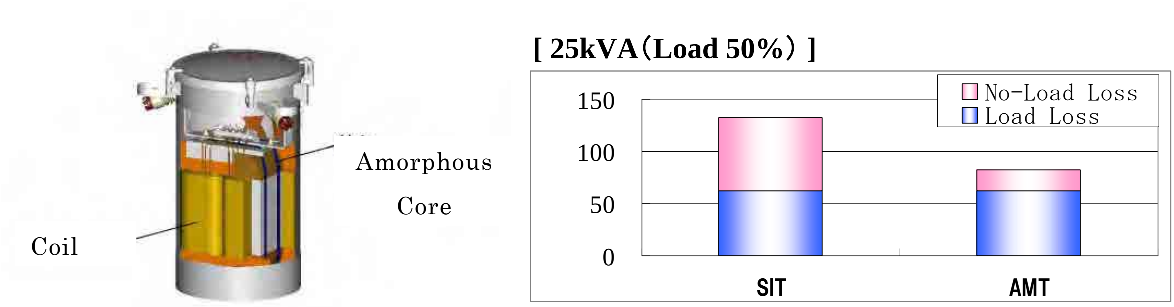


Figure 5-3 Amorphous transformers and its loss reduction

The TA Team described the effects of the verifications for AMDT and the result of the simulations in the manual according to the pilot project of AMDT donated by JICA.

(4) Identifying countermeasures to prevent technical losses for the Medium voltage system

Generally, if the scale of demand becomes large, installation of 23kV and 35kV is more efficient than installation of 13.2 kV, because the merit may become large rather than the increment of cost. Therefore, the TA Team ran a simulation and proposed the loss reduction project, which includes upgrading the voltage level from 13.2 kV to 23 kV.

The contents are the "Methodology of the Calculation of the Operating Status of the Medium Voltage System", "Options of countermeasures to prevent technical losses caused in the medium voltage system", "Criteria for implementing countermeasures of the medium voltage system" and "Appropriate sizes of conductors". Furthermore, the TA team showed specific examples of these options, and described the confirmation of the effects of each countermeasure.

(5) Adding Transformers to Substations / Installation of Substations / Upgrading Voltage of Medium Voltage (MV) Feeders

By dividing the MV distribution line into two or three by installing a new substation is effective for system loss reduction, because the total length of the MV network of the divided line would be shortened and it means both the current and resistance of the wires will decrease. Another practical measure is to upgrade the MV system voltage, which would diminish the network current in accordance with the increased voltage. It is a significant project for the power utilities to install a new substation or to upgrade the MV network, which would take a long time and much money for completion. So the utilities are required to conduct a comprehensive study on the loss-reduction projects.

Chapter 6 of the System Loss reduction manual outlines the general procedures to assess each project proposed to decrease the system losses. The network expansion measures are summarized in 6.1 Methodologies on installing the new substation and upgrading the MV network voltage are spotlighted. In 6.2, the actual plan to install the new substation in some EC was described and explained as a case study model. The items to be examined in the secondary side of the substation and in the MV network were described, when the project on upgrading the voltage is being planned, as the upgrading business affects both the substations and the MV lines.

(6) Non-technical Loss Reduction

According to the NEA data of technical and non-technical losses in 2010, there is a tendency that each categorized EC has the different measurements to reduce their losses as shown in the Figure below.

- Step 1: In the poor performance EC, more than half of the system losses are pilferages and these ECs focus on the measuremants to reduce non technical losses.

- Step 2: It is difficult to reduce non-technical losses to less than several percentages, the ECs try to reduce the technical losses as the next measurements.

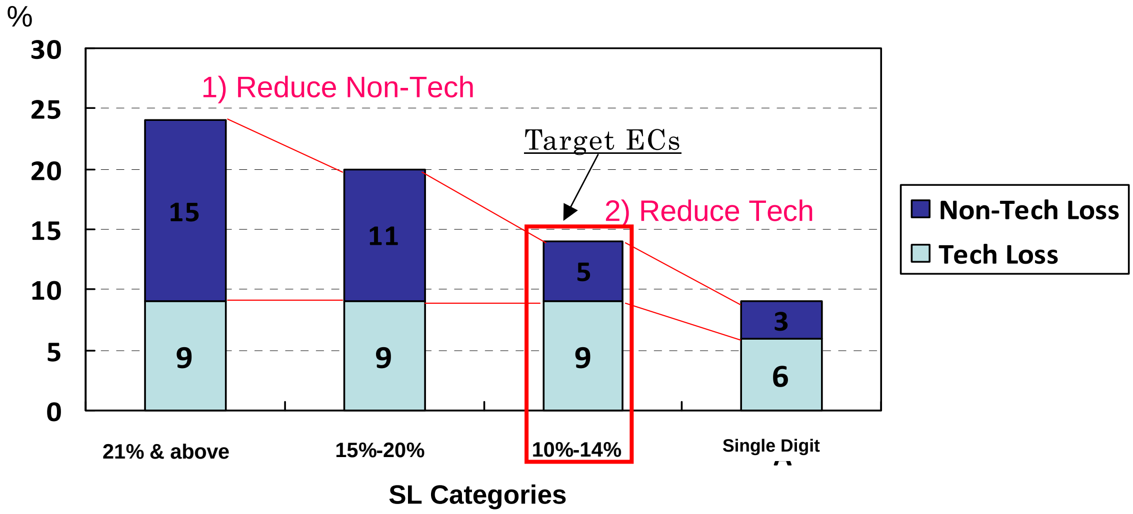


Figure 5-4 NEA data of technical and non-technical losses in 2010

Most of the selected seven ECs in this project are categorized into the ECs of which system losses are about 10-14%. They conduct the measurements to achieve a single digit loss rate to reduce both technical and non-technical losses.

All these seven ECs gave presentations of their loss reduction measurements in the workshop to share the good practices in other ECs, and many ECs already know the proper measurements to reduce especially non-technical losses. Here are the concrete measurements conducted in many ECs.

1) Measurements for distribution lines
   - Periodical patrol to clean and trim the trees near the lines

2) Measurements for the service drop wire
   - Pull-out of the service drop wire and remove the illegal wire

3) Measurements for the Metering System
   - Install pole metering at the secondary line of the TR
   - Clustering meters
   - Meter Box Installation and its seal
   - Defective / Inaccurate meter replacement
   - Correction of the Meter Reading Error

In addition, the TA team made a presentation referring to the lessons of loss reduction in Brazil. This information is very useful in Philippine, because the slum situation is very similar in both countries. Moreover, electric meters are expected to be one of the most effective measurement tools to reduce losses also in the Philippines.

In the second JCC on the 7th, February, both JICA and the Philippine side agreed that the manual to reduce non-technical losses would be made mainly per the Philippine side, and according to that agreement NEA described chapter 8, which is the non-technical loss reduction part.

In addition, the TA Team gave the following format of the good practices for system loss reduction. At the second and third workshop, each EC presented the good practices to achieve system loss reduction. That provided a good opportunity to know the other EC good practices to achieve system loss reduction. These good practices are part of the System Loss Reduction Manual.
Moreover, the TA Team proposed the system for lateral spread of the good practices to achieve system loss reduction in collaboration with NEA.

