Appendix

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Appendix 1
Expert Dispatch Records (1/2)

Appendix 1

Expert Dispatch Records (1/2)

Field	Expert	FY 2012												
		3	4	5	6	7	8	9	10	11	12	1	2	3
Team Leader/ PI Expert	Noboru SEKI													
Distribution Planning	Toshiya MINEJIMA													
	Masahiro MYOGA													
	Satoru KOIZUMI													
Distribution O&M	Junichi OHISHI													
	Kazuhiro YOSHIMURA													
O&M Manual	Eiichi ARAKAWA													
	Masaki IWAMA													
Training Equipment/Facility	Akihiro HAYASHI													
	Sari ISHIZUKA													
Training Planning	Keiihic FUJITANI													

Field	Expert	FY 2013												
		3	4	5	6	7	8	9	10	11	12	1	2	3
Team Leader/ PI Expert	Noboru SEKI													
Distribution Planning	Toshiya MINEJIMA													
	Masahiro MYOGA													
	Satoru KOIZUMI													
Distribution O&M	Junichi OHISHI													
	Kazuhiro YOSHIMURA													
O&M Manual	Eiichi ARAKAWA													
	Masaki IWAMA													
Training Equipment/Facility	Akihiro HAYASHI													
	Sari ISHIZUKA													
Training Planning	Keiichi FUJITANI													
Fault Location (1)	Masakatsu KOBAYASHI													
Fault Location (2)	Keiichi TANII													
Fault Location (3)	Yoshiki NAKANO													

Field	Expert	FY 2014												
		3	4	5	6	7	8	9	10	11	12	1	2	3
Team Leader/ PI Expert	Noboru SEKI													
Distribution Planning	Toshiya MINEJIMA													
	Masahiro MYOGA													
	Satoru KOIZUMI													
Distribution O&M	Junichi OHISHI													
	Kazuhiro YOSHIMURA													
O&M Manual	Eiichi ARAKAWA													
	Masaki IWAMA													
Training Equipment/Facility	Akihiro HAYASHI													
	Sari ISHIZUKA													
Training Planning	Keiichi FUJITANI													

Appendix 2
Expert Dispatch Records (2/2)

Appendix 2

Expert Dispatch Records (2/2)

Field	Expert	Dispatched Period
Team Leader/ PI Expert	Noboru SEKI	Mar. 14 - Mar. 24, 2012
		May 6 - May. 19, 2012
		Jul. 9 - Jul. 20, 2012
		Sep. 9 - Sep. 16, 2012
		Jan. 27 - Feb. 8, 2013
		May 8 - May 17, 2013
		Jul. 6 - Jul. 13, 2013 (New Zealand)
		Jul. 15 - Jul. 24, 2013
		Aug. 22 - Sep. 1, 2013
		Sep. 22 - Sep. 28, 2013
		Jan. 13 - Jan. 26, 2014
		May 12 - May 23, 2014
		Jul. 12 - Jul. 19, 2014
Distribution Planning	Toshiya MINEJIMA	Mar. 17 - Mar. 24, 2012
		May 8 - May. 18, 2012
		Jul. 9 - Jul. 26, 2012
		Sep. 9 - Sep. 16, 2012
	Masahiro MYOGA	Jan. 27 - Feb. 8, 2013
		May 8 - May 17, 2013
		Jun. 10 - Jun. 19, 2013 (Singapore,Indonesia)
		Jun. 23 - Jun. 29, 2013
	Satoru KOIZUMI	Sep. 16 - Sep. 29, 2013
		Jan. 14 - Jan. 29, 2014
		May 12 - May 23, 2014
		Jul. 12 - Jul. 19, 2014
Distribution O&M	Junichi OHISHI	Mar. 18 - Mar. 24, 2012
		May 8 - May. 18, 2012
		Jul. 9 - Jul. 25, 2012
		Sep. 9 - Sep. 16, 2012
		Jan. 27 - Feb. 8, 2013
		May 8 - May 17, 2013
		Jul. 1 - Jul. 6, 2013 (Indonesia)
		Jul. 14 - Jul. 20, 2013
	Kazuhiro YOSHIMURA	Sep. 16 - Sep. 29, 2013
		Jan. 13 - Jan. 29, 2014
		May 12 - May 23, 2014
		Jul. 12 - Jul. 19, 2014

Field	Expert	Dispatched Period
O&M Manual	Eiichi ARAKAWA	Mar. 19 - Mar. 24, 2012
		May 8 - May. 19, 2012
		Jul. 9 - Jul. 26, 2012
		Sep. 9 - Sep. 16, 2012
	Masaki IWAMA	Jan. 27 - Feb. 8, 2013
		May 8 - May 17, 2013
		Jun. 24 - Jun. 29, 2013 (Thailand)
		Jul. 14 - Jul. 24, 2013
		Sep. 16 - Sep. 29, 2013
		Jan. 13 - Jan. 29, 2014
		May 12 - May 23, 2014
		Jul. 12 - Jul. 19, 2014
Training Equipment/Facility	Akihiro HAYASHI	Mar. 14 - Mar. 23, 2012
		May 6 - May. 18, 2012
		Jul. 11 - Jul. 25, 2012
		Sep. 9 - Sep. 16, 2012
	Sari ISHIZUKA	May 8 - May 17, 2013
		Jun. 10 - Jun. 19, 2013 (Malaysia)
		Jun. 23 - Jun. 28, 2013
		Sep. 16 - Sep. 29, 2013
		Jul. 9 - Jul. 18, 2014
Training Planning	Keiichi FUJITANI	Mar. 13 - Mar. 24, 2012
		May 8 - May. 18, 2012
		Jul. 11 - Jul. 25, 2012
		Sep. 10 - Sep. 16, 2012
		Jan. 29 - Feb. 8, 2013
		May 8 - May 17, 2013
		Jul. 14 - Jul. 20, 2013 (Indonesia)
		Aug. 26 - Sep. 6, 2013
		Sep. 18 - Sep. 28, 2013
		Jan. 14 - Jan. 28, 2014
		May 12 - May 23, 2014
		Jul. 12 - Jul. 19, 2014
Fault Location (1)	Masakatsu KOBAYASHI	Jul. 14 - Jul. 20, 2013
Fault Location (2)	Keiichi TANII	Jul. 14 - Jul. 20, 2013
Fault Location (3)	Yoshiki NAKANO	Jul. 14 - Jul. 20, 2013

Appendix 3
The Trainees' Lists of Counterpart Training in Japan

Appendix 3

The trainees' lists of counterpart training in Japan

FY	Period	Name of Participants	Designation	Office address	Organization
2012	2013/3/4 - 2013/3/15	1st Datch counterpart training in Japan			
		Norbu Tshering	General Manager	Distribution & Customer Services Department (DCSD), Thimphu	BPC
		Cheten Tshering	Engineer	Substation Maintenance Division (SMD), Kanglung	BPC
		Tshewang Rinzin	Manager	Central Maintenance & Training Division (CMTD), Begana	BPC
		Nagawang Norbu	Sr. Engineer	Engineering & Design Services Division (EDCD), Thimphu	BPC
		Chhejay Wandi	Manager	Electricity Services Divisions (ESD), Wangdue	BPC
		Vesraj Bhujel	Manager	Rural Electrification Department (RECD) Samtse	BPC
		Sangay Tenzin	Manager	Electricity Services Divisions (ESD), Dagana	BPC
		Ghana Shyam Tamang	Manager	P&RD, Distribution & Customer Services Department(DCSD), Thimphu	BPC
		Kinzang Lhamo	Engineer	Engineering & Design Services Division (EDCD), Thimphu	BPC
		Narapati Sharma	Sr. Engineer	Energy Management (EM) and Customer Care Department(CCD)	BPC
		Sonam Dendup	Engineer	Information Technology Department (ITD), Thimphu	BPC
		Tshering Choden	Manager	HRDD, Human Resource & Administration Department (HRAD, Thimphu	BPC
2013	2013/11/11 - 2013/11/22	2nd Datch counterpart training in Japan			
		Sangay Tenzin	Senior Manager	Operation and Maintenance Division, DCSD, Thimphu	BPC
		Dechen Dema	Senior Manager	Urban Electrification Division, DCSD, Thimphu	BPC
		Tashi Lhamo	Deputy Manager	Human Resources and Administration Department	BPC
		Sandeep Rai	Manager	Energy Management & Customer Care Division, DCSD, Thimphu	BPC
		Ujjwal Deep Dahal	Senior Manager	National Load Dispatching Center, Transmission Wing, Thimphu	BPC
		Phurba	Senior Supervisor	Electricity Supply Division (ESD) Tsirang, DCSD, Tsirang	BPC
		Nidup	Engineer	Engineering Design and Contracts Department (EDCD), Thimphu	BPC
		Nidup Dorji	Senior Supervisor	ESD Thimphu, DCSD, Thimphu	BPC
		Pema Wangchuk	Assistant Manager	Engineering & Design Services Division (EDCD), Thimphu	BPC
		Sonam Phuntsho	Engineer	Central Maintenance & Training Division, DCSD, Begana	BPC
		Kezang Lhazom	Senior Manager	Civil Works Division, DCSD, Thimphu	BPC
		Pasang	Engineer	Distribution & Customer Services Department (DCSD), Thimphu	BPC

Appendix 4
The Participants' Lists of Study Tour in Japan

Appendix 4

The Study Tour in Japan

FY	Period	Name of Participants	Designation	Office address	Organization
2013	2013/10/21 - 2013/10/15	Gem Tshering	Director	Transmission Wing, and Human Resources and Administration Department	BPC
		Sonam Tobjey	Chief Financial Officer	Finance and Accounts Services	BPC
		Mewang Gyeltshen	Chief Engineer	Alternate Energy Division, Department of Renewable Energy	MOEA

Appendix 5
Project Cost

Breakdown list of Project Cost in First Term

Project Cost	118,021,050	yen
Ⅰ Primary Cost	61,143,000	yen
1 Direct Expense	36,499,000	yen
(1) Airfare	22,284,000	yen
(2) Travel Expense except Airfare	10,417,000	yen
(3) Operating Expence	2,294,000	yen
(4) Meeting Expence	559,000	yen
(5) Expence for Counterpart Training in Japan	945,000	yen
2 Labor Cost	24,644,000	yen
Ⅱ Indirect Cost	51,258,000	yen
1 Overhead Cost	29,572,000	yen
2 Technical Fee	21,686,000	yen
Ⅲ Subtotal	112,401,000	yen
Tax	5,620,050	yen
Ⅳ Total	118,021,050	yen

Breakdown list of Project Cost in Second Term

	Project Cost	26,867,160	yen
Ⅰ	Primary Cost	20,103,000	yen
	1 Direct Expense	8,168,000	yen
	(1) Airfare	5,609,000	yen
	(2) Travel Expense except Airfare	1,580,000	yen
	(3) Operating Expence	669,000	yen
	(4) Bookbinding Cost	299,000	yen
	(5) Material Cost	11,000	yen
	2 Labor Cost	5,425,000	yen
	3 Technical Fee	6,510,000	yen
Ⅱ	Overhead Cost	4,774,000	yen
Ⅲ	Subtotal	24,877,000	yen
Tax		1,990,160	yen
Ⅳ	Total	26,867,160	yen

Appendix 6
Plan and Result of the Project

Appendix 6

Plan and Result of the Project

Stage	Project Plan		Project Result														
	Contents	Detailed Contents	Survey											C/P Training	Third Country Survey	Outputs	
			!st	2nd	3rd	4th	5th	6th	7th	8th	9th	10th	11th			BPC	JICA Expert
TOR-1 Preparation	1-1.Prepare Work Plan		○	○													Work plan (1st Term)
	1-2.Baseline survey	(a) Review outcomes and issues of the PI activities done in Phase 1	○														Survey Report
		(b) Rural power supply (BPC's strategy, Human resources, Assistance from other donors)	○	○	○	○	○										Survey Report
		(c) Improvement measures in the capability of distribution O&M		○												O&M manual, Pocket size O&M manual	
		(d) O&M manual for rural power supply		○	○	○										O&M manual, Pocket size O&M manual	
		(e) Training center (Training results, training equipment/facilities)		○			○									CMTD up graduetion concept paper (draft) CMTD training contents (draft) Training Policy & Guideline (draft)	
TOR-2 Implementation	2-1. Enhancement of capacity to handle areas identified under PI activities for rural power supply	(a) Establishment of implementation system for PI activity	○			○					○						
		(b) Support for selecting proper pilot project	○		○		○	○				○				PI Activities Final Presentation	
		(c) Support for implementation of pilot project & monitoring progress	○	○	○	○	○	○	○	○	○	○					
	2-2. Prepare O&M manual for rural power supply	(a) Identify target and form of O&M manual		○					○	○							
		(b) Support for revising O&M manual		○	○					○	○					O&M manual Pocket size O&M manual	
		(c) Support for utilization and familiarization of O&M manual		○	○	○	○	○	○	○	○			○			
	2-3. Upgrade of training capacity of CMTD, Begana, in distribution O&M	(a) Support to create the proposal on the upgrade of CMTD, Begana, prepared by BPC		○	○	○	○	○	○	○							
		(b) Support for upgrade of CMTD, Begana		○	○	○	○	○	○	○	○					Upgradation of CMTD	
	2-4.Counterpart Training	(a) Implementation of counterpart training in Japan												○			C/P Training Report
	2-5.Third Country Survey	(a) Implementation of third Country survey													○	Third Country Survey Reports	
TOR-3 Monitoring	3-1. Visit and Monitor the pilot project						○	○		○	○	○	○				Progress Report, Project Completion Report
	3-2. Visit ESDs and Monitor utilization of O&M manual									○	○	○	○				Progress Report, Project Completion Report
	3-3. Monitor upgrade of CMTD, Begana						○		○	○	○	○	○				Progress Report, Project Completion Report

Appendix 7
Minutes of Meeting

Minute of Meeting for First JCC meeting

Minutes of Meetings
of
the first Joint Coordinating Committee (JCC) meeting
on
JICA Technical Cooperation Project for
Improvement of Efficiency for Rural Power Supply - Phase II (JICA TCP-II)

The first Joint Coordinating Committee (JCC) meeting on the JICA funded Technical Cooperation Project for Improvement of Efficiency for Rural Power Supply - Phase II (JICA TCP-II) was held on 15th May 2012, at Hotel Migmar, Olakha, Thimphu, Bhutan. The meeting was chaired by Mr. Karma Tshering, Director of Renewable Energy Department (DRE), Ministry of Economic Affairs (MOEA), Royal Government of Bhutan (RGOB), Thimphu. The members present were the JCC members mentioned in appendix-I:

Mr. Norbu Tshering, Manager of O&M Division under DCSD, BPC and Project Manager of JICA TCP-II; welcomed the Chairman, the representative from JICA Bhutan Office & GNH Commission, Dasho MD of BPC, Director - TW &HRAD of BPC, the JICA Project team and all other JCC members to the meeting. He briefed on the overview of the progress made in the project since its inception in March 2012. He then offered the floor to the chairman to address the meeting.

The chairman welcomed all the JCC members to the meeting and thanked JICA for hosting the 1st JCC meeting. He expressed his hope that the Bhutan Power Corporation Limited (BPC) shall gain a lot from this project through the generosity of JICA and the keen interest & tireless efforts of the concerned JICA experts and the BPC Project Team, especially in the following area.

- Enhance the Efficiency & Reliability of Power Supply in the Rural Area.
- Set up CMTD as the Centre of Excellence for training in T&D systems.
- Solve the major issues being faced by BPC in Distribution System through the five themes that are indentified for PI solving Activity and the Pilot project that shall be implemented as a result of the study.
- Come up with a practically applicable Distribution O&M Manual.

Further, the chairman said that the diplomatic relation between the Japan and Bhutan could be further enhanced through this project.

The Chairman requested members for their own introduction to know each other more for better understanding & cooperation. After the introduction session, the Chairman in consultation with the JCC members endorsed the composition of JCC members, as mentioned in Appendix-I.

Mr. Noboru Seki, Project Leader, JICA TA Team, made a detail presentation on the project, which is enclosed as Appendix-II for reference. The chairman thanked Mr. Seki for the comprehensive presentation on the project and opened floor for deliberation. Accordingly, the members deliberated on the presentation made and in particular raised the following issues that were clarified accordingly by JICA/BPC.

Sl #	Query/Suggestions made	Clarification/Decision made
1	What could be the reason for the negative energy loss in case of Lhuentse? Does it mean that the customers are over charged?	BPC/JICA clarified that this is a strange data and the real reason is not yet known. That is why Lhuentse has been chosen for the Technical Loss study through the PI solving Activity.
2	What kind of training will be conducted at CMTD and at what level?	BPC clarified that CMTD was established to meet the in-house training needs of BPC in T&D to enhance the efficiency of BPC's technical staff. This is mostly targeted for the Technician level or lineman of BPC. Currently, establishment of CMTD itself is under BPC's scope, and JICA is only to verify the current condition, in terms of facilities, equipment, human resources, courses and etc., and to make necessary recommendations based on the BPC's proposals. Lastly, with the request by BPC, JICA will, with the initiative of BPC, provide necessary recommendations to the roadmaps (to be drafted by BPC) to enhance CMTD.
3	It was suggested that BPC may take over one of the VTIs (like VTI Khuruthang) as proposed by MOLHR to increase the institutional Training Area of BPC instead of building additional infrastructures at the present location of CMTD which has a limited Land Area.	BPC's training is mostly related to T&D specialized for BPCs needs and generalizing the same to the curriculum of VTIs will not meet the need of BPC. Since, CMTD has a limited land area for building further infrastructures; BPC has the plan to set up a training centre at Jigmiling / Gelephu.
4	Will JICA fund the purchase of equipments/tools that are required to be purchased as a result of the PI solving activity & the recommendations thereof?	JICA clarified that the purchase of equipments/tools as a result of PI solving activity is not covered under the scope of the project. What is actually agreed within this project is that BPC shall fund to implement the Pilot Projects as recommended through this project. However, JICA Bhutan Office shall put up the case to JICA Head Office in Japan for consideration only if the case seems crucial.

Sl #	Query/Suggestions made	Clarification/Decision made
5	A member from DRE, RGOB, pointed out that the respective members of each PI Solving Theme have to really work hard to achieve the objectives of the assigned PI Theme. So, the RGOB/BPC shall be grateful if JICA could finance a study tour/training for the teams in Japan or any other alternative country as an incentive for the PI Solving task force members.	JICA clarified that the Project scope requires BPC to implement the work that shall come out as an outcome of the identified PI Solving Activities. Further, from a Japanese perspective, if a person or a group's recommendation / idea is accepted for implementation in an organization, that itself is already an incentive for the concerned person or a group. Therefore, additional trainings, for incentive purpose, seems not necessary. Lastly, JICA has been annually providing trainings for relevant and responsible personnel in both BPC and the Ministry, which in relation to this Project, through its group training scheme; therefore, JICA will pursue the same for this year.
6	What is the difference between the PI Activities carried out in JICA TCP-I & that are covered under this Project (JICA TCP-II)?	BPC & JICA Clarified that : In JICA TCP-I, the individual members selected by GMs of BPC chose the PI Solving activity Theme and presented their report to the BPC Management and JICA. In JICA TCP-II, the theme for the PI solving activity was decided by BPC Management based on the real needs and the concerned task forces members to work on the identified theme was also nominated by BPC Management based on the competence of the members and relevance to the chosen theme. Thus, the recommendations reported through the PI solving activity shall be implemented by BPC with the technical assistance of JICA for enhancing the functions of BPC in rural Power Supply. The same task force members shall also be asked to train other BPC members on PI solving Activity in the future. Thus the PI Solving methodology introduced by JICA shall be extensively used in the future in BPC.
7	The members informed JICA that they need some time to review the work plan report which was received by them only on the meeting day.	The TA Team requested to the JCC members to submit their respective comments for the "Work Plan Report (draft)" as Appendix-III by the end of May and the JCC members agreed.

The meeting ended with the closing address by Dasho MD of BPC. He thanked the Chair person, the Representative from GNH Commission & JICA Bhutan Office, and the JICA Project experts and other JCC members from DRE & BPC for their time & active participation in attending the meeting. He also thanked JICA for hosting the meeting. Lastly, we wished & urged that the objectives of the project be met in time, and the recommendations of the PI Solving activity be implemented within the project.

Mr. Noboru Seki
Project Leader
JICA TA Team

Mr. Kunihiro Shiraishi
Project Formulation Advisor
JICA Bhutan Office

Dasho Bharat Tamang
Managing Director
Bhutan Power Co. Ltd.

