第8章　添付資料

- 添付資料 1 ：Project Design Matrix
- 添付資料 2：専門家派遣の実績 (1/2)
- 添付資料 3：専門家派遣の実績 (2/2)
- 添付資料 4：本邦カウンターパートトレーニング研修員受け入れ実績
- 添付資料 5：機材供与実績
- 添付資料 6：Minutes of Meetings (1st mission to 9th mission)
- 添付資料 7：Workshop 資料

Appendix 1
Project Design Matrix

事業名：フィリピン国 電力協同組合のためのシステムロスの低減プロジェクト
執行機関：国家電化庁
受益者層：**NEA** や特定 **EC** のフィリピン人の技術者、エンジニア
対象地域：フィリピン
事業期間：**2011.3－2013.3 (2** 年**)**

プロジェクト要旨	客観的指標	指標データ入手手段	外部条件
上位目標： EC の配電システムのロスを低減し、電力供給能力を効率的かつ経済的に向上させる	• (2008 年度の)13.87%の合計システムロスを 2015 年までに一桁台まで低減する	• 調査するべき NEA、EC の公的年報 • DOE や NEA による統計的報告書	
プロジェクト目標： EC や NEA による配電システムロスを低減するためのエンジニアリング及び計画立案能力を向上させる	• 特定の EC は独自でノンテクニカルロスとテクニカルロスの分別を効率的に行なうことができる • 配電システム計画が EC 独自の能力で作られる • 電力システムを分析し、その問題点を EC が解決する	• 年間運営報告書 • 調査するべき NEA、EC の公的年報	• (電力セクター政策など)フィリピンの発展計画に大きな変化はない • 施設設備の向上に必要な資金が分配される • 地域工学、マクロエンジニアリング援助、資産管理などの NEA のシステムロス低減プログラムが上手く実施されている
成果： １．システムロス低減のための事業運営マニュアルを用意し、適切に実施する	1.1 システムロス低減マニュアルを用意する。 1.2 NEA および各 EC がワークショップへ参加する 1.3 ワークショップで各 EC が課題解決活動を報告する	1.1.1 プロジェクトで吟味作成されたシステムロス低減マニュアル 1.2.1 報告されたベストプラクティス事例集 1.2.2 ワークショップの記録	• フィリピンの電力セクター政策に大きな変化はない • NEA や EC の経営に必要な予算が継続的に配分される
２．システムロスの量的評価に対するサポートシステムを確立する	2.1 システムロス定量評価手法マニュアルを用意する 2.2 NEA および各 EC がシステムロス定量評価訓練に参加する	2.1 プロジェクトで吟味作成されたシステムロス定量評価手法マニュアル 1.2.2 システムロス定量評価訓練の記録	
３．中圧配電線の昇圧（23kV 化）を行うための支援を実施し、技術基準を確立する	3.1 設備基準・技術基準ガイドラインを用意する	3.1 プロジェクトで吟味作成された設備基準･技術基準ガイドライン	

活動：	投入(方法とコスト)	事前状況
1. システムロス低減のための事業運営マニュアルを用意し、適切に実施する 1-1. 主要 EC のシステムロス低減に対する現在のベストプラクティスを調査 1-2. 日本の経験に基づいた、システムロス低減のためのマニュアルやチェックリストを準備 1-2-1. 電力施設の O&M の基準を準備 1-2-2. 将来の投資計画の作成方法を準備（需要予測、電力フロー分析など） 1-2-3. 財務と経済面での評価方法を準備 1-3. 特定の EC にマニュアルを適用するためのケーススタディの実施 1-3-1. 現状調査(問題の調査) 1-3-2. 特定 EC において、問題を解決するための状況にあった解決策を導入 1-3-3. 将来の計画作成(中期的計画、特定 EC への投資計画) 1-3-4. 特定 EC についてマニュアル草案の有効性を検証 1-4. NEA と共同による EC の非技術的ベストプラクティスの統合を含む上記の活動に基づくマニュアルの完成 1-5. NEA と共同による他の EC にマニュアルの水平展開のための適切な仕組みの提案 2. システムロスの量的評価のためのサポートシステムの確立 2-1. 特定 EC について電力フロー分析のためのソフトウェアの現在の使用状況を調査 2-2. 特定 EC についてシステムロス低減を評価する適切な方法を検討・提案 2-2-1. 技術的損失の把握方法 2-2-2. ロス低減分の価値評価方法 2-3. 特定 EC について 2-1 と 2-2 に基づいた適切な手法を開発 2-4. 上記で確立された方法で、EC の職員を訓練	日本側 日本側に以下の専門家が配置される A. 以下に挙げられているようなパーソネルが提供される <技術専門家チーム> • 総括／電力系統計画 • 経済財政分析 • 系統解析(ソフトウェア) • 配電計画／ロス低減 • 配電管理／維持管理手法 • 能力強化／業務調整 B. 日本での訓練 • 日本でのカウンターパート研修（2 回） C. 設備など (必要であれば)シミュレーションソフトウェア 詳細は事業期間内に検討される フィリピン側： タスクメンバーはプロジェクト・デザイン・マトリックスに要約された関連活動を引き受け、協調的に働くために、それぞれの専門を任される。メンバーは NEA と EC から選抜される。タスクメンバーは JICA の専門家から技術を継承することを主要目標とする 以下に挙げられているようなパーソネルが提供される A. カウンターパート • 事業指揮者(Deputy Administrator for Electric Distribution Utilities Services(NEA)) • 事業管理者(Director for Corporate Planning Office(NEA)) • コーディネーティングキーパーソン(Manager for Strategic Planning Division(NEA)) • 技術者(Technical Loss(NEA)) ・主任技術者(1) ・担当職員(2)	• タスクメンバーが任命され、ワーキンググループが結成される • プロジェクトのために必要な予算とオフィススペースや施設がわりあてられる

3. 中圧配電線の昇圧（23kV 化）を行うための支援を実施し、技術基準を確立する 3-1. 特定 EC の既設設備形態・計画の調査 3-2. NEA と共同による 23kV 配電線の標準デザインとガイドラインを検討・確立 3-3. NEA と共同による 23kV 配電線の設備基準・技術基準ガイドラインを作成 3-4. フルスケールの F/S のための作業準備(配電開発計画の地域の確認分析) 3-4-1. 候補地点確認 3-4-2. F/S における検討項目の確認	• 技術者(Non-Technical Loss(NEA)) ・主任技術者(1) ・担当職員(1) B. 管理部門職員 • 秘書(NEA) • サポート職員(NEA) • 能力強化／業務調整 C. 各 EC 職員 • 技術者(Technical Loss) ・主任技術者(1) ・担当職員(2) • 技術者(Non-Technical Loss) ・主任技術者(1) ・担当職員(1) D. 土地、建設物、その他 • オフィススペース（電力、エアコン、水、通信手段含） • その他必要な機材 E. 事業に必要な予算の分配	

Appendix 2

専門家派遣の実績 (1/2)

Appendix 2

Expert Dispatch Records (1/2)

Field	Expert		FY 2011											
		3	4	5	6	7	8	9	10	11	12	1	2	3
Team Leader/ Power System Planning	Masaharu YOGO		🟥			🟥	🟥		🟥			🟥	🟥	
Distribution Planning / System Loss Reduction	Toshiya MINEJIMA		🟥			🟥	🟥		🟥			🟥	🟥	
	Masahiro MYOGA													
Distribution Management / Maintenance management	Kenichi KUWAHARA		🟥			🟥	🟥		🟥				🟥	
Economic / Financial Analysis	Teru MIYAZAKI		🟥			🟥	🟥		🟥				🟥	
	Takayuki SHIBATA													
Power System Analysis (Software)	Masaki KUROIWA		🟥											
	Junichi OHISHI					🟥	🟥		🟥			🟥	🟥	
Capacity Building/ Coordinator	Keiichi FUJITANI		🟥			🟥	🟥		🟥			🟥	🟥	

Field	Expert		FY 2012											
		3	4	5	6	7	8	9	10	11	12	1	2	3
Team Leader/ Power System Planning	Masaharu YOGO		🟥	🟥		🟥	🟥			🟥		🟥	🟥	🟥
Distribution Planning / System Loss Reduction	Toshiya MINEJIMA		🟥	🟥		🟥	🟥							
	Masahiro MYOGA									🟥		🟥	🟥	🟥
Distribution Management / Maintenance management	Kenichi KUWAHARA		🟥	🟥		🟥	🟥			🟥	🟥	🟥	🟥	🟥
Economic / Financial Analysis	Teru MIYAZAKI		🟥	🟥		🟥	🟥							
	Takayuki SHIBATA									🟥		🟥	🟥	🟥
Power System Analysis (Software)	Masaki KUROIWA		🟥	🟥										
	Junichi OHISHI					🟥	🟥				🟥	🟥	🟥	🟥
Capacity Building/ Coordinator	Keiichi FUJITANI		🟥	🟥		🟥	🟥				🟥	🟥	🟥	🟥

Appendix 3

専門家派遣の実績 (2/2)

Appendix 3

Expert Dispatch Records (2/2)

Field	Expert	Dispatched Period
Team Leader/ Power System Planning	Masaharu YOGO	Apr. 3 - Apr. 16, 2011
		Jul 19 - Aug. 5, 2011
		Oct. 16 - Oct. 28, 2011
		Jan. 30 - Feb. 11, 2012
		May. 22 - Jan. 6, 2012
		Aug. 15 - Aug. 31, 2012
		Nov. 13 - Nov. 30, 2012
		Jan. 6 - Jan. 19, 2013
		Feb. 27 - May 5, 2013
Distribution Planning / System Loss Reduction	Toshiya MINEJIMA	Apr. 10 - Apr. 16, 2011
		Jul 17 - Aug. 5, 2011
		Oct. 13 - Oct. 28, 2011
		Jan. 29 - Jan. 31, Feb. 6 - Feb. 17, 2012
		May. 22 - Jan. 6, 2012
		Aug. 15 - Aug. 31, 2012
	Masahiro MYOGA	Nov. 13 - Nov. 30, 2012
		Jan. 6 - Jan. 19, 2013
		Feb. 27 - May 5, 2013
Distribution Management / Maintenance management method	Kenichi KUWAHARA	Apr. 3 - Apr. 16, 2011
		Jul 19 - Aug. 3, 2011
		Oct. 13 - Oct. 27, 2011
		Feb. 5 - Feb. 17, 2012
		May. 22 - Jan. 6, 2012
		Aug. 20 - Aug. 31, 2012
		Nov. 18 - Dec. 5, 2012
		Jan. 6 - Jan. 18, 2013
		Feb. 18 - May 1, 2013
Economic / Financial Analysis	Teru MIYAZAKI	Apr. 3 - Apr. 16, 2011
		Jul 19 - Aug. 5, 2011
		Oct. 16 - Oct. 28, 2011
		Feb. 5 - Feb. 17, 2012
		May. 22 - Jan. 2, 2012
		Aug. 15 - Aug. 31, 2012
	Takayuki SHIBATA	Nov. 13 - Nov. 30, 2012
		Jan. 6 - Jan. 19, 2013
		Feb. 27 - May 5, 2013

Field	Expert	Dispatched Period
Power System Analysis (Software)	Masaki KUROIWA	Apr. 3 - Apr. 16, 2011
	Junichi OHISHI	Jul 19 - Aug. 5, 2011
		Oct. 16 - Oct. 28, 2011
		Jan. 29 - Feb. 10, 2012
		May. 22 - Jan. 2, 2012
		Aug. 15 - Aug. 31, 2012
		Dec. 4 - Dec. 21, 2012
		Jan. 6 - Jan. 19, 2013
		Feb. 27 - May 5, 2013
Capacity Building/Coordinator	Keiichi FUJITANI	Apr. 3 - Apr. 16, 2011
		Jul 17 - Aug. 1, 2011
		Oct. 13 - Oct. 28, 2011
		Jan. 29 - Feb. 9, 2012
		May. 22 - Jan. 2, 2012
		Aug. 20 - Aug. 31, 2012
		Dec. 3 - Dec. 21, 2012
		Jan. 8 - Jan. 19, 2013
		Feb. 26 - May 5, 2013

Appendix 4

本邦カウンターパート
トレーニング研修員受け入れ実績

Appendix 4

The trainees' lists of counterpart training in Japan

FY	Period	Name of Participants	Designation	Office address	Organization
2011	2012/3/6 - 2012/3/16	MONTANO Virgilio Labuguen	General Manager	Office of the General Manager	ISELCO I
		GAMBOA Enrique Yumang	Manager	Technical Operation Department	PELCO II
		MALENIZA Carmille Sabio	Section Head	Technical Planning Section-Corporate Planning Department	CASURECO II
		OLEA Alfred Dela Cruz	Section Head	System Loss Reduction & Special Equipment-Technical Services Department	CASURECO IV
		HERNANDEZ Jane Gabionza	Division Chief	Planning, Monitoring and Evaluation-Technical Services Department	SORECO I
		FORSUELO Richard Abroso	Section Head	Planning Design & Evaluation-Engineering Services Division	LEYECO III
		DE VEAS Claro Gutierrez	Principal Engineer	Engineering Department, Technical Operations Division	NEA
		CORTES Antonio Dizon	Principal Engineer	Engineering Department, Technical Operations Division	NEA
		DAVID Bonifacio Tolentino	Senior Engineer	Engineering Department, Technical Operations Division	NEA
		EVALE Exequiel Jr Tidalgo	Senior Engineer	Engineering Department, Technical Operations Division	NEA
2012	2012/9/24 - 2012/10/5	BALINGUE Abraham Corpuz	Area Engineer	Technical Services Department	ISELCO I
		DEL FIN Marvin Alimurung	Section Head	Technical Cooperation Department	PELCO II
		MACALALAG Jan Michael Lagradilla	Division Chief	Technical Services Department	FLECO
		NAPAY Joanaiyn Candilosas	Section Head	Engineering Department, Line Operation Division	CASURECO II
		FORTES Roberto Fortes	General Manager	Office of the General Manager	SORECO I
		VILLAREAL Ferdinand Purugganan	Acting Director	Engineering Department, Technical Operations Division	NEA
		SILVANO Ernesto Jr. Oledan	Principal Engineer	Engineering Department, Technical Operations Division	NEA
		VELGADO Enrico Golla	Senior Engineer	Engineering Department, Technical Operations Division	NEA
		FAJARDO Manolito Santiago	Senior Officer	Electric Cooperative Audit Department, Accelerated Total Electrification Division	NEA
		GALARPE Arnel Pascubillo	Officer in Charge	Institutional Development Department, Consumer Development Protection Division	NEA

Appendix 5

機材供与実績

Equipment Administration for the Survey

Date of Registration (Day-Month-Year)	Name of Equipment	Specification	QTY	Unit Price (US$, PHP)	User	Condition
08-Feb-12	SynerGEE Electric Core Load Flow Module and SynerGEE Middlelink Electric	Version 3.8	8	US$110,000	NEA, ISELCO I, PELCO II, FLECO, CASURECO II, CASURECO IV, SORECO I, LEYCO III	Transfer
08-Feb-12	Clamp on Power Hitester	HIOKI 3169-21	14	Procurement by JICA Philippines office	NEA, ISELCO I, PELCO II, FLECO, CASURECO II, CASURECO IV, SORECO I, LEYCO III	Transfer
31-Oct-12	Amorphous Distribution Transformer	10kVA	6	Procurement by JICA Philippines office	ISELCO I, PELCO II, FLECO	Transfer
31-Oct-12	Amorphous Distribution Transformer	15kVA	6	Procurement by JICA Philippines office	ISELCO I, PELCO II, FLECO	Transfer
31-Oct-12	Amorphous Distribution Transformer	25kVA	6	Procurement by JICA Philippines office	ISELCO I, PELCO II, FLECO	Transfer
31-Oct-12	Amorphous Distribution Transformer	37.5kVA	6	Procurement by JICA Philippines office	ISELCO I, PELCO II, FLECO	Transfer
31-Oct-12	Amorphous Distribution Transformer	50kVA	3	Procurement by JICA Philippines office	ISELCO I, PELCO II, FLECO	Transfer

Appendix 6
Minutes of Meetings
(1st mission to 9th mission)

(1st Mission)

Minutes of Meetings
of
the 1st Mission
on
The Project on System Loss Reduction for Philippine Electric Cooperatives (EC's)
between
National Electrification Administration
and the
JICA Technical Assistance Team

The JICA Technical Assistance Team (hereafter referred to as "the TA Team") conducted the 1st Mission for The Project on System Loss Reduction for Philippine Electric Cooperatives (EC's) (hereafter referred to as "the Project") from April 4th, 2011 to April 15th, 2011.

During this mission, discussions and confirmation were conducted in a friendly and cordial atmosphere between National Electrification Administration (hereafter referred to as "NEA") and the TA Team.

The main items that were discussed and confirmed are summarized below.

Kick-off Meeting

Date: April 4th, 2011
Time: 13:30 – 15:30
Venue: NEA Meeting room
Attendee: See Kick-off Meeting of the 1st Mission on "The Project on System Loss Reduction for Philippine Electric Cooperatives (EC's)" Attendee List (Appendix-1)

The TA Team submitted eight (8) copies of "Implementation plan" to NEA and explained the contents based on the supplemental materials (Appendix-2). NEA and The TA Team exchanged opinions of both sides based on the supplemental materials and agreed on the ways of the Project proposed by the TA Team.

Data Collection Status

The TA Team submitted Questionnaires (Appendix-3) to NEA. During the 1st Mission, some of the available data and information were collected and the rest of the data and information will submitted from NEA to the TA Team by the end of June through the e-mail.

Assignment of the representative persons of the joint coordination committee meeting (JCC)

The TA Team requested NEA to assign the representative persons of the joint coordination committee meeting from relevant authorities by the time of 2nd mission and NEA agreed on the cooperation.

Assignment of the representative persons of the work shop (WS)

The TA Team requested NEA to assign the representative 2 or 3 persons of the work shop from selected seven (7) ECs by the time of 2nd mission and NEA agreed on the cooperation.

The schedule of next mission

The schedule of next mission (from July 17th to August 5th) and the Agenda of JCC and Work Shop referred to the documents attached hereto (Appendix 4,5,6) was confirmed by both the counterparts of NEA and the TA Team.

April 15, 2011
Manila, Philippines

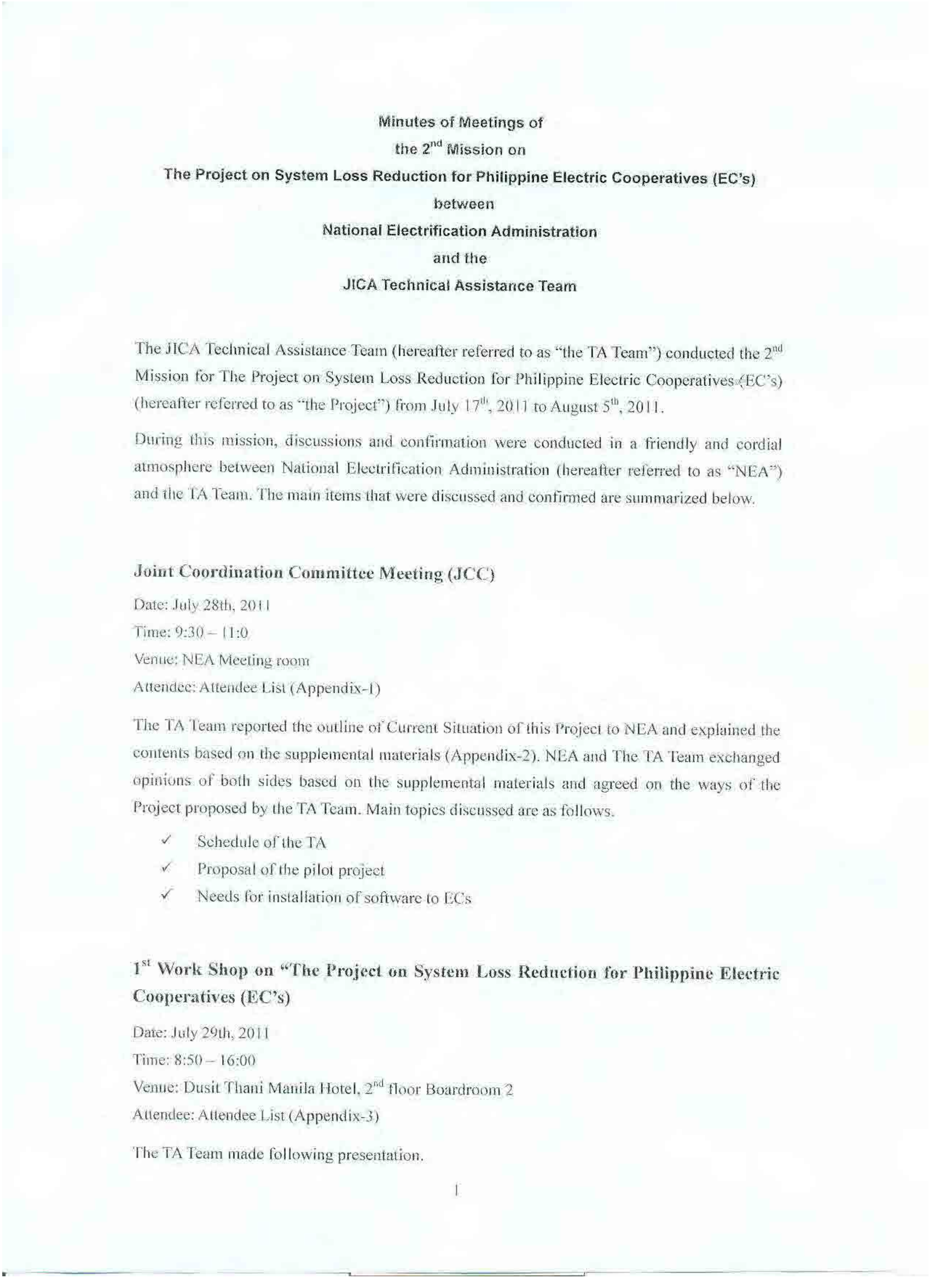
餘語 正晴

Mr. Masaharu YOGO
Team Leader

JICA TA Team

Mr. Edgardo R. Piamonte
Deputy Administrator for Electric
Distribution Utilities Services
National Electrification Administration

(2nd Mission)



Minutes of Meetings of
the 2nd Mission on
The Project on System Loss Reduction for Philippine Electric Cooperatives (EC's)
between
National Electrification Administration
and the
JICA Technical Assistance Team

The JICA Technical Assistance Team (hereafter referred to as "the TA Team") conducted the 2nd Mission for The Project on System Loss Reduction for Philippine Electric Cooperatives (EC's) (hereafter referred to as "the Project") from July 17th, 2011 to August 5th, 2011.

During this mission, discussions and confirmation were conducted in a friendly and cordial atmosphere between National Electrification Administration (hereafter referred to as "NEA") and the TA Team. The main items that were discussed and confirmed are summarized below.

Joint Coordination Committee Meeting (JCC)

Date: July 28th, 2011
Time: 9:30 – 11:0
Venue: NEA Meeting room
Attendee: Attendee List (Appendix-1)

The TA Team reported the outline of Current Situation of this Project to NEA and explained the contents based on the supplemental materials (Appendix-2). NEA and The TA Team exchanged opinions of both sides based on the supplemental materials and agreed on the ways of the Project proposed by the TA Team. Main topics discussed are as follows.

- ✓ Schedule of the TA
- ✓ Proposal of the pilot project
- ✓ Needs for installation of software to ECs

1st Work Shop on "The Project on System Loss Reduction for Philippine Electric Cooperatives (EC's)

Date: July 29th, 2011
Time: 8:50 – 16:00
Venue: Dusit Thani Manila Hotel, 2nd floor Boardroom 2
Attendee: Attendee List (Appendix-3)

The TA Team made following presentation.

- ✓ Outline of Current Situation of this Project
- ✓ Distribution Management method in Japan
- ✓ Technical Loss Reduction using Amorphous Core transformer
- ✓ Distribution Planning in Japan

The NEA made following presentation.

- ✓ Distribution Planning and management method and Current Situation of System Loss Reduction in Philippines

The seven ECs made following presentation.

- ✓ Good practices for system loss reduction Outline of Current Situation of this Project

Pilot Site for Project on System Loss Reduction

The TA Team proposed the pilot sites to be CASURECO II or CASURECO IV according to their current status of loss ratios. However, after evaluation of the selected ECs and observation on the presentation of CASURECO II in 1st Workshop at Dusit Thani Hotel, instead of CASURECO II, other ECs, such as FLECO, ISELCO I or PELCO II seemed suitable for pilot sites from the viewpoints of their data arrangement and the management situations.

The NEA and the TA team agreed on the candidate sites and agreed to cooperate on the pilot site survey.

Counterpart Training in JAPAN

The TA Team proposed the rescheduling counterpart training in JAPAN from the former November, 2011 to March, 2012. The NEA agreed on the proposal.

The schedule of next mission

The schedule of next mission (from October 18th to October 28th) referred to the documents attached hereto (Appendix 4) was confirmed by both the counterparts of NEA and the TA Team.

August 4, 2011
Manila, Philippines

餘語 正晴

Mr. Masaharu YOGO

Team Leader
JICA TA Team

EDGARD R. PIAMONTE

Deputy Administrator for Electric
Distribution Utilities Services
National Electrification Administration

(3rd Mission)

Minutes of Meetings of
the 3rd Mission on
The Project on System Loss Reduction for Philippine Electric Cooperatives (EC's)
between
National Electrification Administration
and the
JICA Technical Assistance Team

The JICA Technical Assistance Team (hereafter referred to as "the TA Team") conducted the 3rd Mission for The Project on System Loss Reduction for Philippine Electric Cooperatives (EC's) (hereafter referred to as "the Project") from October 13th, 2011 to October 28th, 2011.

During this mission, discussions and confirmation were conducted in a friendly and cordial atmosphere between National Electrification Administration (hereafter referred to as "NEA") and the TA Team. The main items that were discussed and confirmed are summarized below.

Assignment of the representative persons of the Joint Coordination Committee meeting (JCC)

The TA Team requested NEA to assign the representative persons of the joint coordination committee meeting from relevant authorities by the time of 4th mission (February 7) and NEA agreed on the cooperation and the agenda of JCC referred to the documents attached hereto (Appendix 1) was confirmed by both the counterparts of NEA and the TA Team.

Assignment of the representative persons of the work shop (WS)

The TA Team requested NEA to assign the representative 2 or 3 persons include engineer of the work shop from selected seven (7) ECs by the time of 4rd mission(February 8) and NEA agreed on the cooperation and the agenda of JCC referred to the documents attached hereto (Appendix 2) was confirmed by both the counterparts of NEA and the TA Team.

Pilot Site for Project on System Loss Reduction

The TA Team proposed the pilot sites to be ISELCO I and PELCO II from the viewpoints of their data arrangement and the management situations.

The TA Team will continue the study of upgrading of medium voltage.

The NEA and the TA team agreed on the candidate sites and agreed to cooperate on the pilot site survey.

Counterpart Training in JAPAN

The TA Team proposed the schedule of counterpart training in JAPAN (from March 5th to March 17th). The NEA agreed on the proposal and the schedule referred to the documents attached hereto (Appendix 3) was confirmed by both the counterparts of NEA and the TA Team..

Assignment of the representative persons of Counterpart Training in JAPAN

The TA Team requested NEA to assign the representative one person from selected seven (7) ECs and more three persons (Total ten person), and submit the list to JICA Philippines Office. NEA agreed on the cooperation.

The schedule of next mission

The schedule of next mission (from January 29th to February 17th) referred to the documents attached hereto (Appendix 4) was confirmed by both the counterparts of NEA and the TA Team.

October 27, 2011
Manila, Philippines

餘語 正晴

Mr. Masaharu YOGO

Team Leader

JICA TA Team

EDGARDO R. PIAMONTE

Deputy Administrator for
Electric Distribution Utilities Services
National Electrification Administration

(4th Mission)

Minutes of Meetings of
the 4th Mission on
The Project on System Loss Reduction for Philippine Electric Cooperatives (EC's)
between
National Electrification Administration
and the
JICA Technical Assistance Team

The JICA Technical Assistance Team (hereafter referred to as "the TA Team") conducted the 4th Mission for The Project on System Loss Reduction for Philippine Electric Cooperatives (EC's) (hereafter referred to as "the Project") from January 29th, 2012 to February 17th, 2012.

During this mission, discussions and confirmation were conducted in a friendly and cordial atmosphere between National Electrification Administration (hereafter referred to as "NEA") and the TA Team. The main items that were discussed and confirmed are summarized below.

Joint Coordination Committee Meeting (JCC)

Date: February 7th, 2012
Time: 10:00 – 11:10
Venue: NEA 6F Meeting room
Attendee: Attendee List (Appendix-1)

The TA Team reported the overall progress and activities carried out of this Project to NEA and explained the outline of the Draft Contents of System Loss Reduction Manual (Appendix-2). NEA and The TA Team exchanged opinions of both sides based on the supplemental materials and agreed on the Draft Contents of System Loss Reduction Manual and next year schedule proposed by the TA Team. Main topics discussed are as follows.

- ✓ Draft Contents of System Loss Reduction Manual
- ✓ Upgrading the distribution line voltage
- ✓ Next fiscal year schedule of the TA
- ✓ Modeling of EC distribution line

2^{nd} Work Shop on "The Project on System Loss Reduction for Philippine Electric Cooperatives (EC's)

Date: February 8th, 2011

Time: 9:30 – 16:00

Venue: Dusit Thani Manila Hotel, 2nd floor Boardroom 2

Attendee: Attendee List (Appendix-3)

The TA Team made following presentation.

- ✓ Overall progress and activities carried out of this Project and the outline of the Draft Contents of System Loss Reduction Manual
- ✓ Methods for evaluating system loss reduction using SynerGEE
- ✓ Economical evaluating for system loss reduction project
- ✓ Effects for introduction of AMDT
- ✓ Useful information of Loss reduction in Slum area in Brazil

The Philec made the following presentation.

- ✓ Current situation of utilization of AMDT in Philippine

The seven ECs made the following presentation.