Good Practices for System Loss Reduction	
No.	FLECO-1(Sample)
EC Name	FLECO
Project Name	Use of Electronic Kilo-Watt Hour Meter
Outline of Project	Switch from electromechanical to electronic kwhr meters Advantages: Higher registration accuracy compared to electromechanical especially at light load
Picture	
Project Piriod	From April, 2009 to Octorber 2009
Estimate Loss Reduction	Meter loss Electronic meter : 0.1971 watts Electro-mechanical : 0.7989 watts Number of change meter : 100 Loss reduction = (0.7989-0.1971)*100*24*365 = 527 kWh / year
Real Loss Reduction (if data has)	Real loss reduction by measuring kWh : 0.5 Wh / one meter / hour Loss reduction = 0.5*100*24*365 = 438 kWh / year
Project Cost	Cost of electronic meter : 500 php Total electronic meter cost : 500*100 = 50,000 php Labor cost = 10,000php Transportation fee(2% of total equipment cost) = 1,000 php Miscellaneous cost(5% of total equipment cost) = 2,500 php Total cost = 63,500 php
Benefit	Equipment Lifetime : 30 years Gross benefit : 438 kWh * 30 years * 10 php /kwh = 131,400 php Net benefit = 131,400 php - 63,500 php = 67,900 php
IRR	5.5%
Remark (if it has)	

Figure 5-5 Format of the good practices for system loss reduction

5.2.6. The pilot projects installing AMDT

The TA Team proposed three pilot projects which will install AMDT at ISELCO I, PELCO II and FELCO. The details of the projects are described as follows.

(1) The background of the pilot project proposal

The TA team discussed the availabilities of the pilot project and agreed with ISELCO I, PELCO II and FELCO to cooperate with the pilot project of the amorphous transformers at 5th mission.

In the Philippines, the load rates of the pole transformers are relatively low, and it is expected that the introduction of amorphous transformers to replace the aged SiFe transformers will have a big effect in reducing the distribution losses. The TA team proposed the pilot project to PELCO II that will supply power to the Pampanga area. PELCO II shows the favorable interests in the amorphous transformers and they can check the transformer performance using the testing facilities by themselves.

Moreover, the TA team proposed the same pilot project to ISELCO I and FELCO that have the same kind of testing equipment for the transformers. They also show favorable interests in the amorphous transformers and they can check the transformer performance using the testing facilities by themselves too.

Additionally, the Japanese manufacturer HITACHI has a dominant market share of the material core part of the AMDT. They positively supported this project to accept the counterpart training in Japan. In this way, this pilot project will promote the introduction of Japanese technology and products to the Philippines.

(2) The concrete procedures of the pilot project

(a) Test Methods

After the preparatory study by the TA team at the end of 2011, the comparison studies of before and after the replacement of the amorphous transformers have difficulties in measuring the exact value of losses, because it is too small for the reduction to measure even if precise meters are used.

The TA team suggested examining the performances of the amorphous transformers by PELCO II and letting them know the effects of the replacement via their testing results.

The proposed examinations of the amorphous transformers are as listed below,

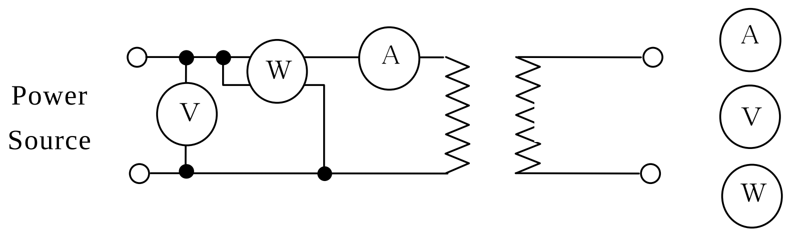
- Non-load test
- Short circuit test

As a pilot project, the result of the examinations between the amorphous transformers and silicon care transformers enable one to indicate the loss reductions and measure the effects of the replacement of the amorphous transformers.

The vilification of the actual system simulation will be mentioned in Chapter 5.2.6 Section (3)-(b)

Non-load test

The no-load loss and the no-load current shall be measured on one of the windings at rated frequency and at a voltage corresponding to rated voltage. The remaining winding or windings shall be left open-circuited.



Short circuit test

The short-circuit impedance and load losses shall be measured at rated frequency with a designated level of sinusoidal voltage applied to the terminals of one winding, with the terminals of the other winding short-circuited, and with possible other windings open-circuited.

$$P_{75} = I^2 Rt \left(\frac{310}{235 + t} \right) + (Pt - I^2 Rt) \left(\frac{235 + t}{310} \right)$$

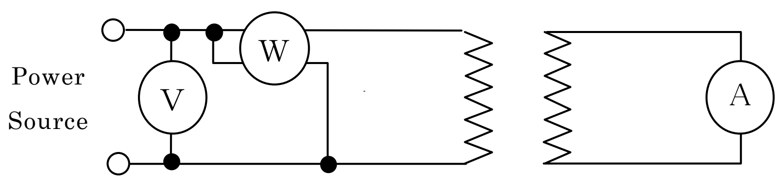
P_{75} : load loss at 75 (W)

P_t : load loss at t (W)

t : temperature of winding at P_t (degrees C)

I : primary current at P_t (A)

R_t : winding resistant at t convert to primary side (Ω)



(b) Specification of AMDT

Phase:	Single
Cooling System:	Oil Immersed (OA)
Frequency:	60Hz
Primary Side:	Double primary bushing with bushing connector that can accommodate up to No.1/0 size of wire
Primary Voltage:	13200/7620 Volts
Secondary Side:	Triple secondary bushing with bushing connector that can accommodate up to No.4/0 size of wire
Secondary Voltage:	240/120 Volts
HV Winding BIL:	95/95
LV Winding BIL:	30/30
Primary Taps, KV:	2.5%, 2A2B
% Impedance @85 deg C:	1.75 - 2.25%

Table 5-5 Number of installation AMDT

(Unit)

Ratings	10KVA	15KVA	25KVA	37.5KVA	50KVA
Units to be procured per rating (ISELCO I)	2 units	2 units	2 units	2 units	1 units
Units to be procured per rating (PELCO II)	2 units	2 units	2 units	2 units	1 units
Units to be procured per rating (FLECO)	2 units	2 units	2 units	2 units	1 units

(c) Cost Comparison between AMDT and SiFe DT

Philec Corp. has succeeded in the bid for AMDT whose core parts are made by Hitachi. Their bidding price of FOB was about 10% higher than that of SiFe as it is described in Table5-6.

After a factory test that was conducted by JICA Philippine and three ECs in November 2012, all the AMDT confirmed its effects and installed a model distribution feeder decided beforehand.

Table 5-6 Unit Price of both AMDT and SiFe DT

Capacity	10 KVA	15 KVA	25 KVA	37.5 KVA	50 KVA
Unit Price of AMDT [PHP/Unit]	56,196	60,118	86,442	108,635	122, 366
Unit Price of SiFe DT[PHP/Unit]	48,716	59,999	77,741	94,828	110,796
Price Deference	115%	100%	111%	115%	110%

(3) The Confirmation of the AMDT Effects

(a) The Result of Transformer Unit Test (Rated Condition)

The Transformer Unit Test in rated condition was conducted by EC to compare the core and cupper loss between AMDT and SiFe.

Because of this test, it was confirmed that the losses by AMDT was about 20% lower than that of SiFe at all the three ECs.