Mr. Karma Tshering
Director of Department of Renewable Energy
Ministry of Economic Affairs

APPENDIX-I

JICA Technical Cooperation Project for Improvement of Efficiency for Rural Power Supply-Phase II (JICA TCP-II)

Joint Coordinating Committee (JCC) Members

Bhutanese side

Sl #	Name & Designation	Role in the JICA Project
1	Mr. Karma Tshering, Director-DRE,MOEA	Chairperson
2	Mr. Rinchen Wangdi, Head of Development Cooperation Division, GNH Commission	Representative from GHN Commission
3	Dasho Bharat Tamang, Managing Director	Policy Advisor to BPC & JICA Team
4	Mr. Gem Tshering, Director-TW,BPC	
5	Mr. Mewang Gyeltshen, Chief Engineer, Alternative Energy Division, DRE,MOEA	
6	Mr. Norbu Tshering, General Manager-DCSD, BPC	Project Director
7	Mr. Subash Rai, Offtg. General Manager-HRAD, BPC	Project Coordinator
8	Mr. Yeshi Dorji, Manager-MD Office, BPC	
9	Mr. Norbu Tshering, Sr. Engineer, DCSD, BPC	Project Manager
10	Mr. Drukchu Dorji-Offtg. GM RED, BPC	Project Member
11	Mr. Tilak Sunwar, Project Manager, Rural Electrification, PCD,DRE,MOEA	Project Member
12	Mr. Ghana Shyam Tamang, Sr. Engineer, DCSD,BPC	Counterpart Engineer-O&M Manual
13	Mr. Tshewang Rinzin, Manager-CMTD, BPC	Coordinator, up- gradation of the training capacity of CMTD, Begana.
14	Ms. Tshering Choden, Manager –HRDD, HRAD, BPC	

Japanese side

Sl #	Name & Agency	Role in the JICA Project
1	Mr. Tomoki Nitta, Chief Representative, JICA Bhutan Office, Thimphu	Representative from JICA Bhutan Office, Thimphu
2	Mr. Kunihiro Shiraishi, Project Formulation Advisor, JICA Bhutan Office, Thimphu	Representative from JICA Bhutan Office, Thimphu
3	Ms. Kuri Orui, JICA	JICA long-term expert (Project Coordination & Facilitation)
JICA Short-term experts		
4	Mr. Noboru Seki, JICA / TEPCO	Project Leader / PI Expert
5	Mr. Toshiya Minejima, JICA / TEPCO	Distribution Planning
6	Mr. Junichi Ohishi, JICA / TEPCO	Distribution O&M
7	Mr. Eiichi Arakawa, JICA / TEPCO	Distribution O&M Manual
8	Mr. Keiichi Fujitani, JICA / TEPCO	Training Planning
9	Mr. Akihiro Hayashi, JICA / TEPCO	Training Equipment / Facility

Minute of Meeting for Second JCC meeting

Minutes of Meetings
of
the second Joint Coordinating Committee (JCC) meeting
on
JICA Technical Cooperation Project for
Improvement of Efficiency for Rural Power Supply - Phase II (JICA TCP-II)

The second Joint Coordinating Committee (JCC) meeting on the JICA funded Technical Cooperation Project for Improvement of Efficiency for Rural Power Supply - Phase II (JICA TCP-II) was held on 14th May 2013, at Hotel Kisa, Thimphu, Bhutan. The meeting was chaired by Dasho Bharat Tamang, MD of BPC. The members present were the JCC members mentioned in appendix-I:

The chairman welcomed the representative from JICA Bhutan Office, JICA/TEPCO expert from Japan, GNH Commission and from Department of Renewable Energy (DRE). The Chairman requested members for their own introduction to know each other more for better understanding & cooperation. After the introduction session, the Chairman offered the floor to the Mr. Noboru Seki, Project Leader, JICA TA Team for presentation on the progress of the project, which is enclosed as Appendix-II for reference

After the presentation by Mr. Noboru Seki, the members deliberated on the presentation made and in particular raised the following issues that were clarified accordingly by JICA/BPC.

Sl #	Query/Suggestions made	Clarification/Decision made
1	The members inquired whether the PI activities have solved any problem or not? And if so whether they are documented or not.	BPC/JICA clarified that earlier activities are all documented and is helping in solving problems. Some of the earlier PI team leader present during the meeting briefed the members on the progress of earlier PI activity and how through PI activity, the issues was resolved, e.g. relay coordination, loss calculation. The chairman pointed out that in the next JCC meeting, BPC/JICA should report the status of PI activity with facts and figures, including the failure.
2	Some members raised the issue on the counterpart training in Japan; Whether the training is required/useful? What is the purpose? After training in Japan, how can the expertise skills be continued?	BPC/JICA clarified that after returning from Japan, the trainees become advisor or instructor for PI team members. It was also agreed that, henceforth, counterpart trainees shall submit the report to BPC and make presentation to BPC management after returning from Japan.

3.	Some members raised the question on transparency in selecting team members in third country survey ? and inquired to clarify issues and to prepare a plan before visiting the third countries.	BPC/JICA clarified that all members of the PI team 2013 shall get the opportunity for the third country survey. BPC/JICA shall submit Terms of Reference for 3rd country training. Once the JICA Headquarters approves the third country survey, JICA TCP-II will send the PI team members to the third countries accordingly.
4.	The members also discussed at length on the mini/micro hydel needs. Whether to continue to maintain the present mini/micro hydel, most of which are more than 27 years old	MD, BPC requested JICA, if they could carry out the study on it, or carry out as part of PI activity.
5.	The member raised the question on CMTD whether it is really necessary to separate the maintenance function from the training function and transfer to to other place though it is costly.	BPC clarified that it is difficult to manage trainings while maintaining transformers in the same venue, hence, separation is required. Begana will be the training center and Gelephu will the maintenance division as better access for transporting transformers from all over the country and procuring spare parts from India.

The meeting ended with the closing address by Dasho MD of BPC. He thanked JICA project office in Bhutan, JICA project experts, GNH commission and DRE for the full support rendered to BPC. The chairman informed that with electricity networks covering almost all parts of Bhutan, the next step of challenges would be in providing reliable power supply, especially in remote corners of Bhutan. He assured that BPC need to try its best to provide the reliable power supply and stress that training is one of the core component in providing the reliable power supply. He also thanked JICA for hosting the meeting.

Mr. Norbu Tshering
JICA Project Director
General Manager of DCSD
Bhutan Power Corporation. Ltd

大類 久見

Ms. Kuri Orui
JICA Long-term Expert
Coordination and Facilitation
JICA TCP-II

Endorsed by

Dasho Bharat Tamang
Managing Director
Bhutan Power Corporation. Ltd

Minute of Meeting for Third JCC meeting

Minutes of Meeting
Third Joint Co-ordination Committee Meeting
JICA Technical Cooperation Project for Improvement of Efficiency for Rural Power Supply - Phase II (JICA TCP II)

Date	:	22 January, 2014
Time	:	15:30 – 17:30 BST
Venue	:	Hotel Phuntsho Pelri, Thimphu.
Attendees	:	As enclosed – *Appendix I*

The third Joint Co-ordination Committee Meeting (JCC) for the JICA TCP-II was held at hotel Phuntsho Pelri on dated 22.01.2014. The meeting was chaired by the Dasho Bharat Tamang, Managing Director, BPC and attended by the JCC members, and PI Solving task force members as attached on *Appendix – I.*

The Chairman BPC welcomed the JCC members to the meeting and thanked JICA for their selfless support to BPC focusing on solving the issues that BPC faced in its day-to-day activities. He recapitulated that even though the PI activities might come to an end, nevertheless BPC will continue seeking assistance and guidance from the JICA/TEPCO for any other Priority Issue activities in future. He also said that the meeting mainly focuses to sort out any issues related to the PI activities and then offered the floor to the JICA Project Leader for his presentation.

The JICA project leader presented the overall structure of the TCP-II Project from the objective, policy, suggestions, overall schedule and future PI activities. He said that although the PI activities might come to an end by the June 2014 but BPC should never hesitate to seek guidance and assistance at any time from JICA/TEPCO. In addition JICA TA team requested BPC with the following points;

- ✓ To increase the manpower for protection and coordination system
- ✓ To effectively install ARCBs at proper places
- ✓ Collect outage dada using new format and set target accordingly
- ✓ Set loss targets for all ESDs considering the pilot project results
- ✓ To clarify ToR for multitask and village electrician
- ✓ Draw road map for GIS system
- ✓ Study ownership of mini/micro hydro power plants
- ✓ Clarify usage of distribution dada and
- ✓ Identify training policy (HR master plan)

He also recommended the following themes for PI activities in the future;

1. Grounding (to keep earth resistance below specified value)
2. Fault locating on overhead line
3. Continuous activities of ongoing PI activities
4. Monitoring of past PI activities

On this, the MD BPC pointed out that BPC has severe earthing problem right upto the individual

households and have been suggesting the members to do some research and find out some alternatives as to how to improve the system. He reiterated that only presentation all the times won't help solving the issues and activities should be put into action rather than just remaining on paper. He asked the JICA/TEPCO experts to suggest some in-house improvement on the earthing system. On this, the experts shared their experience on earthing system in TEPCO such as having parallel earth connections between MV and LV on the composite lines. However, they suggested that it would not be possible for BPC as BPC distribution lines are not composite in nature and therefore, their suggestions may be taken as food for thought.

1. ***Mini/micro hydro power plants***

Mr. Mewang Gyeltshen, Chief Engineer, Alternate Energy Division DRE, MoEA asked about the status of the mini/micro hydro power plants under BPC. The Chairman eminded that in the recent directives from DHI, BPC has been asked to come up with the exit strategy of Mini/Micro hydro plants stating that BPC's main mandate is transmission and distribution of electricity and that operation and maintenance of such plants shall be handed over to the relevant agency. The Chairman informed the floor that he appraised DHI on the studies carried out by the team and shall accordingly make exit proposal. However, some members also pointed out that most of the Mini/Micro plants in BPC have lived their economic life and continuing with the operation and maintenance of such plants does not see any major issue as long as the plants are sustainable and capable of providing energy security in the event of grid failure (best example is Thimphu mini hydro power plant).

Further, the chairman advised the team to consult BEA and DRE for their opinion. He also opined that handing over of such plants to local community could be one option as well. But then due to connection of the existing mini/micro catered villages such as Kikhar and Tangsibji to grid, the communities don't want to take over the responsibilities and charges. However, BPC has already incorporated the R&M cost and asset value in the present tariff revision and thereby BPC shall continue to operate the mini/micro hydro power plants till June 2016 and thereafter a proposal will be submitted to the BPC shareholder. Meanwhile, the DRE requested the BPC to keep them informed of any new developments with the mini/micro hydro power plants.

Director Transmission Wing, BPC said that mini/micro hydro power plants will play a vital role in the distribution network in the event transmission and distribution unbundles at any time in future, and therefore it will be wise for BPC to operate the plants taking into account of such situation.

2. ***Reliability indices (SAIFI/SAIDI)***

JICA experts suggested that every ESDs should start capturing the reliability indices in the new format as it is already incorporated in the PBIS 2014. On this MD, BPC suggested that every ESDs should follow the new format by issuing an executive order and nevertheless BPC is already in the process of introducing smart grid by the end of December 2014 through the BPC owned communication network.

3. Geographical Information System (GIS)

MD, BPC informed that very soon BPC will have an integrated GIS system among asset co-ordination, outage management system, distribution management system and smart metering which was substantiated by the Director Transmission wing that GIS should be clearly co-ordinated with the base map of the National Land Commission (NLC) as NLC have the country wide map.

4. Closing remarks

MD, BPC said that it is very essential to document all the PI activities so that it can be used as a future reference and guidelines which the JICA representatives felt the same. Representative from DRE thanked the JICA for their continued support to BPC and also thanked TEPCO for providing necessary advice and in doing so provided wings to BPC to fly which is entirely the responsibility of BPC as to how high it wants to fly. Further JCC members unanimously approved every plan that was presented in the meeting.

The meeting ended at 17.30 hours.

Dasho Bharat Tamang Managing Director Bhutan Power Corporation Ltd.	Mr. Noboru Seki Project Leader JICA TA Team

Minute of Meeting for Fourth JCC meeting

Minutes of Meeting
Fourth Joint Co-ordination Committee Meeting
JICA Technical Cooperation Project for Improvement of Efficiency for Rural Power Supply - Phase II (JICA TCP-II), BPC, Bhutan.

Date	:	16 July, 2014
Time	:	03:30 – 06:15 BST
Venue	:	Hotel Taj Tashi, Thimphu, Bhutan.
Attendees	:	As enclosed

The last or the fourth Joint Co-ordination Committee Meeting (JCC) for the JICA TCP-II was held at hotel Taj Tashi, Thimphu, on 16th July 2014. The meeting was chaired by Dasho Bharat Tamang, Managing Director of BPC and attended by the JCC members, and the team leader of the respective PI Solving task force members.

The Chairman welcomed the JCC members and other members to the meeting and thanked JICA for their overwhelming support to BPC focusing on solving the issues that BPC faced in its routine works. He reiterated that the PI activities with assistance from JICA might exit shortly, nevertheless BPC will continue identifying issues and solve with the guidance and experience gained so far by the taskforce members. He also said that the project meeting mainly focuses to sort out any concerns related to the PI activities and then offered the floor to the JICA Project Leader for his presentation.

The JICA project leader presented the overall progress of the TCP- II Project right from the objective, policy, suggestions, overall schedule and recommendations for future PI activities. He also recommended that BPC should never feel that the PI activities have already been terminated and then discontinue solving issues, rather BPC should strengthen its capacity to solve any issues and continue moving forward. In addition JICA TA team requested BPC with the following points;

1. To increase the number of Engineers/staff for protection and coordination system,
2. To effectively install ARCBs at proper places by using real working data,
3. To collect outage data by using new format (section wise outage record) at all ESDs and set the target considering the result ,
4. To set the loss target of all ESDs using the Numerical Calculation Method (NCM). Other alternative like the use of MiPower/PSS Adapt may also be explored,
5. To identify efficient MBC system (from company side and customer side),
6. a. To propose appropriate asset level for each ESD and to establish asset allocation system ,
   b. To decide area demarcation of SC and VEEET,
7. To clarify the policy of outsourcing to VEEET. To implement as per the roadmap,
8. To find out root cause of Phobjikha line (ABC cable) outage and to implement effective remedial measure,
9. To review and finalize the road map of Geographic Information System (GIS) in BPC. To tie-up with PEA/MEA for consultation regarding GIS as these utilities have reached advance stage in the deployment of GIS to manage the system,
10. To study ownership of micro hydels, and
11. To clarify the objectives of DT metering (to collect what kind of data and how to use these data etc.),

He also elaborated on future issues and activities such as;

1. Grounding (to keep earth resistance below specified value),
2. Fault locating on overhead line,
3. Continuous activities of 1st and 2nd PI activities and,
4. Monitoring of past PI activities,

On this, the Chief Engineer, DRE has pointed out that the finding PI activity is appreciated but getting resources to put the findings into action might be cumbersome due to shortage of resources.

The chairman pointed out that the task force members should come out with standard guidelines on how to solve PI activities in the future, who should be the resource persons and how to train in the absence of JICA experts. The JICA team leader responded that the preparation of guidelines is underway and most probably will be distributed to the concerned departments and divisions by the end of July 2014. However, on the PI Activity part, the middle level managers should be engaged who are the bridge between the top level & bottom level management in the company.

With the above notes, the following points have been discussed:

Issues discussed	Decisions made
Future advisors and experts and identifying the PI activities	Respective heads of departments to lead the PI activities concerning their department and BPC shall provide incentive to task force members like meritorious promotions, cash awards, study tour/training, etc. Identification of PI issues will be done before budgeting for the financial year so as to approve budget for any PI activities. However, the plans should be materialized if approved to give concrete results.
Issues related to Metering, Billing & Collection: Feasibility of three monthly billing, advance billing and B-wallet system	GM DCSD informed that three monthly billing is authorized as per the distribution codes and for this the task force members have already conducted a feasibility study at Tsirang with overwhelming results and therefore it will be implemented by the end of 2014?. However, this will be targeted only for rural customers.
Approval for up gradation of CMTD Begana	The up gradation of the training facilities are in full swing as per the roadmap and with the concurrence of the Management. However, the approval by the Management is still required.
Effectiveness of GIS system	Will be incorporated with the National Land Commission (NLC) base maps and accordingly implemented. EDCD shall follow up on the matter.
Cable fault Locating devices	BPC shall make best use of the costly equipment and purchase additional ones for the relevant ESDs/RCOs.

JICA PI Project Exit from BPC	JICA Chief Representative reiterated that BPC should solve the PI activities on its own. However, certain critical issues may be referred to JICA Bhutan Office for their review and or assistance in terms of purchase of equipment, resource person, etc, in the future.
Resolutions by JCC members	• BPC shall sustain the PI Solving methodology brought in by JICA. • Carry out the ongoing PI themes with full dedication and come out with the expected result. • DCSD/JICA TCP-II to come up with PI solving guidelines, and working document on all PI themes that were carried out till date. • Each department shall come out with different PI issues with fixed implementation documents.

Closing remarks

The JICA Chief Representative, the Representative from DRE & the GNHC appreciated the hard work done by the project team. They were happy to note that BPC now has 48 well trained Managers/Engineers who can work as advisors for sustaining the PI solving Methodology in BPC. They assured BPC any future support/cooperation on any pertinent issues and wished good luck to BPC in completing the project successfully, and in sustaining the PI solving methodology.

The chairman thanked JICA for funding the project and its team of experts from TEPCO who work tirelessly to achieve the objective of the project. Similarly he appreciated the hard work done by the BPC's project team including the PI members for really capturing the knowledge on the PI solving methodology. He also thanked JICA for inducing excellent work culture to BPC's Managers/Engineers/staff who were involved in the project. He thanked all other JCC members for their time to attend the meeting and their support given.

In particular, the chairman thanked Ms Orui Kuri san - JICA long term expert, who has been the main coordinator in making the project a success. Lastly, we urged DCSD to document all the working papers on the project for future references and implementation.

The chairman concluded the meeting at 06:15 with the word ***"BPC must continue to learn as knowledge is un-limited and will work harder as work is worship"***

Dasho Bharat Tamang
Managing Director
Bhutan Power Corporation Ltd.

Mr. Noboru Seki
Project Leader
JICA TA Team

Appendix 8
The Project Performance and Achievements based on PDM Indicators

Project Design Matrix (PDM)

Outputs	Indicators	Achievement
Project Purpose: **Capacity for operation and maintenance of rural power supply is developed.**	**1 Acceptance letter for the pilot projects is issued by the BPC management.**	1 Achieved. MoM signed between JICA TCP-II team & DCSD general manager to continue PI activities. As a first step, workshop for O&M Heads will be held on 28th and 29th July.
Output 1: Capacity to handle areas identified under PI activities is enhanced.	1-1 All targeted ESDs propose pilot projects	1-1 Achieved. (All PI teams proposed pilot projects) PI Theme#1-5 proposed pilot projects to the BPC management on 11th September 2012 and PI Theme#6-11 proposed on 25th September 2013.
	1-2 All targeted pilot projects are completed	1-2 Almost Achieved. All targeted pilot projects have been carried out based on the proposal. The pilot projects are underway.
	1-3 Final report of the pilot project is completed	1-3 Almost Achieved. Reports of all themes (#1-11) are completed. A PI activities manual is completed.
Project Purpose: **Capacity for operation and maintenance of rural power supply is developed.**	**2 O&M Manual is utilized in fields/ESD of rural power supply.**	2 Achieved. O&M manual and Pocket size O&M manual have been utilized at fields.
Output 2: Operation and maintenance manual (O&M manual) is introduced for rural power supply	2-1 Revised O&M manual is completed and approved by the BPC management.	2-1 Achieved. (1) First Edition of O&M manual was published on 1st July 2012, BPC Day, and distributed to all ESDs at the Progress Review Meeting on 30 -31 July 2012 in Thimphu. (2) Pocket size O&M manual is completed in March 2014 and distributed to all ESDs in April 2014.
	2-2 Two workshops for all ESD managers are conducted	2-2 Achieved (1) For O&M manual, one workshop for all ESDs' O&M in charge was conducted on 24th July 2012 and one workshop for all ESD managers was conducted at the Progress Review Meeting on 30 - 31 July 2012 in Thimphu. (2) For Pocket size O&M manual, workshop for all ESD managers was conducted at the Progress Review on 5-7 February 2014 and modified based on the feedbacks from ESD managers.
	2-3 Three refresher training courses for technicians are conducted	2-3 Achieved (1) For O&M manual, 8 batches of the refresher training courses for technicians were conducted on 21st & 29th July, 4th, 11th, 18th & 25th August, 1st and 5th September 2012 at CMTD, Begana.

		(2) Pocket size O&M manual was introduced at the refresher training course in March 2014 and at VEEET training in May 2014.
Project Purpose: **Capacity for operation and maintenance of rural power supply is developed.**	***3*** **Upgraded CMTD, Begana is utilized for delivering trainings to technicians for rural power supply**	3 Achieved. Up-gradation of CTMD is in process based on the roadmap and is being utilized for trainings.
Output 3: Training capacity of Central Maintenance and Training Division (CMTD), Begana in distribution operation and maintenance is upgraded	3-1 Up-gradation of CMTD, Begana is completed as per the implementation plan	3-1 Almost Achieved. The implementation plan including roadmap was prepared in January 2014 and presented at the third JCC on 22 January 2014 and got consensus among the BPC management. The necessary training equipment and facilities for the up-gradation of CMTD have been purchased and installed based on the plan.

*Theme#1: Protection Coordination、 Theme#2:Standard/Guideline on Installation of Fault Locating and Switching Devices/Equipments in MV Distribution System, Theme#3: Calculation Methodology for Correct Reliability Indices from Customer View Point, Theme#4: To Identify Real Technical Loss of Distribution System, Theme#5: Improvement of Billing and Collection System in Rural Areas, Theme#6: Study on existing manpower and management of existing facilities under DCSD, Theme#7: Study on metering, billing, collection procedures, process and technologies and prepare a road map for implementation including cost benefit analysis, Theme#8: Fault Locating and Rectification of Arial Bundle Conductor (ABC) and Under Ground (UG) cables, Theme#9: Effective utilization of GIS, Theme#10: Study on sustainability and effective usage of existing Mini/Micro Hydels of BPC, Theme#11: Study of Distribution Transformer (DT) metering

Appendix 9
Minutes of Meeting
for BPC Future Plan

Minutes of Meeting
PI Solving Activities – meeting for BPC future plan
JICA Technical Cooperation Project (TCP II)
Improvement of Efficiency for Rural Power Supply - Phase II

Date	:	**July 16, 2014**
Time	:	**10:00 – 11:00**
Venue	:	**Office of the General Manager, BPC Head Office, Thimphu.**

The JICA Technical Assistance Team (hereafter referred to as "the TA Team") conducted the 11th Mission for The Project on Improvement of Efficiency for Rural Power Supply - Phase II (hereafter referred to as "the Project") from July 9th, 2014 to July 19th, 2014.