- ✓ Good practices for system loss reduction

Pilot Site for Project on System Loss Reduction

The TA Team proposed the pilot sites to be ISELCO I and PELCO II from the viewpoints of their data arrangement and the management situations.

The TA Team will continue the study of upgrading of medium voltage.

The NEA and the TA team agreed on the candidate sites and agreed to cooperate on the pilot site survey.

The contents of System Loss Reduction Manual

The TA Team explained the contents of System Loss Reduction Manual. The NEA and the TA team agreed on the contents referred to the documents attached hereto. (Appendix 2)

The schedule of next mission

The schedule of next mission (from May 22nd to June 6th) referred to the documents attached hereto (Appendix 4) was confirmed by both the counterparts of NEA and the TA Team.

The schedule of next year

The schedule of next year referred to the documents attached hereto (Appendix 5) was confirmed by both the counterparts of NEA and the TA Team.

February 10, 2012
Manila, Philippines

餘語 正晴

Mr. Masaharu YOGO

Team Leader

JICA TA Team

EDGARD R. PIAMONTE

Deputy Administrator for Electric
Distribution Utilities Services
National Electrification Administration

(5th Mission)

Minutes of Meetings of
the 5th Mission on
The Project on System Loss Reduction for Philippine Electric Cooperatives (EC's)
between
National Electrification Administration
and the
JICA Technical Assistance Team

The JICA Technical Assistance Team (hereafter referred to as "the TA Team") conducted the 5th Mission for The Project on System Loss Reduction for Philippine Electric Cooperatives (EC's) (hereafter referred to as "the Project") from May 22nd, 2012 to June 6th, 2012.

During this mission, discussions and confirmation were conducted in a friendly and cordial atmosphere between National Electrification Administration (hereafter referred to as "NEA") and the TA Team. The main items that were discussed and confirmed are summarized below.

3rd Work Shop on "The Project on System Loss Reduction for Philippine Electric Cooperatives (EC's)"

Date: May 31st, 2012
Time: 9:30 – 16:30
Venue: Dusit Thani Manila Hotel, 2nd floor Boardroom 2
Attendee: Attendee List (Appendix-1)

The TA Team made following presentation.

- ✓ Overall progress and activities carried out of this Project
- ✓ Sample Analysis of Medium Voltage Line Loss Reduction Measures and Proposed on appropriate mechanism to transfer loss reduction method to all ECs

The NEA made the following presentation.

- ✓ System loss reduction using SynerGEE

The BENECO made the following presentation.

- ✓ Experience of upgrading distribution voltages

The seven ECs made the following presentation.

- ✓ Activities for system loss reduction using software

Pilot Site Project for System Loss Reduction by installing AMDT

The TA Team proposed the pilot site for System Loss Reduction by installing AMDT to be ISELCO I, PELCO II and FLECO from the viewpoints of their data arrangement and the management situations.

The NEA and the TA team agreed on the candidate sites and agreed to cooperate on the pilot site survey.

The schedule of next mission

The schedule of next mission (from August 15th to September 5th) referred to the documents attached hereto (Appendix 2) was confirmed by both the counterparts of NEA and the TA Team.

Counterpart Training in JAPAN

The TA Team proposed the schedule of counterpart training in JAPAN (from September 24th to October 6th). The NEA agreed on the proposal and the schedule referred to the documents attached hereto (Appendix 3) was confirmed by both the counterparts of NEA and the TA Team.

Assignment of the representative persons of Counterpart Training in JAPAN

The TA Team requested NEA to assign the representative one person from selected seven (7) ECs and more three persons (Total ten person), and submit the list to JICA Philippines Office. NEA agreed on the cooperation.

June 5, 2012
Manila, Philippines

餘語 正晴

Mr. Masaharu YOGO

Team Leader

JICA TA Team

EDGARD R. PIAMONTE

Deputy Administrator for Electric
Distribution Utilities Services
National Electrification Administration

(6th Mission)

Minutes of Meetings of
the 6th Mission on
The Project on System Loss Reduction for Philippine Electric Cooperatives (EC's)
between
National Electrification Administration
and the
JICA Technical Assistance Team

The JICA Technical Assistance Team (hereafter referred to as "the TA Team") conducted the 6th Mission for The Project on System Loss Reduction for Philippine Electric Cooperatives (EC's) (hereafter referred to as "the Project") from August 15th, 2012 to August 31st, 2012.

During this mission, discussions and confirmation were conducted in a friendly and cordial atmosphere between National Electrification Administration (hereafter referred to as "NEA") and the TA Team. The main items that were discussed and confirmed are summarized below.

The confirmation of System Loss Reduction Manual

The TA Team explained the System Loss Reduction Manual (Draft) (hereafter referred to as "the Manual"). The TA Team requested NEA to write the "Foreword" and "Chapter 8". NEA agreed on taking charge of writing of the "Foreword" and "Chapter 8".The TA Team requested NEA to check the Manual and distribute the Manual to selected ECs and submit the comments of Manual include selected ECs comments by 24th of September. NEA agreed on the submission of the comments of the Manual. The latest Manual is attached hereto. (Appendix 1)

Pilot Site Project for System Loss Reduction by installing AMDT

The TA Team explained the pilot site for System Loss Reduction by installing AMDT to be ISELCO I, PELCO II and FLECO. The NEA agreed to cooperate on the pilot site survey.

Assignment of the representative persons of the Joint Coordination Committee meeting (hereafter referred to as "JCC")

The TA Team requested NEA to assign the representative persons of the joint coordination committee meeting from relevant authorities by the time of 7th mission (27th of November) and NEA agreed on the cooperation and the agenda of JCC referred to the documents attached hereto (Appendix 2) was confirmed by both the counterparts of NEA and the TA Team.

Assignment of the representative persons of the work shop (hereafter referred to as "WS")

The TA Team requested NEA to assign the representative 2 or 3 persons include engineer of the work shop from selected seven (7) ECs by the time of 7th mission (28th of November) and NEA agreed on the cooperation and the agenda of WS referred to the documents attached hereto (Appendix 3) was confirmed by both the counterparts of NEA and the TA Team.

The schedule of next mission

The schedule of next mission (from November 13th to December 21st) referred to the documents attached hereto (Appendix 4) was confirmed by both the counterparts of NEA and the TA Team.

August 30, 2012
Manila, Philippines

餘語 正晴

Mr. Masaharu YOGO

Team Leader

JICA TA Team

EDGARD R. PIAMONTE

Deputy Administrator for Electric
Distribution Utilities Services
National Electrification Administration

(7th Mission)

Minutes of Meetings of
The 7th Mission on
The Project on System Loss Reduction for Philippine Electric Cooperatives (EC's)
between
The National Electrification Administration
and
The JICA Technical Assistance Team

The JICA Technical Assistance Team (hereafter referred to as the "TA Team") conducted the first half of 7th Mission for The Project on System Loss Reduction for Philippine Electric Cooperatives (EC's) (hereafter referred to as "the Project") from November 13th, 2012 to November 27th, 2012.

During this mission, discussions and confirmation were conducted in a friendly and cordial atmosphere between National Electrification Administration (hereafter referred to as "NEA") and the TA Team. The main items that were discussed and confirmed are summarized below.

Joint Coordination Committee Meeting (JCC)

Date: November 27th, 2012

Time: 10:15 – 11:40

Venue: NEA 6F Meeting room

Attendee: Attendee List (Appendix-1)

The TA Team reported the overall progress and activities carried out of this Project to NEA and explained the outline of the Draft System Loss Reduction Manual (Appendix-2). NEA and the TA Team commented and exchanged opinions based on the supplemental materials and agreed on the Draft System Loss Reduction Manual and the next mission schedule proposed by the TA Team. Main topics discussed are as follows.

- ✓ Draft System Loss Reduction Manual
- ✓ Upgrading the distribution line voltage
- ✓ AMDT pilot project

The confirmation of Draft System Loss Reduction Manual

The TA Team explained the outline of the Draft System Loss Reduction Manual (hereafter referred to as "the Manual"). The TA Team requested NEA to write the "Foreword". NEA agreed on taking charge of writing of the "Foreword". The Preface, which is written by conductor of this mission, is requested by JICA. The TA Team requested NEA to check the Manual and distribute the Manual to selected ECs and submit the comments on the Manual by the 19th of December. NEA agreed on the submission of the comments of the Manual. The latest Manual is attached hereto. (Appendix-2) The manual will be finalized in early January 2013. The finalized Manual will be explained in the workshop (hereafter referred to as "WS").

The recommendation of Voltage Upgrading

The TA Team explained the concept and construction procedure of voltage upgrading from 13.2kV to 23kV. NEA will inform the TA Team's recommendations about the voltage upgrading to the selected ECs and to ask them to give their comments in advance prior to the WS, which would be held next January 2013. NEA mentioned other candidate sites that can be considered to have a 23kV distribution system project introduced. The result of study of actual candidate sites will be reflected in the completion report of this project.

Pilot Site Project for AMDT installation

The TA Team explained that the pilot site for AMDT installation will be ISELCO I, PELCO II and FLECO. The NEA agreed to cooperate on the additional pilot site survey, if necessary.

Assignment of the representative persons of the WS

The TA Team requested NEA to invite 6 or 7 representatives, to include engineers, from selected seven (7) ECs on the 8th mission (16th of January). NEA agreed on the agenda of the WS referred to the documents attached hereto (Appendix 3) as confirmed by the NEA/TA Team.

The schedule of next mission

The schedule of next mission (from January 6th to January 19th) referred to the documents attached hereto (Appendix 4) was also confirmed by the NEA/TA Team.

Other items

NEA proposed to provide a meeting room at NEA for the WS, which will be held on January 16, 2013. The Foreword of the manual was provided by NEA.

November 29, 2012
Manila, Philippines

for 餘語正晴

Mr. Masaharu YOGO

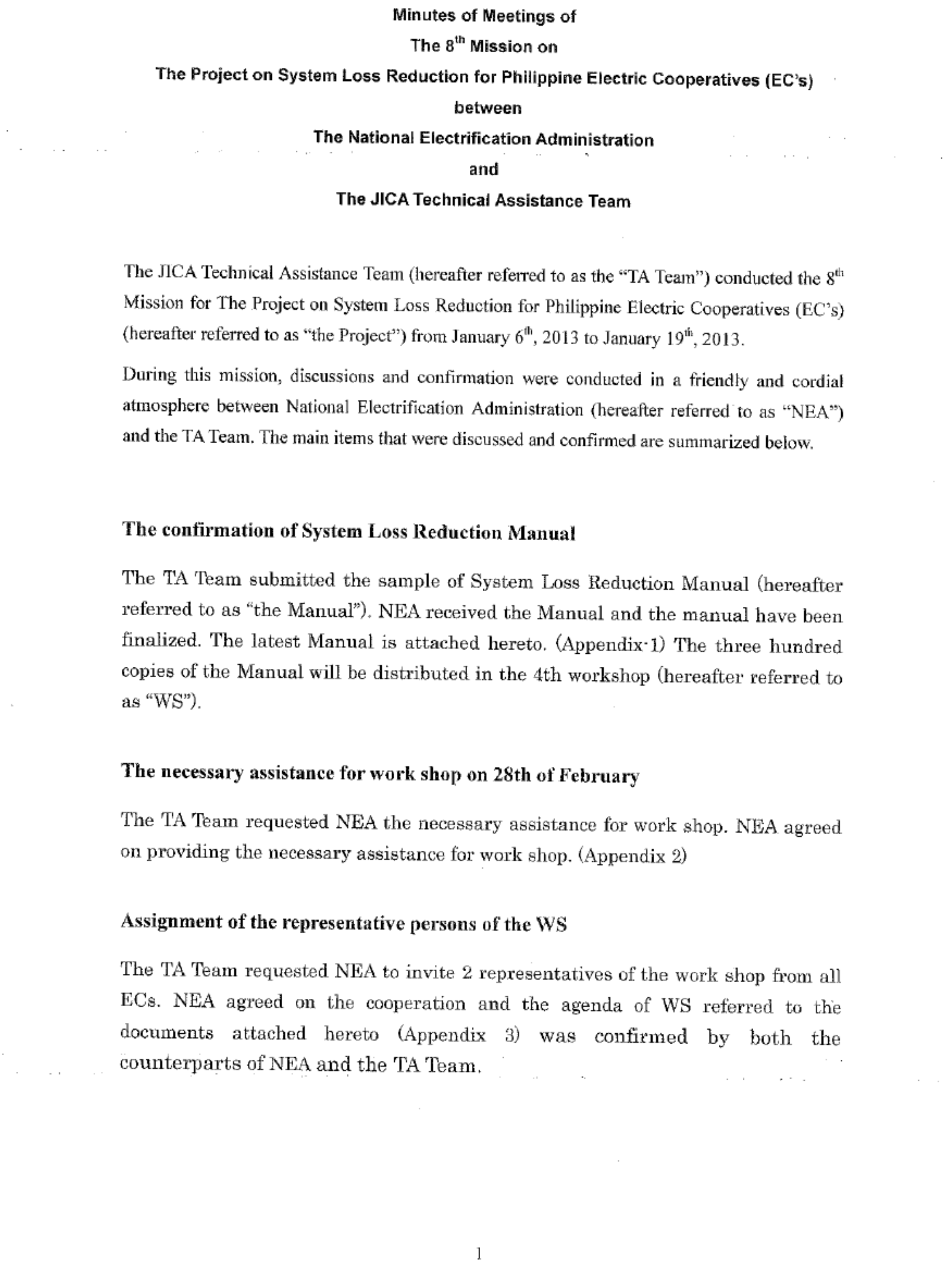
Team Leader

JICA TA Team

EDGARDO R. PIAMONTE

Deputy Administrator for Electric
Distribution Utilities Services
National Electrification Administration

(8th Mission)



Minutes of Meetings of
The 8th Mission on
The Project on System Loss Reduction for Philippine Electric Cooperatives (EC's)
between
The National Electrification Administration
and
The JICA Technical Assistance Team

The JICA Technical Assistance Team (hereafter referred to as the "TA Team") conducted the 8th Mission for The Project on System Loss Reduction for Philippine Electric Cooperatives (EC's) (hereafter referred to as "the Project") from January 6th, 2013 to January 19th, 2013.

During this mission, discussions and confirmation were conducted in a friendly and cordial atmosphere between National Electrification Administration (hereafter referred to as "NEA") and the TA Team. The main items that were discussed and confirmed are summarized below.

The confirmation of System Loss Reduction Manual

The TA Team submitted the sample of System Loss Reduction Manual (hereafter referred to as "the Manual"). NEA received the Manual and the manual have been finalized. The latest Manual is attached hereto. (Appendix-1) The three hundred copies of the Manual will be distributed in the 4th workshop (hereafter referred to as "WS").

The necessary assistance for work shop on 28th of February

The TA Team requested NEA the necessary assistance for work shop. NEA agreed on providing the necessary assistance for work shop. (Appendix 2)

Assignment of the representative persons of the WS

The TA Team requested NEA to invite 2 representatives of the work shop from all ECs. NEA agreed on the cooperation and the agenda of WS referred to the documents attached hereto (Appendix 3) was confirmed by both the counterparts of NEA and the TA Team.

The recommendation of System Voltage Upgrading

The TA Team recommended the system voltage upgrading from 13.2kV to 23kV. NEA agreed the concept of system voltage upgrading and will promote the system voltage upgrading in all ECs area. NEA wishes the grant or the soft loan by JICA as the international aid.

The recommendation of establishment of material center

The TA Team proposed the establishment of material center. NEA operated 9 material center in Philippine. However, all material centers were abolished in 1990th. NEA can not force the establishment of regional material center on ECs because of the respect for EC's autonomy. Therefore NEA recommended that the TA Team should discuss the proposal with ECs.

The schedule of next mission

The schedule of next mission (from February 18th to March 5th) referred to the documents attached hereto (Appendix 4) was also confirmed by the NEA/TA Team.

January 18, 2013
Manila, Philippines

餘語 正晴

Mr. Masaharu YOGO

Team Leader

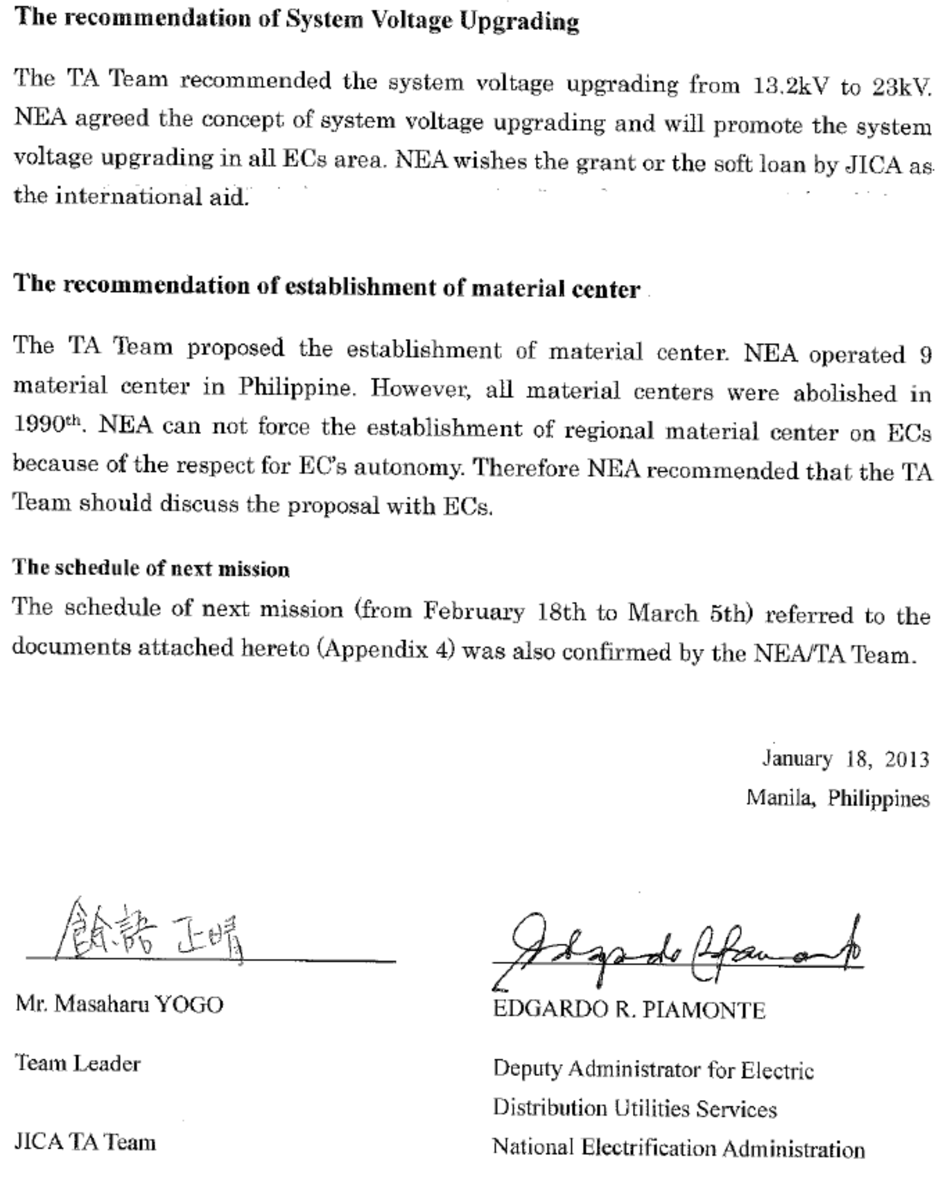
JICA TA Team

Edgardo Piamonte

EDGARDO R. PIAMONTE

Deputy Administrator for Electric
Distribution Utilities Services
National Electrification Administration

(9th Mission)



The recommendation of System Voltage Upgrading

The TA Team recommended the system voltage upgrading from 13.2kV to 23kV. NEA agreed the concept of system voltage upgrading and will promote the system voltage upgrading in all ECs area. NEA wishes the grant or the soft loan by JICA as the international aid.

The recommendation of establishment of material center

The TA Team proposed the establishment of material center. NEA operated 9 material center in Philippine. However, all material centers were abolished in 1990th. NEA can not force the establishment of regional material center on ECs because of the respect for EC's autonomy. Therefore NEA recommended that the TA Team should discuss the proposal with ECs.

The schedule of next mission

The schedule of next mission (from February 18th to March 5th) referred to the documents attached hereto (Appendix 4) was also confirmed by the NEA/TA Team.

January 18, 2013
Manila, Philippines

餘語 正晴

Mr. Masaharu YOGO

Team Leader

JICA TA Team

EDGARDO R. PIAMONTE

Deputy Administrator for Electric
Distribution Utilities Services
National Electrification Administration

The recommendation of System Voltage Upgrading

The TA Team recommended the system voltage upgrading from 13.2kV to 23kV. NEA agreed the concept of system voltage upgrading and will promote the system voltage upgrading in all ECs area. NEA wishes the grant or the soft loan by JICA as the international aid.

The recommendation of establishment of material center

The TA Team proposed the establishment of material center. NEA operated 9 material center in Philippine. However, all material centers were abolished in 1990th. NEA can not force the establishment of regional material center on ECs because of the respect for EC's autonomy. Therefore NEA recommended that the TA Team should discuss the proposal with ECs.

The schedule of next mission

The schedule of next mission (from February 18th to March 5th) referred to the documents attached hereto (Appendix 4) was also confirmed by the NEA/TA Team.

January 18, 2013
Manila, Philippines

餘語 正明

Mr. Masaharu YOGO

Team Leader

JICA TA Team

Edgardo Piamonte

EDGARDO R. PIAMONTE

Deputy Administrator for Electric
Distribution Utilities Services
National Electrification Administration

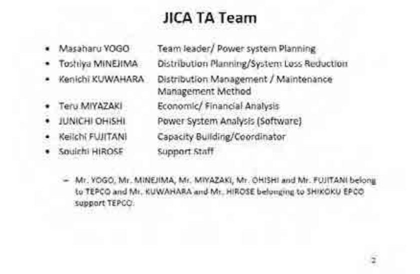
Appendix 7
Presentation Materials
(1st workshop to final workshop)

Presentation Materials of 1st Workshop

JICA
The Project on System Loss Reduction for Philippine Electric Cooperatives

The 1st Joint Coordination Committee Meeting /
The 1st Workshop

M.YOGO
TEPCO/JICA TA Team
Manila
July 28th and 29th 2011



JICA TA Team

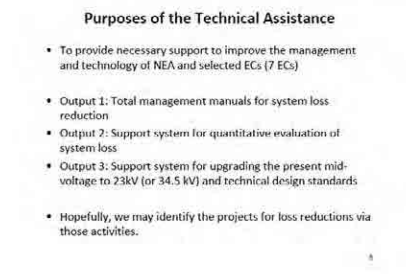
Masaharu YOGO	Team leader/ Power system Planning
Toshiya MINEJIMA	Distribution Planning/System Loss Reduction
Kenichi KUWAHARA	Distribution Management / Maintenance Management Method
Teru MIYAZAKI	Economic/ Financial Analysis
JUNICHI OHISHI	Power System Analysis (Software)
Keiichi FUJITANI	Capacity Building/Coordinator
Souichi HIROSE	Support Staff

- Mr. YOGO, Mr. MINEJIMA, Mr. MIYAZAKI, Mr. OHISHI and Mr. FUJITANI belong to TEPCO and Mr. KUWAHARA and Mr. HIROSE belonging to SHIKOKU EPCO support TEPCO.

Japanese Power Utilities

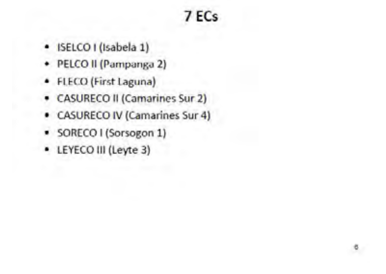
TEPCO's Service Area

	TEPCO	All Japan	TEPCO's share
Peak Demand	64.3GW	182.4GW	35%
Sales	288TWh	859TWh	33%



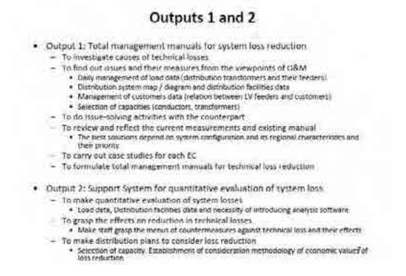
Purposes of the Technical Assistance

- To provide necessary support to improve the management and technology of NEA and selected ECs (7 ECs)
- Output 1: Total management manuals for system loss reduction
- Output 2: Support system for quantitative evaluation of system loss
- Output 3: Support system for upgrading the present mid-voltage to 23kV (or 34.5 kV) and technical design standards
- Hopefully, we may identify the projects for loss reductions via those activities.



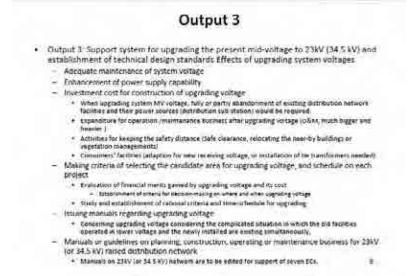
7 ECs

- ISELCO I (Isabela 1)
- PELCO II (Pampanga 2)
- FLECO (First Laguna)
- CASURECO II (Camarines Sur 2)
- CASURECO IV (Camarines Sur 4)
- SORECO I (Sorsogon 1)
- LEYECO III (Leyte 3)



Outputs 1 and 2

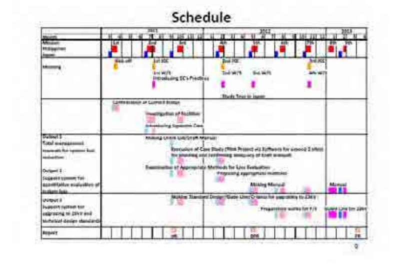
- Output 1: Total management manuals for system loss reduction
  - To investigate causes of technical losses
  - To find out issues and their measures from the viewpoints of O&M
    - Daily management of load data (distribution transformers and their feeders)
    - Distribution system map / diagram and distribution facilities data
    - Management of customers data (relation between LV feeders and customers)
    - Selection of capacities (conductors, transformers)
  - To do issue-solving activities with the counterpart
  - To review and reflect the current measurements and existing manual
    - The best solutions depend on system configuration and its regional characteristics and their priority
  - To carry out case studies for each EC
  - To formulate total management manuals for technical loss reduction
- Output 2: Support System for quantitative evaluation of system loss
  - To make quantitative evaluation of system losses
    - Load data, Distribution facilities data and necessity of introducing analysis software
  - To grasp the effects on reduction in technical losses
    - Make staff grasp the menus of countermeasures against technical loss and their effects
  - To make distribution plans to consider loss reduction
    - Selection of capacity. Establishment of consideration methodology of economic value of loss reduction

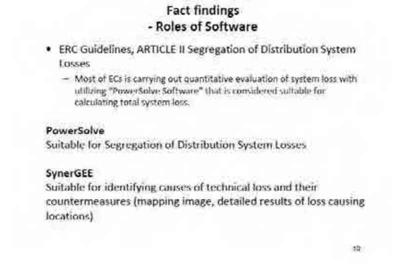


Output 3

- Output 3: Support system for upgrading the present mid-voltage to 23kV (34.5 kV) and establishment of technical design standards Effects of upgrading system voltages
  - Adequate maintenance of system voltage
  - Enhancement of power supply capability
  - Investment cost for construction of upgrading voltage
    - When upgrading system MV voltage, fully or partly abandonment of existing distribution network facilities and their power sources (distribution sub station) would be required.
    - Expenditure for operation /maintenance business after upgrading voltage (O&M, much bigger and heavier)
    - Activities for keeping the safety distance (Safe clearance, relocating the near-by buildings or vegetation managements)
    - Consumers' facilities (adaption for new receiving voltage, or installation of the transformers needed)
  - Making criteria of selecting the candidate area for upgrading voltage, and schedule on each project
    - Evaluation of financial merits gained by upgrading voltage and its cost
      - Establishment of criteria for decision-making on where and when upgrading voltage
    - Study and establishment of rational criteria and time-schedule for upgrading
  - Issuing manuals regarding upgrading voltage
    - Concerning upgrading voltage considering the complicated situation in which the old facilities operated in lower voltage and the newly installed are existing simultaneously.
  - Manuals or guidelines on planning, construction, operating or maintenance business for 23kV (or 34.5 kV) raised distribution network
    - Manuals on 23kV (or 34.5 kV) network are to be edited for support of seven ECs.

Schedule



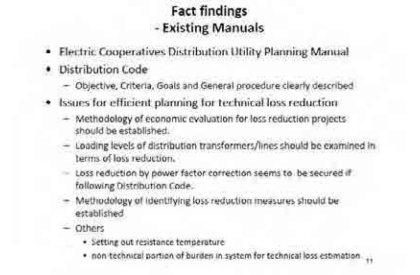


Fact findings
- Roles of Software

- ERC Guidelines, ARTICLE II Segregation of Distribution System Losses
  - Most of ECs is carrying out quantitative evaluation of system loss with utilizing "PowerSolve Software" that is considered suitable for calculating total system loss.