Table 5-7 Result of AMDT Unit Test (3 EC)

FLECO

[KVA]	Amoulphous			Conventional SiFe			Total reduction	
	Core loss[W]	Copper loss[W]	Total Loss[W]	Core loss[W]	Copper loss[W]	Total Loss[W]	[W]	[%]
10	10	126	136	37	135	172	▲ 36	-21%
15	20	103	123	30	134	164	▲ 41	-25%
25	20	207	227	80	227	307	▲ 80	-26%
37.5	30	285	315	100	314	414	▲ 99	-24%
50	50	426	476	130	468	598	▲ 122	-20%
			1,277			1,655	▲ 378	-23%

ISELCO_1

[KVA]	Amoulphous			Conventional SiFe			Total reduction	
	Core loss[W]	Copper loss[W]	Total Loss[W]	Core loss[W]	Copper loss[W]	Total Loss[W]	[W]	[%]
10	12	174	186	45	180	225	▲ 39	-17%
15	15.5	205.5	221	58	215	273	▲ 52	-19%
25	20.5	311.5	332	82	295	377	▲ 45	-12%
37.5	28	412	440	110	400	510	▲ 70	-14%
50	43	543	586	140	490	630	▲ 44	-7%
			1,765			2,015	▲ 250	-12%

PELCO_2

[KVA]	Amoulphous			Conventional SiFe			Total reduction	
	Core loss[W]	Copper loss[W]	Total Loss[W]	Core loss[W]	Copper loss[W]	Total Loss[W]	[W]	[%]
10	10	145	155	37	150	187	▲ 32	-17%
15	14	167	181	40	174	214	▲ 33	-15%
25	19	255	274	71	263	334	▲ 60	-18%
37.5	29	339	368	93	353	446	▲ 78	-17%
50	47	445	492	126	444	570	▲ 78	-14%
			1,470			1,751	▲ 281	-16%

(b) Simulation of Loss Reduction on Actual Distribution Feeders

All the AMDT (nine units each: total 27), which are the most effective and easily manageable model feeders, have already been installed to the three ECs.

- ✓ PELCO2 : Feeder No. 2, No.2 SS (9 units)
- ✓ FLECO : Feeder No. 2 (4 units), Feeder No.4 – Kalayaan Lumban_SS (5 units)
- ✓ ISELCO1 : Feeder 1_Bliss/Villador, Mercedes SS (9 units)

It is very difficult to verify the effects numerically by measuring the actual current in the model distribution feeders given that there are many transformers and customers where the current fluctuates from time to time. Then, the TA Team simulated the effect of the AMDT on the model feeders by using the model load curve shown in the table5-6. The precondition of the operating year, discount rate and wholesale power rate are 30 years, 10% and 5 peso/kWh.

The transformers should be replaced or upsized when it is overloaded or when they exceed their age limits. In this model case, the TA Team has verified economically which transformers were the best to be replaced when existing 10kVA transformers were overloaded.

The hourly load data of the existing 10kVA transformers are as in Figure 5-6. The TA team simulated the core loss and copper loss from this load curve and described in the table 5-8.

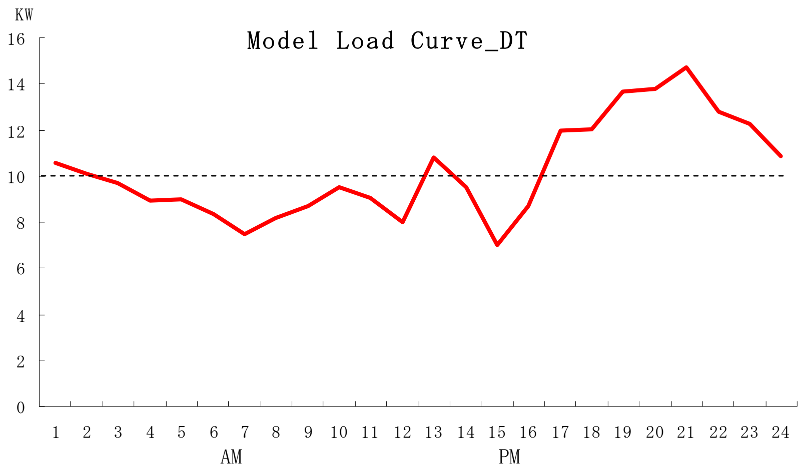


Figure 5-6 Daily Curve of Overloaded Transformer (10kVA)

Table 5-8 Comparison of core loss and copper loss of each DT capacity

		10kVA DT		15kVA DT		25kVA DT		37.5kVA DT		50kVA DT	
		SiFe	AMDT	SiFe	AMDT	SiFe	AMDT	SiFe	AMDT	SiFe	AMDT
CORE LOSS[W]		45	12	58	15	82	20	110	29	140	43
COPPER LOSS[W]		180	173	215	206	295	311	400	416	490	544
TIME	DEMAND (kVA)	LOSSES (Wh)	LOSSES (Wh)	LOSSES (Wh)	LOSSES (Wh)	LOSSES (Wh)	LOSSES (Wh)	LOSSES (Wh)	LOSSES (Wh)	LOSSES (Wh)	LOSSES (Wh)
1:00	10.54	245.0	204.1	164.2	116.3	134.4	75.6	141.6	61.4	161.8	66.8
2:00	10.08	227.8	187.6	155.1	107.6	129.9	70.9	138.9	58.5	159.9	64.8
3:00	9.70	214.4	174.6	147.9	100.7	126.4	67.2	136.8	56.3	158.4	63.1
4:00	8.95	189.2	150.4	134.6	87.9	119.8	60.2	132.8	52.2	155.7	60.1
5:00	8.99	190.3	151.5	135.2	88.5	120.1	60.5	133.0	52.4	155.8	60.2
6:00	8.34	170.3	132.2	124.5	78.3	114.9	55.0	129.8	49.1	153.6	57.8
7:00	7.46	145.1	107.9	111.2	65.5	108.3	48.0	125.8	45.0	150.9	54.8
8:00	8.19	165.8	127.8	122.1	76.0	113.7	53.7	129.1	48.4	153.2	57.3
9:00	8.71	181.6	143.0	130.5	84.0	117.8	58.1	131.6	50.9	154.9	59.2
10:00	9.54	208.7	169.1	144.9	97.8	124.9	65.6	135.9	55.4	157.8	62.4
11:00	9.06	192.9	153.9	136.5	89.8	120.8	61.2	133.4	52.8	156.1	60.5
12:00	7.98	159.5	121.8	118.8	72.8	112.0	52.0	128.1	47.3	152.5	56.5
13:00	10.79	254.4	213.2	169.2	121.1	136.9	78.2	143.1	62.9	162.8	68.0
14:00	9.51	207.8	168.3	144.4	97.4	124.7	65.3	135.7	55.3	157.7	62.3
15:00	7.02	133.8	97.0	105.1	59.7	105.3	44.9	124.0	43.1	149.7	53.4
16:00	8.70	181.1	142.6	130.3	83.8	117.7	58.0	131.5	50.9	154.8	59.1
17:00	11.96	302.7	259.6	194.8	145.7	149.6	91.6	150.7	70.8	168.1	73.8
18:00	12.01	304.5	261.3	195.7	146.6	150.0	92.1	151.0	71.1	168.3	74.0
19:00	13.66	381.1	335.1	236.4	185.6	170.1	113.2	163.1	83.7	176.6	83.3
20:00	13.77	386.5	340.4	239.3	188.4	171.6	114.7	164.0	84.6	177.2	83.9
21:00	14.72	435.0	387.1	265.0	213.0	184.3	128.2	171.6	92.6	182.5	89.8
22:00	12.80	340.0	295.6	214.6	164.7	159.4	101.9	156.6	77.0	172.1	78.3
23:00	12.24	314.8	271.3	201.2	151.8	152.7	94.9	152.6	72.8	169.4	75.3
0:00	10.88	258.1	216.7	171.1	123.0	137.9	79.3	143.7	63.5	163.2	68.4
Average Load											
DAILY ENERGY LOS		5.79	4.81	3.89	2.75	3.20	1.79	3.38	1.46	3.87	1.59
MONTHLY LOSSES [		173.72	144.37	116.78	82.38	96.10	53.71	101.53	43.75	116.19	47.79
ANNUAL LOSS [kWh		2,085	1,732	1,401	989	1,153	644	1,218	525	1,394	574
ENERGY LOSS [peso/year]		10,423	8,662	7,007	4,943	5,766	3,222	6,092	2,625	6,971	2,868
Energy loss in 30 yrs		**98,258**	**81,655**	**66,053**	**46,595**	**54,354**	**30,378**	**57,428**	**24,743**	**65,718**	**27,033**
(Biding cost) [peso]		48,716	56,196	59,999	60,118	77,741	86,442	94,828	108,635	110,796	122,366
Additional Cost of AMDT		**100%**	**115%**	**123%**	**123%**	**160%**	**177%**	**195%**	**223%**	**227%**	**251%**
PW Total Cost in 30 yrs [peso]		146,974	137,851	126,052	106,713	132,095	116,820	152,256	133,378	176,514	149,399
Advantage of AMDT in 30		**100%**	**94%**	**86%**	**73%**	**90%**	**79%**	**104%**	**91%**	**120%**	**102%**