During this mission, discussions and confirmation were conducted in a friendly and cordial atmosphere between the Bhutan Power Corporation Ltd. (hereafter referred to as "BPC") and the TA Team. The main items that were discussed and confirmed are summarized below.

Future Plan after the Project

The TA Team reported the overall progress and activities carried out of this Project to BPC and requested following future plan that BPC will conduct after the Project. BPC and the TA Team exchanged opinions of both sides and agreed on the following future plan.

1. Enhancement of capacity to handle areas identified under PI activities.

   BPC will continue the issue solving activities such as PI activities in order to solve the probrem in BPC using this project exprerience.

2. Revision of the O&M Manual for Power Distribution System

   BPC will timely revise the O&M manuals and incorporate necessary new manuals.

3. Upgrading the training capacity of the BPC training center at CMTD Begana for Power Distribution System.

   BPC will continue with the progress as per the roadmap for upgradation of CMTD, Begana.

Mr. Norbu Tshering	Mr. Noboru Seki
General Manager, DCSD, BPC	Project Leader
Project Director, JICA TCP - II	JICA TCP - II

Appendix 10
Workshop Presentation
(First workshop to seventh workshop)

Presentation Materials of first Workshop

Introduction of TEPCO's Power Distribution Network System

Introduction of TEPCO's Power Distribution Network System

15 May, 2012

Tokyo Electric Power
Tokyo Electric Power Services

TOKYO ELECTRIC POWER COMPANY

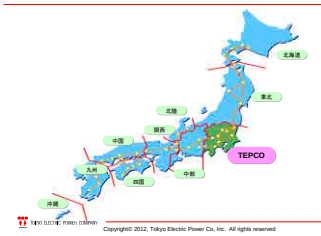
1. Our Features

Japanese power utilities have established

- **Low Network Losses**
  (less than 5%: T&D)
- **High Reliability**
  (SAIDI= 2minutes/customer)
- **Efficient Workforce Management**

based on Smart Grid Technologies.

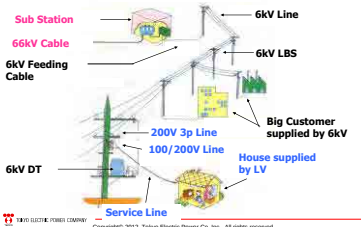
2. Japanese Power Utilities



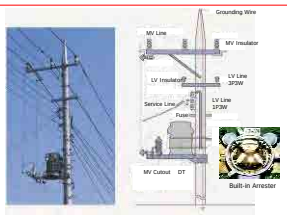
3. TEPCO's Service Area

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

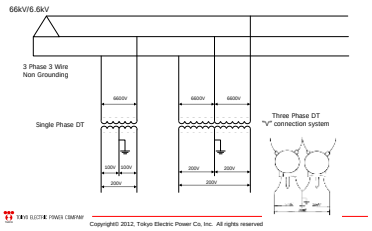
4. TEPCO's Distribution Network (OH)



5. Distribution Facilities (OH)



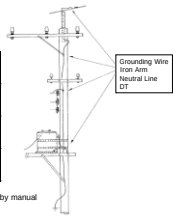
6. Distribution System



7. Distribution Grounding

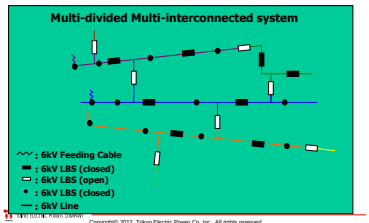
Grounding Resistance Value

Target Facilities	Value
MV Facilities	10Ω
DT Grounding Wire	150/Ig Ig:Ground fault current
LV Facilities	100Ω

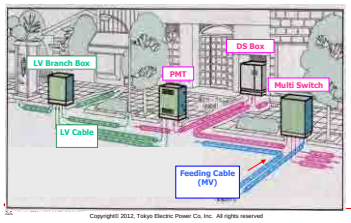


✓ Types, values and positions are regulated by manual
✓ Values are managed by data base system

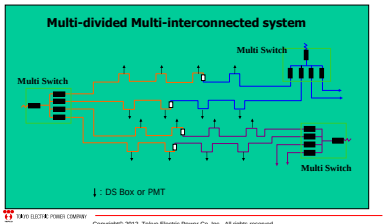
8. Configuration of DA (OH)



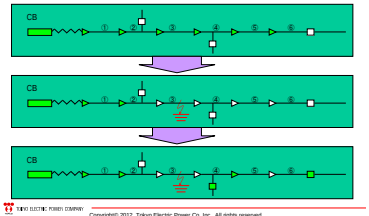
9. TEPCO's Distribution Network (UG)



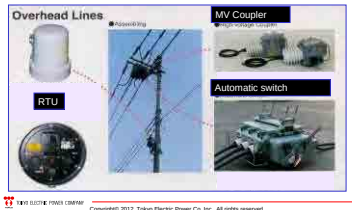
10. Configuration of DA (UG)



11. Switching Operation with DA (OH)

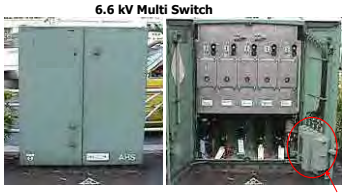


12. Equipments of DA (OH)



13. Equipments of DA (UG)

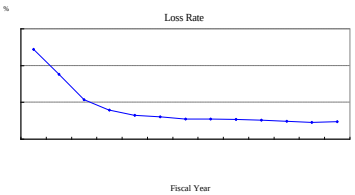
6.6 kV Multi Switch



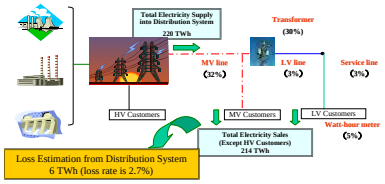
14. Assets for Distribution Network

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

15. Low Network Losses



16. Current Status of Distribution Losses



17. Methodology for Loss-Reduction

1.Macroscopic Approach
(Improving Network)

- Re-balancing the Phase Currents
- Reactive Power Flow Control
- By-passing Low-Load Transformer

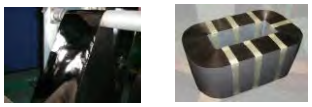
18. Methodology for Loss-Reduction

2.Microscopic Approach
(Improving Equipments)

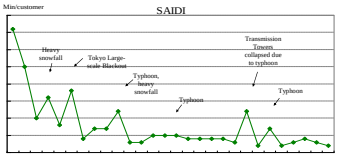
<DT>
Low-loss DT (Silicon Steel Core)
AMT
<LBS>
LBS with Energy-saving Control Circuit
<Meter>
Smart Meter

19. General Info about AMT

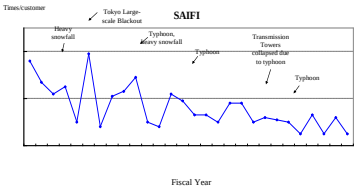
Less No-load Losses – about one-third as compared with Conventional DT
Tend to be larger, heavier and more noisy



20. High Reliability (SAIDI)



21. High Reliability (SAIFI)



22. Approach to raise the Reliability

Improvement of distribution equipment
- Overhead
- Underground

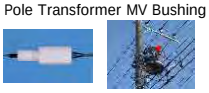
Lightning protection system

Measures for consumers' facilities

Smart Grids (DA & AMI)

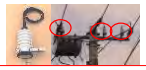
23. Examples of Improved Facilities (OH)

Pole Transformer MV Bushing

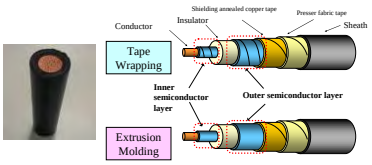


Sealed Type LBS

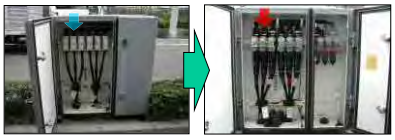
Surge Arrester



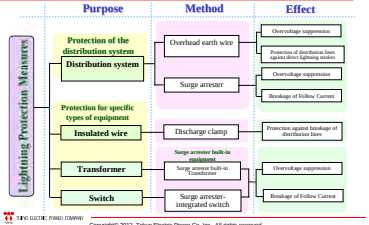
24. Configuration of XLPE Cables



25. Examples of Improved Facilities (UG)



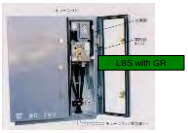
26. Overview of Lightning Protection System



27. LBS with GR

Overhead

Underground



28. Applicability of Distribution Technology

	Reliability Improvement			Environment	
	Fault Frequency	Restoration Time: Sound Area	Restoration Time: Fault Point Elimination	Reduced Loss	Safe Reduced Loss
Machinery Upgrade	v			v	v
T&D System Optimization	v			v	
Distribution Automation	(v)	v	(v)	v	
Smart Meter			(v)		v
Fault Point Detecting Devices			v		
Training for Technicians		v	v		

29. Criteria for Expansion

Distribution Sub Station

Typical : 20MVA×3Banks

Voltage Aspect	Current Aspect
none	<Normal> 110% for Each Bank 105% for Whole SS <N-1 Contingency> 130% for Each Bank

30. Criteria for Expansion

MV Lines

Typical : 240sq HAI (for Backbone)
120sq ACSR (for Branch)
32sq ACSR (for Dead End)

Voltage Aspect
Voltage Drop should not be over <Normal> 300V (Urban), 600V (Rural) <N-1 Contingency> 700V (Urban), 1,000V (Rural)

31. Criteria for Expansion

MV Lines

Typical : 240sq HAI (for Backbone)
120sq ACSR (for Branch)
32sq ACSR (for Dead End)

Current Aspect
Peak Current should not be over <Normal> 510A (240sq), 270A (120sq), 130A (32sq) <N-1 Contingency> 600A (240sq), 360A (120sq)

32. Criteria for Expansion

Utility Poles

Typical : 14m Length (11-12m Top Height)
Standard, Strengthened

Poles are required to stand twice as strong input as designed force.

Stronger poles are needed when 240sq is installed in rural area where wind blows without interruption.

33. Criteria for Expansion

Distribution Transformer

Typical : 10,20,30,50kVA × 1 or 2Banks (3φ)

Voltage Aspect	Current Aspect
none	Year 1 under 80% Year N under 100%

34. Criteria for Expansion

LV Lines

Typical : 120sq ACSR (for single-phase 100V)
32sq ACSR (for three-phase 200V)

Voltage Aspect
Voltage Drop should not be over 3V (single-phase 100V) 15V (three-phase 200V) Under presumption that Voltage Drop of Service Line is 3V(1P) or 5V(3P)

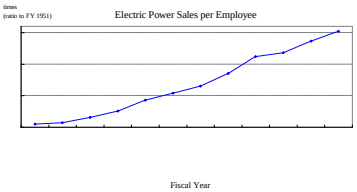
35. Criteria for Expansion

LV Lines

Typical : 120sq ACSR (for single-phase 100V)
32sq ACSR (for three-phase 200V)

Current Aspect
Peak Current should not be over 270A (120sq) 130A (32sq)

36. Efficient Workforce Management

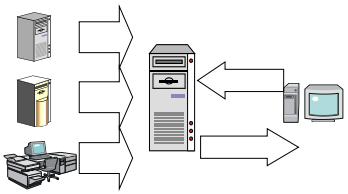


37. Efficient Workforce Management

The planners, designers, field workers and maintenance men are
fully supported by ICT systems

- Distribution Mapping System
- Planning Assist System
- Transaction Management System
- Navigation System for Utility Sites
- PDA equipped for Facility Patrols

38. Outline of Planning Assist System

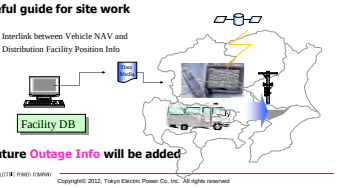


40. Example of Plan proposed by System

41. Navigation System for Utility Sites

Useful guide for site work

Interlink between Vehicle NAV and Distribution Facility Position Info



In future Outage Info will be added

42. PDA equipped for Facility Patrols

Work Efficiency and Data Accuracy improved
Furthermore Work Style might change

Digital-Pen System is also available

Thank you for your kind attention!

TOKYO ELECTRIC POWER COMPANY

Emergency Patrol and Preventive Maintenance

Emergency Patrol
and
Preventive Maintenance

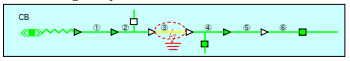
May, 2012

TOKYO ELECTRIC POWER COMPANY

Introduction

Patrol Method according to Type of Fault

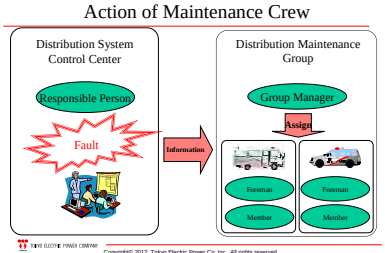
After isolating Faulty Section



How to identify Faulty Point in Faulty Section?

Fault	Emergency Patrol
Grounding	Impulse Generator
Short Circuit	Visual Inspection

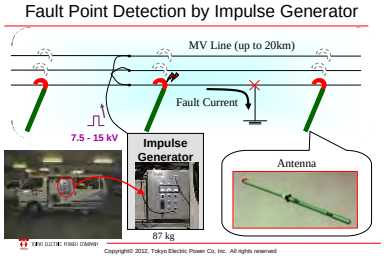
Action of Maintenance Crew



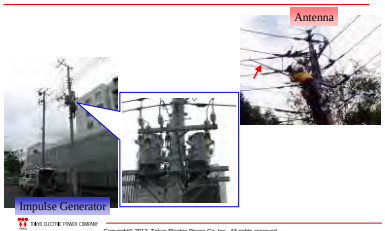
Emergency Patrol Procedure

(Impulse Generator)

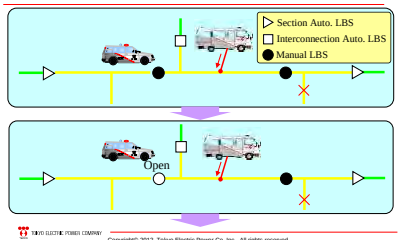
Fault Point Detection by Impulse Generator



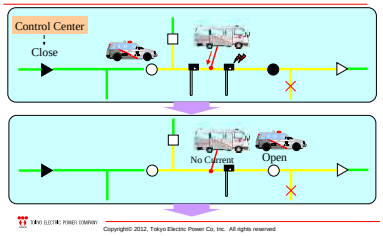
Impulse Generator & Antenna on Site



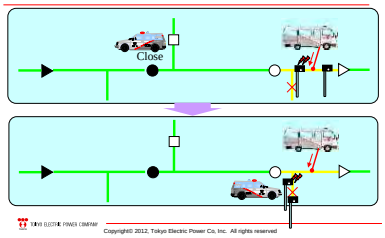
Emergency Patrol (Impulse Generator)



Emergency Patrol (Impulse Generator)



Emergency Patrol (Impulse Generator)

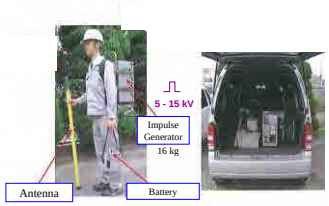


Examples of Fault Point

Tree Contact (Grounding Fault)

Crow Nest (Grounding Fault)

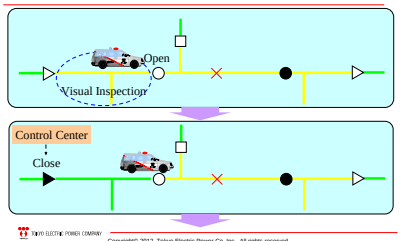
Small Type of Impulse Generator



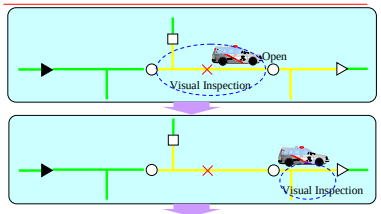
Emergency Patrol Procedure

(Visual Inspection only)

Emergency Patrol (Visual Inspection only)



Emergency Patrol (Visual Inspection only)



Emergency Patrol (Visual Inspection only)

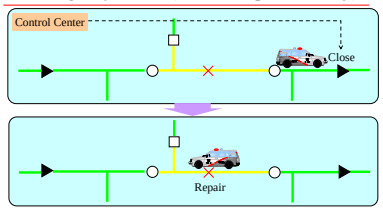
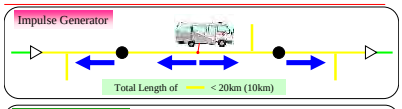
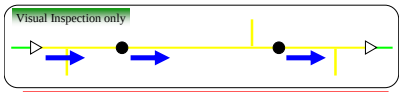


Image of Emergency Patrol



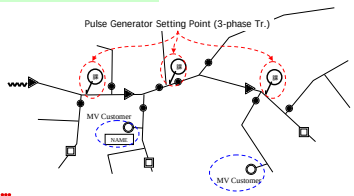


•First Priority: Restoration of Sound Part in Faulty Section
•Every Operation is recorded in office through mutual contact with crew

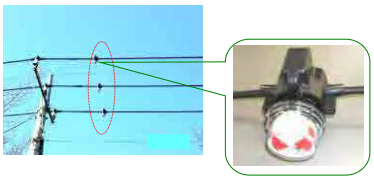
Preparation for Fault Point Detection

Fault Point Detection Map

Prepared for each MV feeder



OCI: Over Current Indicator



Short Circuit Current ⟶ Turn Red

Interruption Report

Image of Interruption Report

Contents of Interruption Report

- Trip Relay
- Weather condition
- Fault Occurrence Time, Arrival Time on Site, Sound Section Restoration Time, Faulty Point Detection Time and Faulty Point Repaired Time
- Switching on/off Time of CB and Isolators, with Number of affected Customers and Outage kW at each step
- First Dispatched Crew and his departure/return time
- Fault Location
- Cause of Fault
- Equipment with Defects

etc.

Preventive Maintenance

Implementation Period

Patrol

- Visual Inspection from G.L.
- All Facilities: Once 5 Years
- Thick Vegetation: Once 1 Year
- Crowded Area: Once 2.5 Years

	Deadline for rectification
Urgent	1 Day
Rapid	2 Months
Normal	1 Year

Inspection

- Close Visual Inspection (including on-pole) and Measurement
- Period: Once 1-6 Years (depending on type of Equipment and its condition)

Rectification Plan

Leveling of Maintenance Quality

Detailed description on Manual

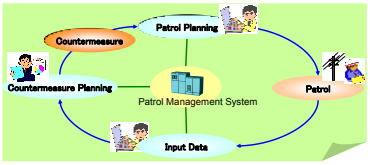
Equipment	Point	Criteria
Pole	Corrosion & Damage	Urgent: Collapse/Broken Rapid: Corrosion hole over 1/4 of circle Normal: Corrosion hole, peel-off, bulge
	MV Cross Arm	
Wire	---	
Tr.		

Visualization

Sample Picture on Manual

Pocketbook for Patrol

Patrol Management System

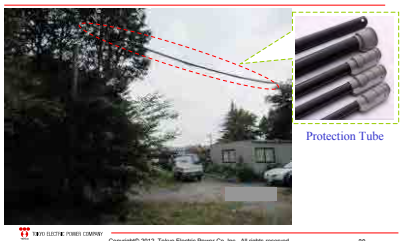


Patrol Management System

Mobile Terminal for Patrol

- On-site data registration
- Upload to Patrol Management System at office

Measure against Vegetation touch



Protection Tube

Thank You for Your kind attention!

Countermeasures for Safety

Countermeasures for Safety

JICA TA Team

Improvement of Efficiency for Rural Power Supply
(Phase II)

TOKYO ELECTRIC POWER COMPANY

Topics

1. Safety Equipments
2. Safety Training for Freshmen
3. Other Activities for Safety

1. Safety Equipment

Safety Equipment
- Normal Works
- Low Voltage Line Works
- Medium Voltage Line Works

Normal Works

Safety Helmet

Safety Belt / Safety Rope

1. Safety Equipment

Low Voltage Line Works

Low Voltage Glove

Low Voltage Detector

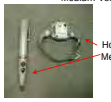
1. Safety Equipment

Medium Voltage Line Works

Medium Voltage Glove

Medium Voltage Boots

MV Hot-Line Shoulder Pad



Hot-Line Proximity Alarm
Medium Voltage Detector

1. Safety Equipment

Safety Rope

Safety Belt

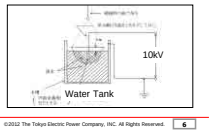
Standard Work Form

1. Safety Equipment

Inspection
- Daily Inspection
  - ✓Before start working
  - ✓Check deterioration and damages visually
- Regular Inspection
  - ✓Every 6 months
  - ✓Check the validity based on the standard

Example : Safety Helmet

Testing Voltage
10kV 1minute



2. Safety Training for Freshman

< Purpose >

- ✓Consider accidents as their own experience
- ✓Realize what is dangerous
- ✓Consider how we can secure safety

< Concept >

- ✓Bodily Sensation
- ✓Experience
- ✓Master

2. Safety Training for Freshman

Bodily Sensation

- ✓Check the past serious accidents
- ✓Think what is an accident
- ✓Discuss about safety in groups

2. Safety Training for Freshman

Experience

- ✓Demonstrate examples which lead to accidents
- ✓Feel accidents with their own skin
- ✓Realize the importance of keeping rules

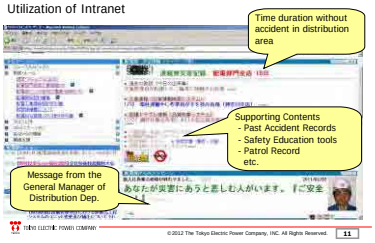

2. Safety Training for Freshman

Master

- ✓Raise awareness about safety through bodily sensation and experience
- ✓Realize why accidents was happened
- ✓Declare their own behaviors for the safety

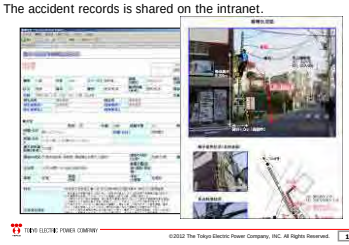

3. Other Activities for the Safety

Utilization of Intranet



3. Other Activities for the Safety

The accident records is shared on the intranet.