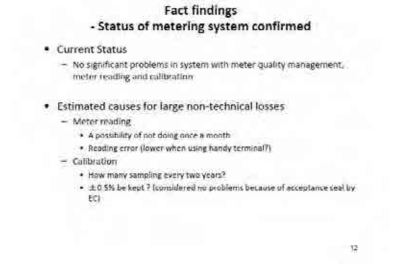
PowerSolve
Suitable for Segregation of Distribution System Losses

SynerGEE
Suitable for identifying causes of technical loss and their countermeasures (mapping image, detailed results of loss causing locations)



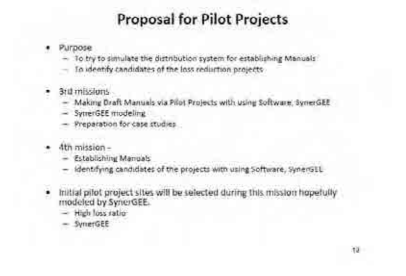
Fact findings
- Existing Manuals

- Electric Cooperatives Distribution Utility Planning Manual
- Distribution Code
  - Objective, Criteria, Goals and General procedure clearly described
- Issues for efficient planning for technical loss reduction
  - Methodology of economic evaluation for loss reduction projects should be established.
  - Loading levels of distribution transformers/lines should be examined in terms of loss reduction.
  - Loss reduction by power factor correction seems to be secured if following Distribution Code.
  - Methodology of identifying loss reduction measures should be established
  - Others
    - Setting out resistance temperature
    - non-technical portion of burden in system for technical loss estimation



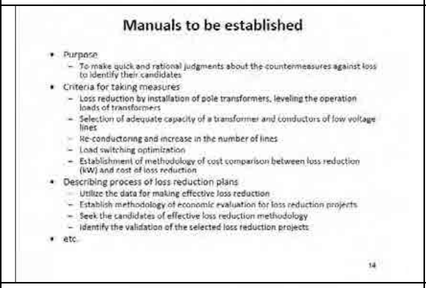
Fact findings
- Status of metering system confirmed

- Current Status
  - No significant problems in system with meter quality management, meter reading and calibration
- Estimated causes for large non-technical losses
  - Meter reading
    - A possibility of not doing once a month
    - Reading error (lower when using handy terminal?)
  - Calibration
    - How many sampling every two years?
    - ±0.5% be kept ? (considered no problems because of acceptance seal by EC)



Proposal for Pilot Projects

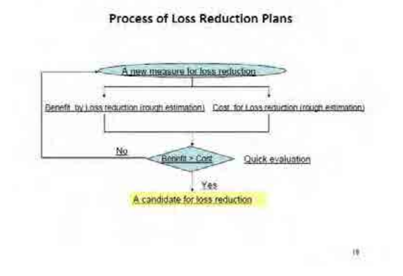
- Purpose
  - To try to simulate the distribution system for establishing Manuals
  - To identify candidates of the loss reduction projects
- 3rd missions
  - Making Draft Manuals via Pilot Projects with using Software, SynerGEE
  - SynerGEE modeling
  - Preparation for case studies
- 4th mission -
  - Establishing Manuals
  - Identifying candidates of the projects with using Software, SynerGEE
- Initial pilot project sites will be selected during this mission hopefully modeled by SynerGEE.
  - High loss ratio
  - SynerGEE



Manuals to be established

- Purpose
  - To make quick and rational judgments about the countermeasures against loss to identify their candidates
- Criteria for taking measures
  - Loss reduction by installation of pole transformers, leveling the operation loads of transformers
  - Selection of adequate capacity of a transformer and conductors of low voltage lines
  - Re-conductoring and increase in the number of lines
  - Load switching optimization
  - Establishment of methodology of cost comparison between loss reduction (kW) and cost of loss reduction
- Describing process of loss reduction plans
  - Utilize the data for making effective loss reduction
  - Establish methodology of economic evaluation for loss reduction projects
  - Seek the candidates of effective loss reduction methodology
  - Identify the validation of the selected loss reduction projects
- etc.

Process of Loss Reduction Plans



A new measure for loss reduction

Benefit by Loss reduction (rough estimation)

Cost for Loss reduction (rough estimation)

No

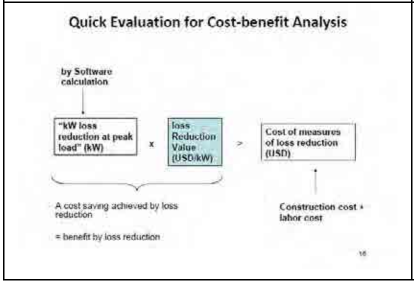
Benefit > Cost

Quick evaluation

Yes

A candidate for loss reduction

Quick Evaluation for Cost-benefit Analysis



by Software calculation

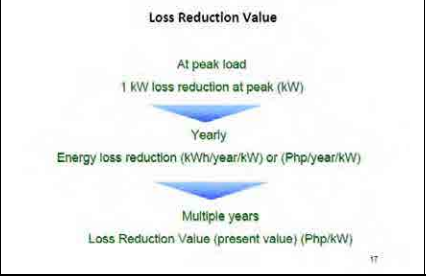
"kW loss reduction at peak load" (kW) x loss Reduction Value (USD/kW) > Cost of measures of loss reduction (USD)

A cost saving achieved by loss reduction

= benefit by loss reduction

Construction cost + labor cost

Loss Reduction Value



At peak load

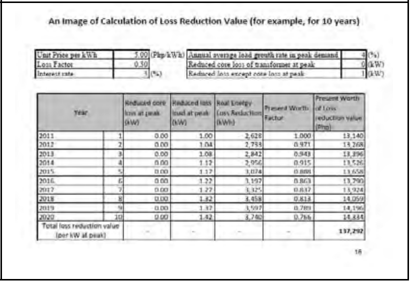
1 kW loss reduction at peak (kW)

Yearly

Energy loss reduction (kWh/year/kW) or (Php/year/kW)

Multiple years

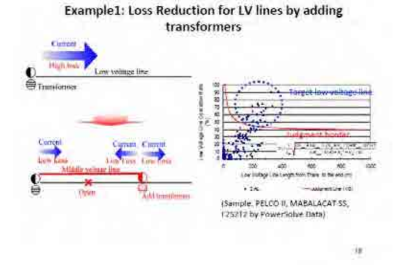
Loss Reduction Value (present value) (Php/kW)



An Image of Calculation of Loss Reduction Value (for example, for 10 years)

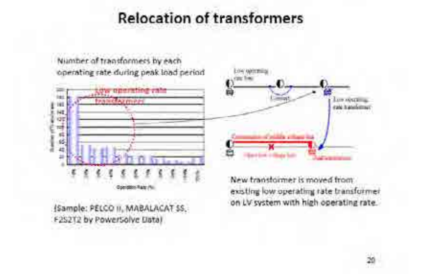
Unit Price per kWh	5.00	(Php/kWh)	Annual average load growth rate in peak demand	4	(%)
Loss Factor	0.30		Reduced core loss of transformer at peak	0	(kW)
Interest rate	3	(%)	Reduced loss except core loss at peak	1	(kW)

Year		Reduced core loss at peak (kW)	Reduced loss load at peak (kW)	Real Energy Loss Reduction (kWh)	Present Worth Factor	Present Worth of Loss reduction value (Php)
2011	1	0.00	1.00	2,628	1.000	13,140
2012	2	0.00	1.04	2,733	0.971	13,268
2013	3	0.00	1.08	2,842	0.943	13,396
2014	4	0.00	1.12	2,956	0.915	13,526
2015	5	0.00	1.17	3,074	0.888	13,658
2016	6	0.00	1.22	3,197	0.863	13,790
2017	7	0.00	1.27	3,325	0.837	13,924
2018	8	0.00	1.32	3,458	0.813	14,059
2019	9	0.00	1.37	3,597	0.789	14,196
2020	10	0.00	1.42	3,740	0.766	14,334
Total loss reduction value (per kW at peak)		-	-	-	-	137,292



Example1: Loss Reduction for LV lines by adding transformers

(Sample: PELCO II, MABALACAT SS, F2S2T2 by PowerSolve Data)

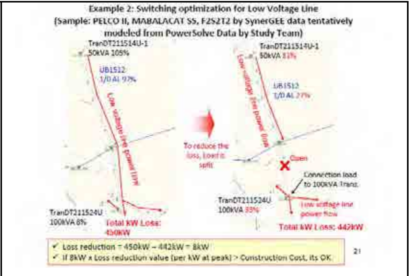


Relocation of transformers

Number of transformers by each operating rate during peak load period

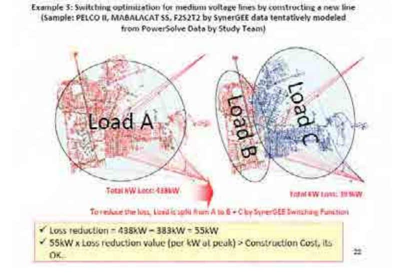
(Sample: PELCO II, MABALACAT SS, F2S2T2 by PowerSolve Data)

New transformer is moved from existing low operating rate transformer on LV system with high operating rate.



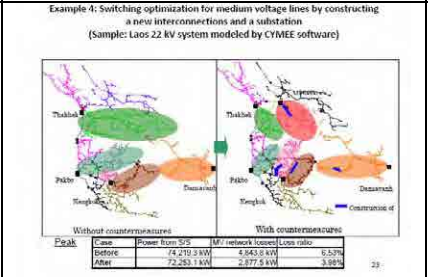
Example 2: Switching optimization for Low Voltage Line (Sample: PELCO II, MABALACAT SS, F2S2T2 by SynerGEE data tentatively modeled from PowerSolve Data by Study Team)

- ✓ Loss reduction = 450kW – 442kW = 8kW
- ✓ If 8kW x Loss reduction value (per kW at peak) > Construction Cost, its OK



Example 3: Switching optimization for medium voltage lines by constructing a new line (Sample: PELCO II, MABALACAT SS, F2S2T2 by SynerGEE data tentatively modeled from PowerSolve Data by Study Team)

- ✓ Loss reduction = 438kW – 383kW = 55kW
- ✓ 55kW x Loss reduction value (per kW at peak) > Construction Cost, its OK.



Example 4: Switching optimization for medium voltage lines by constructing a new interconnections and a substation (Sample: Laos 22 kV system modeled by CYMEE software)

Peak

Case	Power from S/S	MV network losses	Loss ratio
Before	74,219.3 kW	4,843.8 kW	6.53%
After	72,253.1 kW	2,877.5 kW	3.98%

Next Step

- Starting initial Pilot Project at 3rd site survey
- Analyzing Data (expected done by ECs until next W/S)
  - Operation rate of pole transformers (at peak load time and average)
  - Lengths, sending currents, their using conductors and operation rates of LV lines/MV lines
- Examining finance applications

Distribution Management Method in Japan

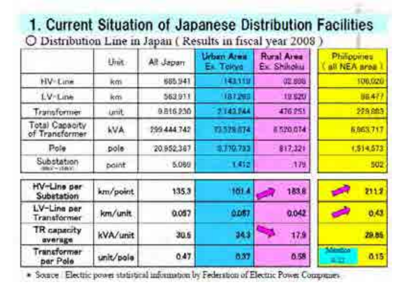
29/07/2011

Contents

1. Current Situation of Japanese Distribution Facilities
   - (1) Segregation of Distribution Loss
   - (2) Measurements of Distribution Loss Reduction
2. Design Concept of Distribution Facilities in Japanese
   - (1) Outline of Distribution Line
   - (2) Planning for strengthen of HV Line
   - (3) HV-Line Installation Method
   - (4) LV-Line Installation Method
   - (5) Distribution Facilities Management Method

Result of analysis

1. Current Situation of Japanese Distribution Facilities

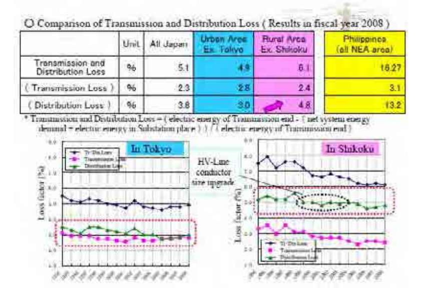


1. Current Situation of Japanese Distribution Facilities

○ Distribution Line in Japan (Results in fiscal year 2008)

	Unit	All Japan	Urban Area Ex. Tokyo	Rural Area Ex. Shikoku	Philippines (all NEA area)
HV-Line	km	685,941	143,110	92,898	106,020
LV-Line	km	563,911	187,280	19,920	98,477
Transformer	unit	9,816,930	2,143,544	476,251	229,883
Total Capacity of Transformer	kVA	299,444,742	73,578,074	8,520,074	6,863,717
Pole	pole	20,952,367	5,770,733	817,321	1,514,573
Substation	point	5,069	1,412	179	502
HV-Line per Substation	km/point	135.3	101.4	183.8	211.2
LV-Line per Transformer	km/unit	0.057	0.087	0.042	0.43
TR capacity average	kVA/unit	30.5	34.3	17.9	29.85
Transformer per Pole	unit/pole	0.47	0.37	0.58	Median 0.22 0.15

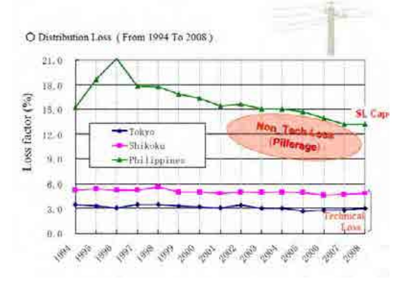
- Source : Electric power statistical information by Federation of Electric Power Companies



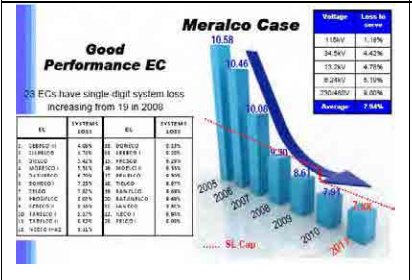
○ Comparison of Transmission and Distribution Loss (Results in fiscal year 2008)

	Unit	All Japan	Urban Area Ex. Tokyo	Rural Area Ex. Shikoku	Philippines (all NEA area)
Transmission and Distribution Loss	%	5.1	4.9	6.1	16.27
(Transmission Loss)	%	2.3	2.8	2.4	3.1
(Distribution Loss)	%	3.8	3.0	4.8	13.2

* Transmission and Distribution Loss = (electric energy of Transmission end - (net system energy demand + electric energy in Substation place)) / (electric energy of Transmission end)



○ Distribution Loss (From 1994 To 2008)

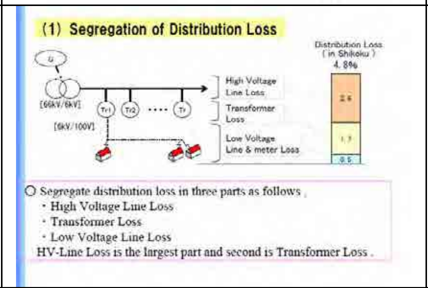


Meralco Case

Good Performance EC

23 ECs have single digit system loss increasing from 19 in 2008

Voltage	Loss to serve
115kV	1.18%
34.5kV	4.42%
13.2kV	4.78%
6.24kV	5.10%
230/460V	8.00%
Average	7.94%



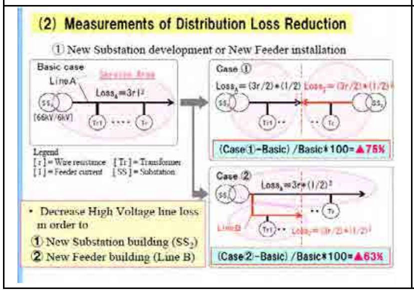
(1) Segregation of Distribution Loss

○ Segregate distribution loss in three parts as follows .
- High Voltage Line Loss
- Transformer Loss
- Low Voltage Line Loss

HV-Line Loss is the largest part and second is Transformer Loss .

(2) Measurements of Distribution Loss Reduction

Items	Concrete Measurements	No.
Reduce load current	・Develop new substation ・Develop new distribution feeder ・Load allocation	①
	・Improving unbalanced current	②
	・Improving Power Factor	③
Reduce wire resistance	・High Voltage line conductor size upgrade	④
	・Shortening Low Voltage line (Split load of one Transformer)	⑤
Reduce Transformer resistance	・Transformer replacement to low loss type (For example : Introduce Amorphous core transformer)	⑥



(2) Measurements of Distribution Loss Reduction

① New Substation development or New Feeder installation

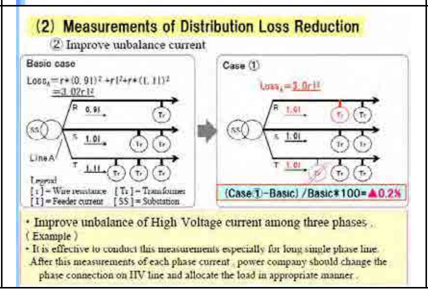
(Case①-Basic) /Basic*100=▲75%

(Case②-Basic) /Basic*100=▲63%

Legend
[r] = Wire resistance [Tr] = Transformer
[I] = Feeder current [SS] = Substation

- Decrease High Voltage line loss in order to

① New Substation building (SS_2)
② New Feeder building (Line B)



(2) Measurements of Distribution Loss Reduction

② Improve unbalance current

Basic case

$$Loss_A = r*(0.9I)^2 + rI^2 + r*(1.1I)^2 = 3.02rI^2$$

Case ①

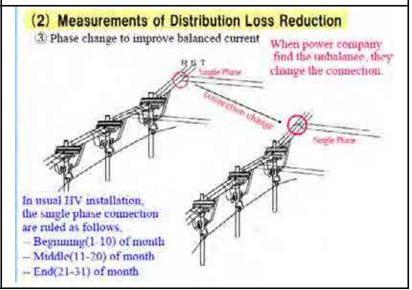
$$Loss_A = 3.0rI^2$$

(Case①-Basic) /Basic*100=▲0.2%

Legend
[r] = Wire resistance [Tr] = Transformer
[I] = Feeder current [SS] = Substation

- Improve unbalance of High Voltage current among three phases .

(Example)
- It is effective to conduct this measurements especially for long single phase line. After this measurements of each phase current , power company should change the phase connection on HV line and allocate the load in appropriate manner .

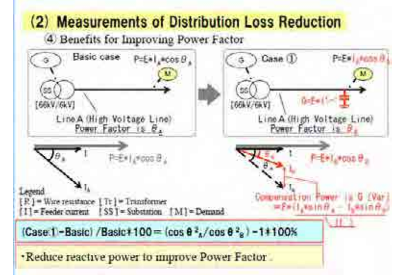


(2) Measurements of Distribution Loss Reduction

③ Phase change to improve balanced current

When power company find the unbalance , they change the connection.

In usual HV installation, the single phase connection are ruled as follows.
- Beginning(1-10) of month
- Middle(11-20) of month
- End(21-31) of month



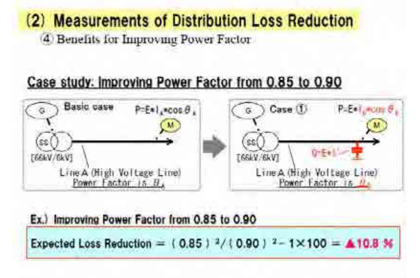
(2) Measurements of Distribution Loss Reduction

④ Benefits for Improving Power Factor

Legend
[R] = Wire resistance [Tr] = Transformer
[I] = Feeder current [SS] = Substation [M] = Demand

$(\text{Case①}-\text{Basic})/\text{Basic}*100=(\cos\theta^2_A/\cos\theta^2_B)-1*100\%$

- Reduce reactive power to improve Power Factor .



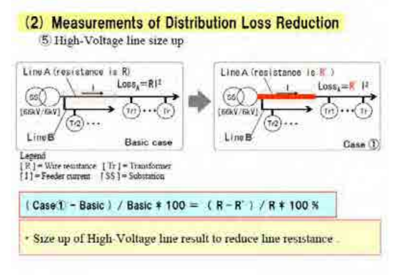
(2) Measurements of Distribution Loss Reduction

④ Benefits for Improving Power Factor

Case study: Improving Power Factor from 0.85 to 0.90

Ex.) Improving Power Factor from 0.85 to 0.90

Expected Loss Reduction $=(0.85)^2/(0.90)^2-1\times100=$ ▲10.8 %



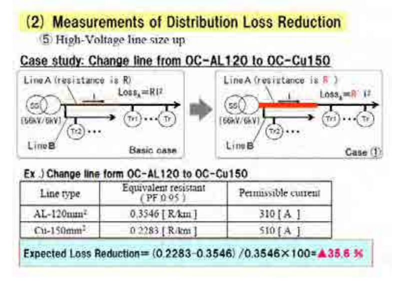
(2) Measurements of Distribution Loss Reduction

⑤ High-Voltage line size up

Legend
[R] = Wire resistance [Tr] = Transformer
[I] = Feeder current [SS] = Substation

$(\text{Case①}-\text{Basic})/\text{Basic}*100=(R-R')/R*100\%$

- Size up of High-Voltage line result to reduce line resistance .



(2) Measurements of Distribution Loss Reduction

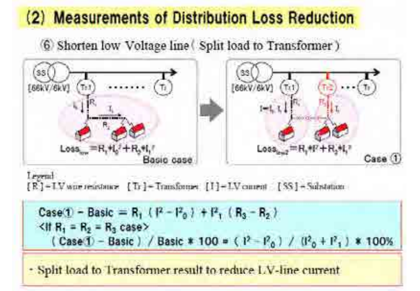
⑤ High-Voltage line size up

Case study: Change line from OC-AL120 to OC-Cu150

Ex .) Change line form OC-AL120 to OC-Cu150

Line type	Equivalent resistant (PF 0.95)	Permissible current
AL-120mm²	0.3546 [R/km]	310 [A]
Cu-150mm²	0.2283 [R/km]	510 [A]

Expected Loss Reduction= (0.2283-0.3546) /0.3546×100=▲35.6 %



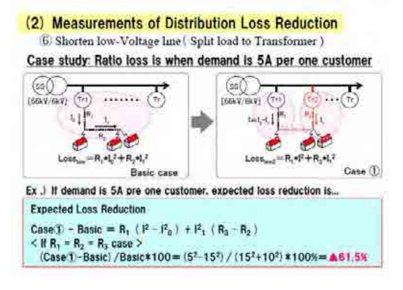
(2) Measurements of Distribution Loss Reduction

⑥ Shorten low Voltage line (Split load to Transformer)

Legend
[R] = LV wire resistance [Tr] = Transformer [I] = LV current [SS] = Substation

$\text{Case①}-\text{Basic}=R_1(I^2-I^2_0)+I^2_1(R_3-R_2)$
$\langle \text{If } R_1=R_2=R_3 \text{ case}\rangle$
$(\text{Case①}-\text{Basic})/\text{Basic}*100=(I^2-I^2_0)/(I^2_0+I^2_1)*100\%$

- Split load to Transformer result to reduce LV-line current



(2) Measurements of Distribution Loss Reduction

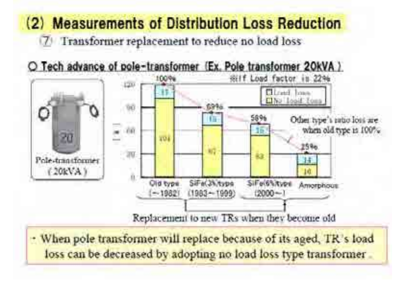
⑥ Shorten low-Voltage line (Split load to Transformer)

Case study: Ratio loss is when demand is 5A per one customer

Ex .) If demand is 5A pre one customer. expected loss reduction is...

Expected Loss Reduction

$\text{Case①}-\text{Basic}=R_1(I^2-I^2_0)+I^2_1(R_3-R_2)$
$\langle \text{If } R_1=R_2=R_3 \text{ case}\rangle$
$(\text{Case①}-\text{Basic})/\text{Basic}*100=(5^2-15^2)/(15^2+10^2)*100\%=$ ▲61.5%

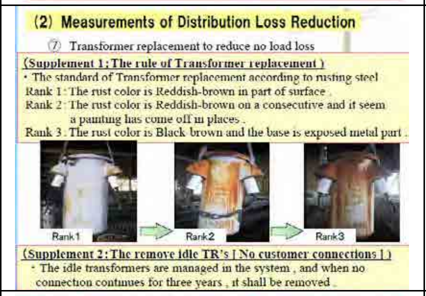


(2) Measurements of Distribution Loss Reduction

⑦ Transformer replacement to reduce no load loss

○ Tech advance of pole-transformer (Ex. Pole transformer 20kVA)

- When pole transformer will replace because of its aged, TR's load loss can be decreased by adopting no load loss type transformer .



(2) Measurements of Distribution Loss Reduction

⑦ Transformer replacement to reduce no load loss

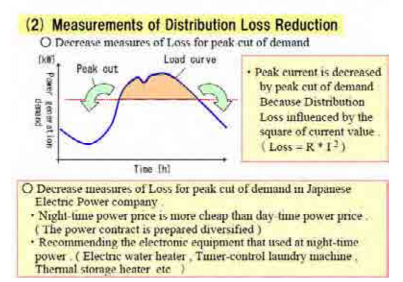
(Supplement 1 : The rule of Transformer replacement)

- The standard of Transformer replacement according to rusting steel

Rank 1 : The rust color is Reddish-brown in part of surface .
Rank 2 : The rust color is Reddish-brown on a consecutive and it seem a painting has come off in places .
Rank 3 : The rust color is Black brown and the base is exposed metal part .

(Supplement 2 : The remove idle TR's [No customer connections])

- The idle transformers are managed in the system , and when no connection continues for three years , it shall be removed .



(2) Measurements of Distribution Loss Reduction

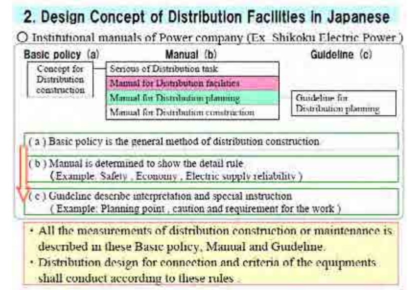
○ Decrease measures of Loss for peak cut of demand

- Peak current is decreased by peak cut of demand Because Distribution Loss influenced by the square of current value . (Loss = R * I²)

○ Decrease measures of Loss for peak cut of demand in Japanese Electric Power company .

- Night-time power price is more cheap than day-time power price . (The power contract is prepared diversified)
- Recommending the electronic equipment that used at night-time power . (Electric water heater , Timer-control laundry machine , Thermal storage heater etc .)

2. Design Concept of Distribution Facilities in Japanese



2. Design Concept of Distribution Facilities in Japanese

○ Institutional manuals of Power company (Ex. Shikoku Electric Power)

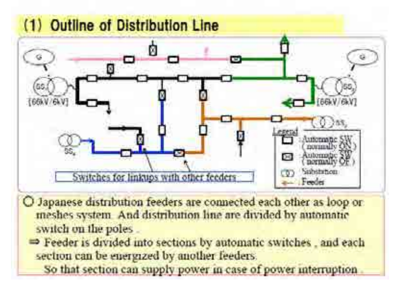
Basic policy (a)	Manual (b)	Guideline (c)
Concept for Distribution construction	Serious of Distribution task	
	Manual for Distribution facilities	
	Manual for Distribution planning	Guideline for Distribution planning
	Manual for Distribution construction	

(a) Basic policy is the general method of distribution construction

(b) Manual is determined to show the detail rule
(Example: Safety , Economy , Electric supply reliability)

(c) Guideline describe interpretation and special instruction
(Example: Planning point , caution and requirement for the work)

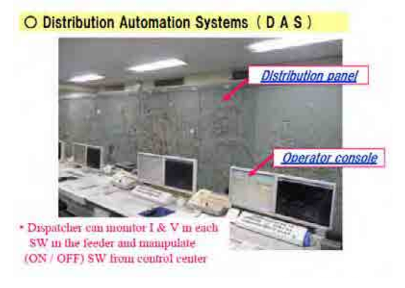
- All the measurements of distribution construction or maintenance is described in these Basic policy, Manual and Guideline.
- Distribution design for connection and criteria of the equipments shall conduct according to these rules .



(1) Outline of Distribution Line

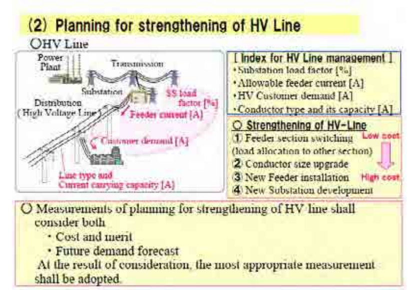
○ Japanese distribution feeders are connected each other as loop or meshes system . And distribution line are divided by automatic switch on the poles .

⇒ Feeder is divided into sections by automatic switches , and each section can be energized by another feeders .
So that section can supply power in case of power interruption .



○ Distribution Automation Systems (D A S)

- Dispatcher can monitor I & V in each SW in the feeder and manipulate (ON / OFF) SW from control center



(2) Planning for strengthening of HV Line

○HV Line

[Index for HV Line management]

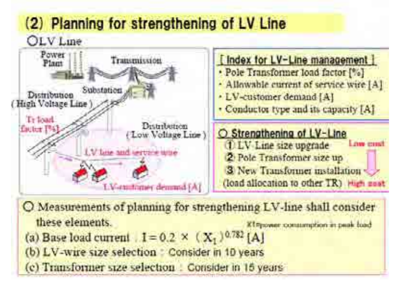
- Substation load factor [%]
- Allowable feeder current [A]
- HV Customer demand [A]
- Conductor type and its capacity [A]

○ Strengthening of HV-Line

① Feeder section switching (load allocation to other section) Low cost
② Conductor size upgrade
③ New Feeder installation High cost
④ New Substation development

○ Measurements of planning for strengthening of HV line shall consider both
- Cost and merit
- Future demand forecast

At the result of consideration, the most appropriate measurement shall be adopted.



(2) Planning for strengthening of LV Line

○LV Line

[Index for LV-Line management]

- Pole Transformer load factor [%]
- Allowable current of service wire [A]
- LV-customer demand [A]
- Conductor type and its capacity [A]

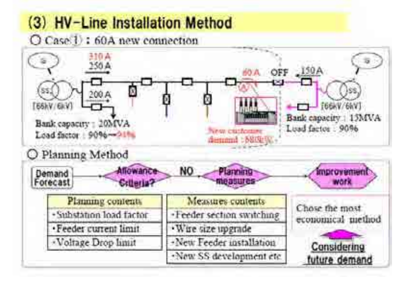
○ Strengthening of LV-Line

① LV-Line size upgrade Low cost
② Pole Transformer size up
③ New Transformer installation (load allocation to other TR) High cost

○ Measurements of planning for strengthening LV-line shall consider these elements.