The core loss is constant depending on the load, but the copper loss is proportional to the square of the load.

Actual Copper Loss [W] = Percent loading^2 * Rated Copper Loss [W]

Annual Energy Loss [W] = (Actual Copper Loss [W] + Core Loss [W]) × 8760[H]

The cost can be calculated by multiplying the wholesale cost at 5 pesos. The present value cost after 30 years is as follows,

PW Cost of Energy Loss [PHP] = Annual Cost of Energy Loss*$(((1+10\%)^{30}-1) / 10\% / (1+10\%)^{30})$

TEPCO

The results of the simulation, 15kVA AMDT is the most economical for the replacement.

Using the same precondition data above, as shown in the table **, AMDT is more economical than SiFe after about 5 years in each capacity of the transformers. JICA explained this result to not only three ECs but also all the ECs in the workshop and in the manual.

JICA convinced them to understand the results of this pilot project that AMDT is more economical than they previously expected.

Considering the fact that MERALCO is accelerating the introduction of AMDT to replace all the aged transformers, NEA also strongly believes that AMDTs are effective and the existing transformers should be replaced in the near future, and NEA will recommend AMDT to EC as well.

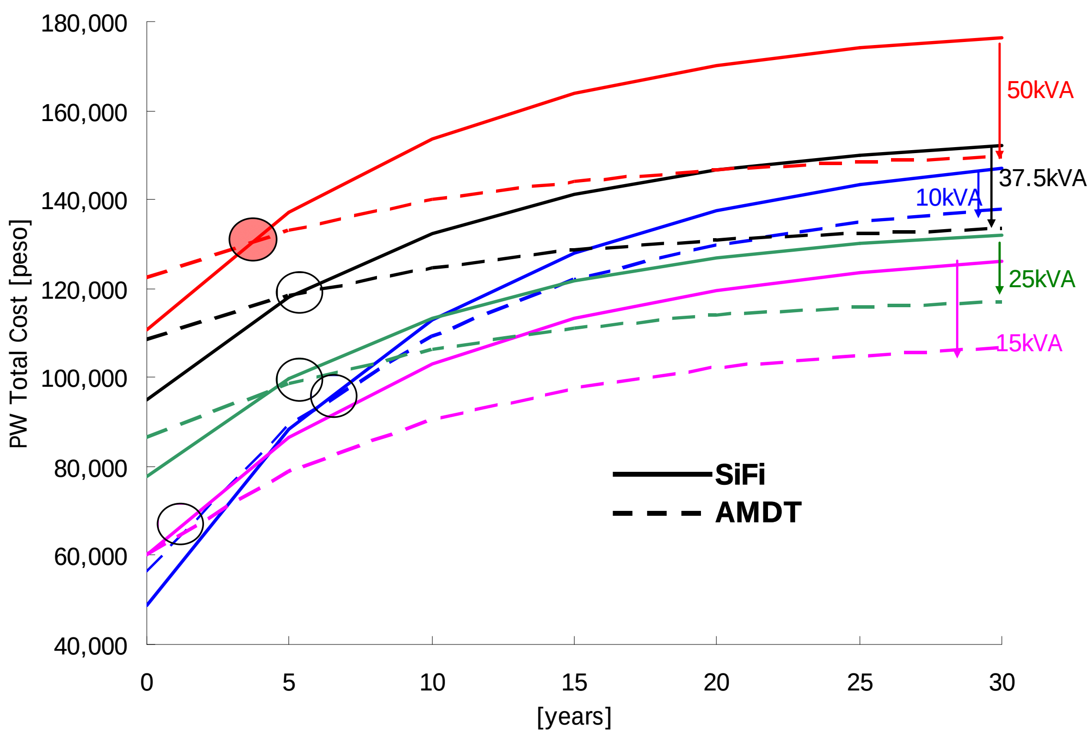


Figure 5-7 Cost Comparison both SiFe and AMDT)

TEPCO

5.2.7. Work preparation to support planning of full-scale F/S (confirmation and analysis of the power distribution development plan)

For work preparation to support the planning of full-scale F/S for the upgrading of an MV network, the TA team evaluated the feasibility of upgrading the MV network.

(1) Power Distribution Development Plans

- CAPEX Data and Plans
  - Each EC submits CAPEX to NEA/ERC for their future projects. The TA team picked up several projects from CAPEX provided by NEA, which planned for a new installation of a distribution substation or replacement of a transformer at a distribution substation in from years 2012 to 2014 and the TA team evaluated the plans.
  - The targeted seven ECs had a few plans for the new installation of a distribution substation or replacement of a transformer at a distribution substation. ISELCO1, FLECO, CASURECO2, CASURECO4, and SORECO1 are examples of candidate plans.
  - Additionally from the TA team's site visit, the TA team picked up a project from PELCO2 for our evaluation.

(2) Candidate Plans

- The Candidate Plans from CAPEX and information from NEA and ECs
  - The next table shows some examples of our candidate plans for evaluation.

Table 5-9 candidate plans for evaluation

EC	Substation	Capacity	Targeted Year
PELCO II	Sta Maria,Mabalacat	10MVA	2013
FLECO	Pagsanjan	10MVA	2012
ISELCO I	R. Mercedez	10MVA	2012*
SORECO I	Bulan	5MVA	2013
CASURECO II	Bagacay Sibulan	50MVA 5MVA	2012 2013
CASURECO IV	Caramoan	5MVA	2012

* Targeted Year for ISELCO I's plan has been changed from 2012 to 2013 or later.

  - Based on a feasibility of the project and our interview to the EC, ISELCO I's plan was selected for the detailed evaluation for upgrading project.

(3) Evaluation method

The evaluation is based on two components. One is initial cost (cost of facilities) and the other is the cost of power losses.

- Initial cost (cost of facilities)
  - The initial cost is the construction costs or replacement costs of MV systems such as the replacements of a transformer at a distribution substation, the replacement of line wires, electric poles, and the replacement of DTs and the insulators if the system voltage is upgraded. For the purpose of the evaluation, the initial cost for the 13.2kV case is based on the original plan that was established by the ECs, but in some cases, the TA team modified the plan. On the other hand, the cost for the 23kV system is based on the installation plans established by the TA team.
- Cost of power losses
  - In 13.2kV cases, based on the new installation of the distribution substation or new feeder, or from the application of a parallel circuit or line thickening, the large loss reduction at the MV system could be achieved. In 23kV cases, based on the upgrading of the system voltage, a large loss reduction at the MV system could also be achieved.
  - The effects of the loss reduction would continue until the facilities reach the end of their life spans. For the evaluation of the upgrading of a system voltage of MV, the evaluation period of the cost of power losses is 15years.
- Total costs
  - The total cost of the plan is obtained from the sum of the initial cost and cost of power losses.