3. Other Activities for the Safety

TBM – Safety Briefing -

Procedure of TBM (Tool Box Meeting)

1. Health check on every team members.
2. Explanation of the following items by Team Leader.
   - ✓Procedure of today's work
   - ✓Work order to each member
   - ✓Latent Dangers on the work
   - ✓Key Point to avoid an Accident
3. "Touch and Call" for Key Point by all members

Target of TBM:
All Members' Awareness of the latent Danger on the Work

Thank you for your attention !!

TEPCO Meter, Billing and Collection

TEPCO Meter, Billing and Collection

15th May 2012
Tokyo Electric Power Company, Inc.

1

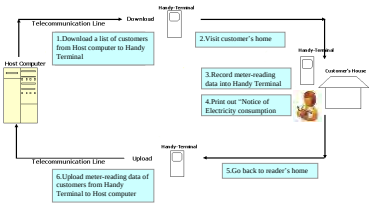
Contents

2

I. TEPCO's Operating Procedures from Meter-reading to Collecting

3

Outline of the Meter-reading Procedure



4

Downloading a list of customers and Uploading meter-reading data between Host computer and Handy Terminal - 1. and 6. in Outline

Handy Terminal (abbr. H.T.)

* Specifications of H.T.: not open to the pubic

5

Meter-reading in customer's home (photograph of demonstration)

6

Inputting consumption data into H.T. (photograph of demonstration) - 3. in Outline

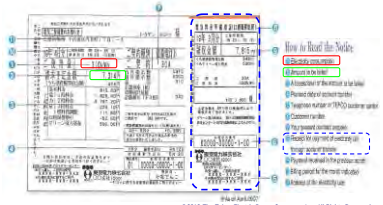
7

Printing out Bill with Notice of consumption data on Mobile Printer (photograph of demonstration) - 4. in Outline

8

Sample of Notice of Electricity consumption

- The notice of electricity consumption indicates customer's monthly electricity consumption and the amount to be billed



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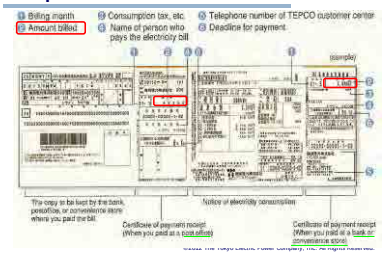
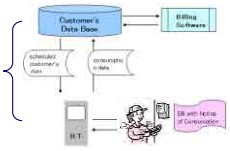
Sample of Bill



10

Operating System with H.T.

1. and 6. in Outline (at reader's home)



3. and 4. in Outline (at customer's home)

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Merit of Meter-reader by H.T.

- 1. Time saving
  - · download/upload of data
  - · commutation (go to from home)
- 2. Reduction of miscalculation
  - · warning for doubtful figure
    - *- a preventive measure against unexpected value*
- 3. Convenience
  - · setup of visiting order
    - *- a preventive measure against no work of meter- reading*
  - · paperless
- 4. Protection of customer's information
  - · electronic data (paperless)

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Reader's situation

- 1. Contract form: unit-price contract for each type of meter-reading
- 2. Payment of salary: monthly, by transfer
- 3. Means of transportation: his/her own motorbike (almost)
- 4. Working hours per day: free (not been determined)
- 5. Incentives for meter-reading: nothing in particular
- 6. Uniform: lent

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How to Pay Electricity Bill

- 1. Account transfer payment (69%)

  Monthly electricity charge is paid automatically out of each customer's bank or post office account.
- 2. Payment by using a payment form (20%)

  Customer can use payment form from TEPCO at the following locations:
  - ・post office
  - ・bank
  - ・convenience store
  - ・TEPCO sales office
- 3. Credit Card payment (11%)

  Payment can be made by credit cards.

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Service to customers

- 1. Discount service for account transfer

  Discount amount of electricity charges per contract is ¥52.50 per month (tax-included).

  * target: pay-as-you-go contract customers supplied by low volage
- 2. Selection service for account transfer date

  According to convenience, customers can choose debit date .

  * target: All customers paying by direct debit
- 3. Other
  - · Payment due date is 30th days from the day following the date of payment obligation occurrence.
  - · Delayed interest is the amount calculated by multiplying target amount of electricity charges (tax-excluded) by 10% per year.

  * source: General Supply Provisions

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II. Verification test of measuring instruments

16

Verification test of measuring instruments

- **1. Purpose**
  - ・To establish the standards of measurement and ensure execution of proper measurement
  - ・Thereby to contribute to economic development and cultural enhancement.
- **2. Implementing agency**
  - ・The Minister of Economy, Trade and Industry
  - ・The prefectural governor
  - ・Japan Electric Meters Inspection Corporation (abbr. JEMIC)
  - ・A person designated by the Minister of Economy, Trade and Industry

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Verification test of measuring instruments

- **3. Main flow**

- ・Test time per measuring instrument for household: about 48 minutes
- ・After the seal, the measuring instrument will be used until the expiration date.
- ・The measuring instrument beyond the expiration date is recovered , repaired, and adjusted by the power company, and it will be used about 30 years after the verification test executed again by JEMIC.

*Source: JEMIC

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Verification test of measuring instruments

- **4.Criteria for Passing**

  ・The structure (including performance and material properties) conforms to technical standards specified by the Ordinance of the Ministry of Economy, Trade and Industry.

  ・The instrumental error does not exceed the verification tolerance specified by the Ordinance of the Ministry of Economy, Trade and Industry.
- **5.Valid period (excerpt of list)**

Measuring instrument type	Rated current	Valid period of verification mark, etc.
Meter	20A,60A	Electronic: 10 years
		Mechanical : 7 years
	30A,120A	***10 years***
	200A	10 years
	250A	10 years

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Verification test of measuring instruments

- **6.Verification mark, etc.**

  ・Sample below is single-phase meter of rated current 30A

Valid period
2018 – 2008 = ***10 years***
*2018
= the 30 year of Heisei era

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End of the Lecture

Thank you for listening!

Introduction of In-house Training for Distribution Technical Employees of Tokyo Electric Power Company

Introduction of In-house Training for Distribution Technical Employees of Tokyo Electric Power Company

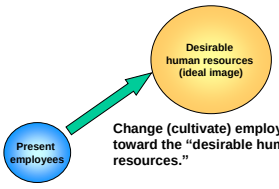
May 2012

Tokyo Electric Power Company, Inc.

1. **Purpose of human resources development**
2. Framework of In-house Training
3. Major group training schemes for technical employees
4. Introduction of the General Training Center

What is human resources development?

Human resources development means to change employees toward the "desirable human resources."



Change (cultivate) employees toward the "desirable human resources."

Capabilities to be required of employees

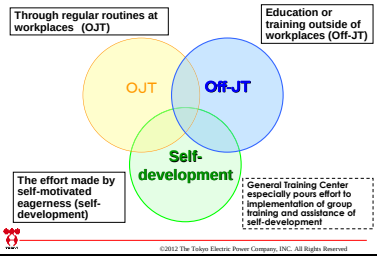
The following capabilities are required of employees:

◎**Required capabilities**

- ●Acquisition of business knowledge/skills and applied skills
- ●Ability to judge the condition
- ●Self-control ability
- ●Affinity to teamwork

etc.

Human resources development methods



Job rotation

Job rotation will be implemented for human resources development.

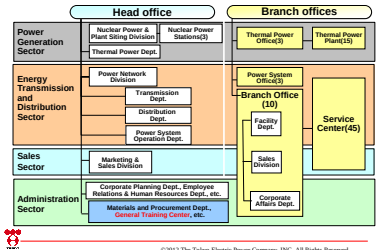
[Concept of personnel allocation and shifts]

- ○ **"Allocate the right person in the right place"**
  Employees will be allocated their most suitable jobs according to their abilities, qualifications, and so on in principle as well as from the perspective of opportunities for them to develop and enhance their abilities through jobs.
- ○ **"Human Resource Development and Allocation"**
  Human resources development will be implemented systematically through such measures as having the employees experience a wide variety of jobs including dispatching and temporary transfer according to their abilities, qualifications, and so on.

Implementation of periodical personnel transfer (every 3-5 year in general)

1. Purpose of human resources development
2. **Framework of In-house Training**
3. Major group training schemes for technical employees
4. Introduction of the General Training Center

Organization chart at TEPCO in 2010 (by division)



System to promote training

- **Key components of designing and implementing training are the followings of three**

TEPCO General Training Center
While dealing with the company-wide challenges, efforts should be concentrated in designing and implementing assistance for cultivation of independent-minded people with not only capabilities to transform but also general foundation, as well as assistance for group training and self-development with the aim to inherit on-site technologies and skills

Divisions (Organizations mainly operating by function)
Design and implement training with the purpose to acquire and improve the specialized knowledge or technologies and skills necessary to execute business task assigned to each

Branch offices (Organizations functioning like local offices)
Design and implement trainings with the purpose to foster people of each branch office, who can handle local needs and facility characteristics

Organization of General Training Center

Number of actual stuff at General Training Center: about 120 in 2010

TEPCO General Training Center

General Training Division : about 40 staffs

The aim is to plan and implement on a corporate scale the development of personnel that can take on the challenge of management innovation and workplace innovation, as well as stimulating the development of personal ability.

Technical-Engineering Training Division : about 80 staffs

Practical training will be planned and implemented in order to promote practical engineering skills and awareness of each engineer for the purpose of improving operation and productivity.

Selection of training instructor

○ **In principle, instructors who is commensurate with a theme should be selected from company members**

- **Such instructors are fostered when needed**

○ **External instructors should be invited when their knowledge gained outside of TEPCO is expected to bring about greater effects**

- **e.g. Educational consultants, professors and others**

○ **Instructors are carefully selected based on the assessment of the following points**

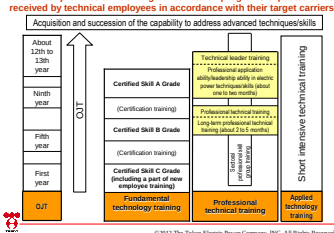
- **Purpose for training and eligibility for prospective result**
- **Specialty and instruction skill, etc.**

- Evaluation made by secretariat, or based on questionnaire from training participants

1. Purpose of human resources development
2. Framework of In-house Training
3. **Major group training schemes for technical employees**
4. Introduction of the General Training Center

Major group training schemes for technical employees

The center provides a wide range of education programs expected to be received by technical employees in accordance with their target carriers.



Major technical group training in 2010

(1) New employee training

(2) Professional technical training

(3) Short intensive technical training

(4) Technical leader training

(5) Operational Technique/Skills Certification System

(1) New employee training

◇ Opening session

(Jointly with administrative employees for about two weeks)

- ●Introduction of the details of internal business
- ●Service disciplines etc.

◇ Basic skill training

(Implemented by sectors approximately four months + four months of power distribution training)

- ●Basics of safety will be learned
- ●Acquisition of basic work skills etc.
- ●Repetitive training

New Employee Basic Skill Training Scene (1)

Lecture: Basic rules, safety management, etc.

FY 2011

316 trainee include distribution(4+5months), transmission and hydropower(4+2 months)

47 trainer include temporary trainer from each service center

In-house electricity line repair training

Source: Tokyo Electric Power Company

New Employee Basic Skill Training Scene (2)

Distribution line work training at training field

Safety training (demonstration of falling)

Source: Tokyo Electric Power Company

Final Test Schedule of New Employee Basic Skill Training

Time	Fault location search	Outage recovery	Facility trouble recovery	Facility operation	breaking wire recovery
8:40~	Opening Remarks				
9:10~10:10	Team1	Team2	Team3	Team4	Team5
Break					
10:30~11:30	Team5	Team1	Team2	Team3	Team4
Lunch Break					
12:50~13:50	Team4	Team5	Team1	Team2	Team3
Break					
14:10~15:10	Team3	Team4	Team5	Team1	Team2
Break					
15:30~16:30	Team2	Team3	Team4	Team5	Team1
16:50~	Closing				

Final Test Schedule on FY 2011

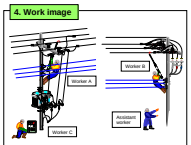
Fault location search (1) Time limit : 60 min.

1. Target
- ・Checking the skill of attaching and detaching of Impulse Generator
- ・Checking the skill of operating Antenna

2. Activities
- ・Attaching and detaching of Impulse Generator
- ・Searching fault point using Antenna
- ・Detaching of Impulse Generator

3.Member
- ・Chief worker : 2 (Instructor)
- ・Worker : 3 (Trainee)
- ・Assistant worker : 2 (Trainee)

4. Work image



Procedure
1. Climb up the pole
2. Attach Impulse Generator cable to DT
3. Check the fault current
4. Check the lines using Antenna
5. Datach Impulse Generator cable from DT
6. Come down from pole

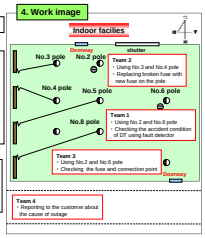
Outage recovery Time limit : 60 min.

1. Target
- ・Checking the skill of outage recovery

2. Activities
- ・Checking the accident condition of DT using fault detector
- ・Replacing broken fuse with new fuse on the pole
- ・Checking the fuse and connection point
- ・Reporting to the customer about the cause of outage

3.Member
- ・Team 1 worker : 3 (Trainee)
- ・Team 2 worker : 4 (Trainee)
- ・Team 3 worker : 4 (Trainee)
- ・Team 4 worker : 2 (Trainee)

4. Work image



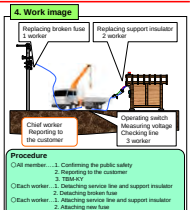
Breaking wire recovery Time limit : 60 min.

1. Target
- ・Checking the skill of replacing broken fuse
- ・Checking the skill of replacing service line
- ・Checking the skill of replacing support insulator

2. Activities
- ・Replacing broken fuse, and service line and support insulator using bucket car
- ・Reporting to the customer about the cause of outage

3.Member
- ・Chief worker : 1 (Trainee)
- ・Worker : 5 (Trainee)
- ・Customer : (Instructor)

4. Work image



Procedure
○All member……1. Confirming the public safety
2. Reporting to the customer
3. 7Shi-Ki-Y
○Each worker…1. Detaching service line and support insulator
2. Detaching broken fuse
○Each worker…1. Attaching service line and support insulator
2. Attaching new fuse
3. Checking the line
4. Reporting to the customer

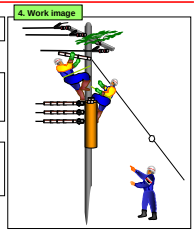
Facility trouble recovery (1) Time limit : 60 min.

1. Target
・Checking the skill of hot line work

2. Activities
・Clear off the obstacle such as tree which was tangled with pole
・Attaching the security protection equipment with MV line

3.Member
・Chief worker : 1 (Trainee)
・Worker A : 1 (Trainee)
・Worker B : 1 (Trainee)
・Assistant worker : 1 (Trainee)

4. Work image



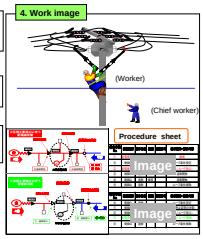
Facility operation (1) Time limit : 60 min.

1. Target
・Checking the skill of operating Automatic Switchgear
・Checking the skill of phase indicator work

2. Activities
・Checking the phase on the pole
・Operating Automatic Switchgear

3.Member
・Chief worker : 1 (Trainee)
・Worker : 2 (Trainee)

4. Work image



(2) Professional technical training

Specific professional techniques/skills will be acquired.

Long-term professional technical training including:

- Facility automation system
- Protection control system

(20 to 50 trainees/year, about two to five months)

(3) Short intensive technical training

Short-term training courses held with cross-sectional themes such as latest technology trends and knowledge about customer consultant activities.

<Course examples>
- CAD application techniques
- Fundamental knowledge about housing-related laws
- Human factor analytical method

(Qualification requirements: All employees; 20 to 30 courses; one to five days/course)
Held 60 to 70 times per year depending on the number of applicants

(4) Technical leader training

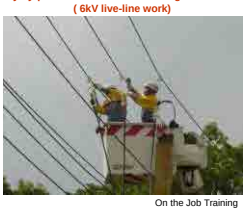
Requirements for leaders of technical workplaces including the following capabilities will be acquired before the employees are appointed to a team leader.

- Team management capability
- Subordinate development capability
- Safety management ability

(Approximately one to two months)

Distribution Emergency Work Training Scene (1)

Temporary by-pass cable connection using aerial work vehicle (6kV live-line work)



On the Job Training

Distribution Emergency Work Training Scene (2)

Source: Tokyo Electric Power Company

Distribution Line Maintenance work Scene

Scene of distribution cable measurement test

On the Job Training

(5) Operational Technique/Skills Certification System (1)

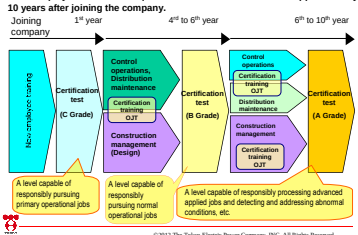
<Objective>
- Further enhancement of required operational technique/skills will be encouraged by clarifying the required levels of operational technique/skills.
- Employees will be further revitalized by fairly certifying the techniques/skills they acquired and allocating them to jobs suitable for such techniques/skills.

<Jobs targeted for skill certification>
Control operations : for distribution system operation
Distribution maintenance: for maintenance and inspection facilities include emergency operation
Construction management: for planning and design

3 fields for distribution

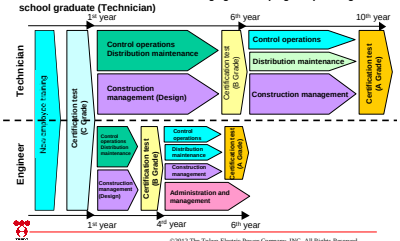
(5) Operational Technique/Skills Certification System (2)

Make employees learn techniques and skills over the course of approximately 10 years after joining the company.



(5) Operational Technique/Skills Certification System (3)

Difference in the schedule between college graduate (Engineer) and high school graduate (Technician)



(5) Operational Technique/Skills Certification System (4)

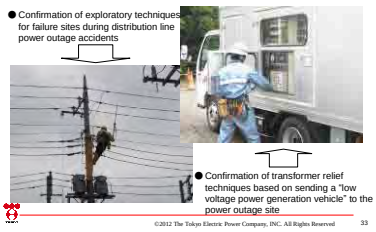
<Certification method>
- **The certification test is held once a year**
- **Mastery of all the predetermined curricula**
- **Prerequisite number of years of practical experience**
- **The practice-related knowledge test and the practical test will be performed according to the levels defined by ranks.**

Certificates will be provided to successful examinees.

Certification Test for B Grade of Distribution Maintenance

Target level: Ability to execute regular on-site operations with responsibility

- Confirmation of exploratory techniques for failure sites during distribution line power outage accidents



- Confirmation of transformer relief techniques based on sending a "low voltage power generation vehicle" to the power outage site

Certification Test for A Grade of Distribution Maintenance

Target level: Ability to process advanced applied approaches as well as perceive and respond to abnormal circumstances, etc. with responsibility, and to also provide guidance.

- Confirmation of burden relief technique for high voltage power outage location based on "industrial switch"

- Confirmation of measurement techniques for site of high voltage underground cable failure based on "underground line measurement vehicle"

New activities

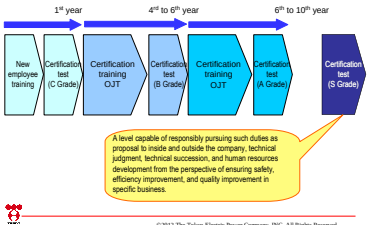
We are implementing activities toward the enforcement of maintenance and succession of techniques and skills.

- Increase in opportunities to directly use techniques and skills
- Enhanced desire to master techniques and skills

1. **Establishment of Certified Skill S Grade**
2. **Establishment of professional technical teams**
3. **Holding of a company-wide skills competition**

Establishment of S Grade

The Operational Technique/Skills Certification System was revised.



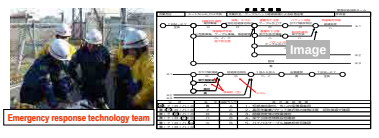
Manifestation of certified S Grade holders

- Personnel with advanced techniques/skills will be certified by the president as specific target human resources beyond A Grade -

Work clothes emblem S Grade uniform Business card

S Grade emblem is a registered trademark of Tokyo Electric Power.

Training of professional technical teams



- Harsh conditions not likely to occur normally are developed intentionally.
- The team members will repeat competitive training over prepared issues.
- The team members will acquire problem-solving abilities by addressing the problems through practice, scientific analysis and thorough discussion rather than instinct, experience, and courage.