X1=power consumption in peak load

(a) Base load current : $I=0.2\times(X_1)^{0.782}$ [A]
(b) LV-wire size selection : Consider in 10 years
(c) Transformer size selection : Consider in 15 years



(3) HV-Line Installation Method

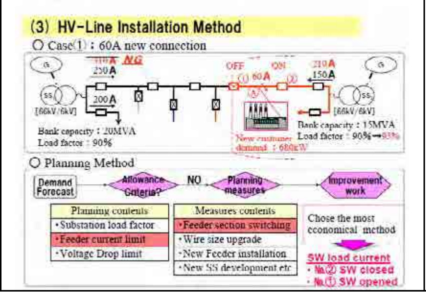
○ Case① : 60A new connection

○ Planning Method

Planning contents	Measures contents
·Substation load factor	·Feeder section switching
·Feeder current limit	·Wire size upgrade
·Voltage Drop limit	·New Feeder installation
	·New SS development etc

Chose the most economical method

Considering future demand



(3) HV-Line Installation Method

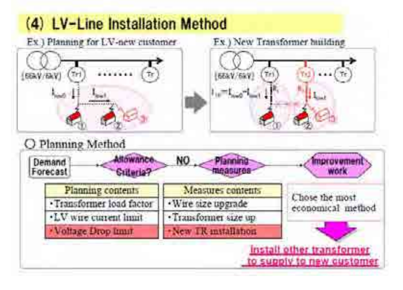
○ Case① : 60A new connection

○ Planning Method

Planning contents	Measures contents
·Substation load factor	·Feeder section switching
·Feeder current limit	·Wire size upgrade
·Voltage Drop limit	·New Feeder installation
	·New SS development etc

Chose the most economical method

SW load current
- №② SW closed
- №① SW opened



(4) LV-Line Installation Method

Ex.) Planning for LV-new customer

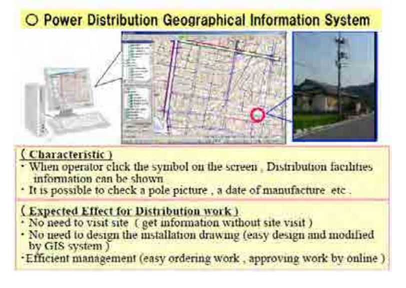
Ex.) New Transformer building

○ Planning Method

Planning contents	Measures contents
·Transformer load factor	·Wire size upgrade
·LV wire current limit	·Transformer size up
·Voltage Drop limit	·New TR installation

Chose the most economical method

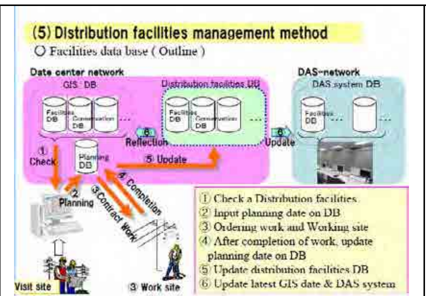
Install other transformer to supply to new customer



○ Power Distribution Geographical Information System

(Characteristic)
- When operator click the symbol on the screen , Distribution facilities information can be shown
- It is possible to check a pole picture , a date of manufacture etc .

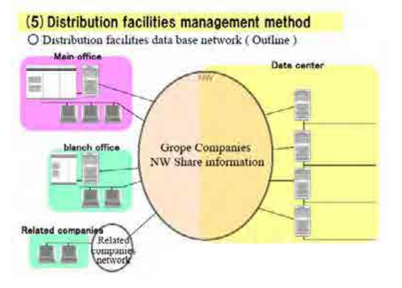
(Expected Effect for Distribution work)
- No need to visit site (get information without site visit)
- No need to design the installation drawing (easy design and modified by GIS system)
- Efficient management (easy ordering work , approving work by online)



(5) Distribution facilities management method

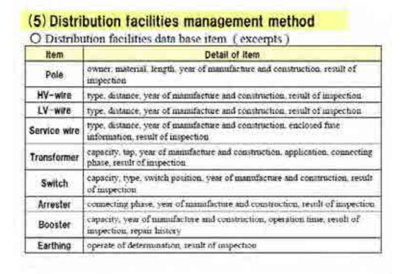
○ Facilities data base (Outline)

① Check a Distribution facilities
② Input planning date on DB
③ Ordering work and Working site
④ After completion of work, update planning date on DB
⑤ Update distribution facilities DB
⑥ Update latest GIS date & DAS system



(5) Distribution facilities management method

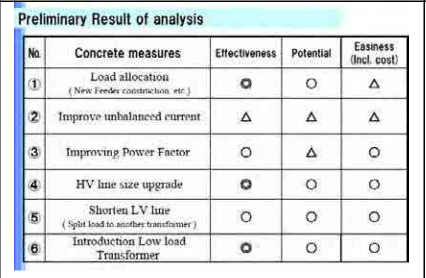
○ Distribution facilities data base network (Outline)



(5) Distribution facilities management method

○ Distribution facilities data base item (excerpts)

Item	Detail of Item
Pole	owner, material, length, year of manufacture and construction, result of inspection
HV-wire	type, distance, year of manufacture and construction, result of inspection
LV-wire	type, distance, year of manufacture and construction, result of inspection
Service wire	type, distance, year of manufacture and construction, enclosed fuse information, result of inspection
Transformer	capacity, tap, year of manufacture and construction, application, connecting phase, result of inspection
Switch	capacity, type, switch position, year of manufacture and construction, result of inspection
Arrester	connecting phase, year of manufacture and construction, result of inspection
Booster	capacity, year of manufacture and construction, operation time, result of inspection, repair history
Earthing	operate of determination, result of inspection



Preliminary Result of analysis

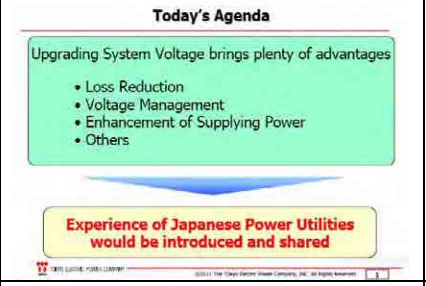
No.	Concrete measures	Effectiveness	Potential	Easiness (Incl. cost)
①	Load allocation (New Feeder construction, etc)	◎	○	△
②	Improve unbalanced current	△	△	△
③	Improving Power Factor	○	△	○
④	HV line size upgrade	◎	○	○
⑤	Shorten LV line (Split load to another transformer)	○	○	○
⑥	Introduction Low load Transformer	◎	○	○

Thank you for your kind attention

Japanese Experience
on
Upgrading Distribution Voltage
in 1960s

Toshiya MINEJIMA / TEPCO

29 July, 2011



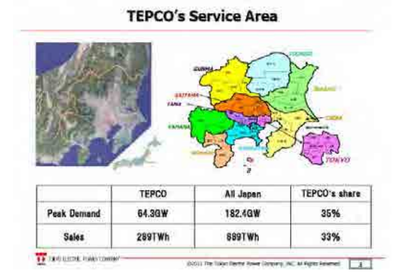
Today's Agenda

Upgrading System Voltage brings plenty of advantages

- Loss Reduction
- Voltage Management
- Enhancement of Supplying Power
- Others

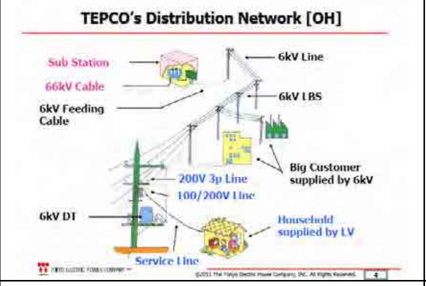
Experience of Japanese Power Utilities would be introduced and shared

10 Utility Companies in Japan

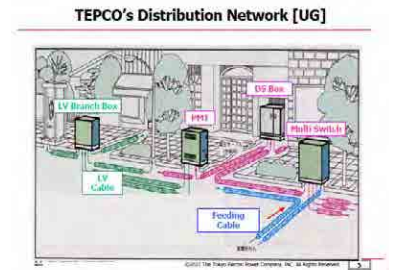


TEPCO's Service Area

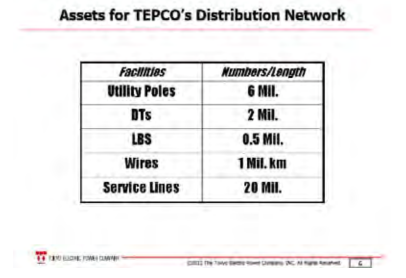
	TEPCO	All Japan	TEPCO's share
Peak Demand	64.3GW	182.4GW	35%
Sales	289TWh	889TWh	33%



TEPCO's Distribution Network [OH]

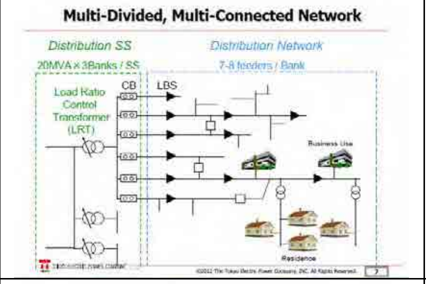


TEPCO's Distribution Network [UG]



Assets for TEPCO's Distribution Network

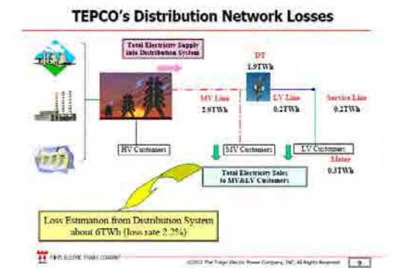
Facilities	*Numbers/Length*
Utility Poles	6 Mil.
DTs	2 Mil.
LBS	0.5 Mil.
Wires	1 Mil. km
Service Lines	20 Mil.



Multi-Divided, Multi-Connected Network

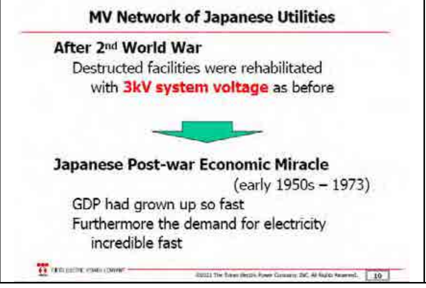
Our Features

We have established
- **High Reliability**
  - *SAIDI=2minutes/customer/year*
  - *SAIFI=0.05times/customer/year*
- **Low Network Losses**
  - *less than 5% : T&D*
  - *as low as 2.2% : Distribution Sector*
- **Efficient Workforce Management**



TEPCO's Distribution Network Losses

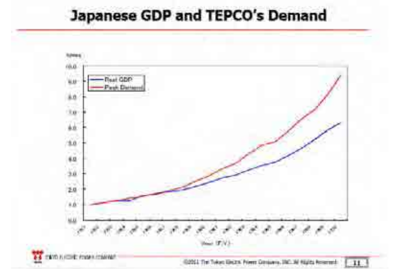
Loss Estimation from Distribution System about 6TWh (loss rate 2.2%)



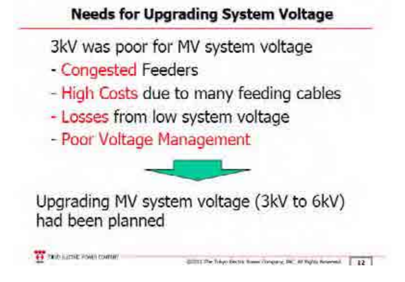
MV Network of Japanese Utilities

After 2nd World War
Destructed facilities were rehabilitated
with **3kV system voltage** as before

Japanese Post-war Economic Miracle
(early 1950s – 1973)
GDP had grown up so fast
Furthermore the demand for electricity
incredible fast



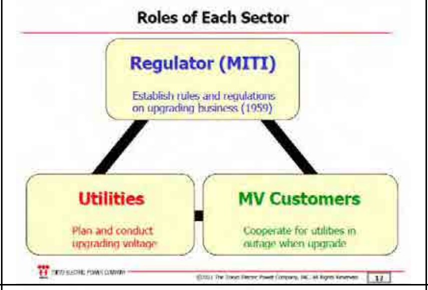
Japanese GDP and TEPCO's Demand



Needs for Upgrading System Voltage

3kV was poor for MV system voltage
- Congested Feeders
- High Costs due to many feeding cables
- Losses from low system voltage
- Poor Voltage Management

Upgrading MV system voltage (3kV to 6kV) had been planned



Roles of Each Sector

Regulator (MITI)
Establish rules and regulations on upgrading business (1959)

Utilities
Plan and conduct upgrading voltage

MV Customers
Cooperate for utilities in outage when upgrade

Rules for Upgrading Biz

- **Upgrade the whole 3kV Network to 6kV within 15years**

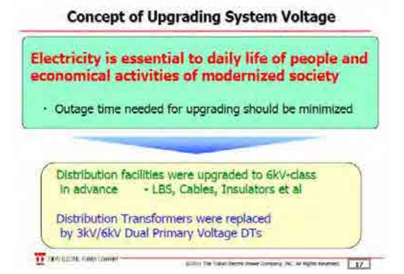
(TEPCO's distribution feeders : 5,020
peak demand : 4.8GW)
as of when upgrading started

Rules for Upgrading Biz

- **Upgrade the whole 3kV Network to 6kV within 15years**
- **Electric Switchboard Equipments <Cubicles> of MV Customers should be modified or renewed by Utilities' payment**

Chronology of TEPCO's Activities

1957	Pre-Upgrading
1959	Main Upgrading Business Start
1973	Almost Finished
1981	Wholly Finished



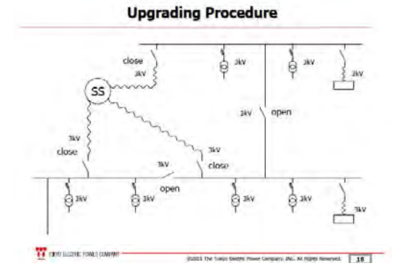
Concept of Upgrading System Voltage

Electricity is essential to daily life of people and economical activities of modernized society

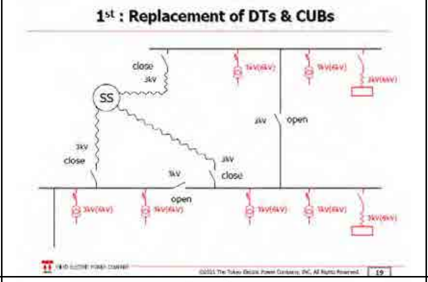
- Outage time needed for upgrading should be minimized

Distribution facilities were upgraded to 6kV-class in advance - LBS, Cables, Insulators et al

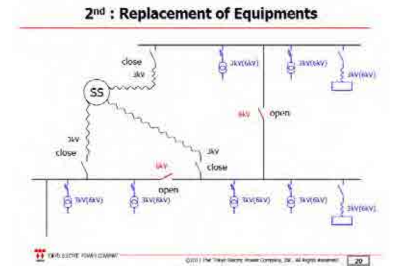
Distribution Transformers were replaced by 3kV/6kV Dual Primary Voltage DTs



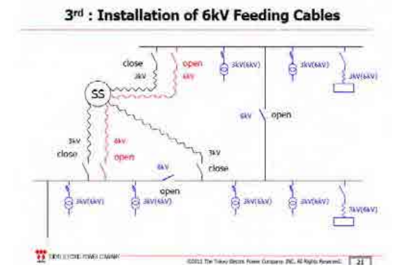
Upgrading Procedure



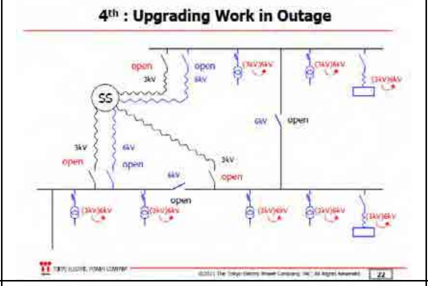
1st : Replacement of DTs & CUBs



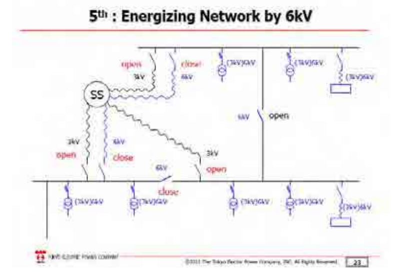
2nd : Replacement of Equipments



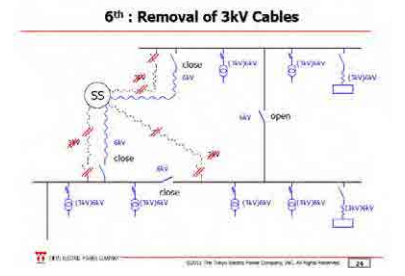
3rd : Installation of 6kV Feeding Cables



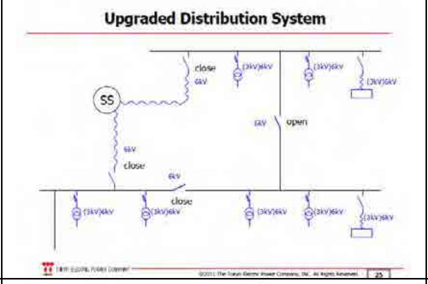
4th : Upgrading Work in Outage



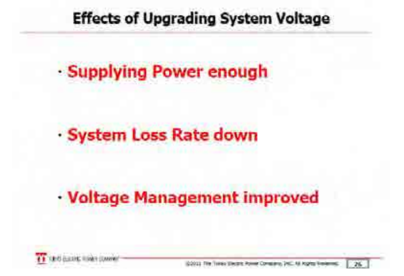
5th : Energizing Network by 6kV



6th : Removal of 3kV Cables



Upgraded Distribution System



Effects of Upgrading System Voltage

- **Supplying Power enough**
- **System Loss Rate down**
- **Voltage Management improved**

Effect for Supplying Power

- **Supplying Power enough** to meet increasing demand

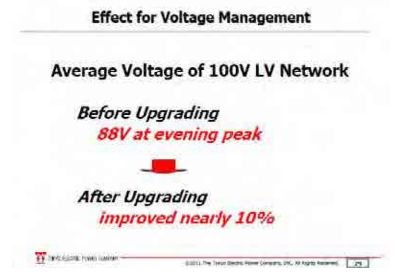
Peak Demand
from 4.8GW to 15.7GW
while Feeders
from 5,020 to 8,042cct

Effect for Loss Reduction

- **System Loss Rate down**

Rate of Distribution Sector
8% or higher

Half Reduction to 4%

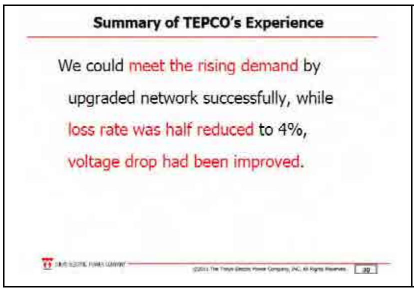


Effect for Voltage Management

Average Voltage of 100V LV Network

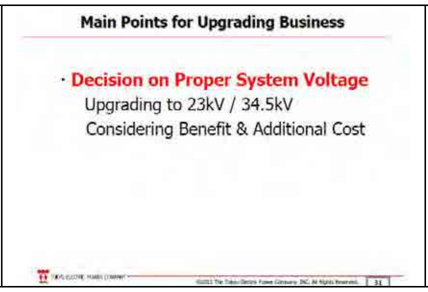
Before Upgrading
88V at evening peak

After Upgrading
improved nearly 10%



Summary of TEPCO's Experience

We could meet the rising demand by upgraded network successfully, while loss rate was half reduced to 4%, voltage drop had been improved.



Main Points for Upgrading Business

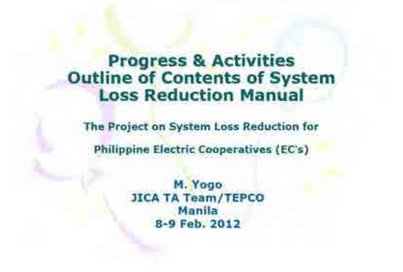
- **Decision on Proper System Voltage**

  Upgrading to 23kV / 34.5kV

  Considering Benefit & Additional Cost

Salamat !!

Presentation Materials of 2nd Workshop

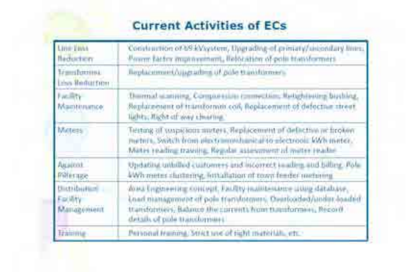


Progress & Activities Outline of Contents of System Loss Reduction Manual

The Project on System Loss Reduction for

Philippine Electric Cooperatives (EC's)

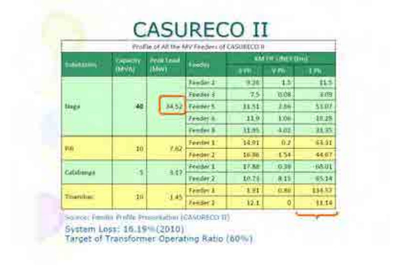
M. Yogo
JICA TA Team/TEPCO
Manila
8-9 Feb. 2012



Current Activities of ECs

Line Loss Reduction	Construction of 69 kV system, Upgrading of primary/secondary lines, Power factor improvement, Relocation of pole transformers
Transformer Loss Reduction	Replacement/upgrading of pole transformers
Facility Maintenance	Thermal scanning, Compression connection, Retightening bushing, Replacement of transformer coil, Replacement of defective street lights, Right of way clearing
Meters	Testing of suspicious meters, Replacement of defective or broken meters, Switch from electromechanical to electronic kWh meter, Meter reading training, Regular assessment of meter reader
Against Pilferage	Updating unbilled customers and incorrect reading and billing, Pole kWh meter clustering, Installation of town feeder metering
Distribution Facility Management	Area Engineering concept, Facility maintenance using database, Load management of pole transformers, Overloaded/under loaded transformers, Balance the currents from transformers, Record details of pole transformers
Training	Personal training, Strict use of right materials, etc.

Technical Situations



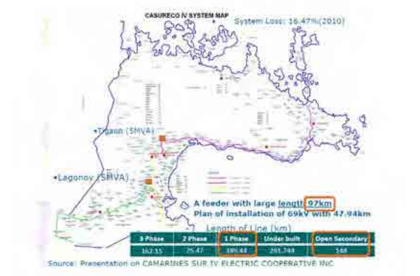
CASURECO II

Profile of All the MV Feeders of CASURECO II

Substation	Capacity (MVA)	Peak Load (MW)	Feeder	KM OF LINES (km)		
				3 Ph	V Ph	1 Ph
Naga	40	34.52	Feeder 2	9.26	1.5	11.5
			Feeder 3	7.5	0.08	3.09
			Feeder 5	11.51	2.86	53.07
			Feeder 6	11.9	1.06	10.28
			Feeder 8	11.95	4.02	31.35
Pili	10	7.62	Feeder 1	14.91	0.2	63.31
			Feeder 2	16.86	1.54	44.67
Calabanga	5	3.17	Feeder 1	17.88	0.38	68.01
			Feeder 2	10.71	8.15	65.14
Tinambac	10	1.45	Feeder 1	3.91	0.86	134.57
			Feeder 2	12.1	0	31.14

Source: Feeder Profile Presentation (CASURECO II)

System Loss: 16.19%(2010)
Target of Transformer Operating Ratio (60%)



System Loss: 16.47%(2010)

A feeder with large length 97km
Plan of installation of 69kV with 47.94km

Length of Line (km)

3 Phase	2 Phase	1 Phase	Under built	Open Secondary
162.15	75.47	189.44	291.744	148

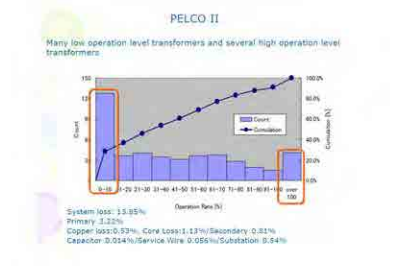
Source: Presentation on CAMARINES SUR IV ELECTRIC COOPERATIVE INC

SORECO I

		ACTUAL METERED		Calculated Loss	
		Input	Sales	Technical	Non-Technical
Sta. Teresita (T2) (69 kV Metering)	F1	18,417	15,644	1,747 9.49%	1,025 5.57%
Sta. Teresita (T1) (13.2 kV Metering)	F2	7,872	7,082	395 5.02%	396 5.03%
Guiang-guiang (Mobile) (69 kV Metering)	F3 F4	11,548	10,223	1,099 9.52%	226 1.96%

Source: Data from SORECO I

Loss 12.92%
Technical 8.57%
Non-technical 4.35%



PELCO II

Many low operation level transformers and several high operation level transformers

System loss: 13.85%
Primary: 3.22%
Copper loss:0.53%, Core Loss:1.13%/Secondary: 0.81%
Capacitor: 0.014%/Service Wire: 0.056%/Substation: 0.54%

FLECO

Substation	MVA Capacity	Peak Demand	% Loading
LM S/S No. 1	5 MVA	3,919 kW	78.38 %
LM S/S No. 2	5 MVA	3,064 kW	61.28 %
PAKIL S/S	5 MVA	3,000 kW	60.00 %
FAMY S/S	10 MVA	4,343 kW	43.43 %

System Loss: 14.76%

Source: Data from FLECO

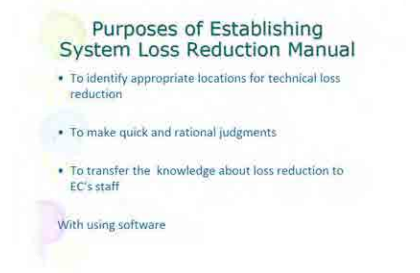
System MAp

Total no. of costumers served = 149,401

Source: Presentation by ISELCO I

LEYECO III

Source: Data from LEYECO III



Purposes of Establishing System Loss Reduction Manual

- To identify appropriate locations for technical loss reduction
- To make quick and rational judgments
- To transfer the knowledge about loss reduction to EC's staff

With using software

Draft Contents of Manual

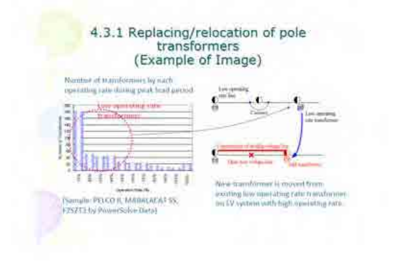
1 Introduction
2 Economic Values of Technical Loss Reduction
3 Methodology of O&M for Data Arrangement of Loss Analysis
4 Identifying Countermeasures against Technical Losses for Low Voltage System
5 Identifying Countermeasures against Technical Losses for Medium Voltage System
6 Installation of Substations / Upgrading Voltage of Medium Voltage System
7 Non-technical Loss Reduction

- 1 Introduction
  - 1.1 Purpose of this manual
  - 1.2 Types of distribution losses and their countermeasures
  - 1.3 Planning procedures of technical loss reduction
  - 1.4 Appropriate methods to manual prevailing
- 2 Economic Values of Technical Loss Reduction
  - 2.1 Methodology of calculating loss reduction values
  - 2.2 Costs of countermeasures
- 3 Methodology of O&M for Data Arrangement of Loss Analysis
  - 3.1 Network data
  - 3.2 Load data

Clamp on Meter
SynerGEE Software

4 Identifying Countermeasures against Technical Losses for Low Voltage system

- 4.1 Methodology of calculation of operating status of low voltage system
  - 4.1.1 Methodology of calculation of loads of transformers
  - 4.1.2 Methodology of calculation of operating status of low voltage lines
  - 4.1.3 Methodology of listing up transformers categorized by their capacities
- 4.2 Options of countermeasures against technical losses caused in low voltage system
- 4.3 Criteria for taking countermeasures
  - 4.3.1 Replacing / relocation of pole transformers
  - 4.3.2 Dividing system by installation of pole transformers
  - 4.3.3 Adding or replacing low voltage feeders
  - 4.3.4 Capacitor placement
- 4.4 Appropriate capacities of pole transformers and sizes of conductors
- 4.5 Installation of amorphous using transformers

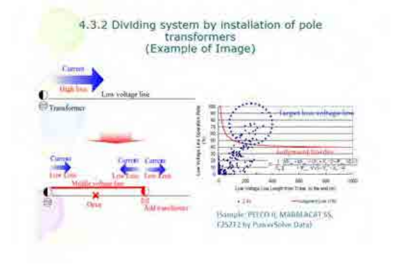


4.3.1 Replacing/relocation of pole transformers (Example of Image)

Number of transformers by each operating rate during peak load period

[Sample: PELCO II, MABALACAT SS, F2SZT3 by PowerSolve Data]

New transformer is moved from existing low operating rate transformer on LV system with high operating rate.



4.3.2 Dividing system by installation of pole transformers (Example of Image)

[Sample: PELCO II, MABALACAT SS, F2SZT2 by PowerSolve Data]

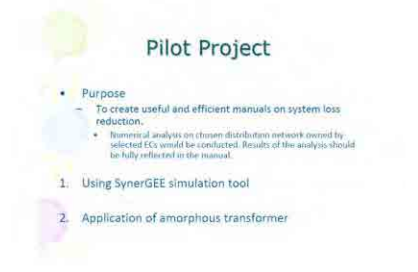
- 5 Identifying Countermeasures against Technical Losses for Medium Voltage System
  - 5.1 Methodology of calculation of operating status of Medium Voltage system
  - 5.2 Options of countermeasures against technical losses caused in medium voltage system
  - 5.3 Criteria for taking countermeasures against technical loss reduction
    - 5.3.1 Adding or replacing medium voltage feeders
    - 5.3.2 Switching optimization
    - 5.3.3 Capacitor placement
    - 5.3.4 Correcting imbalance of phase currents
  - 5.4 Appropriate capacities of pole transformers and sizes of conductors

5.3.2 Switching optimization

To reduce the high current, a part of load is fed by another feeder / substation

🟥 Substation or Feeder

- 6 Adding Transformers to Substations / Installation of Substations / Upgrading Voltage of Medium Voltage Feeders
  - 6.1 Methodology of system development
  - 6.2 Cases of installation of transformers
  - 6.3 Cases of upgrading medium voltage feeders 1
  - 6.4 Cases of upgrading medium voltage feeders 2
- 7 Non-technical Loss Reduction
  - 7.1 Tree touching
    - Meters, Etc.



Pilot Project

- Purpose
  - To create useful and efficient manuals on system loss reduction.
    - Numerical analysis on chosen distribution network owned by selected ECs would be conducted. Results of the analysis should be fully reflected in the manual.