    Total Costs = Initial cost + Cost of Power losses for 15years [PHP]
- Limitation of the evaluation
  - Since based on our project limitations, we could not conduct the measurements of actual feeders such as the length or height of poles or the space of additional wires and a detailed sketch of the distribution facilities such as the configuration of electric poles nor calculate the actual loading of the distribution transformers on the poles. Additionally we could not forecast the development of the area where the feeder supplies electric power.
  - For our evaluation, we use schematic simulation models and from these, we extracted SynerGEE data for the computer simulations and the forecast for the load increase rate and the plans of new supplies were based on information from EC.

(4) ISELCO I

- Original Plan
  - As shown in the next figure, four big loads were planned and will be supplied by the MV feeder from the Mercedes substation. The loads are two big mills, Isabela medical hospital, and a shopping mall. The expected demand of each load is around 0.4MW.
  - Additionally, from ISELCO I's estimation, the base load of the substation is increasing annually at about 3.8%. The estimated demand for the substation in year 2014 is 4.992MW.
  - The original plan by ISELCO I is to replace the transformer at the R. Mercedes substation. The 5MVA transformer will be replaced by the 10MVA transformer.

Table 5-10 Basic information of ISELCO I's candidate site

Substation	Capacity of Tr. [MVA]	% Loading [%]	Increase rate [%]	# of Faders	# of DTs
R. Mercedes	5	84.36	3.8	2	358

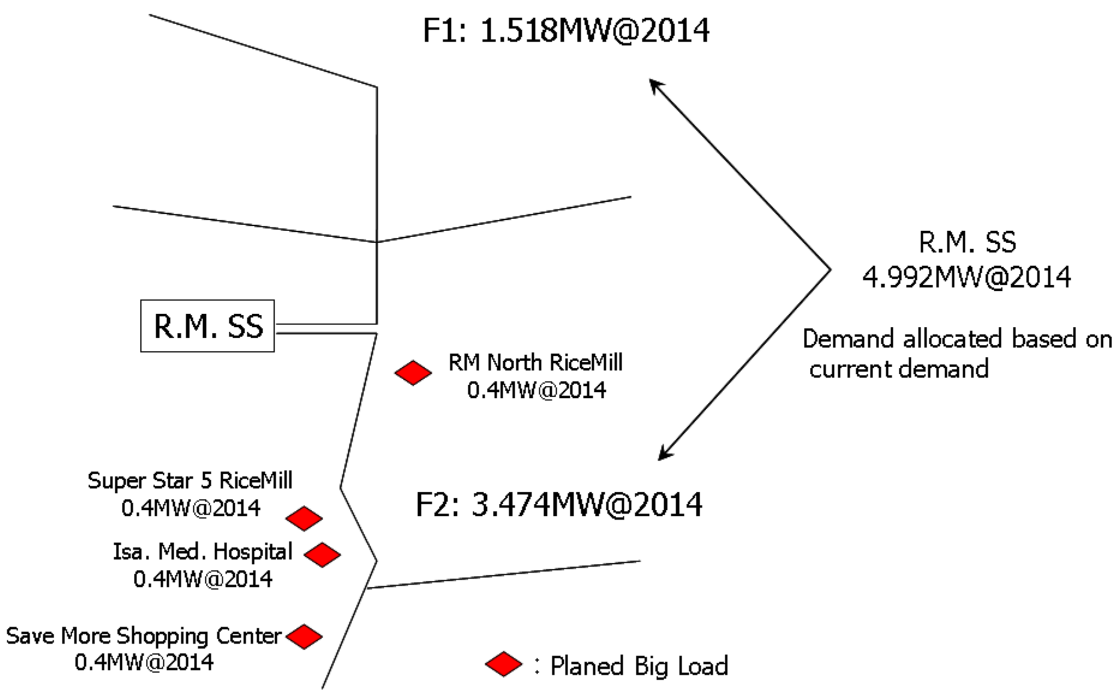
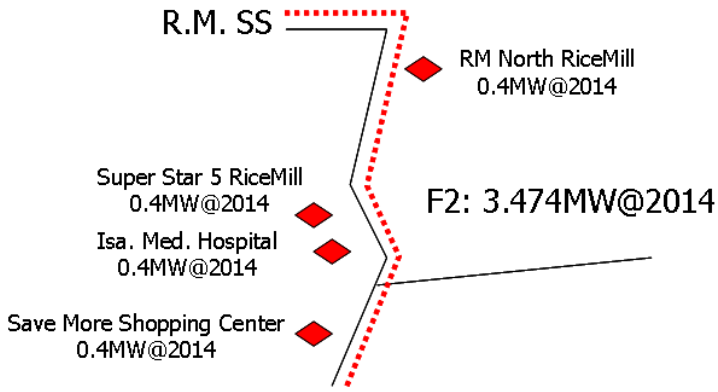


Figure 5-8 Image of ISELCO I 's candidate site

- Evaluation models
  - To evaluate, two evaluation models are set. Case 1 is the 13.2kV and case 2 is the 23kV model. ISELCO I provided us with the SynerGEE data of the whole R. Mercedes substation and from the data, we created the SynerGEE data to evaluate each case and get the results.
  - The next table shows an outline of each case and the figure shows the outline of the MV line.

Table 5-11 Outline of each case (ISELCO I)

Case	System Voltage	Description
Case 1	13.2kV	Construct a new 13.2kV MV line 5.7km long and supply new big loads from a newly installed 13.2kV MV line, fed from an additional 5MVA Tr. (69/13.2kV) at R. Mercedes
Case 2	23kV	Construct a new 23kV MV line for 5.7km and supply new big loads from a newly installed 23kV MV line, fed from an additional 5MVA Tr. (69/23kV) at R. Mercedes



*Dotted red line indicates the newly installed MV line from R.M. SS.

Figure 5-9 Outline of the MV line (ISELCO I)

- Evaluation result
  - The next table shows the results of the simulation. The initial cost for case 1 is 25.9 M PHP and for case 2 is 29.8M PHP. The cost of the losses for over 15years for case 1 is 38.2 M PHP and for case 2 is 29.4 M PHP. Finally, the total cost for 15years for case 1 is 64.1 M PHP and for case 2 is 59.2 M PHP.
  - From this evaluation, we verified that case 1 costs more due to the losses. To apply the 23kV system voltage, we could reduce the losses occurring in the MV system. Even the initial cost for a 23kV is high, because of the loss reduction, the total cost for 23kV is less expensive.

- As shown in this evaluation, the project for R. Mercedes should be conducted with the 23kV system upgrading. This is only one example, but if the big new loads are planned on the same feeder and there is space to construct a new feeder for 23kV, in many cases, applying a 23kV system will be cost effective.

Table 5-12 Evaluation result (ISELCO I)

Case	Cost of Power Loss	Construction cost	Total Cost	Result
Only Upgrade Power Tr.	101,269,882	24,468,405	125,738,332	-
1	38,183,726	25,875,418	64,059,144	
2	29,408,584	29,748,023	59,156,607	◎

*Unit: PHP for 15 years

(5) Propose for Full-scale F/S

Through our evaluations, we find the feasibly of an upgrading project. Since the TA team mainly evaluates the possible projects of the seven targeted ECs, NEA asked the many ECs to submit the candidate site for an upgrading project and the possible sites for an upgrading project were listed and provided for the TA team.