Training of Emergency operation teams

【Recovery operation】

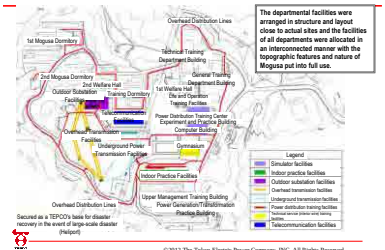
【Emergency power transmission】

Source: Tokyo Electric Power Company

1. Purpose of human resources development
2. Framework of In-house Training
3. Major group training schemes for technical employees
4. **Introduction of the General Training Center**

Layout of training facilities in the General Training Center

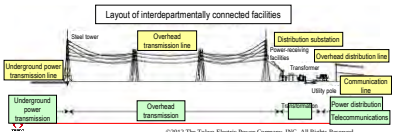
Plan view of training facilities in the General Training Center



Training Facilities Interconnected in Structure and Layout Close to Actual Sites

- The decentralized training facilities are **slightly discrepant from the actual condition** due to "departmental independence" and "simplicity in structure for site constraints."
- **The departmental facilities are interconnected in layout** by integrating **the departmental facilities into a structure and layout close to actual sites** by using topographic features and nature of this training center (Mogusa).
- The training center can hold an interdepartmental cooperation training in preparation for large-scale disasters and can simultaneously hold a technique and skills competition.
- Also effective for education/training programs performed with several departments interconnected.

Layout of interdepartmentally connected facilities



Training facilities in the General Training Center (1)

<Hydroelectric power>

【Min hydroelectric power station】

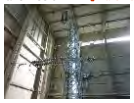
【Horizontal water turbine (model)】

<Underground transmission> 【Cable joint box】

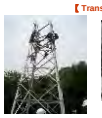
Source: Tokyo Electric Power Company

Training facilities in the General Training Center (2)

<Transmission> 【Transmission Tower (inside)】



【Transmission Tower (outside)】



Source: Tokyo Electric Power Company

Training facilities in the General Training Center (3)

<Substation> 【GCB (inside)】

【Compact type GIS (inside)】

【Protection relay】

【Control panel】

Source: Tokyo Electric Power Company

Namesame
Kadrinche

Presentation Materials of second Workshop

The Smart Meter

The Smart Meter

16th July 2012
Tokyo Electric Power Company, Inc.

1

Contents

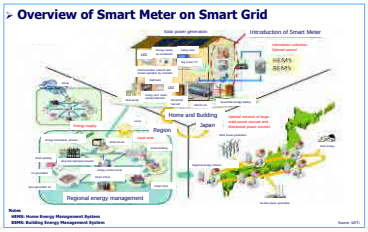
2

I. What's Smart Meter in Japan?

3

Smart Grid and Smart Meter

➢ **Overview of Smart Meter on Smart Grid**



Notes:
HEMS: Home Energy Management System
BEMS: Building Energy Management System

Source: METI

4

Need for Smart Meter on Smart Grid

➢ **A key component of Smart Grid**

✓ **Digital type meter**
Semi-automated digital measurement and meter reading of power data
=Manual intervention in meter reading

✓ **Smart Meter**
Two-way communication in addition to the functions of digital type meter
→ · No manual intervention in meter reading
· Automatically measurement
· Possible to measure and transmit data every short time

Source: METI

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Evolution of watt-hour meter in Japan

1952 ▪▪▪▪▪▪▪▪▪▪ 1990 ▪▪▪▪▪▪▪▪▪ The present

Analog type meter	Digital type meter	Smart meter
Mechanical measurement (read by person)	Electronic measurement (Through person)	Electronic measurement (read by equipment)
Every 1 month	Every 1 month	Every 30 minutes, etc.
	One-way communication	Two-way communication

6

Introduction background of Smart Meter

➢ **Japan**

✓ Introduction expansion of renewable energy such as large amounts of interconnections with solar power generation system
↓
✓ Occurrence of bad influence on the system stability, etc.
✓ Occurrence of surplus power
↓
✓ Means for two-way communications of control information in power system

★ **Introduction of Smart Meter**

Source: METI

7

Introduction background of Smart Meter

➢ **Japan**

✓ Power supply crunch after great earthquake disaster in eastern Japan on March 11, 2011
↓
✓ Heightened awareness of energy saving on customer side
✓ Power system reform
↓
✓ Demand response

★ **Introduction of Smart Meter**

Source: METI

8

Concept of Smart Meter

➢ **Smart Meter in the narrow sense**
Meter with minimum functions of remote automatic meter reading, remote opening and closing, collection and transmission of measurement data

➢ **Smart Meter in the broad sense**
Meter with visualization of the information such as energy consumption for energy saving and energy management function, to introduce renewable energy such as large amounts of interconnections with solar power generation system and build a flexible system for electricity charges such as time of use in the future, in addition to functions of meter in the narrow sense

Source: METI

9

Difference between AMR,AMM,SM,or AMI

✓ **AMR: Automated Meter Reading**
Remote meter reading by one-way communication

✓ **AMM: Automated Meter Management**
Remote opening and closing Two-way communication, in addition to the functions of AMR

✓ **Smart Meter**
Interval metering and information·data storage, in addition to the functions of AMR and AMM

✓ **AMI: Advanced Metering Infrastructure**
Whole system of information collection and management, including communication from power company side and communication network such as HAN*, in addition to the functions of SM

* HAN: Home Area Network

Source: METI

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Functions of Smart Meter required in Japan

➢ **Functions of Smart Meter required at present**

✓ **Time axis of meter introduction**
Technological development cycle of meter, etc.

✓ **Overseas cases**
Introduction of meter in Europe: Emphasis on functions such as remote meter reading by two-way communication

✓ **Present situation in Japan**
Increase in costs (cost-benefit), Needs of customer-side for apparatus control, Introduction amount of solar power generation, etc.

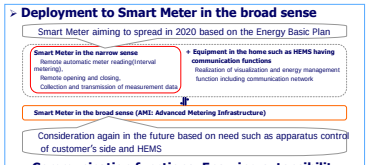
★ **Smart Meter in the narrow sense**

Source: METI

11

Extensibility of Smart Meter function

➢ **Deployment to Smart Meter in the broad sense**



➢ **Communication functions: Ensuring extensibility of information network**
✓ An increase in the number of Smart Meter
✓ An increase in the number of communication amount and measuring time of Smart Meter itself

Source: METI

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Effect expected with introduction of Smart Meter

➢ **Merit of customer's side**

Application example of information using such as electricity	Expected merit
Addition of remote automatic meter reading and remote opening and closing function	Monitoring of load condition and immediate response of power company during outage
Visualization of usage information such as electricity and charge information, Provision of energy-saving diagnostic services, etc.	Energy and CO_2-saving, Effect of household saving
Optimal apparatus control by HEMS introduction, setting and using of segmentalized charge menu	Further energy and CO_2-saving, Effect of household saving
Centralized grasp and management as energy information added to usage information such as gas	Provision of comprehensive energy and CO_2-saving services
Application of detailed electricity usage information as lifestyle of customer	Provision of watching and application to nursing service for elderly people

Source: METI

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Effect expected with introduction of Smart Meter

➢ **Merit of electric power companies, etc.**

Application example of information using such as electricity	Expected merit
Addition of remote automatic meter reading and remote opening and closing function	Operational efficiency of local services, etc.
Visualization of usage information such as electricity and charge information	Raising awareness of customers for energy saving, improvement of customer satisfaction
Application to consideration of electricity charge menu by the data of supply and demand patterns including renewable energy	Consideration of way of electricity charge for efficient use of energy, load balancing by induction of demand
Grasp of detailed usage of distribution facilities such as transformers, etc.	Efficient formation of facilities according to actual Use Condition of distribution facilities

Source: METI

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II. Activities related to Smart Meter of TEPCO

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Overview of TEPCO's Smart Meter

Smart Meter
- Electronic measurement
- Every 30 minutes, etc. (Interval metering)
- Two-way communication (between Meter and Company)
- Remote automatic meter reading
- Remote opening and closing function
- Collection and transmission of measurement data

- Have introduced experimentally to approximately 1,200 households in model areas of Tokyo from the second half of FY 2010.
- Experimenting demonstration of the communication function, etc.

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Demonstration experiment for Smart Meter expansion of TEPCO

➢ **Overview of demonstration experiment**

Item	Technical verification	Operational verification
Implementation period	Introduction start from the second half of FY ☒☐	Introduction start from the second half of FY ☒☐
Implementation outline	Demonstration experiment of functions of communication, etc.	Demonstration experiment of business operation on automated meter reading in the entire office ・Remote meter reading, etc.
Introduction number	House: about ☒☐ households Mansion: about ☒☐ households	All customers in the district of one service office: about ☒ thousand households
Verification content (Evaluation criteria)	Transmission quality and connection quality of communication	Verification of effect on improving efficiency of business operation

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Major activities of TEPCO

➢ **Measures to Peak Shift**
Considering the menu of electricity charges for control of peak demand

➢ **Improving efficiency of business operation**
Considering flow and verification methods of business operation for realization of new business focusing on no visit

➢ **Cost reduction of Smart Meter**
Reducing procurement costs by optimizing specifications of Smart Meter

➢ **Demonstration of direct provision of measurement data**
Scheduled for realization of provision of measurement data (30 minutes value) directly from Smart Meter to HEMS in Yokohama Smart City Project (YSCP)

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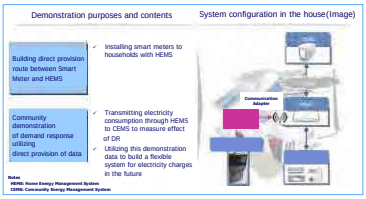
Activities related to Smart Meter in Yokohama Smart City Project (YSCP)

➢ **Provision of measurement data directly from Smart Meter to HEMS (Image)**



19

III. Introduction situation of Smart Meter in the world

20

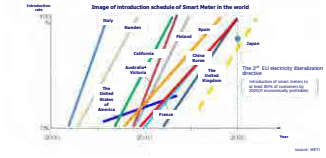
Situation related to Smart Meter in each country

➢ **Overview of a major case in each country**

21

Introduction Situation and plan of Smart Meter in the world

- In the countries and states decided or mandated to introduce Smart Meters on a large scale, the introduction of almost all the meters are expected to be completed in the 2010s.
- In Japan, in the Basic Energy Plan which was revised in June, "Fully considering cost-effectiveness, etc., we aim the introduction of smart meters to all consumers in principle as early as possible of the 2020s".



22

Introduction background of Smart Meter

➢ **The United States of America**

- ✓ Occurrence of large-scale outage (August 2003)
- ✓ Increase in demand
  - ✓ Instability of supply reliability
  - ✓ Demand response (Measures to control demand)
- ✓ Environmental Limitation, etc.
  - ✓ Difficult situation of new power generation installation

★ **Introduction of Smart Meter** ×

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Introduction background of Smart Meter

➢ **Europe**

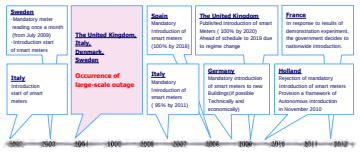
- ✓ Power theft prevention
- ✓ Occurrence of outages in many parts of Europe (2003)
- ✓ Introduction expansion of renewable energy such as large amounts of interconnections with wind power generation system
- ✓ Remote meter reading, Grasp of system information

★ **Introduction of Smart Meter**

24

Introduction progress of Smart Meter in EU major countries

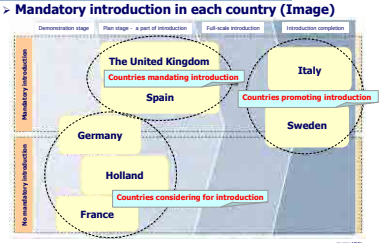
➢ **Outline in each country**



25

Deployment status of Smart Meter in EU major countries

➢ **Mandatory introduction in each country (Image)**



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Introduction situation of Smart Meter in Asia

➢ **Introduction Progress in each country**

Country name	Smart meter number	All meter number	Outline
China	63,000,000	385,000,000	・Implementing large-scale introduction in accordance with smart grid plan of government ・Introducing 58.5 million smart meters by September 2011 ・Scheduled for introduction 230 million smart meters by 2015
Korea	3,010,000	22,217,471	・Published "National road map of smart grid" in January 2010 ・Building infrastructure of smart meter and two-way communication system for all customers by 2020
India	225,000	144,000,000	・Planned introduction of smart meters as a part of R-APDRP expanded to reduce distribution loss. ・Expected to be introduced around IT companies
Taiwan	100,000	12,387,370	・Published the start of AMI project in 2010 ・Planed to change the meters of all of 12 million housing customers. to smart meters
Thailand	5,000	18,352,498	・Planned by PEA to introduce 3 million smart meters by 2016, 15 million ones by 2021
Singapore	-	-	・Implementing demonstration experiment for introduction of smart meters
Philippines	7,000	15,600,000	・Ditto

Source: METI
Smart Meter number : Introduction situation of AMI (Projects' until 2010)

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Overseas meter market, manufacturer trends

- Smart meter of the top manufacturers in global market share has been adopted in each country in the world.
- Compared with about 34% world market share of top three manufacturers (Itron/Actaris, Landis+Gyr, Elster) in the world, Japanese market share is about 1.8%.
- Manufacturers in China and India is expanding from the domestic market, their share are higher in the background a huge domestic market.

Meter manufacturer share in the world

The Japan market value (reference) is the ratio of the domestic manufacturing number for the world's annual production number.

<Overseas meter trends >
- The number of installed meter in the world (including mechanical type) is about 1.7 billion, annual production number is about 130 million ($ 5.0 billion).
- In the background such as replacement demand in the countries and states decided to introduce smart meters on a large scale, further expansion of the meter market in the future is expected.

All data in 2009
source: METI

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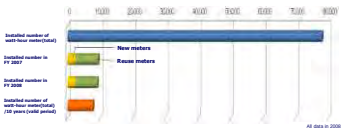
Situation of watt-hour meter in Japan

- Japan market scale is about 30 billion yen, compared with about $ 5.0 billion world market. (Production amount is 30.5 billion yen, including export amount is 100 million yen)
- Annual installed number is about 9.0 million, including about 1.9 million new meters. The rest are the existing reuse meters to be collected and repaired.
- Reuse of mechanical-type meters account for the majority and the annual new demand is about 20% of the annual installed number. Production amount per manufacturer is less than overseas manufacturer's. For example, in case five companies supply the smart meters for all meters in Japan(number of contracts: about 80 million, replacement in 10 years), annual supply amount per manufacturer is 1.6 million. However, if the meter of each power company is different, production scale per model will be reduced.

Installed number of watt-hour meter and annual installed number in Japan unit : 1 thousand number



All data in 2008
source: METI

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Situation of watt-hour meter in Japan

Installed number of watt-hour meter and annual installed number in Japan

unit : 1 thousand number

Power company	Installed number of watt-hour meter (total) (A)	Annual installed number				(B)/10 years (valid period)
		2007		2008		
		Installed number	New meters	Installed number	New meters	
Hokkaido	3,636	412	109	404	94	364
Tohoku	6,723	760	217	721	190	672
Tokyo	27,189	3,038	662	2,859	663	2,719
Chubu	9,428	1,080	178	1,065	167	943
Hokuriku	1,805	215	55	211	54	181
Kansai	12,636	1,623	327	1,585	343	1,264
Chugoku	4,927	659	119	611	126	493
Shikoku	2,730	307	45	329	50	273
Kyusyu	8,178	836	175	824	175	818
Okinawa	800	93	23	98	28	80
Total	78,052	9,024	1,909	8,706	1,890	7,805

All data in 2008
source: METI

Introduction of In-house Training of Tokyo Electric Power Company

Introduction of In-house Training of Tokyo Electric Power Company

July 2012

Tokyo Electric Power Company, Inc.

1. Management principle and management guidelines, and Fundamental principles and system
2. Points of concern in designing and conducting training
3. Introduction of New Employees training and Grade system
4. Incentive system (Introduction of Front-line Workplaces Activities in TEPCO)

Management principle and management guidelines

Management Vision 2010

◆Group Management Principle◆

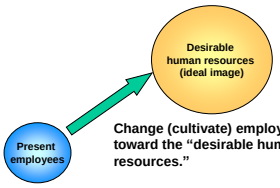
Contribute to the realization of affluent living and pleasant environment by offering optimal energy services

◆Group management guidelines◆

Management Guideline No.1	Management Guideline No.2	Management Guideline No.3
"Win the Trust of Society"	"Survive the Struggle in Competition"	"Foster People and Technology"
Eligibility to participate in the competitive markets is the "trust" that society places in us.	Nothing makes TEPCO Group happier than customer "satisfaction".	"People and technologies" open up the future of our Group.

What is human resources development?

Human resources development means to change employees toward the "desirable human resources."



Review

Changing of Capabilities to be required

Capabilities to be required for technical engineer/technician is changing

[Old requirement]	[New requirement]
・be amenable to discipline	・ability to take action even at contingency
・orderly mind	・spirit of challenge
・steady thinking	・zero-based thinking
・conservative mind	・creative mind

Fundamental principles of human resource development

Main method of Training for the technical engineer/technician is on the job training

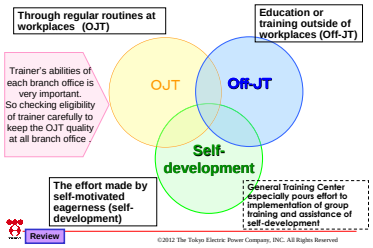
O Fundamental principles

- ・Job rotation
- ・On the job training (OJT)
- ・Group training — Complementary method

O Major training schemes

- ・Group training
- ・Supporting self-development

Human resources development methods



Review

1. Management principle and management guidelines, and Fundamental principles and system
2. Points of concern in designing and conducting training
3. Introduction of New Employees training and Grade system
4. Incentive system (Introduction of Front-line Workplaces Activities in TEPCO)

Basic idea and structure of training - changes in management environment -

- Impact on the style of organization, human resources and job

Organi-zation	Swift decision-making by flattering corporate structure. "Customer service" and "construction, maintenance and operation of facility" in an integrated manner
Human resources	The system of pay and benefits was reviewed to make it more merit-/ability- based.
Practice	Business operation structure best suited for electricity business was reestablished. Intensive enhancement and effective utilization of facility maintenance.

Basic idea and system of training - challenges and direction of measures -

- Cultivation of human resources based on OJT should be maintained while the system focusing on the followings requires development

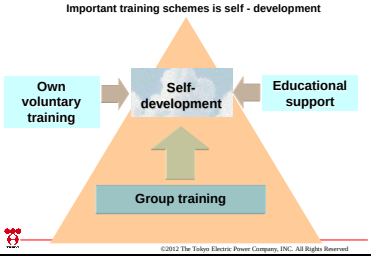
Improvement of front-line technologies and skills as well as ability to discover and solve issues

Enhancement of management ability among management-level staffs

Leadership for innovation

Training schemes for human resource development

Important training schemes is self - development



4-[2]. Points of concern in designing and conducting training

◆Tasks ◆Points of concern

Tasks	Points of concern	
Designing of training	Company-wide recognition of challenges Review of training system * Selection of instructors *Selection of text books	Utilization of external resources (Instructors in particular)
Conducting of training (Operation)	*Awareness of purpose and significance *Ex ante assignment *Assistance to practice at a workplace (including ex post assignment)	Quality maintenance Effect measurement

Selection of training instructor

O In principle, instructors who is commensurate with a theme should be selected from company members

- Such instructors are fostered when needed

O External instructors should be invited when their knowledge gained outside of TEPCO is expected to bring about greater effects

- e.g. Educational consultants, professors and others

O Instructors are carefully selected based on the assessment of the following points

- Purpose for training and eligibility for prospective result
- Specialty and instruction skill, etc.

- Evaluation made by secretariat, or based on questionnaire from training participants

Review

Important parts of training implementation

○ Contents are set from the perspective of followings upon the consultation with training instructors

1. Ex ante assignment
   - should inspire motivation about participating in training
   - Set one's own agenda, upon consultation with boss, before taking a training
2. Educational materials
   - should supplement content of a lecture
   - could be what instructors use during a lecture
   - Requires to be well organized, purposeful and easy to understand while including up-to-the-minute details
3. Ex post assignment
   - should be associated with what was learned from a training and practical skills
   - Take action toward problem-solving after receiving a training
   - Follow-up provided by the center

Quality maintenance and effect measurement of trainings

[Quality]

- O Discovering quality and eligibility of an instructor as well as content and skill level provided by the instructor
- O Observation on a degree of response from participants
- O Provision of feedback composed of obtained results to instructors

- To maintain and improve training, every training undergoes quality control and effect measurement

[Effect measurement]

- O Evaluation of training based on questionnaire filled out by participants and their boss
  - Benefits, earned throughout trainings, of practicing at a workplace
  - Practicality in terms of action
  - Benefits of each program
- O Confirmation on implementation status of practical skills executed at workplaces (WPL: Work Place Learning)

- Confirm whether participants put what they learned from trainings in practice at their workplaces

1. Management principle and management guidelines, and Fundamental principles and system
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4. Incentive system (Introduction of Front-line Workplaces Activities in TEPCO)

Annual Training Schedule for New Employees

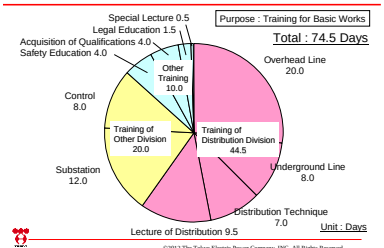
	First Half-Year 4 5 6 7 8 9	Second Half-Year 10 11 12 1 2 3
OJT	Branch Office • Education at the time of employment • Legal education • Basic manner training	Service Center • OJT • Collective Training in the branch office
GT*	Training Center (4 months) • Collective training of first half-year • For all new employees of technical division • Basic training	Training Center (5 months) • Collective training of second half-year • For new employees of distribution division • Advanced training

* Group training

Training Composition of First Half-Year

Purpose : Training for Basic Works

Total : 74.5 Days

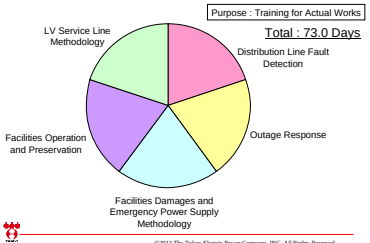


Unit : Days

Training Composition of Second Half-Year

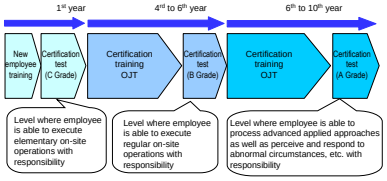
Purpose : Training for Actual Works

Total : 73.0 Days



Grade system

The level of Operational Technique/Skills Certification System



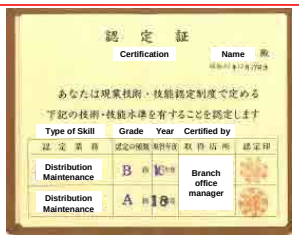
Level where employee is able to execute elementary on-site operations with responsibility

Level where employee is able to execute regular on-site operations with responsibility

Level where employee is able to process advanced applied approaches as well as perceive and respond to abnormal circumstances, etc. with responsibility

- Chef worker / Supervisor need to have A Grade
- Emergency maintenance team leader need to have A Grade

Grade Certification



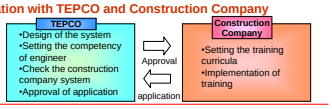
Relation and Level of Construction Company

Type of Technique/Skills

- Construction Technique/Skills (1st , 2nd, 3rd Grade)
  (Overhead line course, Undergrad cable course)
- Construction management Technique/Skills

Level of Technique/Skills

Relation with TEPCO and Construction Company



1. Management principle and management guidelines, and Fundamental principles and system
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4. **Incentive system (Introduction of Front-line Workplaces Activities in TEPCO)**

Qualification Reward System

- TEPCO supports staffs to pass Public Qualification Tests and reward those who passed the tests with financial incentives

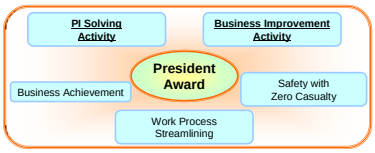
Public Qualification Test	Financial Incentive
Qualified Electrical Chief Engineer (1st grade) National Judicial Examination (Lawyer) Certified Public Accountant Doctor's Degree (Ph. D)	Nu. 214,000
Patent Attorney Processional Engineer	Nu. 142,000
First-class Architect Certified Tax Accountant	Nu. 71,000

*1.4 JPY /BTN

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

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 357,000 BTN

New activities

We are implementing activities toward the enforcement of maintenance and succession of techniques and skills.