1. Using SynerGEE simulation tool
2. Application of amorphous transformer

Pilot Project Sites

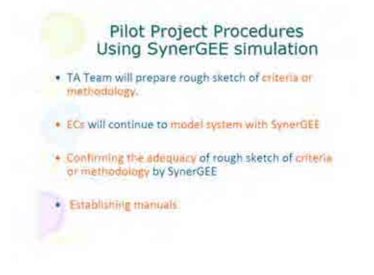
So far, we select PELCOII and ISELCOI for the following Pilot Projects.

PELCOII	ISELCOI
SynerGEE (Focusing on LV)	SynerGEE (Focusing on MV)
Amorphous	

Because,

PELCOII seems to have enough data to study pole transformers and LV system.

ISELCOI's substations have high operating ratios. It seems to have much room to be improved.



Pilot Project Procedures Using SynerGEE simulation

- TA Team will prepare rough sketch of criteria or methodology.
- ECs will continue to model system with SynerGEE
- Confirming the adequacy of rough sketch of criteria or methodology by SynerGEE
- Establishing manuals

Pilot Project Procedures Testing Installation of Amorphous Transformers

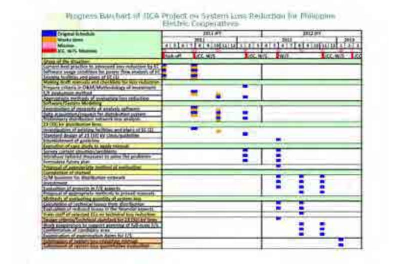
Evaluation of loss reduction value

1. Measure the existing transformers (by PELCOII-owned power tester)
2. Measure new amorphous transformers
3. Calculate differences between existing transformers and amorphous transformers
4. Evaluate the quantity of loss reduction

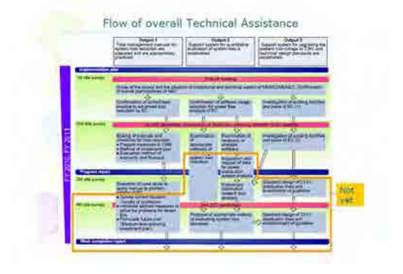
・Capacity of transformer : 5, 10, 15, 25, 37.5, 50, 75, 100kV(kVA)
・Number of transformer : 8 (one per each capacity)

Qualitative effect

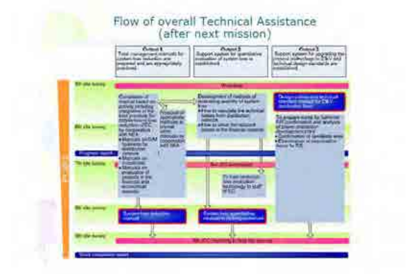
・Qualitative loss reduction effect
・Experience of construction and maintenance of amorphous transformer
・Showcase effect for other EC's



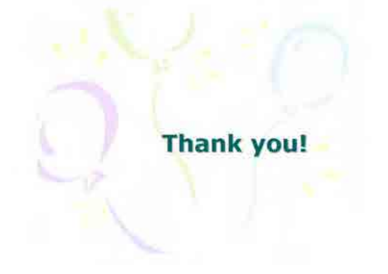
Progress Barchart of JICA Project on System Loss Reduction for Philippine Electric Cooperatives



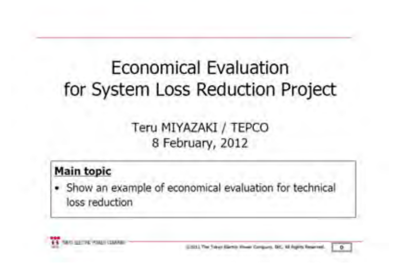
Flow of overall Technical Assistance



Flow of overall Technical Assistance (after next mission)



Thank you!

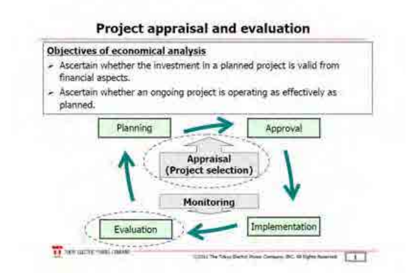


Economical Evaluation for System Loss Reduction Project

Teru MIYAZAKI / TEPCO
8 February, 2012

Main topic

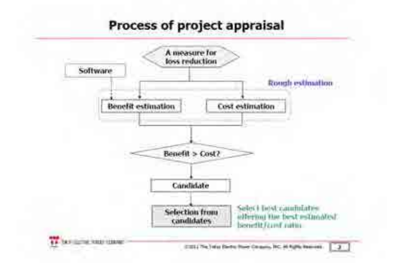
- Show an example of economical evaluation for technical loss reduction



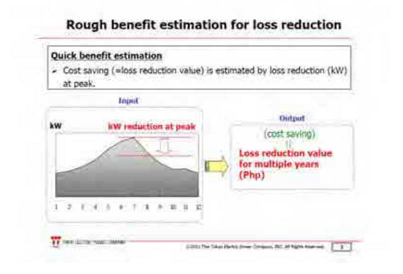
Project appraisal and evaluation

Objectives of economical analysis

- Ascertain whether the investment in a planned project is valid from financial aspects.
- Ascertain whether an ongoing project is operating as effectively as planned.



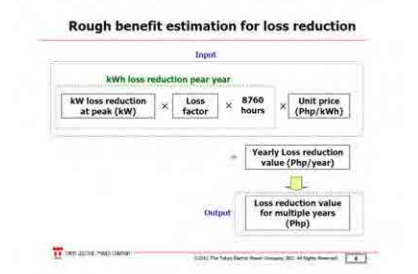
Process of project appraisal



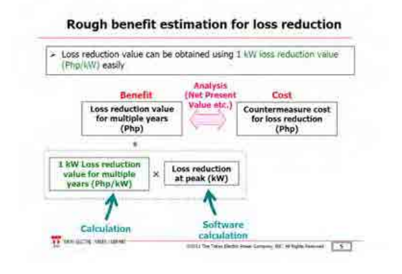
Rough benefit estimation for loss reduction

Quick benefit estimation

- Cost saving (=loss reduction value) is estimated by loss reduction (kW) at peak.

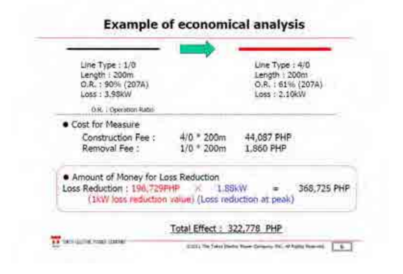


Rough benefit estimation for loss reduction



Rough benefit estimation for loss reduction

- Loss reduction value can be obtained using 1 kW loss reduction value (Php/kW) easily



Example of economical analysis

Line Type : 1/0
Length : 200m
O.R. : 90% (207A)
Loss : 3.98kW

Line Type : 4/0
Length : 200m
O.R. : 61% (207A)
Loss : 2.10kW

O.R. : Operation Ratio

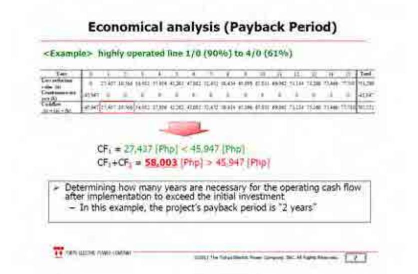
- Cost for Measure

Construction Fee :	4/0 * 200m	44,087 PHP
Removal Fee :	1/0 * 200m	1,860 PHP

- Amount of Money for Loss Reduction

Loss Reduction : 196,729PHP × 1.88kW = 368,725 PHP
(1kW loss reduction value) (Loss reduction at peak)

Total Effect : 322,778 PHP

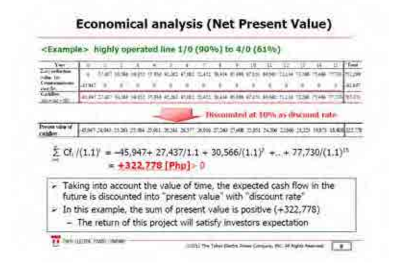


Economical analysis (Payback Period)

<Example> highly operated line 1/0 (90%) to 4/0 (61%)

CF_1 = 27,437 [Php] < 45,947 [Php]
CF_1+CF_2 = 58,003 [Php] > 45,947 [Php]

- Determining how many years are necessary for the operating cash flow after implementation to exceed the initial investment
  - In this example, the project's payback period is "2 years"

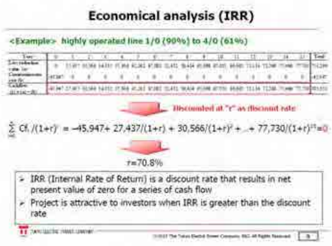


Economical analysis (Net Present Value)

<Example> highly operated line 1/0 (90%) to 4/0 (61%)

$$\sum CF_i/(1.1)^i = -45{,}947 + 27{,}437/1.1 + 30{,}566/(1.1)^2 + \ldots + 77{,}730/(1.1)^{15}$$
$$= +322{,}778\ [Php] > 0$$

- Taking into account the value of time, the expected cash flow in the future is discounted into "present value" with "discount rate"
- In this example, the sum of present value is positive (+322,778)
  - The return of this project will satisfy investors expectation



Economical analysis (IRR)

<Example> highly operated line 1/0 (90%) to 4/0 (61%)

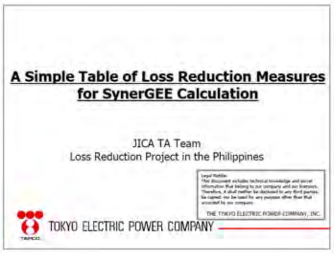
Discounted at "r" as discount rate

$\sum Cf_t/(1+r)^t = -45{,}947 + 27{,}437/(1+r) + 30{,}566/(1+r)^2 + \ldots + 77{,}730/(1+r)^{15} = 0$

r=70.8%

- IRR (Internal Rate of Return) is a discount rate that results in net present value of zero for a series of cash flow
- Project is attractive to investors when IRR is greater than the discount rate

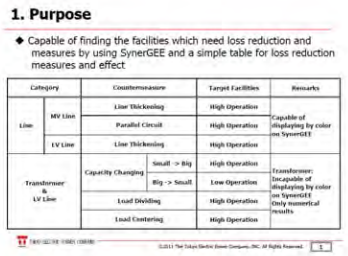
Thank you for listening!



A Simple Table of Loss Reduction Measures for SynerGEE Calculation

JICA TA Team
Loss Reduction Project in the Philippines

TOKYO ELECTRIC POWER COMPANY



1. Purpose

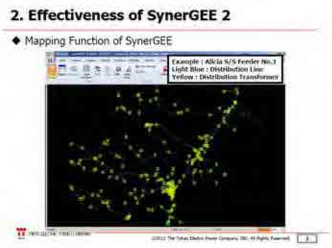
◆ Capable of finding the facilities which need loss reduction and measures by using SynerGEE and a simple table for loss reduction measures and effect

Category		Countermeasure		Target Facilities	Remarks
Line	MV Line	Line Thickening		High Operation	Capable of displaying by color on SynerGEE
		Parallel Circuit		High Operation	
	LV Line	Line Thickening		High Operation	
Transformer & LV Line		Capacity Changing	Small -> Big	High Operation	Transformer: Incapable of displaying by color on SynerGEE Only numerical results
			Big -> Small	Low Operation	
		Load Dividing		High Operation	
		Load Centering		High Operation	

2. Effectiveness of SynerGEE 1

◆ Comparison between PowerSolve and SynerGEE

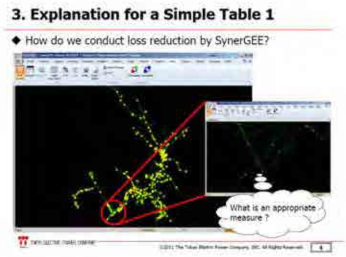
Item	PowerSolve	SynerGEE
Mapping function	△	○
Specification of loss generating source	△	○
Planning for loss reduction measures	△	○
Data input	△	△
Price	9,800 USD	14,800 USD



2. Effectiveness of SynerGEE 2

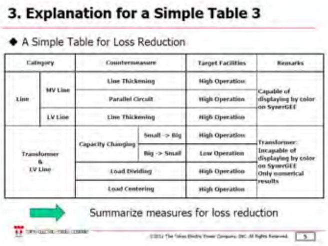
◆ Mapping Function of SynerGEE

Example : Alicia S/S Feeder No.3
Light Blue : Distribution Line
Yellow : Distribution Transformer



3. Explanation for a Simple Table 1

◆ How do we conduct loss reduction by SynerGEE?

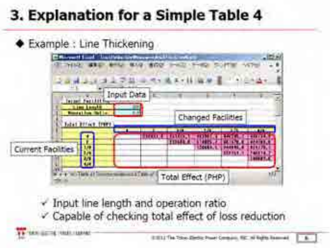


3. Explanation for a Simple Table 3

◆ A Simple Table for Loss Reduction

Category		Countermeasure		Target Facilities	Remarks
Line	MV Line	Line Thickening		High Operation	Capable of displaying by color on SynerGEE
		Parallel Circuit		High Operation	
	LV Line	Line Thickening		High Operation	
Transformer & LV Line		Capacity Changing	Small -> Big	High Operation	Transformer: Incapable of displaying by color on SynerGEE Only numerical results
			Big -> Small	Low Operation	
		Load Dividing		High Operation	
		Load Centering		High Operation	

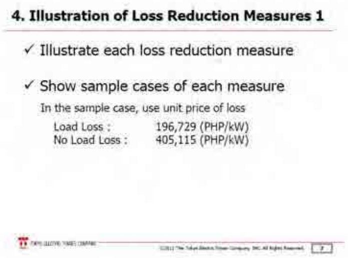
Summarize measures for loss reduction



3. Explanation for a Simple Table 4

◆ Example : Line Thickening

✓ Input line length and operation ratio
✓ Capable of checking total effect of loss reduction



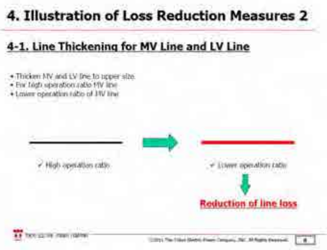
4. Illustration of Loss Reduction Measures 1

✓ Illustrate each loss reduction measure

✓ Show sample cases of each measure

In the sample case, use unit price of loss

Load Loss :	196,729 (PHP/kW)
No Load Loss :	405,115 (PHP/kW)



4. Illustration of Loss Reduction Measures 2

4-1. Line Thickening for MV Line and LV Line

- Thicken MV and LV line to upper size
- For high operation ratio MV line
- Lower operation ratio of MV line

4. Illustration of Loss Reduction Measures 2

Line Type : 1/0
Length : 200m
O.R. : 90% (207A)
Loss : 3.98kW

Line Type : 4/0
Length : 200m
O.R. : 61% (207A)
Loss : 2.10kW

O.R. : Operation Ratio

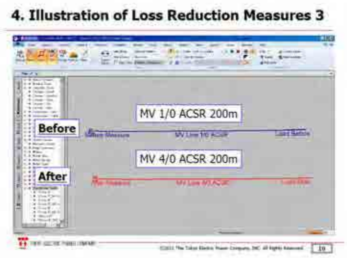
- Cost for Measure

Construction Fee :	4/0 * 200m	44,087 PHP
Removal Fee :	1/0 * 200m	1,860 PHP
	Subtotal : 45,947 PHP	

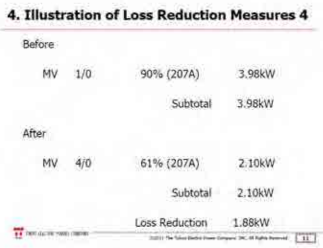
- Amount of Money for Loss Reduction

Loss Reduction :	1.88kW	368,725 PHP
	Subtotal : 368,725 PHP	

Total Effect : 322,778 PHP



4. Illustration of Loss Reduction Measures 3



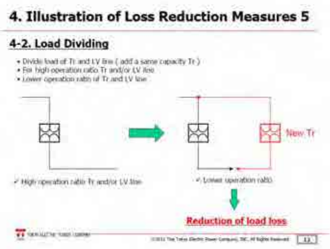
4. Illustration of Loss Reduction Measures 4

Before

MV	1/0	90% (207A)	3.98kW
		Subtotal	3.98kW

After

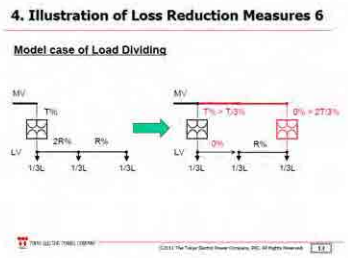
MV	4/0	61% (207A)	2.10kW
		Subtotal	2.10kW
		Loss Reduction	1.88kW



4. Illustration of Loss Reduction Measures 5

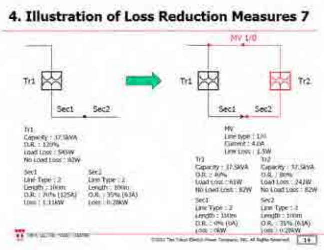
4-2. Load Dividing

- Divide load of Tr and LV line (add a same capacity Tr)
- For high operation ratio Tr and/or LV line
- Lower operation ratio of Tr and LV line



4. Illustration of Loss Reduction Measures 6

Model case of Load Dividing



4. Illustration of Loss Reduction Measures 7

Tr1
Capacity : 37.5kVA
O.R. : 120%
Load Loss : 545W
No Load Loss : 82W

Sec1
Line Type : 2
Length : 100m
O.R. : 70% (125A)
Loss : 1.11kW

Sec2
Line Type : 2
Length : 100m
O.R. : 35% (63A)
Loss : 0.28kW

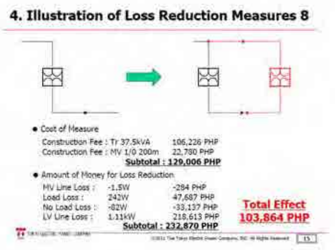
MV
Line type : 1/0
Current : 4.0A
Line Loss : 1.5W

Tr1
Capacity : 37.5kVA
O.R. : 40%
Load Loss : 61W
No Load Loss : 82W

Tr2
Capacity : 37.5kVA
O.R. : 80%
Load Loss : 242W
No Load Loss : 82W

Sec1
Line Type : 2
Length : 100m
O.R. : 0% (0A)
Loss : 0kW

Sec2
Line Type : 2
Length : 100m
O.R. : 35% (63A)
Loss : 0.28kW



4. Illustration of Loss Reduction Measures 8

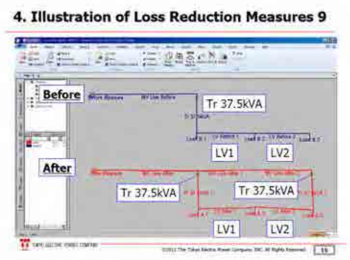
- Cost of Measure

Construction Fee : Tr 37.5kVA	106,226 PHP
Construction Fee : MV 1/0 200m	22,780 PHP
	Subtotal : 129,006 PHP

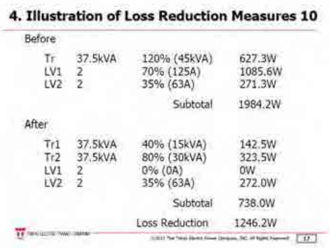
- Amount of Money for Loss Reduction

MV Line Loss :	-1.5W	-284 PHP
Load Loss :	242W	47,687 PHP
No Load Loss :	-82W	-33,137 PHP
LV Line Loss :	1.11kW	218,613 PHP
		Subtotal : 232,870 PHP

Total Effect 103,864 PHP



4. Illustration of Loss Reduction Measures 9



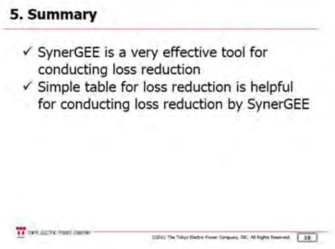
4. Illustration of Loss Reduction Measures 10

Before

Tr	37.5kVA	120% (45kVA)	627.3W
LV1	2	70% (125A)	1085.6W
LV2	2	35% (63A)	271.3W
		Subtotal	1984.2W

After

Tr1	37.5kVA	40% (15kVA)	142.5W
Tr2	37.5kVA	80% (30kVA)	323.5W
LV1	2	0% (0A)	0W
LV2	2	35% (63A)	272.0W
		Subtotal	738.0W
		Loss Reduction	1246.2W



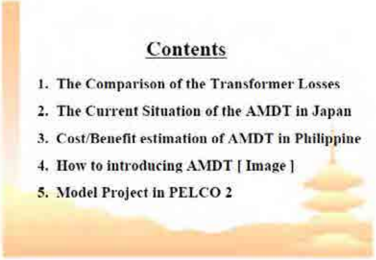
5. Summary

- ✓ SynerGEE is a very effective tool for conducting loss reduction
- ✓ Simple table for loss reduction is helpful for conducting loss reduction by SynerGEE

Thank you for your attention !!

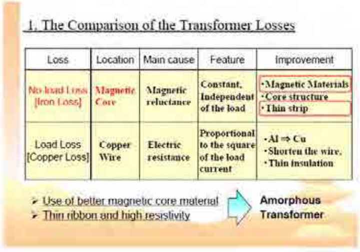
The Effects to Introducing Amorphous Transformer in Philippine

2012／02／08



Contents

1. The Comparison of the Transformer Losses
2. The Current Situation of the AMDT in Japan
3. Cost/Benefit estimation of AMDT in Philippine
4. How to introducing AMDT [Image]
5. Model Project in PELCO 2

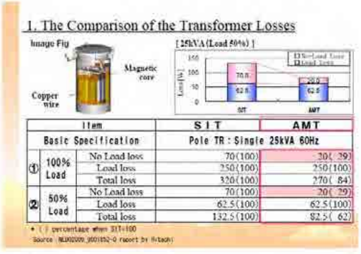


1. The Comparison of the Transformer Losses

Loss	Location	Main cause	Feature	Improvement
No-load Loss [Iron Loss]	Magnetic Core	Magnetic reluctance	Constant, Independent of the load	·Magnetic Materials ·Core structure ·Thin strip
Load Loss [Copper Loss]	Copper Wire	Electric resistance	Proportional to the square of the load current	·Al ⇒ Cu ·Shorten the wire. ·Thin insulation

- Use of better magnetic core material
- Thin ribbon and high resistivity

⇨ Amorphous Transformer



1. The Comparison of the Transformer Losses

Item			SIT	AMT
Basic Specification			Pole TR : Single 25kVA 60Hz	
①	100% Load	No Load loss	70(100)	20(29)
		Load loss	250(100)	250(100)
		Total loss	320(100)	270(84)
②	50% Load	No Load loss	70(100)	20(29)
		Load loss	62.5(100)	62.5(100)
		Total loss	132.5(100)	82.5(62)

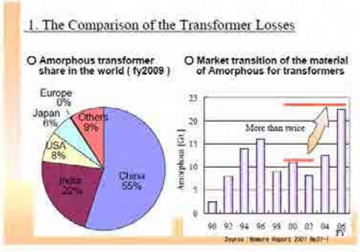
- ( ) percentage when SIT=100

Source : NEDO2009_0001852-0 report by Hitachi

1. The Comparison of the Transformer Losses

○ Typical Transformer No-Load Losses (Silicon Steel vs. Amorphous Metal)

Source : First Philec data and Hitachi

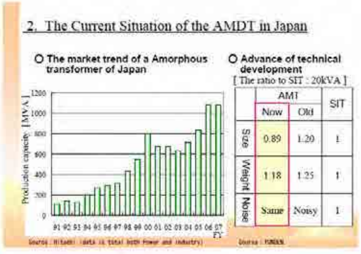


1. The Comparison of the Transformer Losses

○ Amorphous transformer share in the world (fy2009)

○ Market transition of the material of Amorphous for transformers

Source : Nomura Report 2007 No.07-1



2. The Current Situation of the AMDT in Japan

○ The market trend of a Amorphous transformer of Japan

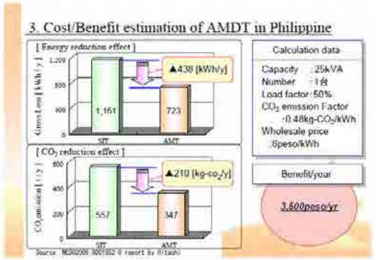
Source : Hitachi (data is total both Power and industry)

○ Advance of technical development

[The ratio to SIT : 20kVA]

	AMT		SIT
	Now	Old	
Size	0.89	1.20	1
Weight	1.18	1.25	1
Noise	Same	Noisy	1

Source : [illegible]



3. Cost/Benefit estimation of AMDT in Philippine

[Energy reduction effect]

[CO₂ reduction effect]

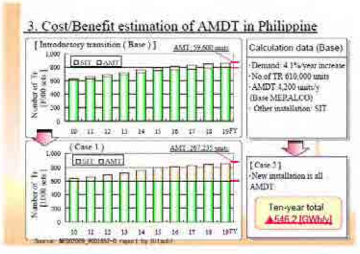
Calculation data

Capacity : 25kVA
Number : 1台
Load factor : 50%
CO₂ emission Factor : 0.48kg-CO₂/kWh
Wholesale price : 8peso/kWh

Benefit/year

3,600peso/yr

Source : NEDO2009_0001852-0 report by Hitachi



3. Cost/Benefit estimation of AMDT in Philippine

[Introductory transition (Base)]

Calculation data (Base)

- Demand: 4.1%/year increase
- No of TR 610,000 units
- AMDT 4,200 units/y (Base MERALCO)
- Other installation: SIT

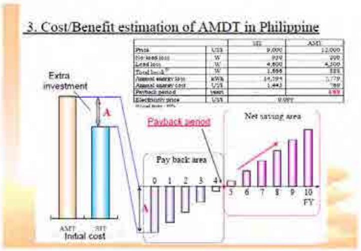
(Case 1)

[Case 2]

- New installation is all AMDT

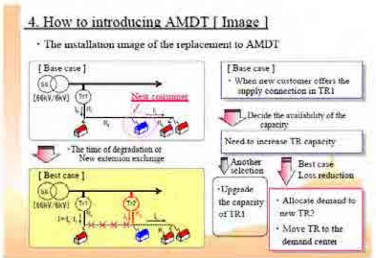
Ten-year total ▲546.2 [GWh/y]

Source : NEDO2009_0001852-0 report by Hitachi



3. Cost/Benefit estimation of AMDT in Philippine

		SIT	AMT
Price	US$	9,000	12,000
No load loss	W	[illegible]	[illegible]
Load loss	W	4,800	4,300
Total loss	W	[illegible]	[illegible]
Annual energy loss	kWh	[illegible]	[illegible]
Annual energy cost	US$	1,443	[illegible]
Payback period	years		[illegible]
Electricity price	US$	[illegible]	



4. How to introducing AMDT [Image]

- The installation image of the replacement to AMDT

[Base case]

- The time of degradation or New extension exchange

[Best case]

[Base case]

- When new customer offers the supply connection in TR1

Decide the availability of the capacity

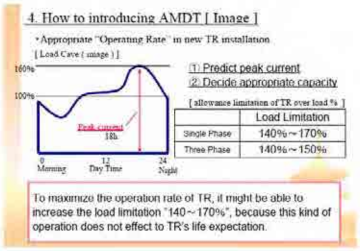
Need to increase TR capacity

Another selection

- Upgrade the capacity of TR1

Best case Loss reduction

- Allocate demand to new TR2
- Move TR to the demand center



4. How to introducing AMDT [Image]

- Appropriate "Operating Rate" in new TR installation

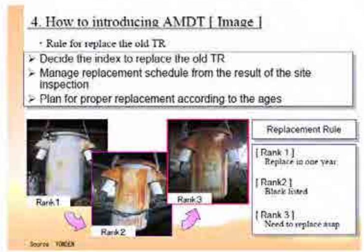
[Load Cave (image)]

① Predict peak current
② Decide appropriate capacity

[allowance limitation of TR over load %]

	Load Limitation
Single Phase	140%～170%
Three Phase	140%～150%

To maximize the operation rate of TR, it might be able to increase the load limitation "140～170%", because this kind of operation does not effect to TR's life expectation.



4. How to introducing AMDT [Image]

- Rule for replace the old TR
- Decide the index to replace the old TR
- Manage replacement schedule from the result of the site inspection
- Plan for proper replacement according to the ages

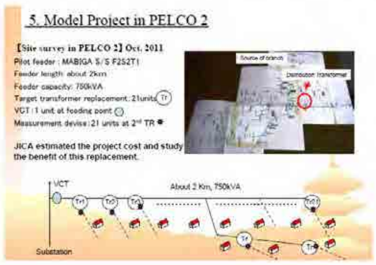
Replacement Rule

[Rank 1]
Replace in one year

[Rank2]
Black listed

[Rank 3]
Need to replace asap

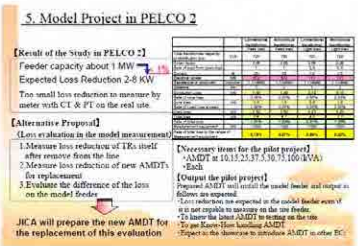
Source : YOKDEN



5. Model Project in PELCO 2

【Site survey in PELCO 2】Oct. 2011
Pilot feeder : MABIGA S/S F252T1
Feeder length: about 2km
Feeder capacity: 750kVA
Target transformer replacement: 21units (Tr)
VCT : 1 unit at feeding point
Measurement devise : 21 units at 2nd TR

JICA estimated the project cost and study the benefit of this replacement.



5. Model Project in PELCO 2

【Result of the Study in PELCO 2】
Feeder capacity about 1 MW
Expected Loss Reduction 2-8 KW
Too small loss reduction to measure by meter with CT & PT on the real site.