- Candidate Sites for the Upgrading Project
  - The next table shows the candidate sites for an upgrading project which were provided by NEA to the TA team.
  - Roughly speaking from our evaluation shown in this chapter, the typical feasible site for an upgrading project is where an increase rate of the load at the site is high and the percent loading of the transformer at the site is also high. The table listed in descending order in terms of an increase rate and the percentage loading of a transformer.

Table 5-13 Candidate Sites

EC	Substation	Capacity (MVA)	%Loading	Increase Rate (%)	Feeder	Length (km)	DT (Units)
BENECO	Atok	5	43.96	2.01	Circuit1	39.0	158
					Circuit2	51.0	55
					Circuit3	35.0	84
	Mankayan	3.75	90	2.75	Circuit4	60.0	419
					Circuit5	23.5	84
CAGELCO II	Bantay	5	62.72	3	Feeder 2	18.6	272
CANORECO	Lag-on	10	68.94		Feeder 1	1.4	43
					Feeder 2	3.5	77
					Feeder 3	12.4	70
					Feeder 4	37.6	382
	Calintaan	5	40.26		Feeder 1	14.0	304
		10	43.14		Feeder 1	13.0	659
	Talobatib	5	97.68		Feeder 1	64.6	200
					Feeder 2	24.0	272
	Tawig	5	56.52		Feeder 1	12.5	20
					Feeder 2	11.6	190
	Sta Rosa	5	67.54		Feeder 1	9.0	52
					Feeder 2	22.9	294
ISECO	Sta Cruz	10	48.86	2.77	Feeder 1	380.9	534
					Feeder 2		
	Cabugao	10	44.25	3.27	Feeder 1	565.2	446
					Feeder 2		
ISELCO I	Mercedes	5	84.36	7.66	Feeder 1	13.6	99
					Feeder 2	12.8	248
ORMECO	Diamond	30	59	5.95	Feeder 1	94.8	4082
					Feeder 2		
					Feeder 3		
					Feeder 4		
					Feeder 5		
PELCO II	Guagua	15	84.63	0.58	F2S1T2	12.3	231
					F3S1T2	6.3	164
					F5S1T2	11.4	291
					F6S1T2	1.8	35
					F7S1T2	0.4	17
		10	75.93		F4S1T1	12.5	200
					F1S1T1	9.8	282
	Mabiga	25	66.51	0.59	F3S2T2	10.1	708
					F4S2T2	11.4	641
					F5S2T2	3.5	156
					F6S2T2	0.5	25
		10	77.84		F2S2T1	6.4	301
	Pio	10	108.74	0.81	F2S3T1	10.9	368
					F4S3T1	15.4	350
		5	83.39		F1S3T2	13.8	114
					F3S3T2	7.0	55
	Remedios	10	59.23	2.31	F1S4T1	7.6	267
					F2S4T1	5.7	254
					F3S4T1	5.3	117
	Sta Cruz	10	61.09	2.45	F1S5T1	1.9	112
					F2S5T1	6.9	166
SAMELCO II	Bagolibas	5	83.32	5 to 6%	Feeder 1	82.1	220
					Feeder 2	50.4	184

- Further Feasibility Study Needs
  - As shown in section (4), the effectiveness of an upgrading project changes with the geographic structure of the feeder and the geographic location of customers that are supplied by the feeder and so on. More importantly, detailed information for new supplies for big customers is needed. i.e. location, demand, the distance from the substation, the expected data for the new supply will be started and so on.
  - The TA team strongly recommends conducting site surveys for the candidate sites. Through the site surveys, information important for further evaluations should be acquired. The typical example data which should be additionally acquired are;
    - Upcoming new supplies; demand, expected demand curve, type of customers (houses, commercial entities, industries or etc), location, distance from the substation, expected date for new supply, and so on.
    - Load forecasting for the area supplied by the candidate sites.
    - Peripheral environment; Type of area (houses, farmlands, commercial entities, industries, forests, or etc), Roads (Widths, space to erect new poles), River (Widths), Space (Erect new poles), and any laws or rules that restrict construction of the new feeder.
    - DTs; Capacity, current load, load curve, load forecast, connected phase, and age
    - Pole; Size, height, design strength, space for additional lines, and age
    - MV line; Geographic area supplied by the feeder, Phase (single, or three phase), size, current, size and number of insulators, Circuits (Single or parallel) and age
    - Substation ; Number of Tr. and capacity of each Tr., %loading of each Tr., load forecast for each Tr., age of Tr., number of feeders fed by each Tr., area of the site used up and free space, possibility to acquire adjacent space to expand the substation if needed
    - Typical construction costs for the DT, MV line, Poles, and Substation (including new installations, replacements, removals) for candidate sites
    - Detailed information of any existing plans related to the candidate site

Chapter 6 Project Performance and Achievements

6.1. System loss reduction manual

(1) Current Status of C/Ps and Other Target Groups

- The system loss reduction manual was created in collaboration with NEA and 7ECs.
- In preparation for the system loss reduction manual, The TA team introduced Japan's latest technology in advance. Then, the system loss reduction technique was guided through meetings with the counterparts, the field meetings with the 7EC engineers and four workshops. Therefore, they have learned the necessary technical requirements necessary for the system loss reduction planning.
- The good practices of the non-technical loss reductions was put together by NEA, and was included in the system loss reduction manual. Moreover, the lateral spread of the good practices was attempted through presentations at workshops from each EC. As a result, the non-technical loss reduction projects modeled after the good practices of the other ECs was proposed.
- In the workshops, the opportunity to carry out the presentation to NEA and the 7ECs was prepared, and it strove for capability improvements considered on their own leading to the system loss reductions. As a result, the problem-solving capability of the counterparts and the administrator of the targeted ECs has improved, and have reached a level where the can propose solutions on their own.
- The system loss reduction manual was distributed to all the ECs, and in the final workshop, in the system loss reduction manual it was explained that many ECs would strive to spread of manual. As a result, in all of the ECs, the countermeasures of the system loss reduction using this manual is to be expected from now on.

(2) Achievement Indicators

(a) The category of the targeted ECs

The category of the targeted ECs in 2007, when the preliminary survey was conducted, and the newest category of the targeted ECs is shown in the following table.

Although it is believed that the effects of the loss reduction using the system loss reduction manual will show up several years later, in the 7ECs, the latest results have exceeded the results in 2007, and the effects of the system loss reduction per this project and the improvements in the capability of the data management is accepted.

Table 6-1 Category of targeted EC and comments

EC	2007	2011	comment
ISELCO I	C	A	Engineers tackled numbering of transformer for equipment
PELCO II	D	B	Young engineers tackled the modeling for plan of loss reduction project.
FLECO	D	A	NEA engineer tackled the management improvement.
CASURECO II	C	C	Engineers understood the advantage of modeling.
CASURECO IV	B	B	Engineers understood the advantage of modeling.
SORECO I	E	B	Engineers tackled non-technical loss reduction.
LEYECO III	C	A	Manager tackled non-technical loss reduction.

(Source: NEA data)

(b) Number of times of workshop holding

A workshop was held three times for the targeted 7ECs and one time for all the ECs. The number of participants is shown in the following table. 350 people participated.