- Increase in opportunities to directly use techniques and skills
- Enhanced desire to master techniques and skills

1. **Establishment of Certified Skill S Grade**
2. **Establishment of professional technical teams**
3. **Holding of a company-wide skills competition**

Review

Establishment of S Grade

◇Established as a grade upper than A Grade

Human resources capable of responsibly pursuing technical succession and human resources development (with a high technical capability and leadership ability) will be certified through the following tests.

- **Test on sector-specific professional techniques**
- **Test on leader competence**

A certificate will be granted by the president.

The certified personnel will be also permitted to wear a special design uniform.

Establishment of professional technical teams

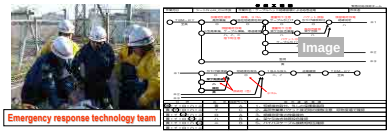
Professional technical teams will be established chiefly under the direct control of the head office to maintain and strengthen techniques/skills.

<Example of professional teams>

Sector		Professional technical team	Major practical activity
Transmission	Hydro power generation	Water turbine generator engineering team	・Designing, construction, test of water turbine repair works
	Overhead transmission	Steel tower maintenance technology team	・Basic displacement, variation diagnosis, structural component deterioration diagnosis, steel tower strength determination, designing of optimum repair/reform
	Power transformation	Protection control engineering team	・Designing, construction, test of switchboards ・Business improvement/efforts on problem solving
	Power distribution	Emergency response technology team	・Repeated training specialized in improvement of practical technologies from judgment to treatment of facilities incidents
		Maintenance technology team	・Practice of measurement/diagnosis technologies accompanied by advanced evaluation
		Distribution equipment engineering team	・Investigation and analysis of faulty equipment

5 to 10 persons/team

Training of professional technical teams



Emergency response technology team

- Harsh conditions not likely to occur normally are developed intentionally.
- The team members will repeat competitive training over prepared issues.
- The team members will acquire problem-solving abilities by addressing the problems through practice, scientific analysis and thorough discussion rather than instinct, experience, and courage.

Review

Company-wide technique and skills competition (president cup)

Held with the aim of improving the desire to acquire techniques and skills, creating the corporate culture respecting techniques and skills, and vitalizing workplaces.

- Evaluated with "safety," "quality," and "efficiency" as common criteria
- The actual number of participants in the competition was expanded by holding elimination contests.
- The competition functions as a setting to spread the possessed techniques throughout the company.

Power distribution maintenance; Emergency power transmission

Overhead transmission line; Jumper operation

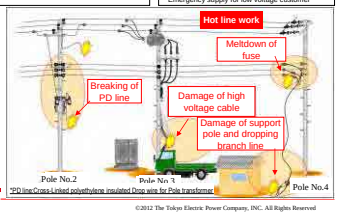
Power transformation; Pre-service inspection of mobile switch

Theme of president cup

Time limit : 75 min.

1. Target
・Recovery work of damaged line and emergency electric power supply

2. Activities
・Recovery work of damaged line
・Emergency supply for high voltage customer
・Emergency supply for low voltage customer



Effects of competition

- Engineering capabilities were enhanced through the training toward the competition.
  - Elimination contests were held at some branch offices. (Effective in further expanding the actual number of participants.)
- Consciousness of participants was enhanced by the observation of the management.
- The competition functions as a setting to spread the possessed techniques of TEPCO throughout the company.
  - Deepened technical exchanges with other branches and other sectors

Namesame
Kadrinche

Presentation Materials of third Workshop

Protection Relay and Relay Coordination

Protection Relay and Relay Coordination

February 2013

Tokyo Electric Power Company, Inc.

1. Outline of Protection Relay and Coordination
2. Outline of Protection Relay and Coordination in the TEPCO System
3. Protection Relay and Coordination in the TEPCO 66kV System
4. Protection Relay and Coordination in the TEPCO 6.6kV System
5. Preferred Specifications
6. Technical Trends

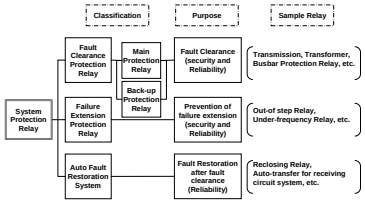
Purpose of Protection Relay

[purpose]

Isolating the faulty part from the healthty system so that fault does not spread over the other points

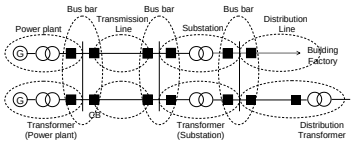
- ✓ **Security :**
  - ➢ Damage prevention of the power facility
  - ➢ Public safety
- ✓ **Reliability :**
  - ➢ Minimization of the outage area
  - ➢ Stabilization of the power system

Classification of Protection Relay



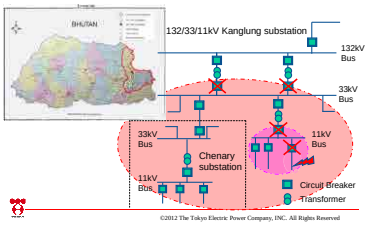
Covered area of Protection Relay

Each Protection Relay has the protection area for minimizing the outage area and reliability of the power system



G : Generator
CB: Circuit Breaker

Purpose of Protection Relay

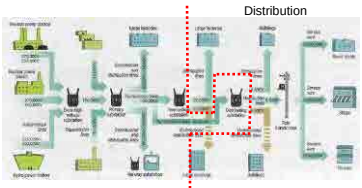


1. Outline of Protection Relay and Coordination
2. Outline of Protection Relay and Coordination in the TEPCO System
3. Protection Relay and Coordination in the TEPCO 66kV System
4. Protection Relay and Coordination in the TEPCO 6.6kV System
5. Preferred Specifications
6. Technical Trends

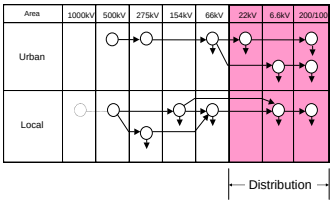
[Review] Outline of TEPCO Power System

500kV UG
275kV UG
500kV OH
275kV OH

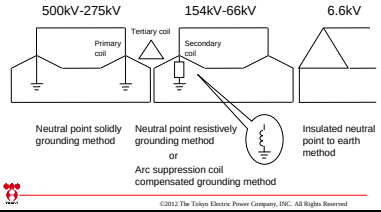
[Review] Outline of TEPCO Power System



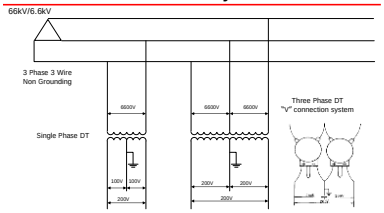
[Review] TEPCO's Voltage Leve



[Review] Transmission System



[Review] Distribution System



Guiding principle of Protection Relay Coordination

[Guiding principle]

- ➢ It is necessary to clarify the purpose of installing protection relay equipment , the covered area of protection relay and the type of accident which the protection relay can operate with.
- ➢ It is necessary to coordinate the other relay for reliable operation and prevention of improper operation.
- ➢ It is necessary to calculate the setting value in consideration of real system configuration and manner of operation.

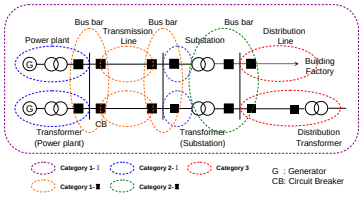
[Necessary information for Protection Relay Coordination]

- ➢ System configuration, Impedance, Power flow, Zero-phase circulating current, Steady state stability, Transient stability, Short circuit capacity (current) etc.
- ➢ Protection relaying scheme, Characteristic of existing protection relay
- ➢ Characteristic of current transformer and voltage transformer
- ➢ Break time and make time of circuit breaker
- ➢ Capacity of line conductor, bus bar and power facilities

Category of Protection Relay (TEPCO)

- ✓ **Category 1- Ⅰ**
  Protection relay for whole system protection (Under-Frequency Relay, etc.)
- ✓ **Category 1- Ⅱ**
  Protection relay which is operated by system load dispatching office (500kV line Protection Relay, etc.)
- ✓ **Category 2- Ⅰ**
  Protection relay which is operated by branch office load dispatching station (66kV Line Protection Relay, etc.)
- ✓ **Category 2- Ⅱ**
  Protection relay which is operated by service center control and maintenance office (66/6kV Transmission Protection Relay, etc.)
- ✓ **Category 3**
  Other protection relay (6kV Line Protection Relay, etc.)

Image of Covered area of Protection Relay



G : Generator
CB: Circuit Breaker

Responsible of Implementation of Protection Relay Setting

Category of Protection Relay	Department in charge
Category 1- Ⅰ	Service center control and maintenance office
Category 1- Ⅱ	
Category 2- Ⅰ	
Category 2- Ⅱ	Power plant
Category 3	

Responsible of Operation of Protection Relay Setting

Category of Protection Relay	Department in charge
Category 1- Ⅰ	System load dispatching office
Category 1- Ⅱ	
Category 2- Ⅰ	Branch office load dispatching station
Category 2- Ⅱ	Service center control and maintenance office
Category 3	Service center control and maintenance office Power plant

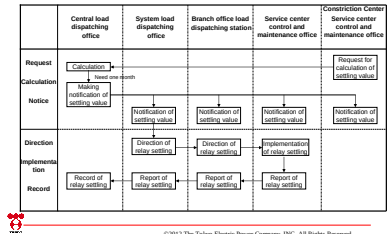
Responsible of Recordkeeping of Protection Relay Setting

Category of Protection Relay	Department in charge
Category 1- Ⅰ	Central load dispatching office
Category 1- Ⅱ	System load dispatching office
Category 2- Ⅰ	Branch office load dispatching station
Category 2- Ⅱ	
Category 3	

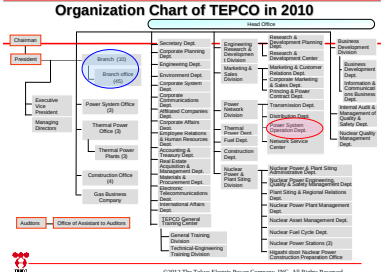
Analysis software for Calculation of Protection Relay Setting

Department	Department in charge
Central and System load dispatching office Branch office load dispatching station	GST:Phase fault analysis Ground fault analysis NTR-Y:Stability analysis FDC:Power flow analysis (*Self - developed software)
Engineering Department Branch Office	GST etc. (*Self - developed software)
Distribution Department	Self - developed software PQQAS (Power Quality Analysis) (*Self - developed software)

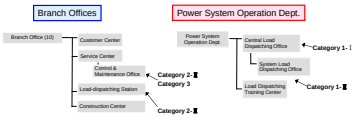
Process of Protection Relay Setting (Category 1- Ⅰ)



Organization Chart of TEPCO in 2010

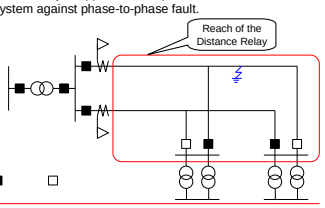


Organization Chart of TEPCO in 2010



Phase-to-Phase Fault Protection for 66kV transmission lines

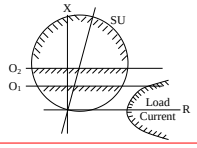
Distance Relay is applied for the protection of the 66kV system against phase-to-phase fault.



Distance Relay Setting

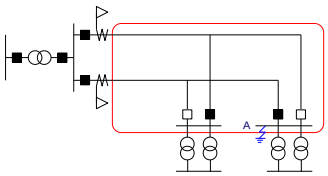
O*i* (Reactance): Correctly detects the distance regardless of arc resistance

SU (MHO): Correctly detects the direction of the fault regardless of load current



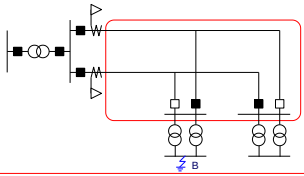
Distance Relay Setting

A fault at the end of the transmission line causes minimum fault current within the reach of the distance relay.

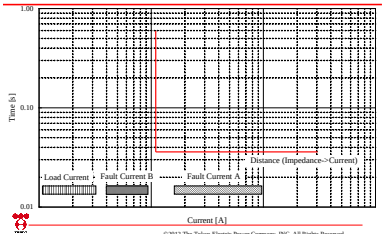


Distance Relay Setting

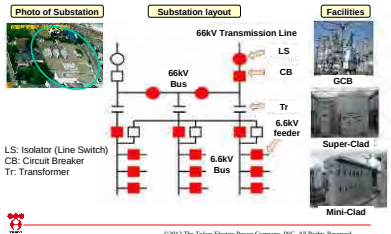
The distance relay shouldn't trip the line by the fault on the secondary side bus of the 66/6.6kV transformer.



Distance Relay Setting



Distribution Substation (66kV/6.6kV) Facilities



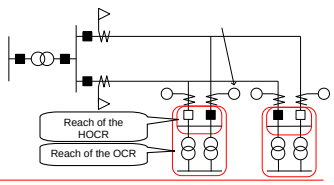
Main Relay Type of Substation (66kV/6.6kV)

Standard Relay Setting in the TEPCO 66kV/6.6kV substation

Relay Name	Relay Type	Purpose	Standard Relay Setting (Sample)
Phase fault relay	Over current relay (OCR) (51L)	Phase fault protection for whole substation	Value: 150% of installed transformer capacity Time:0.6-1.0s
	Over current relay (HOCR) (51H)	Phase fault protection for 66kV system	Value: <150% of maximum short circuit current at transformer secondary winding >50% of minimum short circuit current at 66kV busbar Time: 0.05s
	Over current relay (HOCR) (51T)	Phase fault protection for transformer and 6.6kV system	Value: 160% of rated current Time: 0.6-0.1s
Earth fault relay	Over current relay (OCGR)	Earth fault protection for 66kV system	Value: 30A Time: 0.05-0.0759s
Percentage differential relay	Percentage differential relay (RDfR)	Transformer fault protection	Value: 67% of rated current Percentage differential : 50% Time: instant

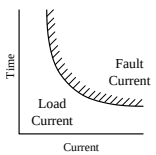
Phase-to-Phase Fault Protection for 66/6.6kV substations

Overcurrent Relay is applied for the protection of the 66/6.6kV substation against phase-to-phase fault.

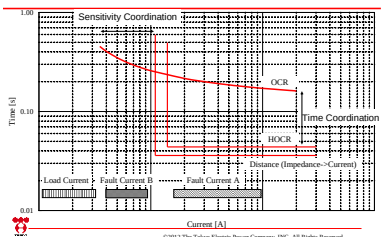


OCR Setting

A setting of OCR has an inverse time characteristic.

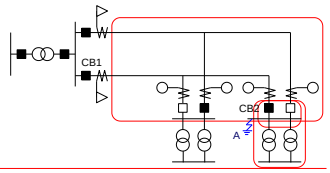


Relay Coordination



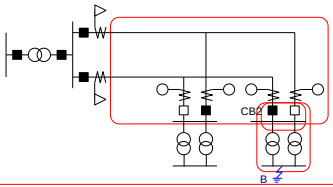
Relay Coordination

Distance relay trips CB1 instantly at the same time as HOCR trips CB2.



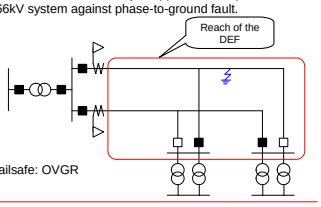
Relay Coordination (Sensitivity Coordination)

For the fault on the secondary side of the 66/6.6kV transformer, OCR trips CB2.



Phase-to-Ground Fault Protection for 66kV transmission lines

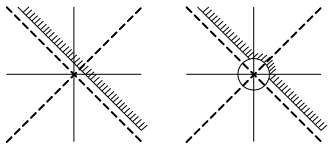
Directional Earth-Fault Relay is applied for the protection of the 66kV system against phase-to-ground fault.



Failsafe: OVGR

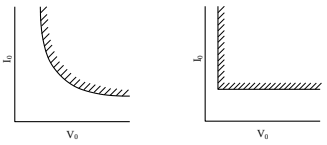
DEF Relay Setting

Phase Characteristics



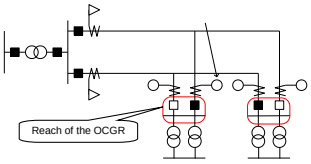
DEF Relay Setting

V_0-I_0 Characteristics



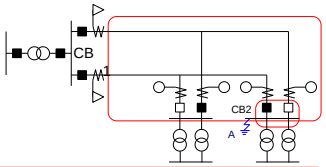
Phase-to-Ground Fault Protection for 66/6.6kV substations

Overcurrent Ground Relay is applied for the protection of the 66/6.6kV substation against phase-to-ground fault.



Relay Coordination (Time Coordination)

OCGR trips CB2 before DEF trips CB1.



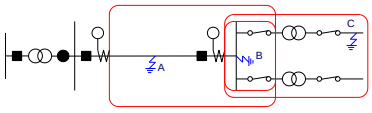
Relay Type of 6.6kV System

Standard Relay Setting in the TEPCO 6.6kV System

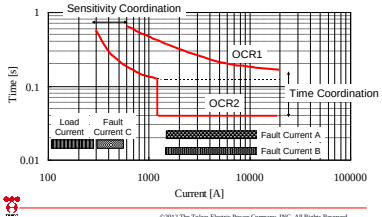
Relay Name	Relay Type	Purpose	Operating duty	Standard Relay Setting (Sample)
Phase fault relay	Over current relay (OCR)	Phase fault protection	Operating at the distribution line end fault (less than 85%)	Value: 150% of maximum allowable current Time: 0.2s
Earth fault directional relay	Earth fault directional relay (DEF)	Earth fault protection	Operating at 30% of earth fault	Value: 200mA Time: 0.9s
Earth fault overvoltage relay	Voltage detecting relay	Voltage detecting (using the part of Earth fault directional relay)	-	Value: 10% of normal voltage Time: 0.9s

Phase-to-Phase Fault Protection for the 6.6kV system

Overcurrent Relay is applied for the protection of the 6.6kV system against phase-to-phase fault.