【Alternative Proposal】
(Loss evaluation in the model measurement)
1.Measure loss reduction of TRs itself after remove from the line
2.Measure loss reduction of new AMDTs for replacement
3.Evaluate the difference of the loss on the model feeder

JICA will prepare the new AMDT for the replacement of this evaluation

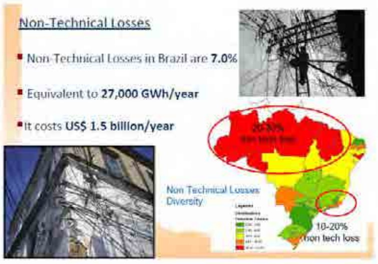
【Necessary items for the pilot project】
- AMDT at 10,15,25,37.5,50,75,100(kVA)
- Each

【Output the pilot project】
Prepared AMDT will install the model feeder and output as follows are expected.
- Loss reduction are expected in the model feeder even if it is not capable to measure on the site feeder.
- To know the latest AMDT to testing on the site
- To get Know-How handling AMDT
- Expect as the showcase to introduce AMDT in other ECs

The lessons of Loss reduction in Slum area in Brazil

Favela = Slum

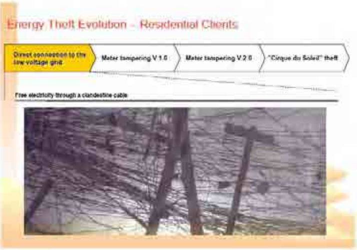
2012／02／08



Non-Technical Losses

- Non-Technical Losses in Brazil are **7.0%**
- Equivalent to **27,000 GWh/year**
- It costs **US$ 1.5 billion/year**

Non Technical Losses Diversity



Energy Theft Evolution – Residential Clients

Direct connection to the low voltage grid → Meter tampering V 1.0 → Meter tampering V 2.0 → "Cirque du Soleil" theft

Free electricity through a clandestine cable

Energy Theft Evolution – Residential Clients

Direct connection to the low voltage grid → **Meter tampering V 1.0** → Meter tampering V 2.0 → "Cirque du Soleil" theft

Free electricity by stopping the meter wheel ... or by getting the meter to sleep

Energy Theft Evolution – Residential Clients

Direct connection to the low voltage grid → Meter tampering V 1.0 → **Meter tampering V 2.0** → "Cirque du Soleil" theft

Stealing all the energy by changing meter gears ... or just part of it by smoothing gears over

Energy Theft Evolution – Residential Clients

Direct connection to the low voltage grid → Meter tampering V 1.0 → Meter tampering V 2.0 → **"Cirque du Soleil" theft**

More Energy Theft – Corporate Clients

Disconnected wires → Electronic Fraud

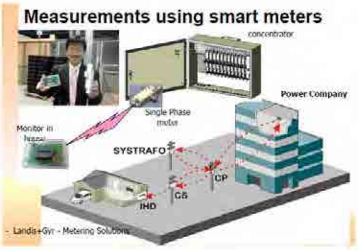
Due to:

- High tariffs
- Inadequate instruments to inspect the clients
- Employees corruption (wages vs. bribe value)
- Clients corruption (average billed value vs. bribe value)
- Difficult access to the clients facilities
- (access time vs. time to disassemble the fraud)
- Metering system cabin is built by 3rd parties
- (fraud arranged by the constructor)

More Energy Theft – Corporate Clients

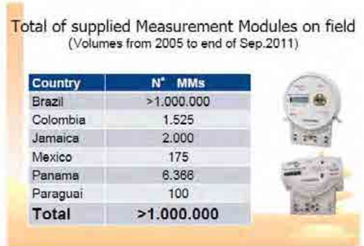
Disconnected wires → **Electronic Fraud**

Changing conductors polarity



Measurements using smart meters

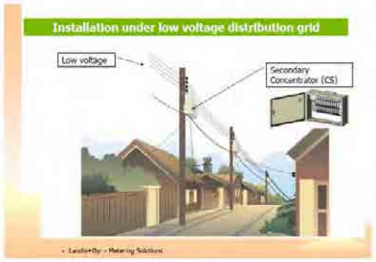
- Landis+Gyr - Metering Solutions



Total of supplied Measurement Modules on field

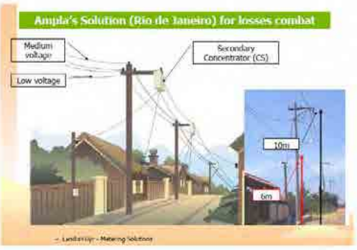
(Volumes from 2005 to end of Sep.2011)

Country	N° MMs
Brazil	>1.000.000
Colombia	1.525
Jamaica	2.000
Mexico	175
Panama	6.366
Paraguai	100
Total	**>1.000.000**



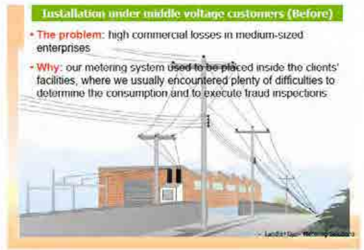
Installation under low voltage distribution grid

- Landis+Gyr - Metering Solutions



Ampla's Solution (Rio de Janeiro) for losses combat

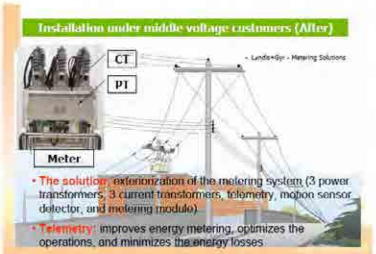
- Landis+Gyr - Metering Solutions



Installation under middle voltage customers (Before)

- **The problem**: high commercial losses in medium-sized enterprises
- **Why**: our metering system ~~used to be placed~~ inside the clients' facilities, where we usually encountered plenty of difficulties to determine the consumption and to execute fraud inspections

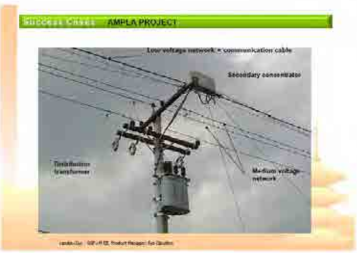
- Landis+Gyr - Metering Solutions



Installation under middle voltage customers (After)

- Landis+Gyr - Metering Solutions

- **The solution**: externalization of the metering system (3 power transformers, 3 current transformers, telemetry, motion sensor detector, and metering module)
- **Telemetry**: improves energy metering, optimizes the operations, and minimizes the energy losses



Success Cases AMPLA PROJECT

Presentation Materials of 3rd Workshop

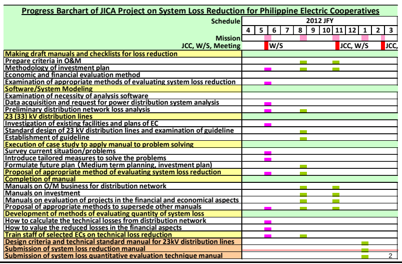
The 3rd Workshop on
The JICA Project on System Loss Reduction for Philippine Electric Cooperatives (EC's)

Overall Progress and Activities

JICA TA Team
Manila
The Philippines
May 31, 2011

THE TOKYO ELECTRIC POWER CO.,INC.

Schedule from May 2012



Progress Barchart of JICA Project on System Loss Reduction for Philippine Electric Cooperatives

Schedule: 2012 JFY — 4 5 6 7 8 9 10 11 12 1 2 3

Mission

JCC, W/S, Meeting: W/S; JCC, W/S; JCC,

- **Making draft manuals and checklists for loss reduction**
  - Prepare criteria in O&M
  - Methodology of investment plan
  - Economic and financial evaluation method
  - Examination of appropriate methods of evaluating system loss reduction
- **Software/System Modeling**
  - Examination of necessity of analysis software
  - Data acquisition and request for power distribution system analysis
  - Preliminary distribution network loss analysis
- **23 (33) kV distribution lines**
  - Investigation of existing facilities and plans of EC
  - Standard design of 23 kV distribution lines and examination of guideline
  - Establishment of guideline
- **Execution of case study to apply manual to problem solving**
  - Survey current situation/problems
  - Introduce tailored measures to solve the problems
  - Formulate future plan（Medium term planning, investment plan)
- **Proposal of appropriate method of evaluating system loss reduction**
- **Completion of manual**
  - Manuals on O/M business for distribution network
  - Manuals on investment
  - Manuals on evaluation of projects in the financial and economical aspects
  - Proposal of appropriate methods to supersede other manuals
- **Development of methods of evaluating quantity of system loss**
  - How to calculate the technical losses from distribution network
  - How to value the reduced losses in the financial aspects
- **Train staff of selected ECs on technical loss reduction**
- **Design criteria and technical standard manual for 23kV distribution lines**
- **Submission of system loss reduction manual**
- **Submission of system loss quantitative evaluation technique manual**

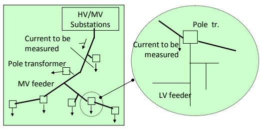
Contents in the Schedule

Tasks	Contents/Status
Making Draft Manuals and Checklist	(Starting)
Software /System Modeling	**•SynerGEE modeling** **•Investigation of methodologies of data arrangement**
Execution Case Study to Apply Manual to Problem Solving	**•SynerGEE modeling** **•Amorphous transformer pilot project**
23 kV (33 kV) Distribution Lines	**•Investigation of cost and specifications**

Goals
- **Proposal of Appropriate Method of Evaluating System Loss Reduction**
- **Completion Manuals**

Modeling Peak Load Situation with SynerGEE

Peak Load Allocation
⇩
Peak loss calculation for each feeder
⇩
Peak loss [kW]



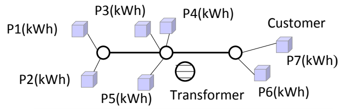
How to obtain the peak load data and maintain its data?

Peak Load Data Correction and Its Modeling

- Some options
  - Clamp-on meters measurement of peak current of pole transformers
  - Power solve data (ERC Data Templates) with customer data
  - MV feeders load measurement or purchasing amount of power -> load allocation

---

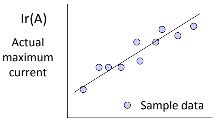
<Ref: TEPCO's Example> Computation of Load Current & Voltage Drop



Ie ＝ A × Σpi ＋ b
Maximum load current Ie is calculated
based on Σpi by using multiplier A & constant b
determined from the regional demand character
Voltage drop is also calculated

<Ref: TEPCO's Example> Relationship between Maximum Measured Current & Sales Energy

Ie ＝ A × Σpi ＋ b



Σ pi(kWh)
Summation of energy sales

Establish the Methodology of Peak Loss Estimation of Pole Transformers

- Clamp-on meters measurement of peak current of pole transformers
- Power solve data (ERC Data Templates) with customer data
- Customer billing data

⇕ Finding out their relations

Estimating peak loads at pole transformers

Establish the methodology of loss evaluation values

Peak Loss reduction	1	kW
Unit value	5	PHP/kWh
Loss factor	0.3	

Establish the Methodology of Peak Loss Evaluation Values

Method 1

Considering load growth, interest rate and inflation rate

Load growth	4	%/year
Interest rate	10	%/year
Inflation rate	3	%/year
Cost saving for 15 years	**196,729**	**PHP/kW/15 year**

* Assuming LF=0.3 5php/kWh

Method 2

Juts considering one-year cost saving multiplied by certain years

Cost saving for a year	13,140	PHP/year
Cost saving for 5 years	**65,700**	**PHP/kW/5 year**
Cost saving for 10 years	**131,400**	**PHP/kW/10 year**
Cost saving for 15 years	**197,100**	**PHP/kW/15 year**

- Other factors affecting: evaluation period, using PHP/kW
- Methodology to be formulated for evaluation

Resistance and Capacities of MV(13.2 kV) Line Conductors

Line Type	Resistance Three-phase ohms per phase per km. of line (source: **DX3430.48)**	Capacity (A)
336.4	0.173	530
266.8	0.217	460
4/0	0.274	340
3/0	0.345	300
2/0	0.436	270
1/0	0.55	230
2	0.876	180
4	1.391	140

Peak Loss in MV(13.2 kV) Lines (KW/km & million PHP/15years) (3 phase)

Line Type	Peak Current (A)	20	30	40	50	60	70	80	90	100	110	120	130	140	150	200
336.4	Loss (kW/km)	0.21	0.47	0.83	1.30	1.87	2.54	3.32	4.20	5.19	6.28	7.47	8.77	10.17	11.68	20.76
4/0		0.33	0.74	1.32	2.06	2.96	4.03	5.26	6.66	8.22	9.95	11.84	13.89	16.11	18.50	32.88
3/0		0.41	0.93	1.66	2.59	3.73	5.07	6.62	8.38	10.35	12.52	14.90	17.49	20.29	23.29	41.40
2/0		0.52	1.18	2.09	3.27	4.71	6.41	8.37	10.59	13.08	15.83	18.84	22.11	25.64	29.43	52.32
1/0		0.66	1.49	2.64	4.13	5.94	8.09	10.56	13.37	16.50	19.97	23.76	27.89	32.34	37.13	66.00
2		1.05	2.37	4.20	6.57	9.46	12.88	16.82	21.29	26.28	31.80	37.84	44.41	51.51	59.13	
4		1.67	3.76	6.68	10.43	15.02	20.45	26.71	33.80	41.73	50.49	60.09	70.52			

Line Type	Peak Current (A)	20	30	40	50	60	70	80	90	100	110	120	130	140	150	200
336.4	million PHP/km/15years	0.01	0.03	0.05	0.09	0.12	0.17	0.22	0.28	0.34	0.41	0.49	0.58	0.67	0.77	1.36
4/0		0.02	0.05	0.09	0.14	0.19	0.26	0.35	0.44	0.54	0.65	0.78	0.91	1.06	1.22	2.16
3/0		0.03	0.06	0.11	0.17	0.24	0.33	0.44	0.55	0.68	0.82	0.98	1.15	1.33	1.53	2.72
2/0		0.03	0.08	0.14	0.21	0.31	0.42	0.55	0.70	0.86	1.04	1.24	1.45	1.68	1.93	3.44
1/0		0.04	0.10	0.17	0.27	0.39	0.53	0.69	0.88	1.08	1.31	1.56	1.83	2.12	2.44	4.34
2		0.07	0.16	0.28	0.43	0.62	0.85	1.11	1.40	1.73	2.09	2.49	2.92	3.38	3.88	
4		0.11	0.25	0.44	0.69	0.99	1.34	1.75	2.22	2.74	3.32	3.95	4.63			

Total Cost including Construction for 15 years in Case of New MV(13.2 kV) Lines (3 Phase)

Line Type	Peak Current (A)	20	30	40	50	60	70	80	90	100	110	120	130	140	150	200
336.4	million PHP/km/15years	0.80	0.85	0.92	1.01	1.12	1.26	1.41	1.58	1.78	1.99	2.23	2.48	2.76	3.06	4.85
4/0		0.52	0.60	0.71	0.86	1.04	1.25	1.49	1.76	2.07	2.41	2.79	3.19	3.63	4.10	6.93
3/0		0.40	0.50	0.64	0.83	1.05	1.32	1.62	1.97	2.36	2.79	3.26	3.77	4.32	4.91	8.48
2/0		0.40	0.53	0.71	0.94	1.23	1.56	1.95	2.39	2.88	3.42	4.01	4.65	5.35	6.10	10.6
1/0		0.37	0.53	0.76	1.05	1.41	1.83	2.32	2.87	3.49	4.17	4.92	5.74	6.61	7.56	13.2
2		0.39	0.64	1.01	1.47	2.04	2.72	3.49	4.37	5.36	6.45	7.64	8.93	10.3	11.8	
4		0.46	0.87	1.45	2.19	3.09	4.16	5.39	6.79	8.36	10.1	12.0	14.0			

🟨 Suitable Size for Construction

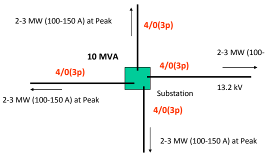
Total Cost including Construction for 5 years in Case of New MV(13.2 kV) Lines (3 Phase)

Line Type	Peak Current (A)	20	30	40	50	60	70	80	90	100	110	120	130	140	150	200
336.4	million PHP/km/5years	0.77	0.78	0.81	0.84	0.88	0.92	0.97	1.03	1.10	1.17	1.25	1.33	1.42	1.52	2.12
4/0		0.47	0.50	0.54	0.59	0.65	0.72	0.80	0.89	0.99	1.11	1.23	1.37	1.51	1.67	2.61
3/0		0.35	0.38	0.43	0.49	0.56	0.65	0.75	0.87	1.00	1.14	1.30	1.47	1.65	1.85	3.04
2/0		0.33	0.37	0.43	0.51	0.61	0.72	0.85	0.99	1.16	1.34	1.53	1.75	1.98	2.23	3.73
1/0		0.28	0.34	0.41	0.51	0.63	0.77	0.93	1.12	1.32	1.55	1.80	2.07	2.36	2.68	4.58
2		0.25	0.33	0.45	0.61	0.80	1.02	1.28	1.58	1.91	2.27	2.67	3.10	3.56	4.06	
4		0.24	0.38	0.57	0.82	1.12	1.47	1.88	2.35	2.87	3.45	4.08	4.76			

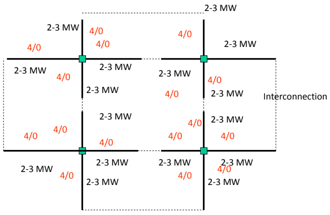
🟨 Suitable Size for Construction

- Standardized conductor size for bulk MV lines and MV system configuration for loss reduction and enhancement of power supply reliability to be established.

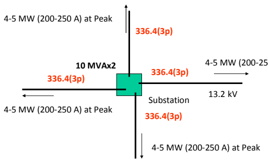
Example of MV (13.2 kV) System Configuration for Low Demand Density Area



Example of MV (13.2 kV) System Configuration with Interconnections for Low Demand Density Area



Example of MV (13.2 kV) System Configuration for High Demand Density Area



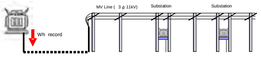
- Comparing 22 kV and 13.2 kV
  - Cost benefit analysis
  - Other factors

- Studying 22 kV System

Amorphous Transformer Pilot Project

(A) Replacement Project (Measurement conventional and amorphous transformer)

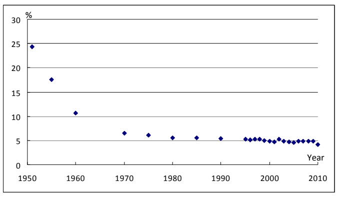
1. Load Data Measurement (with clamp-on meters for peak and off-peak)
2. Amorphous Transformers Measurement / Installation
3. Existing Pole-transformers Measurement with a Power Tester
4. Estimate Loss Reduction with Amorphous Transformers



(B) Splitting LV Loads Project

- Identifying locations with large voltage drops and heavy loads
- Installation of Amorphous Transformers
- Confirm its effects on loss reduction with using SynerGEE

<Ref> Transmission & Distribution Loss Ratio of TEPCO



<Ref> TEPCO's Distribution System

- Transmission system

  500 kV, 275 kV, 154 kV, 66 kV

- Distribution system

  22 kV : Three phase-four wires (Neutral point grounding)

  6.6 kV : Three phase-three wires (No-grounding)

  LV

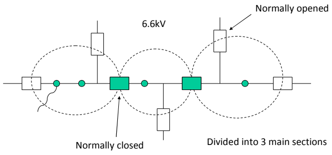
<Ref> 66/6.6kV Substation of TEPCO

Area	Scale
High demand density area	30 MVA x 3
Tokyo/ Urban areas surrounding Tokyo	20 MVA x 3
Other areas	10MVA x 3 or 2

Capacity of a transformer	Standard number of feeders
30 MVA	8
20 MVA	7
15 MVA	4
10 MVA	4

* 1 feeder: around 2-3MW at peak load

<Ref> System Configuration of 6.6kV Overhead System



- In case of a fault, one section can be supplied from another feeder.

<Ref> Capacity of Bulk Lines of 6.6 kV

		Capacity of Bulk lines	
		Capacity (A)	Short time capacity (A)
Overhead	Large Capacity	450-530*	600
	General	230-270*	300-360*
Underground	Large Capacity	400	600
	General	260	400

* Depending on the types of automatic control scheme or conductors

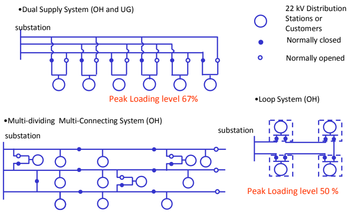
---

<Ref> Typical Conductors used for 22 kV and 6.6 kV system

	Type name	Size		Application
		Copper	Aluminum	
22 kV	HCVT-SS	200 mm^2	-	Large Cap.
	CVT-SS	100 mm^2	-	General
6.6 kV	SN-OC	-	HAL 240 mm^2 (0.122 Ω/km)	Large Cap.
	SN-OE	-	ACSR 120 m^2 (0.25 Ω/km) ACSR 32 mm^2 (0.928 Ω/km)	General

* Other types are used for salty areas etc.

22kV System



Sample Analysis of Medium Voltage Line Loss Reduction Measures and Propose for appropriate mechanism to transfer loss reduction method to all ECs

May 2012

Tokyo Electric Power Company, Inc.

---

1. Method of Loss Reduction for Medium Voltage Line
2. Sample Analysis of Loss Reduction for MV Line using SynerGEE
3. Propose for appropriate mechanism to transfer loss reduction method to all ECs
4. Incentive system (Introduction of Front-line Workplaces Activities in TEPCO)

Method of Loss Reduction for Medium Voltage Line

1.1 Method of Loss Reduction for Medium Voltage Line

Category		Countermeasure		Target Facilities	Remarks
Line	MV Line	Line Thickening		High Operation	Capable of displaying by color on SynerGEE
		Parallel Circuit		High Operation	
		Load Balancing		Unbalence line	Incapable of displaying by color on SynerGEE Only numerical results
		Capacitor placement/replacement		Low Power Factor line	
		Switching optimization		Multi-interconnection system	Effective method for multi-interconnection system
	LV Line	Line Thickening		High Operation	Capable of displaying by color on SynerGEE
Transformer & LV Line		Capacity Changing	Small -> Big	High Operation	Transformer: Incapable of displaying by color on SynerGEE Only numerical results
			Big -> Small	Low Operation	
		Load Dividing		High Operation	
		Load Centering		High Operation	

Method of Loss Reduction for Medium Voltage Line

1.2 Method of Loss Reduction for MV Line (1)

Review of 2nd work shop

<Line Thickening>

- Thicken MV line to upper size
- For high operation ratio MV line
- Lower operation ratio of MV line

✓ High operation ratio

✓ Lower operation ratio

Reduction of line loss

Method of Loss Reduction for Medium Voltage Line

1.2 Method of Loss Reduction for MV Line (1)

Review of 2nd work shop

Line Type : 1/0	Line Type : 4/0
Length : 200m	Length : 200m
O.R. : 90% (207A)	O.R. : 61% (207A)
Loss : 4.71kW	Loss : 2.35kW

O.R. : Operation Ratio

- Cost for Measure

Construction Fee :	4/0 * 200m	44,087 PHP
Removal Fee :	1/0 * 200m	1,860 PHP

Subtotal : 45,947 PHP

- Amount of Money for Loss Reduction

Loss Reduction :	2.36kW	464,278 PHP

*Total loss reduction value:196,728PHP/kW

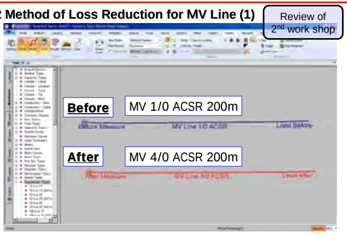
Subtotal : 464,278 PHP

Total Effect : 418,331 PHP

Method of Loss Reduction for Medium Voltage Line

1.2 Method of Loss Reduction for MV Line (1)

Review of 2nd work shop



Method of Loss Reduction for Medium Voltage Line

1.2 Method of Loss Reduction for MV Line (1)

Review of 2nd work shop

Before

MV	1/0	90% (207A)	3.98kW
		Subtotal	3.98kW

After

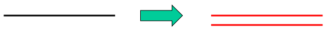
MV	4/0	61% (207A)	2.10kW
		Subtotal	2.10kW
		Loss Reduction	1.88kW

Method of Loss Reduction for Medium Voltage Line

1.3 Method of Loss Reduction for MV Line (2)

<Parallel Circuit>

- Install new MV line
- For high operation ratio MV line
- Lower operation ratio of MV line



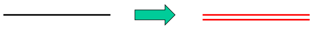
✓ High operation ratio

✓ Lower operation ratio

Reduction of line loss

Method of Loss Reduction for Medium Voltage Line

1.3 Method of Loss Reduction for MV Line (2)



Line Type : 4/0
Length : 200m
O.R. : 90% (306A)
Loss : 5.13kW
O.R. : Operation Ratio

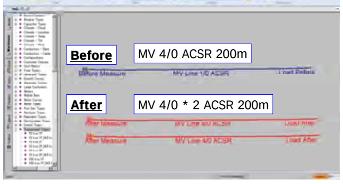
Line Type : 4/0 * 2
Length : 200m
O.R. : 45% (153A)
Loss : 1.28*2=2.57kW

- Cost for Measure
  Construction Fee : 4/0 * 200m 44,087 PHP
  Subtotal : 44,087 PHP
- Amount of Money for Loss Reduction
  Loss Reduction : 2.56kW 503,623 PHP
  *Total loss reduction value:196,728PHP/kW
  Subtotal : 503,623 PHP

Total Effect : 459,536 PHP

Method of Loss Reduction for Medium Voltage Line

1.3 Method of Loss Reduction for MV Line (2)



Method of Loss Reduction for Medium Voltage Line

1.3 Method of Loss Reduction for MV Line (2)

Before

MV	4/0	90% (306A)	4.59kW
		Subtotal	4.59kW

After

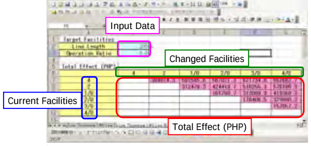
MV	4/0	50% (153A)	1.15kW
MV	4/0	50% (153A)	1.15kW
		Subtotal	2.30kW
		Loss Reduction	2.29kW

Method of Loss Reduction for Medium Voltage Line

1.4 Evaluation of suitable size for MV line (1)

Review of 2nd work shop

< Line Thickening >

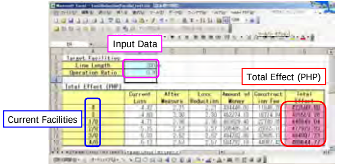


✓ Input line length and operation ratio
✓ Capable of checking total effect of loss reduction

Method of Loss Reduction for Medium Voltage Line

1.5 Evaluation of suitable size for MV line (2)

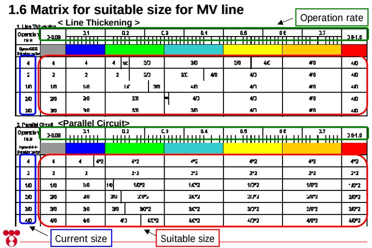
<Parallel Circuit>



✓ Input line length and operation ratio
✓ Capable of checking total effect of loss reduction

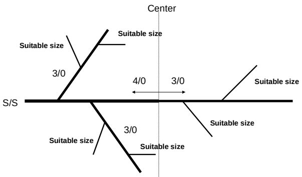
Method of Loss Reduction for Medium Voltage Line

1.6 Matrix for suitable size for MV line



Method of Loss Reduction for Medium Voltage Line

1.7 Image of ideal MV line system based on loss reduction evaluation

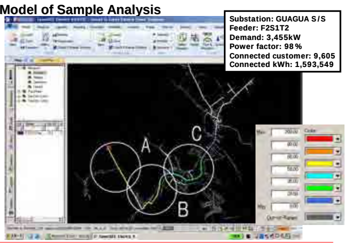


---

1. Method of Loss Reduction for Medium Voltage Line
2. **Sample Analysis of Loss Reduction for MV Line using SynerGEE**
3. Propose for appropriate mechanism to transfer loss reduction method to all ECs
4. Incentive system (Introduction of Front-line Workplaces Activities in TEPCO)

Sample Analysis of Loss Reduction for MV Line using SynerGEE

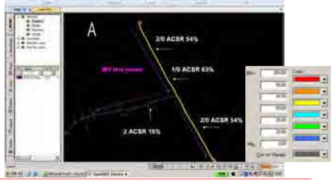
2.1 Model of Sample Analysis



Substation: GUAGUA S/S
Feeder: F2S1T2
Demand: 3,455kW
Power factor: 98%
Connected customer: 9,605
Connected kWh: 1,593,549

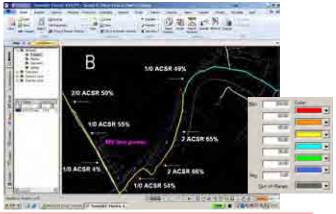
Sample Analysis of Loss Reduction for MV Line using SynerGEE

2.2 Result of Sample Analysis before countermeasure(A)



Sample Analysis of Loss Reduction for MV Line using SynerGEE

2.2 Result of Sample Analysis before countermeasure(B)

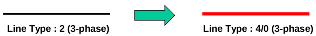


Sample Analysis of Loss Reduction for MV Line using SynerGEE

2.2 Result of Sample Analysis before countermeasure(C)

Sample Analysis of Loss Reduction for MV Line using SynerGEE

2.3 Necessary countermeasure for loss reduction



Line Type : 2 (3-phase)
Length : 767m

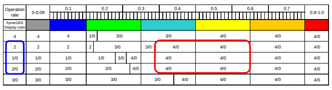
Line Type : 4/0 (3-phase)
Length : 767m

Line Type : 1/0 (3-phase)
Length : 2,212m

Line Type : 4/0 (3-phase)
Length : 2,212m

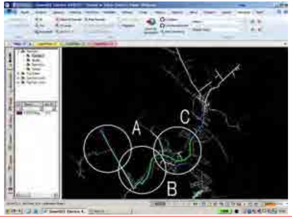
Line Type : 2/0 (3-phase)
Length : 1,187m

Line Type : 4/0 (3-phase)
Length : 1,187m



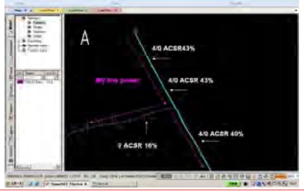
Sample Analysis of Loss Reduction for MV Line using SynerGEE

2.4 Result of Sample Analysis before countermeasure



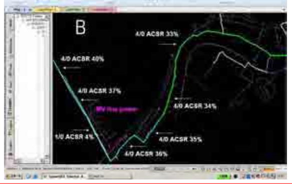
Sample Analysis of Loss Reduction for MV Line using SynerGEE