Table 6-2 Number of workshop participants

(Number)

Title	NEA	ECs	JICA and JICA TA Team	Other	Total
1th Workshop	19	28	13	0	60
2nd Workshop	24	24	10	0	58
3rd Workshop	11	22	10	0	43
Final Workshop	30	109	10	40	189
Total	84	183	43	40	350

6.2. Support system for quantitative evaluation of system loss

(1) Current Status of C/Ps and Other Targeted Groups

- Per a request from the NEA that the system loss reduction manual should be packed into one volume, the TA team held discussions with NEA and JICA. As a result of the discussion, the support system for the quantitative evaluation of the system losses was included in the system loss reduction manual. For this reason, the support system for the quantitative evaluation of the system losses was created also in collaboration with NEA and 7ECs.
- The quantitative evaluation techniques of the system losses were guided through the meetings with the counterparts, the field meetings with 7EC engineers, four

workshops and AMDT pilot projects. Therefore, they have learned the necessary technical requirements necessary to conduct a quantitative evaluation of the system losses.

- For improvements in the capability of the quantitative evaluation of the system losses and data management, power distribution system analysis software (SynerGEE) was introduced, and software training was provided, and strove to improve the capabilities of the NEA engineers and the 7ECs. As a result, it reached a level where they are able to come up with a proposal on their own for a system loss reduction project using SynerGEE.
- The quantitative evaluation of the system losses and data management and system losses were put into practice through the AMDT pilot project. As a result, they reached a level where they were able to conduct evaluations on their own of the test results of the transformer and an evaluation of the loss reduction effects.

(2) Achievement Indicators

(a) Number of AMDT pilot projects

The pilot projects using AMDT were carried out in ISELCO I, PELCO II, and FELCO as described in detail in Chapter 5.2.6.

(b) Number of SynerGEE Training Classes

The SynerGEE basic training and SynerGEE advanced training were carried out for NEA and the seven targeted EC as follows. The number of trainees is shown in Table 5-2.

Table 6-3 Schedule of SynerGEE training

EC	Basic trainig	Advance trainig
ISELCO I	January 31 to February 2, 2012	May 24 to May 25, 2012
PELCO II	February 22 to February 24, 2012	May 29 to May 30, 2012
FLECO	February 29 to March 2, 2012	June 18 to June 19, 2012
CASURECO II	April 2 to April 4, 2012	June 5 to June 6, 2012
CASURECO IV	April 2 to April 4, 2012	June 7 to June 8, 2012
SORECO I	April 10 to April 12, 2012	June 21 to June 22, 2012
LEYECO III	April 18 to April 20, 2012	June 14 to June 15, 2012

6.3. Support system for upgrading the present medium voltage

(1) Current Status of C/Ps and Other Targeted Groups

- Per the request from NEA that the system loss reduction manual should be packed into one volume, the TA team held discussions with NEA and JICA. As a result of the discussion, the support system to upgrade the present medium voltage was included in the system loss reduction manual. For this reason, the support system to upgrade the present medium voltage was created also in collaboration with NEA and 7ECs.

- The technique to upgrade the present medium voltage was guided through the meetings with the counterparts, the field meetings with the 7EC engineers and four workshops. Therefore, they have learned the necessary technical requirements necessary for the upgrading of the present medium voltage.
- The model case of upgrading the medium voltage line was introduced to all ECs, and the technical instructions on the criteria and the method of the upgrading was carried out. As a result, it is expected that the system loss reduction project, which includes the upgrading of the medium voltage line at some ECs will be proposed from now on.

(2) Achievement Indicators

(a) Number of Model Cases of Medium Voltage Line Upgrades

The TA Team carried out a model study to upgrade the medium voltage lines at ISELCO I and PELCO II as described in detail in Chapter 5.2.7.

6.4. Current Status of the Targeted ECs

(1) ISELCO I

- They tackled the AMDT pilot project.
- 22 engineers participated in the SynerGEE software training.
- Two engineers participated in the Counterpart Training in Japan.

(2) PELCO II

- They tackled the AMDT pilot project.
- 22 engineers participated in the SynerGEE software training.
- Two engineers participated in the Counterpart Training in Japan.

(3) FLECO

- They tackled the AMDT pilot project.
- 25 engineers participated in the SynerGEE software training.
- Two engineers participated in the Counterpart Training in Japan.

(4) CASURECO II

- 19 engineers participated in the SynerGEE software training.
- Two engineers participated in the Counterpart Training in Japan.

(5) CASURECO IV

- 11 engineers participated in the SynerGEE software training.
- One engineer participated in the Counterpart Training in Japan.

(6) SORECO I

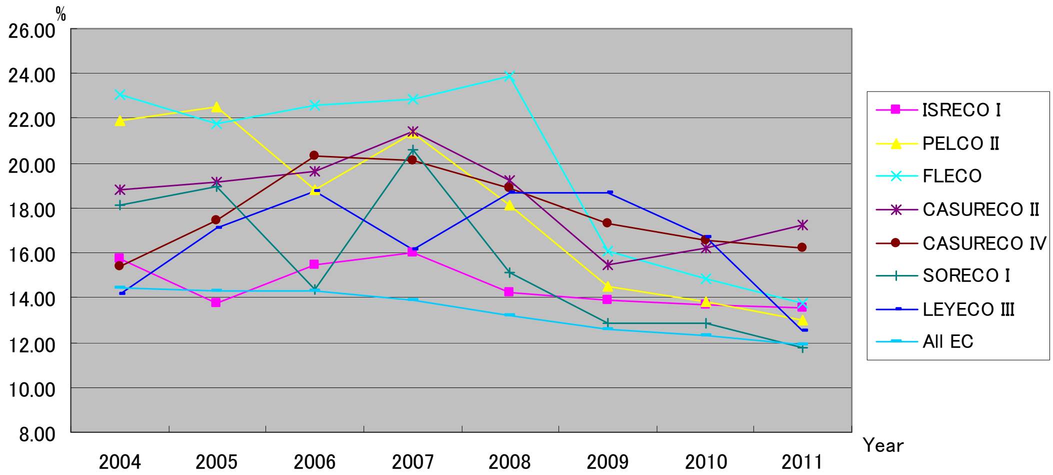
- 21 engineers participated in the SynerGEE software training.
- Two engineers participated in the Counterpart Training in Japan.

(7) LEYECO III

- 13 engineers participated in the SynerGEE software training.
- One engineer participated in the Counterpart Training in Japan.

6.5. Target Index Trends

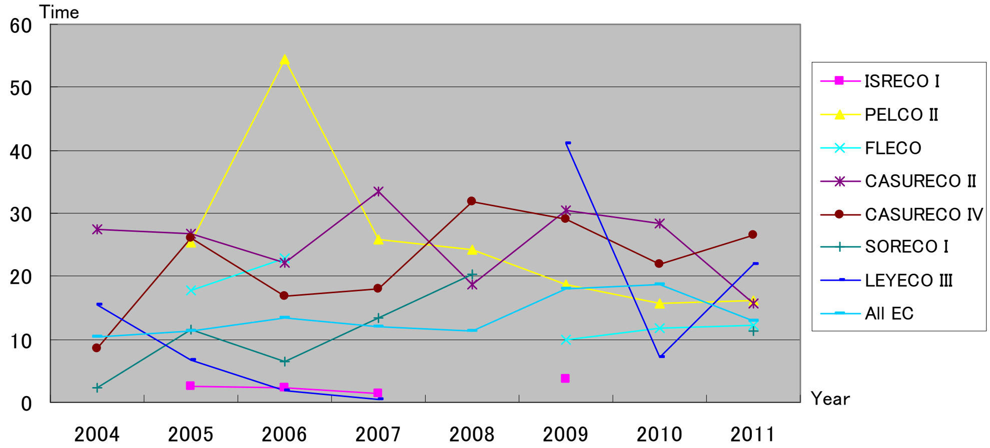
The trends of the system loss rate, SAIFI, and SAIDI, which are relevant to electric supply reliability, in the seven targeted ECs are shown below.