Relay Coordination

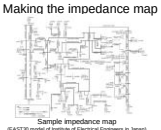


Method of the Relay coordination

1. Making the impedance map of necessary section
2. Calculation of the short circuit current
3. Calculation of the continuous rating current of the CT
4. Calculation of the overcurrent strength of the current transformer (thermal strength, mechanical strength)
5. Setting OCR for incomer feeder (receiving circuit)
6. Setting OCR for main transformer
7. Setting OCR for outgoing feeder
8. Drawing protection coordination curve

Method of the Relay coordination

1. Making the impedance map of necessary section



Sample impedance map (EAST30 model of Institute of Electrical Engineers in Japan)

Sample impedance map for calculation of the short circuit current

2. Calculation of the short circuit current

Method of the Relay coordination

3. Calculation of the continuous rated current of the CT (6.6kV)

Case 1 Using contract demand data

$$I_{N\_contract} = \frac{P_C}{\sqrt{3}\times 6.6\times\cos\phi}\times\alpha$$

$I_{N\_contract}$: continuous rated current of CT [A]
P_C: contract demand [kW]
α : safety margin [1.3-2]
Cosφ : demand power factor [0.8-0.95]

Case 2 Using installed capacity (installed facilities data)

$$I_{N\_facility} = \frac{P_A + P_B}{\sqrt{3}\times 6.6}\times\alpha$$

$I_{N\_facility}$: continuous rated current of CT [A]
P_A: apparent Power of transformer [kVA]
P_B: equivalent capacity of moter [kVA]
α : safety margin [1.3-2]

Case 3 Using overcurrent constant data

$$I_{3LS} \le I_{N\_constant}\times n_x$$

$$I_{N\_constant} \ge \frac{I_{3LS}}{n_x} \quad n_x = \left|\frac{Z_s + Z_t}{Z_t + Z_m}\right| \times n$$

n: rated overcurrent constant
n_x: overcurrent constant of each demand
Z_S: secondary winding impedance [Ω]
Z_T: rated demand impedance [Ω]
Z_m: each demand impedance [Ω]

Method of the Relay coordination

4. Calculation of the overcurrent strength of the current transformer (thermal strength, mechanical strength)

4-1 Thermal strength

$$(I_N\times D)^2\times 1\text{sec} \ge I_S^2\times t$$

$$D \ge \frac{I_S}{I_N}\sqrt{t}$$

I_N: primary rated current of CT [A]
I_S: short circuit current [A]
D: overcurrent strength of the current transformer
t: time of short circuit current [s]

4-2 Mechanical strength

$$I_N\times D\times 2.5 \le I_S\times k$$

$$D \ge \frac{I_S}{I_N}\times\frac{2.5}{k}$$

$$k = \sqrt{2}\left(1+\varepsilon^{-\frac{R}{X}}\right)$$

k: maximum current instantaneous value factor
R: combined resistance
X: combined reactance

Method of the Relay coordination

5. Setting OCR for incomer feeder (receiving circuit)

5-1 Setting OCR (51L)

a. Value setting

$$T \ge I_L = \frac{P}{\sqrt{3}V_n}\times\frac{1}{CT\_ratio}\times(1.5)[A]$$

P: installed transformer capacity [MVA]
I_L: 150% continuous rated current [A]
T: tap value

b. Checking the loop current

Using impedance map

in house standard

c. Time setting

Using in house standard (1.0s)

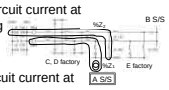
Method of the Relay coordination

5. Setting OCR for incomer feeder (receiving circuit)

5-2 Setting HOCR (51H)

a. Calculation of maximum short circuit current at transformer secondary winding

$$I_{S1} = \frac{P_s\times 100}{\sqrt{3}\times V_n\times\sum\%Z_1}\times\frac{1}{CT\_ratio}[A]$$



b. Calculation of minimum short circuit current at 66kV busbar

$$I_{S2} = \frac{P_s\times 100}{\sqrt{3}\times V_s\times\sum\%Z_2}\times\frac{1}{CT\_ratio}\times\frac{\sqrt{3}}{2}[A]$$

P_S: Base capacity
V_S: Base voltage
%Z_2: Percent impedance

c. Value setting: $I_1\times(1.5)\le T\le I_2\times(0.5)$

in house standard

d. Time setting: Using in house standard (0.05s)

Method of the Relay coordination

6. Setting OCR (51T) for main transformer

a. Calculation of transformer rated current

$$I_T = \frac{P_t}{\sqrt{3}\times V_t}\times\frac{1}{CT\_ratio}[A]$$

P_t: Transformer capacity [MVA]
V_t: Transformer rated voltage

b. Calculation of short circuit current at 6.6kV busbar

$$I_S = \frac{P_s\times 100}{\sqrt{3}\times V_t\times\%Z}\times\frac{1}{CT\_ratio}\times\frac{\sqrt{3}}{2}[A]$$

P_S: Base capacity
V_t: Transformer rated voltage
%Z: Percent impedance

c. Value setting: $I_T\times(1.6)\le T\le I_S\times(0.5)$

d. Time setting: Using in house standard (0.75s)

in house standard

Method of the Relay coordination

7. Setting OCR for outgoing feeder

a. Checking of continues allowable current : I

b. Temporary value setting: $T_T \geq I \times (1.5)$

T_T: Temporary setting value
P_C: Base capacity
V_C: Base voltage
%Z: Percent impedance

c. Calculation of short circuit current at the terminal point of distribution line

$$I_{Si} = \frac{P_c \times 100}{\sqrt{3} \times V_c \times \%Z} \times \frac{1}{CT\_ratio} \times \frac{\sqrt{3}}{2} [A]$$

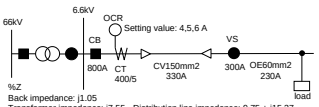
in house standard

d. Checking the short-time allowable current

e. Value setting

d. Time setting: Using in house standard (0.2s)

Sample Relay Setting of Phase fault relay



(a) 150% of maximum allowable current = 230A * 150% * (5/400) = 4.31 (A)
(b) Temporary setting value: 5 A (5 > 4.31)
(c) Check the distribution line end fault
%Z = j1.05 + j7.55 + (9.75 + j15.27) = 9.75 + j23.87 = ((9.75)2 + (23.87)2)-0.5 = 25.78%
Phase fault current (2phase) = (10 * 100) / 25.78 * 1 / (√3 *6.6) * √3 / 2 = 2.94 (kA)
2940 / 400 *100 = 735 (%) > 150(%)
(d) Setting value: 5 A
(d) Setting Time: 0.2s (Standard)

Example of the time coordination

Combination of high-speed relay and time-lag relay

Step	Time setting	Time lag
1	0.2	-
2	0.5	0.3
3	0.8	0.3
4	1.1	0.3

Combination of induction disc type relay

Step	Time setting	Time lag
1	0.2	-
2	0.6	0.4
3	1.0	0.4
4	1.5	0.5

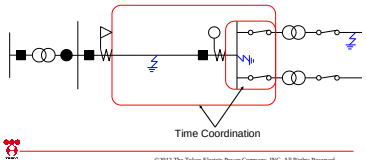
Example of the time coordination

・Incomer feeder OCR: 0.7～0.75 s
・Outgoing feeder OCR: 0.2 s
・Customer OCR: 0.15 s

Phase-to-Ground Fault Protection for the 6.6kV system

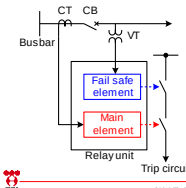
DEF and OCGR is applied for the protection of the 6.6kV system against phase-to-ground fault.

(same as the 66kV system)



Hardware Design

Avoid malfunction cased by single failure mode of hardware



Separate hardware assigned for main relay and fail safe relay elements including input and trip output circuits

Hardware Design

Radio Noise Interference

No maloperation under the following radio noise conditions

- 5W transceivers with 150MHz and 400MHz
- Mobile phone with 900MHz
- Edge of antenna directly touches or becomes close to the relay

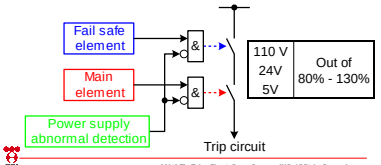
Measures to avoid maloperation

- Shield printed circuit boards
- Lower power source impedance (Thicker pattern)
- Appropriate component layout to minimize circuit length
- Application of appropriate parts such as bypass capacitors for absorbing noise

Hardware Design

DC Supply Fluctuation

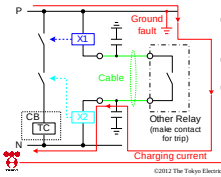
When voltage fluctuation including ON/OFF switching is detected on DC supply circuit, trip circuit shall be blocked



Hardware Design

DC Supply (Ground Fault)

When DC supply circuit touches earth circuit, malfunction shall be prevented

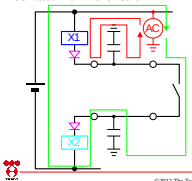


- Dual coil allocation for trip signal receiving circuit from another relay
- Effective in either P or N polarity grounding
- Downgrade of relay sensitivities
  - Voltage: 30- 40V
  - Current: >80mA

Hardware Design

DC Supply (Contact with AC circuit)

Measure to avoid malfunction when AC circuit comes into contact with DC circuit

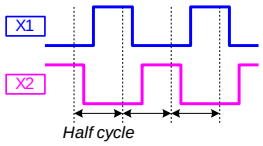


- Insert diodes in series to block simultaneous operation of both auxiliary relays, X1 and X2
- Similar effect against alternating grounding of DC circuit

Hardware Design

DC Supply (Contact with AC circuit)

Take care of coordination between operation and reset times for X1 and X2



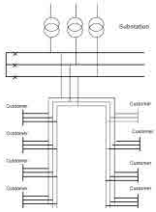
Operation Principles

Static Type (Module Composition) Digital Type

Operation Principles

	Electromagnetic	Static Type	Digital Type
Function	Limited to simple characteristics Limited speed △	Higher sensitivity, more complicated characteristics, and faster speed than electromagnetic type ○	More stable calculation, more complicated characteristics, and faster speed than static type ◎
Reliability	Effect from a change in circuit constant and mechanical condition No automatic monitoring ×	Lowered reliability due to increased electronics parts Automatic monitoring ○	No deterioration with age in calculation error Enhanced automatic monitoring ◎
Maintenance	Not patterned hardware Large-size test set for test input Small inspection interval △	Not patterned hardware Smaller test set, and extended inspection interval compared to electromagnetic type ○	Patterned hardware Smaller test set, and further extended inspection interval compared to static type ◎

New technology in Japan Spot Network System

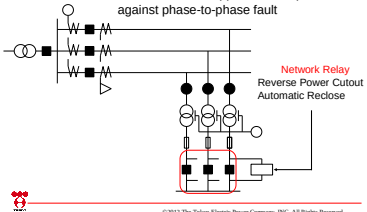


High Reliability

- Each customer is connected to the network through three feeders.
- Loading level of one distribution line is limited within 67% of its capacity, so there is no power outage under N-1 contingency.

New technology in Japan Spot Network System

Protector fuse is applied for the protection against phase-to-phase fault



Namesame
Kadrinche

Presentation Materials of fourth Workshop

Distribution System Planning (Distribution System Planning in TEPCO)

Distribution System Planning in TEPCO (about grid system)

14 May 2013

TOKYO ELECTRIC POWER COMPANY

Today's Contents

1. Outline of TEPCO's distribution
2. Distribution grid System Planning
3. Improvement of System Reliability
   - Shortening of the power outage
4. Improvement of System Reliability
   - Fault Prevention Measures
5. Maintain appropriate Voltage
6. Summary

1. Outline of TEPCO's distribution

TEPCO's voltage criteria

Area	1000kV	500kV	275kV	154kV	66kV	22kV	6.6kV	200/100
Urban		○	○	○	○	○	○	
Local	○			○	○	○		

Distribution division

1. Outline of TEPCO's distribution

Power supply method by the contract demand

Contract demand	Electric supply method	Application
Less than 50 kW	・AC100V 1-phase 2-wire system ・AC100V/200V -phase 3-wire system ・AC200V 3-phase 3-wire system	- Residence - Small factory, office / commercial building
50 - 2,000 kW	・AC6.6kV 3-phase 3-wire ・22kV in high density demand area (Over 500kW)	- Medium size factory, building - Large size shop - Pump station
2,000 - 10,000kW	・AC22kV or 66kV 3-phase 3-wire system	- Large size building and factory - Department store - Pump station - Sewage treatment factory
10,000 - 50,000 kW	・AC 66kV 3-phase wire system	- Large size building and factory - Substation for train
Over 50,000 kW	・AC 154kV 3-phase wire system	- Large size factory - Substation for train

2. Distribution grid System Planning

What is distribution system planning?

Thorough demand trend and grasp of the facilities actual situation and feasibility study

Middle and Long term planning

Stable Power Supply

keep appropriate voltage

Improvement of the investment efficiency

System coherent way of thinking

Supply reliability
Securing of social security

Maintenance operative cooperation with aspects of facilities

Securing of service level

Cooperation with the community

Basic concepts: Effective investment (Reduce total system cost)

2. Distribution grid System Planning

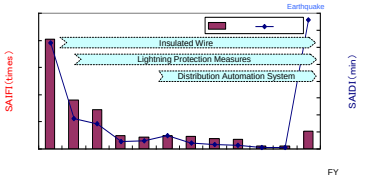
- Stable power supply
  Stable frequency and voltage, suppression harmonics distortion and flicker, continuously power supply etc.
- System Reliability
  decrease or maintain low level SAIFI and SAIDI index
- Maintain appropriate supply voltage (LV)
  follow (national) regulations

- Technical solutions -
✓Distribution system configuration
✓Distribution equipment specification R&D

3. Improvement of System Reliability (Shortening of the power outage)

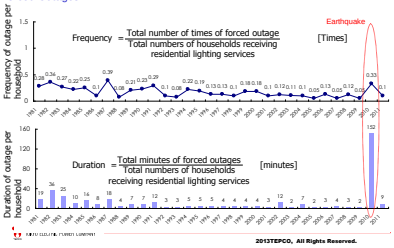
Contribute to Higher Reliability

TEPCO's Historical Trend of SAIDI and SAIFI



3. Improvement of System Reliability (Shortening of the power outage) Reference

Forced Outages

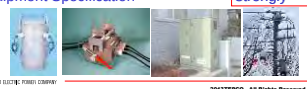


3. Improvement of System Reliability (Shortening of the power outage)

➢Distribution System configurations

➢Improvement of Distribution Equipment Specification

Rerationing each other strongly



3. Improvement of System Reliability (Shortening of the power outage)

➢Distribution System configuration

History of TEPCO Distribution System

- Individual Distribution System (No Interconnection) → Same as BPC's current system
- Multi-Dividing & Multi-Connecting (MD-MC) System
  - Immediate Isolation of Fault Section by Time-Limit Changeover Device
  - Minimizing Power Interruption Area in the event of Fault
- Distribution Automation System [DAS]
  - Remote Operation of Switches based on MD-MC System
  - Effective Use of Facilities (Maximizing Loading Level)
  - Minimizing Power Interruption Area in the event of Fault
- Further Reliability Improvement
  - Main & Reserve System
  - Loop System (Closed)
  - Spot Network (SPN) System (22kV only)

3. Improvement of System Reliability (Shortening of the power outage)

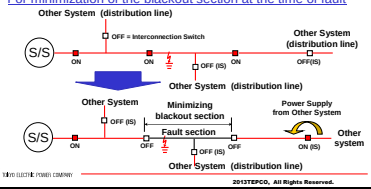
➢Distribution System configuration

Multi-Dividing & Multi-Connecting System

○ Dividing a distribution line into several sections

○ Installing interconnection switches to each sections with other system

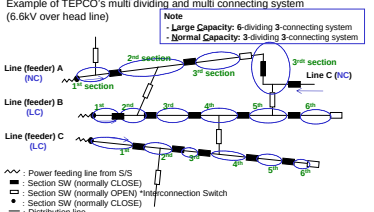
For minimization of the blackout section at the time of fault



3. Improvement of System Reliability (Shortening of the power outage)

➢Distribution System configuration

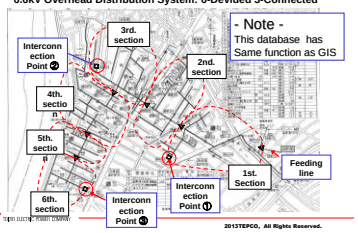
Example of TEPCO's multi dividing and multi connecting system (6.6kV over head line)



3. Improvement of System Reliability (Shortening of the power outage) Reference

➢Distribution System configuration

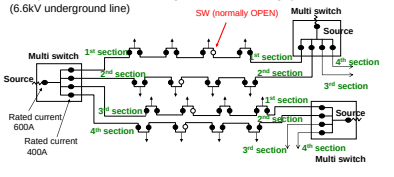
6.6kV Overhead Distribution System: 6-Devided 3-Connected



3. Improvement of System Reliability (Shortening of the power outage)

➢Distribution System configuration

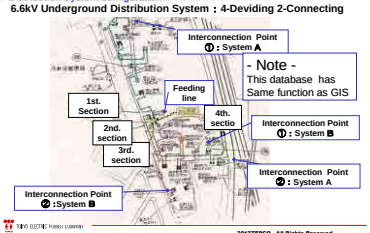
Example of TEPCO's multi dividing and multi connecting system (6.6kV underground line)



3. Improvement of System Reliability (Shortening of the power outage) Reference

➢Distribution System configuration

6.6kV Underground Distribution System ; 4-Deviding 2-Connecting



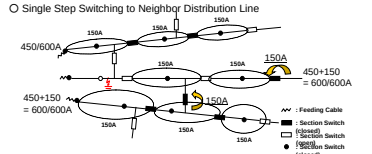
3. Improvement of System Reliability (Shortening of the power outage)

Reference

➢Distribution System constitution

Loading Level and System Operation in 6-Devided 3-Connected System

- Continuous Current Rating; 450A, Loading Level ; 75% (450/600)
- Over Load Current Rating; 600A
- Single Step Switching to Neighbor Distribution Line



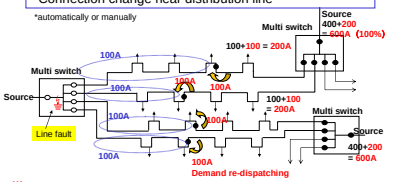
3. Improvement of System Reliability (Shortening of the power outage)

Reference

Example of the operation rate and system operation of 4 divide and 2 connected system

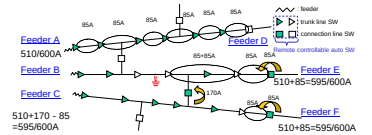
- Continuous capacity : 400A (operation rate: 67%)
- Connection change near distribution line

*automatically or manually



3. Improvement of System Reliability (Shortening of the power outage)

➢Distribution System configuration (DAS: Distribution Automation System)



- Automatic Switching (fault condition)
- Manual Switching (planned)

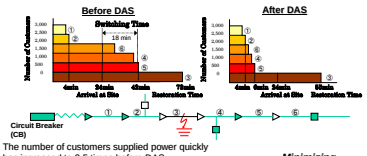
The System calculate re-dispatching method and done switching automatically in case of fault occurs

3. Improvement of System Reliability (Shortening of the power outage)

Reference

➢Distribution System configuration (DAS: Distribution Automation System)

Minimizing Power Interruption Area & Restoration Time (example)



The number of customers supplied power quickly has increased to 2.5 times before DAS.

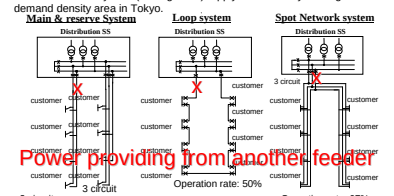
Interruption duration after DAS has been reduced to approximately 10% (average) before DAS.

Minimizing Restoration Time

3. Improvement of System Reliability (Shortening of the power outage)

➢Distribution System configuration

22kV distribution system (underground): apply it restrictively in a high demand density area in Tokyo.



Power providing from another feeder

4. Improvement of System Reliability (Fault Prevention Measures)

➢Distribution System configuration
& Improvement of Distribution Equipment Specification

Lightning Protection

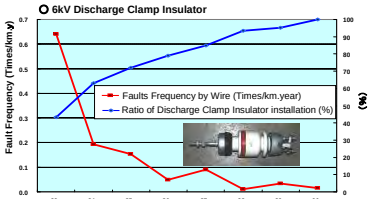
Countermeasures are Based on statistics and analyzing of fault causes

Difference insulating strength

4. Improvement of System Reliability (Fault Prevention Measures)

➢Lightning Protection

O 6kV Discharge Clamp Insulator



4. Improvement of System Reliability (Fault Prevention Measures)

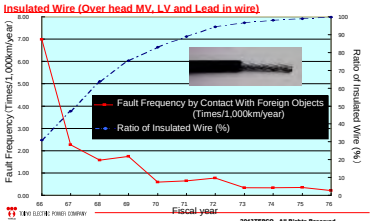
➢Lightning Protection

- **Transformers with built-in arrester are used in TEPCO in case of new installation.**

4. Improvement of System Reliability (Fault Prevention Measures)

➢Contact protection

Insulated Wire (Over head MV, LV and Lead in wire)

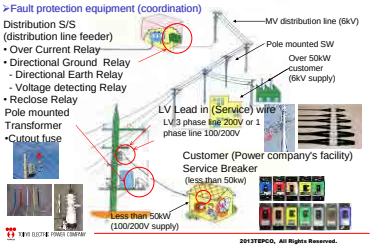


4. Improvement of System Reliability (Fault Prevention Measures)

➢Fault protection equipment (coordination)

Distribution S/S (distribution line feeder)
- Over Current Relay
- Directional Ground Relay
  - Directional Earth Relay
  - Voltage detecting Relay
- Recluse Relay

Pole mounted Transformer
- Cutout fuse



5. Maintain appropriate Voltage

➢Japanese electric power supply regulation

Voltage Maintaining by distribution division

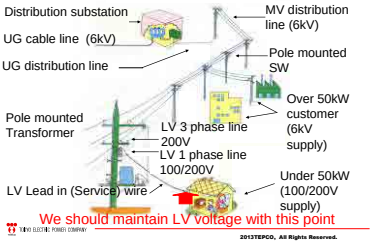
The LV supply Voltage regulation

Standard voltage	Sustaining voltage
100 V	101 V±6 V
200 V	202 V±20 V

※ The MV supply voltage does not have the national regulation.

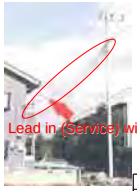
Keep sustain appropriate Voltage
- Supply Voltage control on the S/S (LDC: Line voltage drop compensator)
- Management of pole Transformer tap
- countermeasures distribution line facility (MV & LV line, service wire etc.)