2.4 Result of Sample Analysis before countermeasure (A)



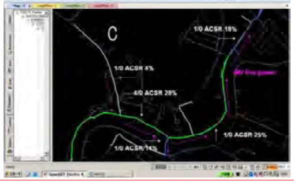
Sample Analysis of Loss Reduction for MV Line using SynerGEE

2.4 Result of Sample Analysis before countermeasure (B)



Sample Analysis of Loss Reduction for MV Line using SynerGEE

2.4 Result of Sample Analysis before countermeasure (C)



Sample Analysis of Loss Reduction for MV Line using SynerGEE

2.5 Effect of countermeasure

- Cost for Measure

Construction Fee :	4/0 * 4,166m	1,884,940 PHP
Removal Fee :	2 * 767m	11,190 PHP
	1/0 * 2,212m	43,165 PHP
	2/0 * 1,187m	28,792 PHP

Subtotal : 1,968,087 PHP

Construction Fee :	4/0(3-phase)	452,458 PHP/km
Removal Fee :	2(3-phase)	14,590 PHP/km
	1/0(3-phase)	19,514 PHP/km
	2/0(3-phase)	24,256 PHP/km

- Amount of Money for Loss Reduction (result from SynerGEE)

Loss Reduction : 64.5kW 12,688,956 PHP

Before: 308.2kW
After: 243.7kW

*Total loss reduction value:196,728PHP/kW

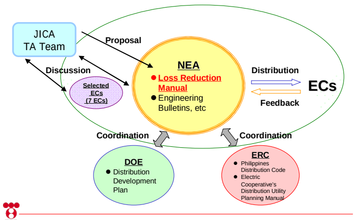
Subtotal : 12,722,526 PHP

Total Effect : 10,720,869 PHP

1. Method of Loss Reduction for Medium Voltage Line
2. Sample Analysis of Loss Reduction for MV Line using SynerGEE
3. **Propose for appropriate mechanism to transfer loss reduction method to all ECs**
4. Incentive system (Introduction of Front-line Workplaces Activities in TEPCO)

Propose for appropriate mechanism to transfer loss reduction method to all ECs

3.1 Image of establishment of Loss Reduction Manual



Propose for appropriate mechanism to transfer loss reduction method to all ECs

3.2 Draft Contents of Manual

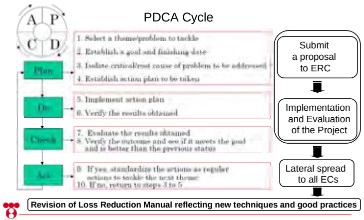
1 **Introduction**
2 **Economic Values of Technical Loss Reduction**
3 **Methodology of O&M for Data Arrangement of Loss Analysis**
4 **Identifying Countermeasures against Technical Losses for Low Voltage System**
5 **Identifying Countermeasures against Technical Losses for Medium Voltage System**
6 **Installation of Substations / Upgrading Voltage of Medium Voltage System**

7 **Non-technical Loss Reduction**

Important to revise periodically for reflecting new techniques and good practices

Propose for appropriate mechanism to transfer loss reduction method to all ECs

3.3 Revision method of Loss Reduction Manual



1. Select a theme/problem to tackle
2. Establish a goal and finishing date
3. Isolate critical/root cause of problem to be addressed
4. Establish action plan to be taken
5. Implement action plan
6. Verify the results obtained
7. Evaluate the results obtained
8. Verify the outcome and see if it meets the goal and is better than the previous status
9. If yes, standardize the actions as regular actions to tackle the next theme
10. If no, return to steps 3 to 5

Submit a proposal to ERC

Implementation and Evaluation of the Project

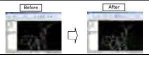
Lateral spread to all ECs

Revision of Loss Reduction Manual reflecting new techniques and good practices

Propose for appropriate mechanism to transfer loss reduction method to all ECs

3.4 Sample of Loss Reduction Sheet

Good Practices for System Loss Reduction

No.	PELCO-99(Sample)
EC Name	PELCO2
Project Name	Backbone Line Thickening
Outline of Project	Find out the main loss generation point of MV line by analyzing MV distribution line using SynerGEE. Change the conductor from 2 ACSR, 1/0 ACSR, 2/0 ACSR to 4/0 ACSR.
Picture	 Before After
Project Piriod	From May, 2012 to Octorber 2012
Estimate Loss Reduction	Amount of Money for Loss Reduction (result from SynerGEE) Loss Reduction : 64.5kW
Real Loss Reduction	Plan to measure the actual line after completion of work
Project Cost	Construction Fee : 4/0 * 4,166m 1,884,940 PHP Removal Fee : 2 * 767m = 11,190 PHP, 1/0 * 2,212m = 43,165 PHP, 2/0 * 1,187m = 28,792 PHP **Total : 1,968,087 PHP**
Benefit	Loss Reduction: 64.5kW (Before: 308.2kW, After: 243.7kW) *Total loss reduction value:196,728PHP/kW Benefit from loss reduction: 12,722,526 PHP **Total benefit: 10,720,869 PHP**
IRR	
Remark (if it has)	

1. Method of Loss Reduction for Medium Voltage Line
2. Sample Analysis of Loss Reduction for MV Line using SynerGEE
3. Propose for appropriate mechanism to transfer loss reduction method to all ECs
4. **Incentive system (Introduction of Front-line Workplaces Activities in TEPCO)**

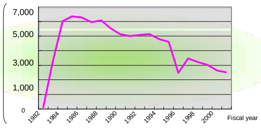
Incentive system (Introduction of Front-line Workplaces Activities in TEPCO)

4.1 Quality Control (QC) Circle Activity (not only loss reduction activities but all activities)

Background

- High demand for the quality of electric power and services
- Necessity of the cost reduction
- Necessity of the company system reform

Steps toward activity of reform



Incentive system (Introduction of Front-line Workplaces Activities in TEPCO)

4.2 Priority Issue (PI) Solving Activity

Change from QC circle activity to PI solving activity

Lately issue

- To associate the name of circle activity with extra activity from work and compulsory work
- No means for requesting reforms to other section and management division
- To assume that it must be completed within own section

Point of review

- Change in name to PI solving activity
- Assessment of tackling to other section
- Establishment of means for requesting reforms to other section and management division through changing of manual

PI solving activity Start！
FY 1995

Incentive system (Introduction of Front-line Workplaces Activities in TEPCO)

4.3 Business Improvement Activity

- Accessible and Immediate Improvement, which Employees voluntarily think, devise and do by themselves (since 1956)

ex) Reuse of blank backside of Printed Papers,
Creation of Guide for exceptional billing treatment,
Creation of Administration table for taking out mobile PCs

- Target is to pursue mobility and a number of proposals
- Rewarded with 500 to 15,000 PHP according to estimation at their office
- "Petit Improvement" * is acceptable since 2003

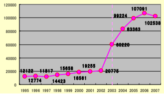


Fig. The number of proposals in recent years

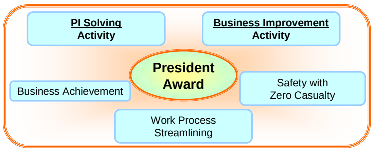
* This Proposal level is not so high but estimated as "Improvement" in any way

ex) Reuse of Post-it (Sticky note),
Posting of Reminders on car doors for ensuring parking-break

Incentive system (Introduction of Front-line Workplaces Activities in TEPCO)

4.4 President Award System

- TEPCO incorporate "Business Improvement Activity" and "PI solving activity" into President Award System



- Remarkable Cases can be rewarded as the President Award
- Maximum Reward Incentive is 250,000 PHP

Presentation Materials of Final (4th) Workshop

The Final Workshop on "The Project on System Loss Reduction for Philippine Electric Cooperatives (EC's)"

Manila, February 28, 2013
National Electrification Administration (NEA)
Japan International Cooperation Agency (JICA)
assisted by
Tokyo Electric Power Company (TEPCO)

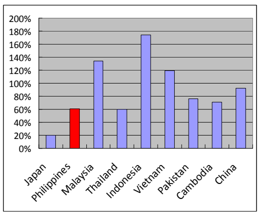
Overall Project Activities and Outline of System Loss Reduction Manual

The Final Workshop
on
"The Project on System Loss Reduction for Philippine Electric Cooperatives (EC's)"
Feb. 28, 2013
Masaharu Yogo
JICA Technical Assistance Team/TEPCO

Background

- The rate of self-sufficient of energy in the Philippines is low compared with other Asian countries. Energy policies state the enhancement of energy efficiency in the Philippines.
- For years both NEA and ECs have come up with strategic initiatives that will reduce power distribution loss levels.
- NEA sought the assistance of JICA which sent the Technical Assistance Team to provide necessary support to develop technical capacity and planning abilities of ECs to reduce distribution system losses.

Self Sufficient Energy Ratios of Asian Countries



Source: Energy Balances of OECD / non-OECD Countries 2009

Purposes

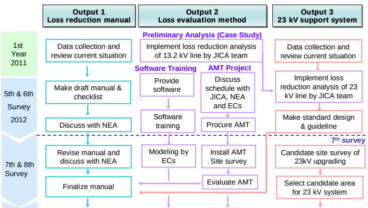
- The main purpose of this Project is to provide necessary support to improve the skills for loss reduction planning and its technology of NEA and ECs.

  7 targeted ECs
  - ISELCO I (Isabela 1)
  - PELCO II (Pampanga 2)
  - FLECO (First Laguna)
  - CASURECO II (Camarines Sur 2)
  - CASURECO IV (Camarines Sur 4)
  - SORECO I (Sorsogon 1)
  - LEYECO III (Leyte 3)

Goals

- **Output 1:** Total management manuals for system loss reduction
  - To support NEA and EC staff in the smooth implementation of the power distribution loss reduction plans by summarizing their procedures.
- **Output 2:** Support for quantitative evaluation of system loss
  - To introduce Software with mapping fuctions
  - Amorphous Distribution Transformer Pilot Project
- **Output 3:** Support for upgrading the present mid-voltage to 23kV and its technical design standards

Workflow carried out since Mar.2011



Output 1
Loss reduction manual

Output 2
Loss evaluation method

Output 3
23 kV support system

1st Year 2011

5th & 6th Survey 2012

7th & 8th Survey

9th Survey

Preliminary Analysis (Case Study)

Software Training

AMT Project

7th survey

Data collection and review current situation

Make draft manual & checklist

Discuss with NEA

Revise manual and discuss with NEA

Finalize manual

Implement loss reduction analysis of 13.2 kV line by JICA team

Provide software

Software training

Modeling by ECs

Discuss schedule with JICA, NEA and ECs

Procure AMT

Install AMT Site survey

Evaluate AMT

Data collection and review current situation

Implement loss reduction analysis of 23 kV line by JICA team

Make standard design & guideline

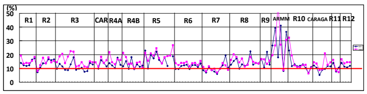
Candidate site survey of 23kV upgrading

Select candidate area for 23 kV system

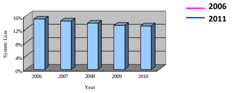
Report results of overall activities

ECs' Distribution Loss Ratios

ECs loss ratio

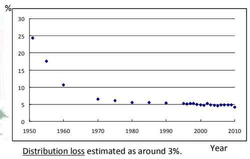


Averaged ECs loss ratio



Some ECs could achieve single digit loss ratio. But more could be reduced.

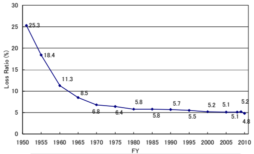
TEPCO's Transmission & Distribution Loss Ratio



Distribution loss estimated as around 3%.

	TEPCO
Maximum Peak Demand	64.3GW (recorded Jul. 2001)
Sales	293.4TWh (2010)

Japanese Utilities' Transmission & Distribution Loss Ratios



	Japanese 9 Utilities
Maximum Peak Demand	181.3GW (recorded Jul. 2001)
Sales	912.1TWh (2007)

Counterpart Training in Japan Mar.2012 & Sep.-Dec.2012

- Participants visited the Japanese Major Manufacturers.
- Various distribution facilities in Tokyo and Shikoku were good reference to understand urban distribution system of Japan.

Technical Situations of Some ECs - From the Results of Site Surveys in 2011

- There are some;
  - substations with its heavy load
    - CASURECOII, ISELCOI, FLECO, etc.
  - large length medium voltage lines and their single phase lines
    - CASURECOII, CASURECOIV, etc.
  - pole transformers with too much capacities or insufficient capacities
    - most Ecs
  - too much technical loss
    - SORECOI, etc.

JICA provided Clamp-on Meters targeted ECs and NEA.

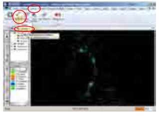
AMDT Project

- On mid of Nov. 2012 JICA and three ECs (FLECO, ISELCO1 and PELCO2) conducted Factory Test of Amorphous Distribution Transformers at Philec factory and they received 9 AMDTs each from JICA.
- EC staff could measure the effects of amorphous with their own measurement equipments and confirm the superiority of the amorphous transformers.

Distribution Analysis Software

- **PowerSolve**
- Suitable for Segregation of Distribution System Losses
- **SynerGEE**
- Mapping image, detailed results of loss causing locations and easy to find out loss reduction options

JICA provided targeted ECs and NEA with SynerGEE and its training course.



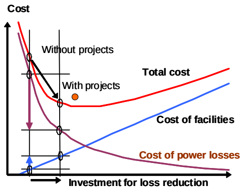
Contents of Loss Reduction Manual

- Introduction
- Economic Evaluation for Technical Loss Reduction
- Methodology of O&M for Data Arrangement of Loss Analysis
- Identifying Countermeasures against Technical Losses for the LV System
- Identifying Countermeasures against Technical Losses for MV System
- New Installation of Distribution Substation and Upgrading MV Network
- Using SynerGEE
- Non-Technical Loss Reduction Activities → Summarizing NEA&ECs know-how.

Description of Manual

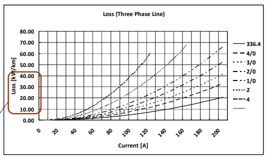
- Economical Evaluation
- Utilizing Distribution Software
- Adoption of larger size conductors
- Recommendation to the selection of the appropriate sizes of transformers
- Loss reduction effects of the amorphous transformers
- Criteria for application of 23 kV
- Summary of the activities for non-technical loss reduction by NEA and ECs.

Concept of Seeking Appropriate Measures for Loss Reduction



Conductor Losses

	Current Capacity [A]
336.4	530
4/0	340
3/0	300
2/0	270
1/0	230
2	180
4	140



Conductor 1 km loss sometimes reaches an amount of load of a pole transformer !

Summary and Recommendation

•Utilization of Manual and Distribution Analysis Software
•Upgrading Medium Voltage to 23kV
•Application of Amorphous Transformers

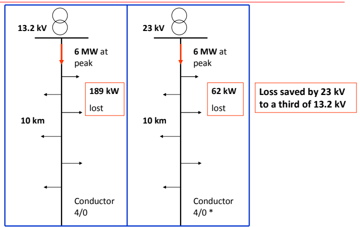
Utilization of Manual and Distribution Analysis Software

- The System Loss Reduction Manual has been prepared and quantitative evaluation of system loss using the distribution analysis software would be supported.
- The institutional promotion system of Manual should be established by NEA and ECs to become able to implement its recommendation and revise them in case of change in the situations.
- Database should be maintained to promote to making system models on the distribution analysis software.
- We recommend that many loss reduction plans should be looked into that are able to yield benefits far exceeding costs for its measures by utilization of this Manual.

Upgrading Medium Voltage to 23kV

- The voltage upgrading of medium voltage systems was preliminary studied and its technical guideline was recommended in the Manual.
- It can be found out that in some cases the application of 23 kV may be superior to 13.2 kV from the economic point of view.
- We recommend that the detailed studies should be implemented for the evaluation of the candidate sites of 23 kV upgrading regarding their feasibility, costs and benefits brought by loss reduction.

An Example of 23kV Upgrading



*but, conductor 336.4 may be more preferable.

Effects of 23kV Upgrading

- We can expect,

The Technical Loss Reduction

Max. 60% down for MV System

(20% for Whole System)

The Extension of Power Supply Area

Max. 70% up

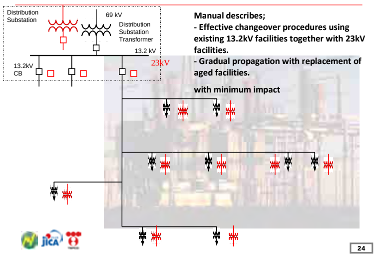
(Improvement of Voltage Drop)

The Capacity Reinforcement

Max. 70% up per feeder

(In terms of Supply Power)

23kV Upgrading



Manual describes;
- Effective changeover procedures using existing 13.2kV facilities together with 23kV facilities.
- Gradual propagation with replacement of aged facilities.

with minimum impact

Application of Amorphous Transformers

- The amorphous transformer pilot project has been executed. Its effects on loss reduction could be confirmed.
- We recommend that the installation of amorphous transformers should be promoted in all the ECs with their adequate economic evaluation.

Thank you!

Final Work Shop on
"The Project on System Loss Reduction for Philippine Electric Cooperatives (EC's)"

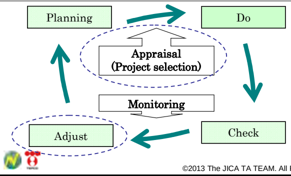
Economical Evaluation for Technical Loss Reduction

Takayuki Shibata / JICA TA TEAM
28th February, 2013

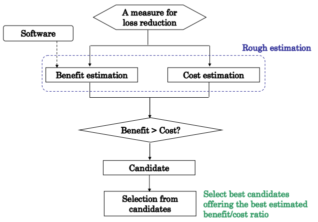
Interactive Four Step Management

Objectives of economical analysis

- Ascertain whether the investment in a planned project is valid from financial aspects.
- Ascertain whether an ongoing project is operating as effectively as planned.



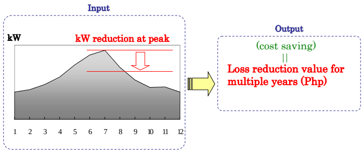
Project Assessment



Rough Benefit Estimation for Loss Reduction

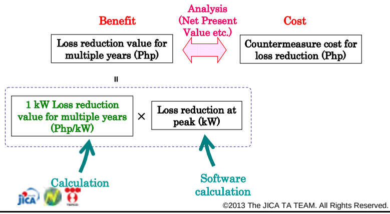
Quick benefit estimation

- Cost saving (=loss reduction value) is estimated by loss reduction (kW) at peak.

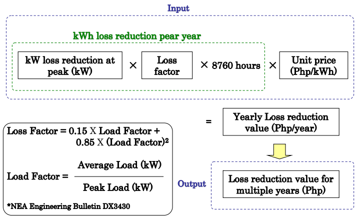


Rough Benefit Estimation for Loss Reduction

- Loss reduction value can be obtained using 1 kW loss reduction value (Php/kW) easily



Rough Benefit Estimation for Loss Reduction



$$\text{Loss Factor} = 0.15 \text{ X Load Factor} + 0.85 \text{ X (Load Factor)}^2$$

$$\text{Load Factor} = \frac{\text{Average Load (kW)}}{\text{Peak Load (kW)}}$$

*NEA Engineering Bulletin DX3430

Example of Economical Analysis

Line Type : 1/0	Line Type : 4/0
Length : 200m	Length : 200m
O.R. : 90% (207A)	O.R. : 61% (207A)
Loss : 3.98kW	Loss : 2.10kW

O.R. : Operation Ratio

- Cost for Measure

Construction Fee :	4/0 * 200m	44,087 Php
Removal Fee :	1/0 * 200m	1,860 Php

Subtotal : 45,947 Php

- Benefit for Loss Reduction

Benefit :	1.88kW	368,725 Php

Subtotal of 15y NPV : 368,725 Php

Unit Price/kWh	5.00Php
Interest Rate	10%
Inflation Rate	3%
Annual Load Growth	4%

Total Effect : 322,778 Php

Economical Analysis (Payback Period)

<Example> Line reinforcement from 1/0 (90%) to 4/0 (61%)

Year	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	Total
Loss reduction value (a)	0	27,437	30,566	34,052	37,936	42,262	47,082	52,452	58,434	65,098	67,051	69,062	71,134	73,268	75,466	77730	751,299
Countermeasure cost (b)	-45,947	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-45,947
Cashflow (c) = (a) + (b)	-45,947	27,437	30,566	34,052	37,936	42,262	47,082	52,452	58,434	65,098	67,051	69,062	71,134	73,268	75,466	77,730	705,351

$CF_1 = 27,437$ [Php] < 45,947 [Php]

$CF_1+F_2 = $ **58,003** [Php] > 45,947 [Php]

The expected payback period is "2 years"

Economical Analysis (Net Present Value)

<Example> Line reinforcement from 1/0 (90%) to 4/0 (61%)

Year	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	Total
Loss reduction value (a)	0	27,437	30,566	34,052	37,936	42,262	47,082	52,452	58,434	65,098	67,051	69,062	71,134	73,268	75,466	77730	751,299
Countermeasure cost (b)	-45,947	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-45,947
Cashflow (c) = (a) + (b)	-45,947	27,437	30,566	34,052	37,936	42,262	47,082	52,452	58,434	65,098	67,051	69,062	71,134	73,268	75,466	77,730	705,351

Discounted at 10% as discount rate

Present value of cashflow	-45,947	24,943	25,261	25,584	25,911	26,241	26,577	26,916	27,260	27,608	25,851	24,206	22,666	21,223	19,873	18,608	322,778

$$\sum_{i=0}^{n} Cf_i/(1.1)^i = -45{,}947 + 27{,}437/1.1 + 30{,}566/(1.1)^2 + \ldots + 77{,}730/(1.1)^{15}$$

$$= +322{,}778\ [\text{Php}] > 0$$

- Taking into account the value of time, the expected cash flow in the future is discounted into "present value" with "discount rate"
- The sum of present value is positive (+322,778)
  -The return of this project will satisfy investors expectation

Economical Analysis (IRR)

<Example> Line reinforcement from 1/0 (90%) to 4/0 (61%)

Year	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	Total
Loss reduction value (a)	0	27,437	30,566	34,052	37,936	42,262	47,082	52,452	58,434	65,098	67,051	69,062	71,134	73,268	75,466	77730	751,299
Countermeasure cost (b)	-45,947	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-45,947
Cashflow (c) = (a) + (b)	-45,947	27,437	30,566	34,052	37,936	42,262	47,082	52,452	58,434	65,098	67,051	69,062	71,134	73,268	75,466	77,730	705,351

Discounted at "r" as discount rate

$$\sum_{i=0}^{n} Cf_i/(1+r)^i = -45{,}947 + 27{,}437/(1+r) + 30{,}566/(1+r)^2 + \ldots + 77{,}730/(1+r)^{15} = 0$$

r=70.8%

- IRR (Internal Rate of Return) is a discount rate that results in net present value of zero for a series of cash flow
- IRR is greater than the discount rate (10%)
  -The Project is attractive to investors

Thank you for your attention!

Final Work Shop on
"The Project on System Loss Reduction for Philippine Electric Cooperatives (EC's)"

Methodology of O&M for Data Arrangement
of Loss Analysis
Identifying Countermeasures against Technical Losses
for the Low Voltage System

Junichi OHISHI / JICA TA Team
28th February, 2013

Contents of This Presentation

1. **Contents of Chapter 3**
2. **Outline of Chapter 3**
3. **Brief Explanation of Ch.3**
4. **Contents of Chapter 4**
5. **Outline of Chapter 4**
6. **Brief Explanation of Ch.4**
7. **Contents of Chapter 7**
8. **Brief Explanation of Ch.7**

1. Contents of Chapter 3

Chapter 3

◆ Title

Methodology of O&M for Data Arrangement of Loss Analysis

◆ Composition of this chapter

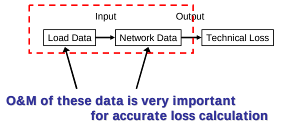
3.1. Network data
3.2. Load data

2. Outline of Chapter 3

◆ Outline

Methodology about O&M of data for loss analysis is explained in this chapter.

- Image of Technical Loss Calculation

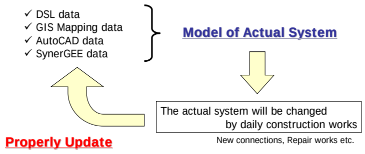


O&M of these data is very important for accurate loss calculation

3. Brief Explanation of Ch. 3

◆ Section 3.1 Network Data

- Examples of Network Data



✓ DSL data
✓ GIS Mapping data
✓ AutoCAD data
✓ SynerGEE data

Model of Actual System

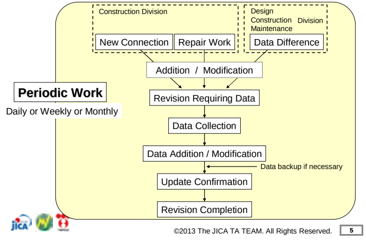
The actual system will be changed by daily construction works

New connections, Repair works etc.

Properly Update

3. Brief Explanation of Ch. 3

- General Work Flow of Data O&M Work



3. Brief Explanation of Ch. 3

◆ Section 3.2 Load Data

- Examples of Load Data

✓ Customer's Energy Consumption Data
✓ Feeder Current Data of Distribution Lines
✓ Distribution Transformer Load Data

Measured by Measurement Devices
Recorded by Engineering Staff

Two Important Items
1. **Proper Data Record and Storage**
2. **Time Consistency of Facilities and Data**

3. Brief Explanation of Ch. 3

- Proper Data Record and Storage

Load Data - Basically Recorded by Engineering Staff (Manual)

⇨ **Possibility of Errors or Lacks**

✓ **Confirm whether the data is peculiar or not**
✓ **Recorded by selected staff at a decided time**

- Time Consistency of Facilities and Data

Load Data - Changed by climate condition and system changes

⇨ **Carefully check the consistency of the timing between the load data and the facilities data**

4. Contents of Chapter 4

Chapter 4

◆ Title

Identifying Countermeasures against Technical Losses for Low Voltage System

◆ Composition of this chapter

4.1. Methodology of calculation of operating status of low voltage system
4.2. Options of countermeasures against technical losses caused in low voltage system

My part

4.3. Criteria of countermeasures against technical loss reduction
4.4. Recommended capacity of transformer and size of electric wire
4.5. Installation of amorphous using transformer

Mr. KEN's part

5. Outline of Chapter 4

◆ Outline

Countermeasures against technical losses for low voltage system is explained in this chapter.

◆ Section 1

It is important to grasp operating status of low voltage system.

⇨ Possible to find out facilities which need loss reduction

Two(2) methodologies are explained in this section.

1. Methodology based on DSL data
2. Methodology based on SynerGEE data → Chapter 7

◆ Section 2

General countermeasures are explained in this section.