(Source: NEA data)

Figure 6-1 Trend of the system loss rate in the seven targeted ECs

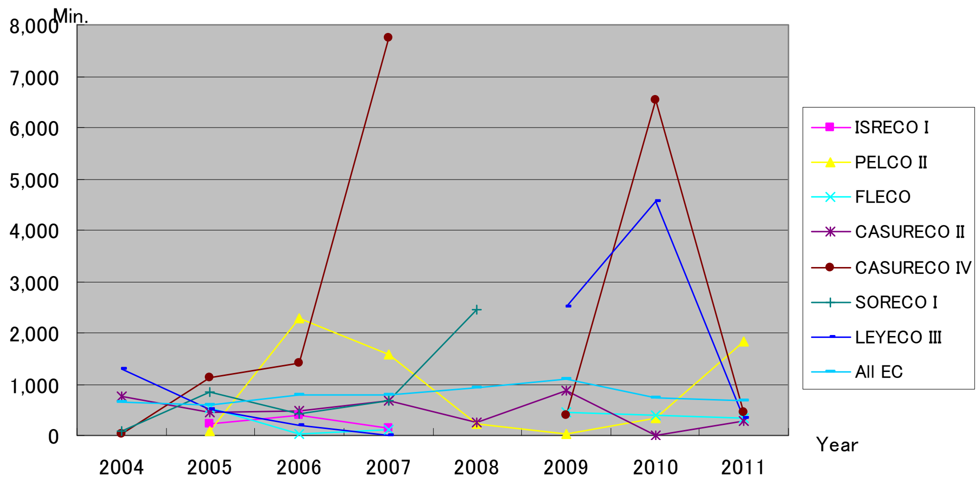
TEPCO



* They are those with the deficit data in part.

(Source: NEA data)

Figure 6-2 Trend of SAIFI in the seven targeted ECs



* They are those with the deficit data in part.

(Source: NEA data)

Figure 6-3 Trend of the SAIDI in the seven targeted ECs

The system loss rate in the seven targeted ECs has been decreasing and can expect more of a decrease using the created system loss reduction manual from now on.

The achievement of an “Objectively verifiable indicator” for the “Overall Goal”, which means overall system losses of 13.87% (yearend 2008) being reduced to a single digit level by 2015, is also expected.

On the other hand, although all EC’s on average show an almost fixed tendency with regards SAIFI and SAIDI, which are indexes relevant to electric supply reliability, in the individual seven targeted ECs, the per-year fluctuation is large and reflects the specific impact from typhoons etc. Therefore, future predictions are difficult.

Table 6-4 "Objectively verifiable indicator" for the "Overall Goal"

Indicator	Before project 2007	Present (2011)	Target (2015)
Overall system losses	13.87%	11.87%	less than 10%

Three objectively verifiable indicators to the project target on PDM are as follows.

- The selected EC can segregate non-technical loss and technical loss.
- Power distribution system plan is made by EC's own capacity.
- Power system is analyzed, and its problems are resolved by EC's.

Each targeted EC can introduce the proposal that contain the three above-mentioned objectively verifiable indicators at the workshop through the AMDT pilot project, SynerGEE training, and model case analysis of the 23kV up grading. This point is an achievement of this project. It is thought that it is a cause of the improvement in a category of the targeted EC as shown in Table 6-1.

Chapter 7 Conclusion and Recommendations

The main purpose of this Project is to provide the necessary support to improve the skills for the loss reduction planning and NEA and EC technology. The System Loss Reduction Manual has been prepared and a support system for the quantitative evaluation of system losses using the distribution analysis software was established. The voltage upgrading of the medium voltage systems was preliminary studied and its technical guidelines were recommended in the Manual. The pilot projects of the adoption of amorphous transformers were executed to confirm its effects on loss reductions.

We expect that the outputs of this Project will be reflected into the policy and plans of the distribution system loss reductions of EC and NEA.

7.1. The System Loss Reduction Manual

The purpose of this manual is to support NEA and the EC staff in the smooth implementation of the power distribution loss reduction plans by summarizing their procedures.

We have attempted to make this manual easier to use by showing the criteria or indications to achieve technical loss reductions. The reason for this is that it is sometimes very difficult for the staff to quantitatively understand the effectiveness of the technical loss reductions due to their large number of options.

We put the utilization of the distribution analysis software with the distribution system images to the conditions for loss analysis to have an adequate grasp of the distribution losses. The methodologies of the required data arrangement are also described such as the distribution facility data and load data. The methodologies of the identification of those places where technical losses occur and obtaining a numerical understanding are explained using this software.

The manuals describe the adoption of larger size conductors, a recommendation of the selection of the appropriate transformer sizes, the criteria for the application of 23 kV, the loss reduction effects of the amorphous transformers with small core losses and the recommended cases for their applications and a summary of the activities for non-technical loss reductions by NEA and ECs. This manual prepares the criteria corresponding to the amount of the peak loads that can be grasped by the distribution analysis software.

On the other hand, this manual also takes the role of a guide to show an adequate way of thinking about the technical considerations of loss reduction. We recommend that ECs understand its meaning and that NEA and the ECs establish an institutional promotion system of the manual. The reason is to be able to implement its recommendations and implement revisions in the case of a situation change such as an increase in the power generation costs or the re-arrangement of the steps for the voltage upgrades owing to urbanization.

Overall, it cannot be said that the power distribution system losses of the ECs have been sufficiently reduced. There is still much room for improvement in the area of power distribution losses.

We recommend that many loss reduction plans should be looked into that are able to yield benefits far exceeding the costs for its measures by utilizing this Manual.

7.2. Utilization of Distribution Analysis Software

JICA provided the seven targeted ECs and NEA with the distribution system analysis software “SynerGEE” that is equipped with the mapping functions in order to grasp the distribution system losses adequately. The technical transfer was also provided through the training courses including the methodology of inputting the distribution system data and their operations.

We expect that each EC will achieve more of a loss reduction by utilizing this software and the aforementioned Manual thorough the expansion of the data input to SynerGEE under the support of NEA.

We recommend that the database be maintained and periodically revised such as the geographical information, specification of facilities and the load data to promote the making of the models of the actual distribution system for using the distribution analysis software.

7.3. Upgrading Medium Voltage to 23kV

It can be found that in some cases the application of 23 kV is superior to 13.2 kV from an economic perspective owing to its large effects on the loss reductions. The multiple candidates for the 23 kV upgrades have been found based on the results of the examination of NEA and some ECs.

Thus, we recommend that detailed studies be implemented to evaluate the candidate sites of the 23 kV upgrading regarding their feasibility and the costs and benefits brought about by the loss reduction.

7.4. Application of Amorphous Transformers

The amorphous transformers were purchased and introduced as a pilot project to three of the targeted ECs. The EC staff could measure the effects of the amorphous transformers on the loss reductions using their own measurement equipment and confirm the factory data. The superiority of the amorphous transformer could be confirmed with the possibility of reducing the losses effectively by expanding its installations.

Thus, we recommend that the installation of amorphous transformers be promoted in all the ECs with an adequate economic evaluation conducted.