✓ Explanation of each countermeasure

6. Brief Explanation of Ch. 4

◆ Section 4.1

Methodology of calculation of operating status of low voltage system

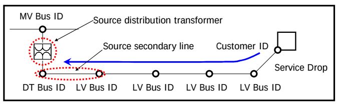
- Methodology based on the DSL data

✓ How to calculate operating status of low voltage system
✓ This section is based on the DSL data

Possible to obtain necessary information
- **Operation ratio of facilities**
- **Composition of facilities etc.**

6. Brief Explanation of Ch. 4

- Image of composition image of DSL data



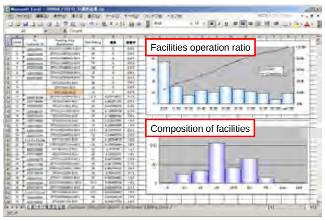
- Service drop line data
Confirm the connecting secondary line

Secondary Customer Service Drop ID	From Bus ID	To Customer ID
KSA0202181170	G13300950-DE1	0202181170

- Secondary line data
Connecting the secondary line
-> Distribution transformer

Secondary Distribution Line ID	From Bus ID	To Bus ID
OSA0080-CL	DT11240080U-BUS	G11240080-DE-CL

6. Brief Explanation of Ch. 4



6. Brief Explanation of Ch. 4

◆ Section 4.2

Options of countermeasures against technical losses caused in the low voltage system

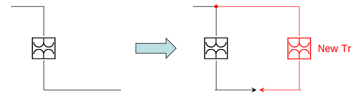
- Table of Countermeasures

Category	Countermeasure		Target Facilities
LV Line	Line Thickening		High Operation
Combination DT & LV Line	Capacity Changing	Small -> Big	High Operation
		Big -> Small	Low Operation
	Load Dividing		High Operation
	Load Centering		High Operation

6. Brief Explanation of Ch. 4

Example : Load Dividing

- Divide load of Tr and LV line (add a same capacity Tr)
- For high operation ratio Tr and/or LV line
- Lower operation ratio of Tr and LV line



✓ High operation ratio Tr and/or LV line

✓ Lower operation ratio

Reduction of load loss

7. Contents of Chapter 7

Chapter 7

◆ Title Using SynerGEE

◆ Composition of this chapter

7.1. Confirming the operating status of the distribution system — My part

7.2. Procedure of load allocation
7.3. Power flow analysis
7.4. Method of capacitor placement using SynerGEE
7.5. Method of switching optimization using SynerGEE
7.6. Load balancing improvement using SynerGEE
7.7. Phase balancing improvement using SynerGEE

Mr. Fujitani's part

8. Brief Explanation of Ch. 7

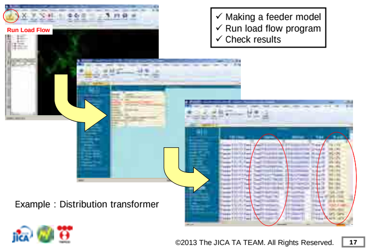
◆ Section 7.1

Options of countermeasures against technical losses caused in the low voltage system

- Composition of this section
  1. Implementation of load flow by SynerGEE
  2. Confirmation of operating status of distribution transformer
  3. Confirmation of operating status of low voltage line

Possible to obtain same information of Sec. 4.1. by using SynerGEE
- **Operation ratio of facilities**
- **Composition of facilities etc.**

8. Brief Explanation of Ch. 7



✓ Making a feeder model
✓ Run load flow program
✓ Check results

Example：Distribution transformer

Final Work Shop on
"The Project on System Loss Reduction for Philippine Electric Cooperatives (EC's)"

Economical Sizing of the Transformer and the Electric Wire of the Low Voltage System

- Introduction of AMDT Pilot Project-

KEN Kuwahara / JICA TA Team

28th February, 2013

Loss Reduction of Low Voltage Facilities

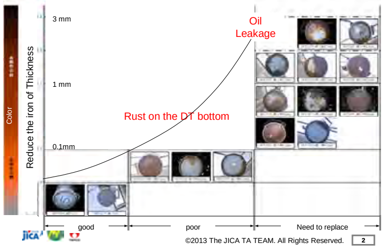
Contents

1. The study of economical sizing for transformer
2. The study of economical sizing for Low voltage line
3. The Pilot Study of Introduction AMDT

Concept to have Effective Low Voltage Facilities

1) Minimize the failures caused by overloaded conditions
2) Reduced core losses (Non-load losses) from inappropriate size
3) Reduced Copper losses (load losses) from inappropriate size
4) Minimize voltage fluctuation
5) Reduced voltage drop

Aged Power Transformer Condition



Permissible Overload of Transformer

Equivalent Load in % of Rated KVA Before Peak Load: 50 %

Hours of Peak Load	Ambient in Degrees C					
	0℃	10℃	20℃	30℃	40℃	50℃
1/2	200%	200%	200%	200%	194%	178%
1	200%	200%	195%	183%	169%	155%
2	189%	179%	169%	157%	145%	131%
4	163%	154%	145%	134%	123%	111%
8	145%	136%	127%	118%	108%	97%
24	128%	122%	111%	102%	92%	81%

The IEEE Guide for Loading Oil-Immersed Power Transformers

Economical Sizing for Pole Transformer

CH4 P★

Case Study

20kW loading

Transformer Capacity Size [kVA]	Actual Copper Loss [kW] (*1)	Energy Loss [W] (*2)	Annual Cost of Energy Loss [PHP] (*3)	PW Cost of Energy Loss [PHP] (*4)
10kVA	0.83	3,013	15,065	142,016
15 kVA	0.42	1,850	9,249	87,192
25 kVA	0.21	1,381	6,905	65,097
37.5 kVA	0.13	1,363	6,815	64,245

(*1)Actual Copper Loss [W] = (Peak Load / Transformer Capacity / Power Factor)2 * Rated Copper Loss [W]

(*2) Energy Loss [W] = (Actual Copper Loss [W]×Loss Factor[%] + Core Loss[W])× 8760[H]

(*3) Annual Cost of Energy Loss [PHP] = Energy Loss [W]×Unit price [PHP /kWh]

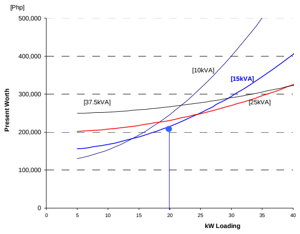
(*4) PW Cost of Energy Loss [PHP] for 30 years = Annual Cost of Energy Loss*(((1+10%)30-1) / 10% / (1+10%)30)

Transformer Size [KVA]	Initial Cost [PHP] (Table 4.4.3)	PW O&M Cost [PHP] (*1)	PW Cost of Energy Loss [PHP] (Table 4.4.5)	PW Total Cost [PHP]
10kVA	53,588	50,517	142,016	246,121
15 kVA	65,999	52,856	87,192	215,489
25 kVA	85,515	60,123	65,097	231,227
37.5 kVA	104310	68,216	64,245	266,889

(*1) PW O&M cost = (Initial Cost *10 %) * (((1+10%) ^ 30-1) / 10% / (1+10%) ^ 30)

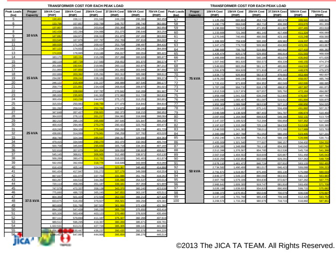
Result of the Case Study of TR Sizing

CH4 P★



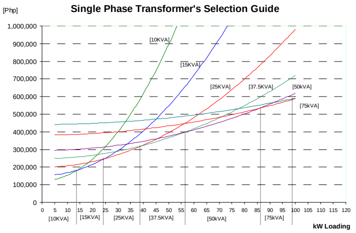
Summary : Economical Transformer Sizing

CH4 P★



Summary : Economical Transformer Sizing

CH4 P★



Low Voltage Wire Selection Method

CH4 P★

Precondition

Existing line size	ACSR 1/0
Existing line length	100 m
Operation ration	33 %
Evaluation period	5 years

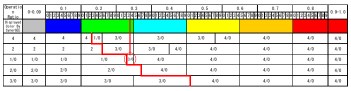
Loss of ACSR 1/0 Wire at 100m = 0.550Ω/km * (230A *0.33)^2*0.1km = 317 W
Loss of ACSR 2/0 Wire at 100m = 0.436Ω/km * (230A *0.33)^2 *0.1km = 251 W
Loss of ACSR 3/0 Wire at 100m = 0.345Ω/km * (230A *0.33)^2 *0.1km = 199 W
Loss of ACSR 4/0 Wire at 100m = 0.274Ω/km * (230A *0.33)^2 *0.1km = 158 W

Result of the case study

	Loss reduction value (PHP)	Construction fee (PHP)	Benefit (PHP)
Changing from ACSR1/0 to ACSR2/0	5,404	8,628	- 3,224
Changing from ACSR1/0 to ACSR3/0	9,718	9,227	492
Changing from ACSR1/0 to ACSR4/0	13,084	12,991	93

Summary : Economical LV Wire Sizing

CH4 P★



Operation Ratio	0-0.09	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9-1.0
Displayed Color By SynerGEE	▨	🟦	🟩	🟩		🟨	🟧		🟥	🟥
4	4	4	4 1/0 3/0	3/0		3/0 4/0	4/0		4/0	4/0
2	2	2	2 3/0	3/0	4/0	4/0	4/0		4/0	4/0
1/0	1/0	1/0	1/0	3/0 4/0		4/0	4/0		4/0	4/0
2/0	2/0	2/0	2/0	4/0		4/0	4/0		4/0	4/0
3/0	3/0	3/0	3/0	3/0		4/0	4/0		4/0	4/0

Methodology of DT Valuation

TOC：Total Owing Cost

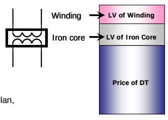
TOC = Price of DT + Loss Valuation* of DT
Initial Cost **Running Cost**

Loss Valuation (LV) of DT

LV of Iron Core + LV of Winding

LV of Iron Core = A* × No Load Loss
LV of Winding = B* × Load Loss

*A and B are factors which reflect investment plan, fuel cost, etc



Composition of DT Price

DT is valuated by not only the price of DT but also the amount of DT loss

Evaluation of AMDT Model Project

CH4 P★

REPLACEMENT AMDT from existing SiFe DT

About 20% loss reductions are expected

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%

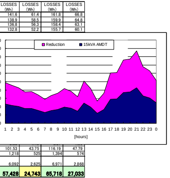
PELCO_2

[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%

CH4
P★

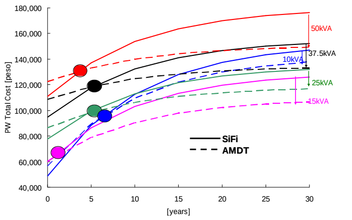
Actual Energy Loss Calculation of AMDT

		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					
6:00	8.34	170.3	132.2	124.5	78.3	114.9					
7:00	7.46	145.1	107.9	111.2	65.5	108.3					
8:00	8.19	165.8	127.8	122.1	76.0	113.7					
9:00	8.71	181.6	143.0	130.5	84.0	117.8					
10:00	9.54	208.7	169.1	144.9	97.8	124.9					
11:00	9.06	192.9	153.9	136.5	89.8	120.8					
12:00	7.98	159.5	121.8	118.8	72.8	112.0					
13:00	10.79	254.4	213.2	169.2	121.1	136.9					
14:00	9.51	207.8	168.3	144.4	97.4	124.7					
15:00	7.02	133.8	97.0	105.1	59.7	105.3					
16:00	8.70	181.1	142.6	130.3	83.8	117.7					
17:00	11.96	302.7	259.6	194.8	145.7	149.6					
18:00	12.01	304.5	261.3	195.7	146.6	150.0					
19:00	13.66	381.1	335.1	236.4	185.6	170.1					
20:00	13.77	386.5	340.4	239.3	188.4	171.6					
21:00	14.72	435.0	387.1	265.0	213.0	184.3					
22:00	12.80	340.0	295.6	214.6	164.7	159.4					
23:00	12.24	314.8	271.3	201.2	151.8	152.7					
0:00	10.88	258.1	216.7	171.1	123.0	137.9					
Average Load											
DAILY ENERGY LOS		5.79	4.81	3.89	2.75	3.20					
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%



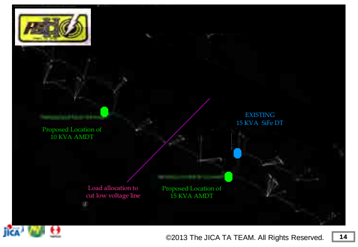
CH4
P★

Summary :
Economical TR Sizing (AMDT & SiFe)



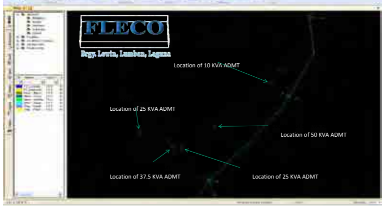
PELCO
2

From the Pilot Project Study PELCO2



FLECO

From the Pilot Project Study in FLECO



ISELCO

From the Pilot Project Study in ISELCO1

	Silicon	Amorphous
kWH Purchased/day	463	493
kWH Sales/day	384	423
System Loss (kWH)	78	70
System Loss (%)	17%	14%
Computed Core Loss kWH/day	9.22	2.33
Core Loss (%)	1.99%	0.47%
kWH Savings/day	6.89	

Final Work Shop on
"The Project on System Loss Reduction for Philippine Electric Cooperatives (EC's)"

Identifying Countermeasures against Technical Losses for Medium Voltage System

Keiichi Fujitani / JICA TA TEAM
28th Feburary, 2013

---

1. Method of Loss Reduction for Medium Voltage Line
2. Criteria for Taking Countermeasures against Technical Loss Reduction in the Medium Voltage System
3. Result of Study on Loss Reduction Project
4. Sample Analysis of Loss Reduction for MV Line using SynerGEE at FLECO

Method of Loss Reduction for Medium Voltage Line

1.1 Method of Loss Reduction for Medium Voltage Line

Category		Countermeasure	Target Facilities	Remarks
Line	MV Line	Line Thickening	High Operation	Requiring some amount of investment on facilities to reduce power losses
		Parallel Circuit	High Operation	
		Upgrading Voltage	High Operation	
		Capacitor Placement/ Replacement	Low Power Factor line	
		Phase Increasing	High Operation	
		Load Balancing	Unbalence line	Carrying out with small amount expenses through daily work
		Switching Optimization	Multi-interconnection system	Effective method for multi-interconnection system

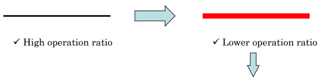
---

Method of Loss Reduction for Medium Voltage Line

1.2 Method of Loss Reduction for MV Line (1)

<Line Thickening>

- Thicken MV line to upper size
- For high operation ratio MV line



✓ High operation ratio

✓ Lower operation ratio

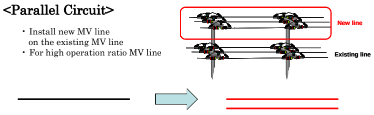
Reduction of line loss

Method of Loss Reduction for Medium Voltage Line

1.3 Method of Loss Reduction for MV Line (2)

<Parallel Circuit>

- Install new MV line on the existing MV line
- For high operation ratio MV line



✓ High operation ratio

✓ Lower operation ratio

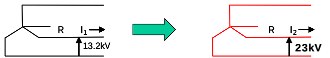
Reduction of line loss

Method of Loss Reduction for Medium Voltage Line

1.4 Method of Loss Reduction for MV Line (3)

<Upgrading Voltage >

- Upgrading MV Voltage from 13.2 to 23kV
- For high operation ratio MV line



$I_1 > I_2$
$RI_1^2 > RI_2^2$

✓ High operation ratio

✓ Lower operation ratio

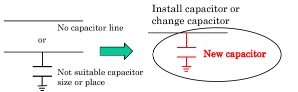
Reduction of line loss

Method of Loss Reduction for Medium Voltage Line

1.5 Method of Loss Reduction for MV Line (4)

<Capacitor Placement/Replacement >

- Install new capacitor or change capacitor location on the existing MV line
- For low power factor MV line



✓Improve power factor and voltage level

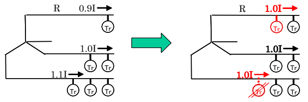
Reduction of line loss

Method of Loss Reduction for Medium Voltage Line

1.6 Method of Loss Reduction for MV Line (5)

<Load Balancing >

- Change the phase connection of pole transformer on the existing MV line
- For unbalanced phase current MV line



✓ Unbalance line

✓balance current

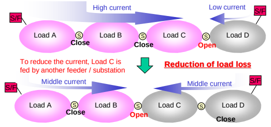
Reduction of line loss

Method of Loss Reduction for Medium Voltage Line

1.7 Method of Loss Reduction for MV Line (6)

<Switching Optimization >

- Leveling of the distribution load by switching at optimal point on the existing MV line
- For Multi-interconnection MV line system



To reduce the current, Load C is fed by another feeder / substation

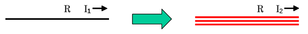
Reduction of load loss

Method of Loss Reduction for Medium Voltage Line

1.8 Method of Loss Reduction for MV Line (7)

<Phase Increasing >

- Increase the phase number on the existing MV line
- For high operation ratio MV line



✓ High operation ratio

$I_1 > I_2$
$RI_1^2 > RI_2^2$

✓ Lower operation ratio

Reduction of line loss

---

1. Method of Loss Reduction for Medium Voltage Line
2. Criteria for Taking Countermeasures against Technical Loss Reduction in the Medium Voltage System
3. Result of Study on Loss Reduction Project
4. Sample Analysis of Loss Reduction for MV Line using SynerGEE at FLECO

Criteria for Taking Countermeasures against Technical Loss Reduction in the Medium Voltage System

2.1 Conditions of study on medium voltage system

Economic Evaluation Study	5 years / 15 years
Load Factor	0.57
Unit Price per kWh	5 PHP/kWh
Inflation Rate	3%
Annual Growth Rate	4%
Discount Rate	10%
kW Value of load loss	82,291 PHP(5 years) / 237166 PHP(15 years)
kW Value of core loss	180,573 PHP(5 years) / 404,115 PHP(15 years)

The construction costs are calculated via the MATDX (FY2010)

Criteria for Taking Countermeasures against Technical Loss Reduction in the Medium Voltage System

2.2 Study example (Line Thickening)

Line Type : ACSR 2/0
Length : 1 km
Operation Ratio : 40%

Line Type : ACSR 4/0 or 336
Length : 1 km

* The loss reduction value and the construction fee, which include removable fee and O/M cost for 15 years

	Loss reduction value (PHP)	Construction fee (PHP)	Benefit (PHP)
Not change	0	0	0
Changing from ACSR2/0 to ACSR4/0	448,171	293,107	155,064
Changing from ACSR2/0 to ACSR336	727,538	485,724	241,814

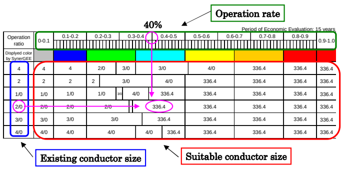
The line thickening from the ACSR2/0 size line to ACSR336 size line is most effective in this case.

---

1. Method of Loss Reduction for Medium Voltage Line
2. Criteria for Taking Countermeasures against Technical Loss Reduction in the Medium Voltage System
3. **Result of Study on Loss Reduction Project**
4. Sample Analysis of Loss Reduction for MV Line using SynerGEE at FLECO

Result of Study on Loss Reduction Project

3.1 Appropriate Line Thickening conductor sizes



Period of Economic Evaluation: 15 years

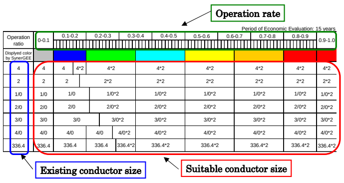
Operation ratio	0-0.1	0.1-0.2	0.2-0.3	0.3-0.4	0.4-0.5	0.5-0.6	0.6-0.7	0.7-0.8	0.8-0.9	0.9-1.0
4	4	4	2/0 3/0	3/0		4/0	336.4		336.4	336.4
2	2	2	2 3/0		4/0	336.4	336.4		336.4	336.4
1/0	1/0	1/0	1/0 3/0	4/0 336.4		336.4	336.4		336.4	336.4
2/0	2/0	2/0	2/0	336.4		336.4	336.4		336.4	336.4
3/0	3/0	3/0	3/0	336.4		336.4	336.4		336.4	336.4
4/0	4/0	4/0	4/0	4/0	336.4	336.4	336.4		336.4	336.4

* The loss reduction value and the construction fee, which include removable fee and O/M cost for 15 years

---

Result of Study on Loss Reduction Project

3.2 Appropriate conductors sizes of parallel circuit



Period of Economic Evaluation: 15 years

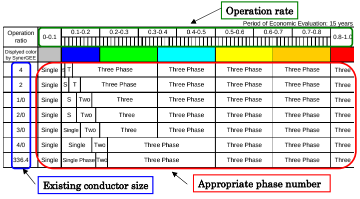
Operation ratio	0-0.1	0.1-0.2	0.2-0.3	0.3-0.4	0.4-0.5	0.5-0.6	0.6-0.7	0.7-0.8	0.8-0.9	0.9-1.0
4	4	4 4*2	4*2	4*2		4*2	4*2		4*2	4*2
2	2	2 2*2		2*2		2*2	2*2		2*2	2*2
1/0	1/0	1/0	1/0*2	1/0*2		1/0*2	1/0*2		1/0*2	1/0*2
2/0	2/0	2/0	2/0*2	2/0*2		2/0*2	2/0*2		2/0*2	2/0*2
3/0	3/0	3/0	3/0*2	3/0*2		3/0*2	3/0*2		3/0*2	3/0*2
4/0	4/0	4/0	4/0 4/0*2	4/0*2		4/0*2	4/0*2		4/0*2	4/0*2
336.4	336.4	336.4	336.4 336.4*2	336.4*2		336.4*2	336.4*2		336.4*2	336.4*2

* The loss reduction value and the construction fee, which include removable fee and O/M cost for 15 years

---

Result of Study on Loss Reduction Project

3.3 Appropriate phase number



Period of Economic Evaluation: 15 years

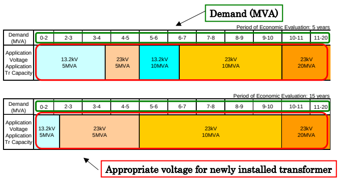
Operation ratio	0-0.1	0.1-0.2	0.2-0.3	0.3-0.4	0.4-0.5	0.5-0.6	0.6-0.7	0.7-0.8	0.8-1.0
4	Single	S T Three Phase		Three Phase		Three Phase	Three Phase		Three
2	Single	S T Three Phase		Three Phase		Three Phase	Three Phase		Three
1/0	Single	S Two Three		Three Phase		Three Phase	Three Phase		Three
2/0	Single	S Two Three		Three Phase		Three Phase	Three Phase		Three
3/0	Single	Single Two	Three	Three Phase		Three Phase	Three Phase		Three
4/0	Single	Single Two	Three Phase			Three Phase	Three Phase		Three
336.4	Single	Single Phase Two	Three Phase			Three Phase	Three Phase		Three

* The loss reduction value and the construction fee, which include removable fee and O/M cost for 15 years

---

Result of Study on Loss Reduction Project

3.4 Appropriate voltage for newly installed transformer



Period of Economic Evaluation: 5 years

Demand (MVA)	0-2	2-3	3-4	4-5	5-6	6-7	7-8	8-9	9-10	10-11	11-20
Application Voltage Application Tr Capacity	13.2kV 5MVA		23kV 5MVA		13.2kV 10MVA	23kV 10MVA				23kV 20MVA	

Period of Economic Evaluation: 15 years

Demand (MVA)	0-2	2-3	3-4	4-5	5-6	6-7	7-8	8-9	9-10	10-11	11-20
Application Voltage Application Tr Capacity	13.2kV 5MVA	23kV 5MVA			23kV 10MVA					23kV 20MVA	

* The loss reduction value and the construction fee, which include removable fee and O/M cost for 5 and 15 years

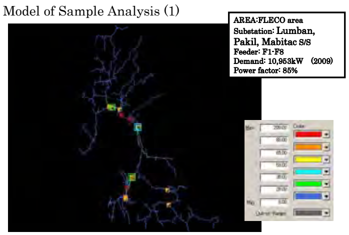
---

1. Method of Loss Reduction for Medium Voltage Line
2. Criteria for Taking Countermeasures against Technical Loss Reduction in the Medium Voltage System
3. Result of Study on Loss Reduction Project
4. **Sample Analysis of Loss Reduction for MV Line using SynerGEE at FLECO**

Sample Analysis of Loss Reduction for MV Line using SynerGEE at FLECO

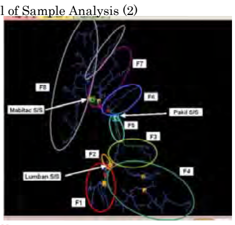
4.1 Model of Sample Analysis (1)

AREA:FLECO area
Substation: Lumban, Pakil, Mabitac S/S
Feeder: F1-F8
Demand: 10,953kW (2009)
Power factor: 85%



Sample Analysis of Loss Reduction for MV Line using SynerGEE at FLECO

4.1 Model of Sample Analysis (2)



Sample Analysis of Loss Reduction for MV Line using SynerGEE at FLECO

4.2 Result of Sample Analysis before countermeasure (Using SynerGEE Load Flow analysis)

Feeder	Feeder Name	Substation	Demand			Ampere	Loss			
			kW	Var	kVA	A	kW	%	Line(kW)	Tr(kW)
F1	Pagsanjan	Lumban1	2,370	1,460	2,784	119	145	6.10	99	46
F2	Lumban	Lumban2	1,001	620	1,178	53	20	1.99	7	13
F3	Kalayaan	Lumban2	770	477	906	40	35	4.57	24	11
F4	Cavinti	Lumban2	786	485	923	41	60	7.65	42	18
F5	Paete/Pakil	Pakil	1,579	977	1,857	80	57	3.63	28	30
F6	Pangil	Pakil	727	450	855	37	18	2.45	5	13
F7	Siniloan/Famy	Mabitac	2,034	1,259	2,392	104	77	3.80	41	36
F8	Mabitac/Sta. Maria	Mabitac	1,686	1,044	1,983	86	77	4.54	43	34
		Total	10,953	6,772	12,878	-	489		289	201

Select load-flow And Run

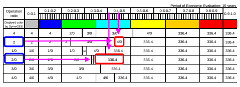
Load flow report window

Sample Analysis of Loss Reduction for MV Line using SynerGEE at FLECO

4.3 Necessary countermeasure for loss reduction (Line Thickening base on manual)

Feeder	Feeder Name	Existing Line Size	Percentage Loading	Phase	New Line Size	Percentage Loading	Length
			%(reference)		A	%(reference)	m
F1	Pagsanjan	2/0 ACSR	about 40-44	three	336 ACSR	about 19-23	3,534
F2	Lumban	2/0 ACSR	about 20	three	-	-	-
F3	Kalayaan	1/0 ACSR	about 20	single	-	-	-
F4	Cavinti	2/0 ACSR	about 15	three	-	-	-
F5	Paete/Pakil	2/0 ACSR	about 23	three	-	-	-
F6	Pangil	2/0 ACSR	about 15	three	-	-	-
F7	Siniloan/Famy	2/0 ACSR	about 34-37	three	336 ACSR	about 17-20	1,425
F8	Mabitac/Sta. Maria	2 ACSR	about 43-45	three	4/0 ACSR	about 23-24	189

The condition is referred to the following table



Period of Economic Evaluation: 15 years

Operation ratio	0-0.1	0.1-0.2	0.2-0.3	0.3-0.4	0.4-0.5	0.5-0.6	0.6-0.7	0.7-0.8	0.8-0.9	0.9-1.0
4	4	4	2/0 3/0	3/0		4/0	336.4		336.4	336.4
2	2	2	2 3/0		4/0	336.4	336.4		336.4	336.4
1/0	1/0	1/0	1/0 3/0	4/0 336.4		336.4	336.4		336.4	336.4
2/0	2/0	2/0	2/0	336.4		336.4	336.4		336.4	336.4
3/0	3/0	3/0	3/0	336.4		336.4	336.4		336.4	336.4
4/0	4/0	4/0	4/0	4/0	336.4	336.4	336.4		336.4	336.4

Sample Analysis of Loss Reduction for MV Line using SynerGEE at FLECO

4.4 Result of Sample Analysis after countermeasure (Line Thickening base on manual)

Feeder	Feeder Name	Substation	Demand			Ampere	Loss			
			kW	Var	kVA	A	kW	%	Line(kW)	Tr(kW)
F1	Pagsanjan	Lumban1	2,363	1,470	2,783	119	90	3.79	43	47
F2	Lumban	Lumban2	1,001	620	1,178	53	20	1.99	7	13
F3	Kalayaan	Lumban2	770	477	906	40	35	4.57	24	11
F4	Cavinti	Lumban2	786	485	923	41	60	7.65	42	18
F5	Paete/Pakil	Pakil	1,579	977	1,857	80	57	3.63	28	30
F6	Pangil	Pakil	727	450	855	37	18	2.45	5	13
F7	Siniloan/Famy	Mabitac	2,030	1,261	2,390	104	60	2.94	23	37
F8	Mabitac/Sta. Maria	Mabitac	1,685	1,044	1,982	86	74	4.40	40	34
		Total	10,941	6,784	12,874	-	414		212	203

Feeder	Loss (kW)		Loss Reduction (kW)
	Before Countermeasure	After Countermeasure	
F1	145	90	55
F7	77	60	17
F8	77	74	3

Sample Analysis of Loss Reduction for MV Line using SynerGEE at FLECO

4.5 Effect of countermeasure for loss reduction (Line Thickening)

- Cost for Measure

Construction Fee :	4/0 * 189m		85,515 PHP
	336 * 4,959m		3,739,974 PHP
Removal Fee :	2 * 189m		2,758 PHP
	2/0 * 4,959m		120,285 PHP

Subtotal : 3,948,532 PHP

Construction Fee :	4/0(3-phase)	452,458 PHP/km
	336(3-phase)	754,179 PHP/km
Removal Fee :	2(3-phase)	14,590 PHP/km
	2/0(3-phase)	24,256 PHP/km

- Amount of Money for Loss Reduction (result from SynerGEE)

Loss Reduction : 75kW 17,787,450 PHP

Before: 489kW
After: 414kW

*Total loss reduction value:237,166PHP/kW

Subtotal : 17,787,450 PHP

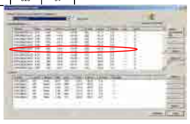
Total Effect : 13,838,918 PHP

Sample Analysis of Loss Reduction for MV Line using SynerGEE at FLECO

4.6 Necessary countermeasure for loss reduction (Capacitor Setting using SynerGEE Capacitor Placement)

Feeder	Feeder Name	Var before setting	pF before setting	Capacitor Size	Var after setting	pF after setting
		var	%		var	%
F1	Pagsanjan	1,460	85	450	1,026	92
F2	Lumban	620	85	450	190	98
F3	Kalayaan	477	85	150	345	91
F4	Cavinti	485	85	450	84	99
F5	Paete/Pakil	977	85	450	531	95
F6	Pangil	450	85	300	143	98
F7	Siniloan/Famy	1,259	85	450	823	93
F8	Mabitac/Sta. Maria	1,044	85	450	610	94

The result of Capacitor Placement by SynerGEE



Sample Analysis of Loss Reduction for MV Line using SynerGEE at FLECO

4.7 Result of Sample Analysis after setting Capacitor

Feeder	Feeder Name	Substation	Demand			Ampere	Loss			
			kW	Var	kVA	A	kW	%	Line(kW)	Tr(kW)
F1	Pagsanjan	Lumban1	2,369	1,026	2,582	110	130	5.49	84	46
F2	Lumban	Lumban2	1,001	190	1,019	45	19	1.87	6	13
F3	Kalayaan	Lumban2	770	345	844	38	31	3.99	19	11
F4	Cavinti	Lumban2	790	84	794	35	51	6.49	33	19
F5	Paete/Pakil	Pakil	1,580	531	1,667	72	51	3.23	21	30
F6	Pangil	Pakil	727	143	741	32	17	2.33	4	13
F7	Siniloan/Famy	Mabitac	2,033	823	2,194	96	71	3.49	34	37
F8	Mabitac/Sta. Maria	Mabitac	1,685	610	1,792	78	70	4.15	36	34
		Total	10,955	3,752	11,633	-	440		237	203

Feeder	Loss (kW)		Loss Reduction (kW)
	Before Countermeasure	After Countermeasure	
F1	145	130	15
F2	20	19	1
F3	35	31	4
F4	60	51	9
F5	57	51	6
F6	18	17	1
F7	77	71	6
F8	77	70	7

Sample Analysis of Loss Reduction for MV Line using SynerGEE at FLECO

4.8 Effect of setting Capacitor

- Cost for Measure

Construction Fee :	150var * 1	60,083 PHP
	300var * 1	72,601 PHP
	450var * 6	483,480 PHP

Subtotal : 616,164 PHP

Construction Fee :	150var(3-phase)	60,083 PHP/set
	300var(3-phase)	72,601 PHP/set
	450var(3-phase)	80,580 PHP/set

- Amount of Money for Loss Reduction (result from SynerGEE)

Loss Reduction : 49kW 11,621,134 PHP

Before: 489kW
After: 440kW

*Total loss reduction value:237,166PHP/kW

Subtotal : 11,621,134 PHP

Total Effect : 11,004,970 PHP

Thank you for your attention!