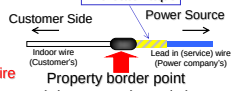
5. Maintain appropriate Voltage



We should maintain LV voltage with this point

5. Maintain appropriate Voltage



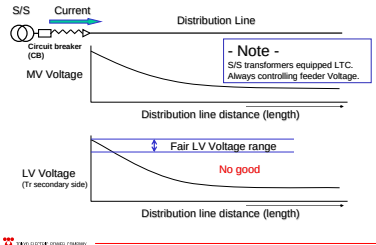


Property border point (wire connecting point)

We should keep sustaining voltage this point

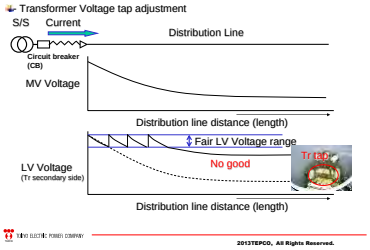
Standard voltage	Sustaining voltage
100 V	**101 V±6 V**
200 V	**202 V±20 V**

5. Maintain appropriate Voltage



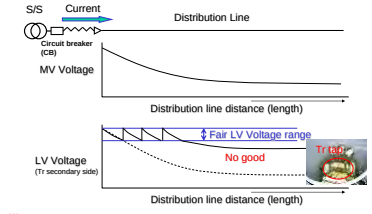
5. Maintain appropriate Voltage

Transformer Voltage tap adjustment



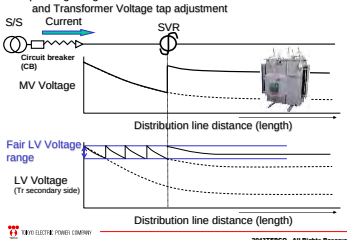
5. Maintain appropriate Voltage

- Transformer Voltage tap adjustment



5. Maintain appropriate Voltage

- Step Voltage Regulator on the MV line and Transformer Voltage tap adjustment



5. Maintain appropriate Voltage

- another countermeasures
  - Increase MV line cross section conductors
  - Increase MV line length
  - Divide demand
  - Establish new distribution line
  - Establish new substation Etc.

6. Summary

Planning will be determined by the data of the current situation and Historical facts. Therefore, by recording various data(the cause of the accident, facilities, equipment etc.), analyze, and manage, please control the fact of BPC's future.

Thank you for your kind attention!!

Smart Grid (Overview of Smart Grid in TEPCO)

TEPCO's Challenges towards Smarter Grid

Position of TEPCO
- Service Area : 39,000 km² — One-tenth of Japan's land area
- Population : 45 million
- Electricity Sales : 270 billion kWh (FY 2011)
- Peak Demand : 64.3 GW (July 2001) — One-third of Japan's total demand; 70% of the demand within a 40km radius of Tokyo

May 14, 2013

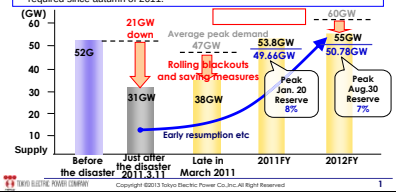
Masahiro Myoga
Manager,
Distribution Department
Power Grid Company
Tokyo Electric Power Co.,Inc.

TOKYO ELECTRIC POWER CO.,INC.

1. Change of Energy Supply and Demand Structure after the Great East Japan Earthquake

(1) Decreased supply capacity due to the earthquake

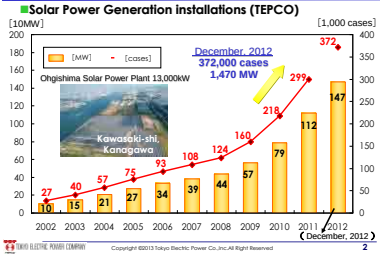
- About 21GW of Nuclear, Thermal and Hydro power plants were damaged.
- In spite of early resumption and emergency installation of facilities, demand was forcefully restricted via rolling blackouts and legal measures.
- Given the insufficient supply capacity, electricity saving measures has been required since autumn of 2011.



1. Change of Energy Supply and Demand Structure after the Great East Japan Earthquake

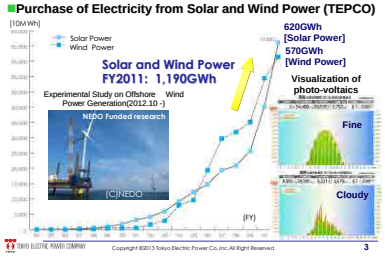
(2) Integration of Renewable Energy

Solar Power Generation installations (TEPCO)



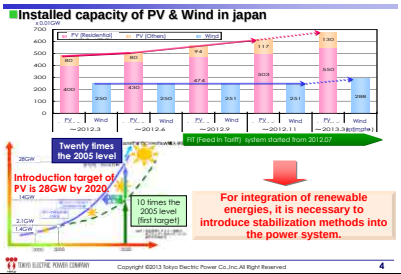
1. Change of Energy Supply and Demand Structure after the Great East Japan Earthquake

Purchase of Electricity from Solar and Wind Power (TEPCO)



1. Change of Energy Supply and Demand Structure after the Great East Japan Earthquake

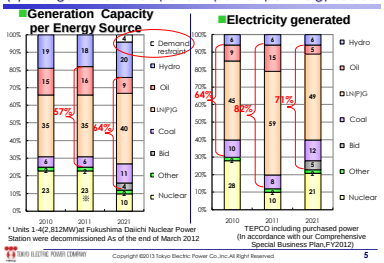
Installed capacity of PV & Wind in japan



For integration of renewable energies, it is necessary to introduce stabilization methods into the power system.

1. Change of Energy Supply and Demand Structure after the Great East Japan Earthquake

(3)Changes in Power Output Composition per Energy Source

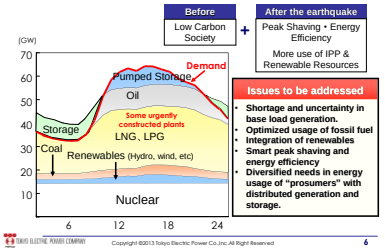


* Units 1-4(2,812MW)at Fukushima Daiichi Nuclear Power Station were decommissioned As of the end of March 2012

TEPCO including purchased power (In accordance with our Comprehensive Special Business Plan,FY2012)

1. Change of Energy Supply and Demand Structure after the Great East Japan Earthquake

(4) Supply demand balance after the Great Earthquake



Issues to be addressed
- Shortage and uncertainty in base load generation.
- Optimized usage of fossil fuel
- Integration of renewables
- Smart peak shaving and energy efficiency
- Diversified needs in energy usage of "prosumers" with distributed generation and storage.

2. Towards optimization of energy usage with our customers and society

◆Smart grid in Tepco

A Platform to innovate energy service with customers and society and to improve energy efficiency and optimize usage via the coordination of demand and supply

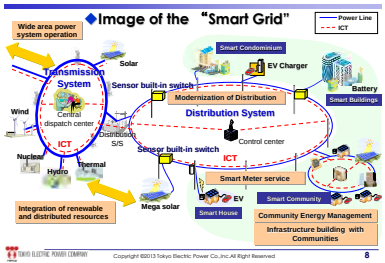
◆Objective

To establish an advanced "smart grid", in which both grid generators and customers are mutually coordinated, in order to realize the following objectives as "a network service integrator"

- ☐ Provision of more options for customers to meet diverse needs
  - ✓ Various tariff and energy management services via business alliances
- ☐ Additional reduction of peak demand and more efficient use of facilities
  - ✓ Developments and proposals for new services with smart meters, energy solutions and so on.
- ☐ Grid Integration of a large amount of renewable resources and coordination with on-site generation systems
  - ✓ Enhancement of neutrality and fairness in network service divisions establishment of a network, in which efficiency and the reliability of facilities are improved by ICT

2. Towards optimization of energy usage with our customers and society

◆Image of the "Smart Grid"



3. Efforts in realize "Smart Grid"

(1) Key concepts

1. Efficient & optimized energy usage with customers and society.

① Active adoption of Smart Meters. / Expansion of new services.
② Construction of Demand-Response program for efficient energy usage with demand side & supply side.
③ Realization of Smart Communities/Towns with customers & areas.

2. Integration of renewable and distributed resources with the help of the modernization of power networks.

① Upgrading distribution network by taking advantage of ICT.
② Widening of power system operation.
③ Development of next-generation transmission & distribution network system concerned with integration of residential PV.
④ Development of integrated control of battery energy storage.

(2) Positive introduction and practical use of a smart meter system

I. Active adoption of Smart Meters / Expansion of new services

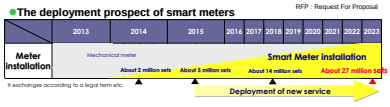
- The advantage of smart meter implementation (27 million sets)

Operation cost reduction
Wider Tariff choices
The visualization of power consumption data
Demand control by two-way communication
Creation of new value-added service

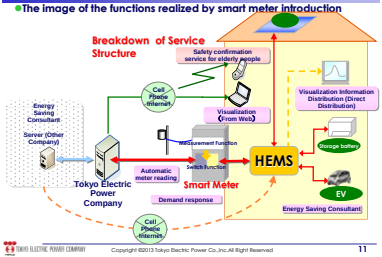
- Operational reforms
- Better customer service
- Cut back on investments by DSM

- The deployment prospect of smart meters

RFP : Request For Proposal



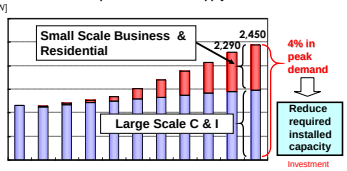
- The image of the functions realized by smart meter introduction



II. Construction of Demand-Response program for efficient energy usage with demand side & supply side

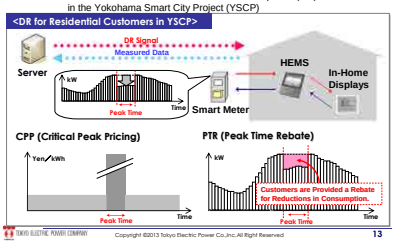
- Planned Demand Response in Demand-Supply Plan

[MW]

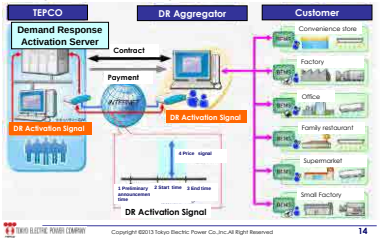


- Research on Introducing Dynamic Pricing for Residential Customers
  - Measurement and Verification of Demand Response (DR) in the Yokohama Smart City Project (YSCP)

<DR for Residential Customers in YSCP>



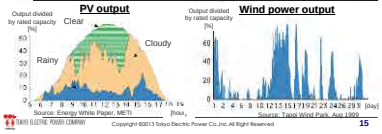
- Request of Demand Response



(3) Integration of renewable and distributed resources by modernizing power networks

- Grid Intermittent output of PV and wind Power
  - Intermittent output of PV and wind power is subject to weather condition

☐ Network Reinforcement is required for more RE integration to realize interactive coordination between grids and generators
→Smart Grid with interactive communication
☐ Much discussion is needed to decide who should pay the reinforcement costs



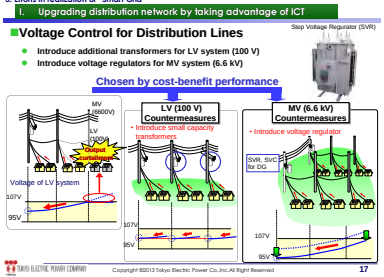
- Integration of Renewable Energy

	Challenges	Solutions
Voltage Developed	**Overvoltage on distribution system** ● Voltage rises at the end of the distribution lines due to renewable energies	・Additional transformers ・Installation of voltage regulators
Frequency Developing	**Absorption of surplus power** ● PV output causes surplus power during off peak demand period	・Curtailment of PV ・Electrification ・Widening of power system operation
	Improvement in output estimation ● How to estimate intermittent output	・Estimation of intermittent output
	Sufficient frequency control capability ● Insufficient frequency control of generation system due to renewable energies	・Integrated system of batteries for generation control ・Widening of power system operation

I. Upgrading distribution network by taking advantage of ICT

- Voltage Control for Distribution Lines
  - Introduce additional transformers for LV system (100 V)
  - Introduce voltage regulators for MV system (6.6 kV)

Chosen by cost-benefit performance

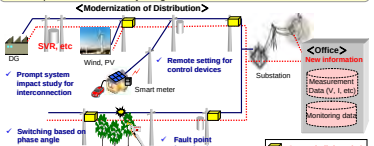


- Optimization of Distribution Network

Merits of monitoring and control system with sensor built-in switch

- Securing power quality using measurement data (V, I) for RE integration study
- Quick fault detection and prompt restoration to prevent faults
- Improvement of efficiency using the remote control

<Modernization of Distribution>



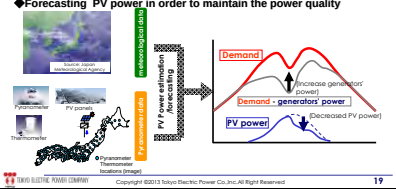
Installment of batteries for distribution (under consideration)

II. Development of next-generation transmission & distribution network system concerned with integration of residential PV

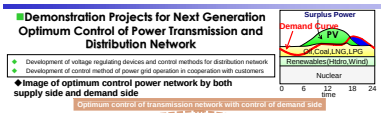
- Demonstration project of forecast technologies for photovoltaic power generation

◆ Development of a method to estimate the current photovoltaic power generation output from weather data or sunlight data
◆ Develop method to forecast the photovoltaic power generation output

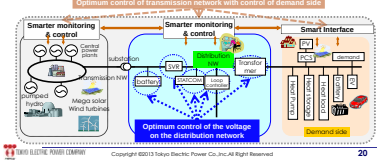
◆Forecasting PV power in order to maintain the power quality



- Demonstration Projects for Next Generation Optimum Control of Power Transmission and Distribution Network

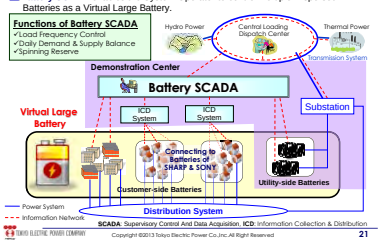


◆Image of optimum control power network by both supply side and demand side

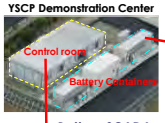


III. Development of integrated control of battery energy storage

Battery SCADA enables the System Operator to control Multiple Dispersed Batteries as a Virtual Large Battery.



YSCP Demonstration Center



Lithium ion Batteries of HITACHI, MEIDENSHA/NEC, TOSHIBA from the right

Battery SCADA

HITACHI	250kW/51kWh or 100kW/100kWh※1
MEIDENSHA /NEC	250kW/ 250kWh※1
TOSHIBA	300kW/ 100kWh※2

※1：nominal capacity ※2: operational capacity

4. Conclusions

Change in Demand-Supply Structure

1. Efficient & optimized energy usage with customers and society
2. Integration of renewable and distributed resources with the help of the modernization of power networks

S+3E Achievements
- Energy security
- Environmental conservation
- Economy
- Safety

① Supply Side: Integration of RES DER, New Supply Capacity
X
② Demand Side: Various energy services, Efficient energy usage

Flexible & Robust
"Smart Grid"

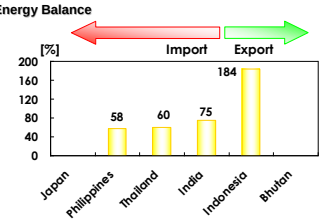
- Innovate our energy services with our customers and society
- Realize a platform that enables efficient and optimized energy usage with a demand and supply side perspective

What do you think?

What is your smart grid?

What is your smart grid?

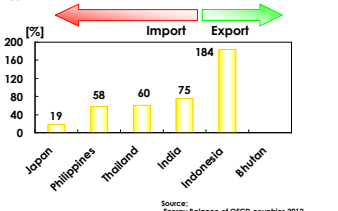
- Energy Balance



Source:
Energy Balance of OECD countries 2012
Energy Balance of non-OECD countries 2012

What is your smart grid?

- Energy Balance



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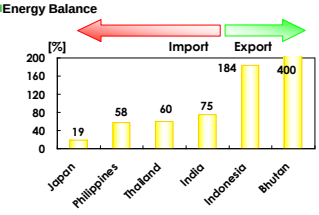
Energy Balance of OECD countries 2012
Energy Balance of non-OECD countries 2012

What is your smart grid?

■Energy Balance



Source;
Energy Balance of OECD countries 2012
Energy Balance of non-OECD countries 2012

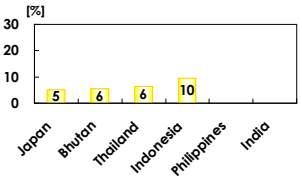
What is your smart grid?

★SUBARU Plug-In Stella ★NISSAN LEAF ★HONDA FIt EV

★CHAdeMO DC Fast Charger ★MITSUBISHI i-MiEV ★TOYOTA eQ

What is your smart grid?

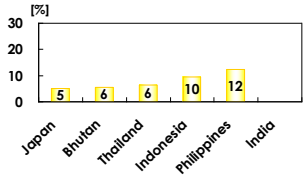
■Transmission & Distribution Loss



Source: JEPIC Report

What is your smart grid?

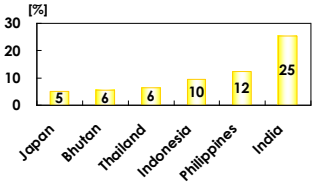
■Transmission & Distribution Loss



Source: JEPIC Report

What is your smart grid?

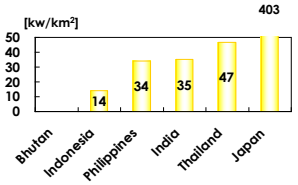
■Transmission & Distribution Loss



Source: JEPIC Report

What is your smart grid?

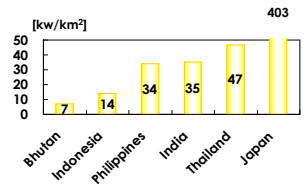
■Load Density



Source: JEPIC Report

What is your smart grid?

■Load Density



Source: JEPIC Report

Presentation Materials of fifth Workshop

Priority Issue Solving

Issue Solving Activity

July 2013
Tokyo Electric Power Company

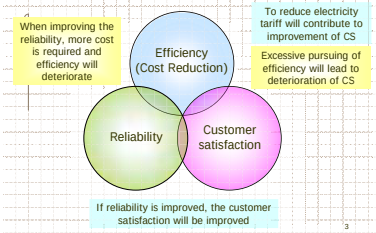
1

Relationship between Supplier and Customer

- In case of general products
  - Customer selects the product (supplier)
- In case of power sector
  - General customers have no choice to select their supplier
  - Most citizens have no choice but to purchase the product (electricity) with determined cost and quality
- Less incentive for power suppliers to improve the power quality or customer satisfaction

2

- Major Three Factors that Power Sector shall aim
- Be gradually improved in well balance



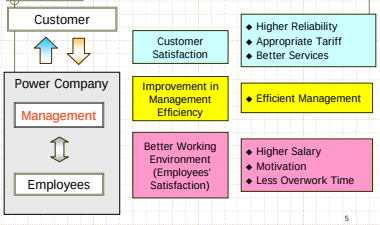
3

Opportunities to utilize TQM Activity

- Improvement of system reliability or customer satisfaction with less investment
  - There are some measures by ingenuity without so much investment.
- Efficient Investment
  - Plan with higher effect shall be prioritized
- Improvement of work efficiency
  - Spare power can be utilized to improvement of system reliability or customer satisfaction

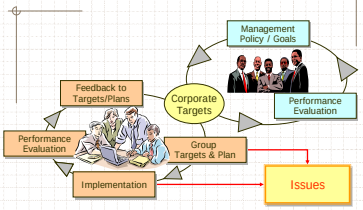
4

Situations Surrounding Power Company



5

Manager's Role & Responsibility



6

What is Priority Issue (PI) Solving Activity?

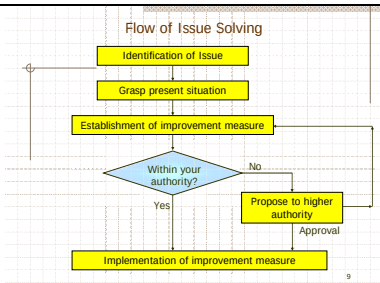
7

Objectives

- The active and proper contributions of the middle-class managers are indispensable to improving the management situations at your office.
- The main objective is to enable the middle-class managers to tackle…
  - Issues/problems to achieve their group targets / the management goals
  - Issues/problems that are significant in their working places

8

Flow of Issue Solving



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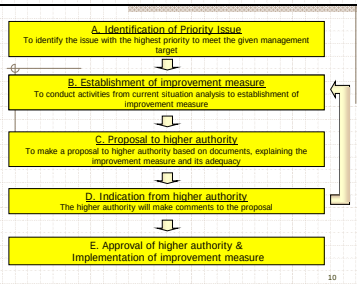


10

A. Identification of Priority Issue

- Identify a problem/issue
  - Look at things from customers' viewpoints. (if you are a customer)
  - Think about what the ideal situations are.
- Issues to be solved with top priority to realize visions of the company
  - Improvement of supply reliability, Loss reduction, Improvement of customer satisfaction, Securing of personnel safety etc. (for example)
  - Identify issue (theme) specifically

11

B. Establishment of Improvement Measure

1. Evaluation, Quantification of Current Badness
2. Cause Analysis
3. Plan out various Measures
4. Evaluation of Cost-Benefit Performance
5. Determination of Implementing Measure

12

B-1. Evaluation, Quantification of Current Badness

- Use data, facts, and common words in order to describe actual phenomenon precisely in
  - understanding current situations,
  - analyzing problems, and
  - confirming impacts of measures / verifying your assumption.
- Understand things based on data, instead of judging things only on speculation or in the illusionary belief.

13

How to handle the data

- The aim of using data is to solve problems, not to gather more data.
  - Step 1: Think about what you want to describe, analyze, confirm, verify.
  - Step 2: Think about how you should handle or show the data. It is because its aim is to make people understand easily and correctly or to appeal to people.

14

How to handle the data

- The use of data is to help right understandings and prevent interpersonal misunderstandings
- Data contradicting with your story should not be neglected
- Unreliable data should not be used
- Data must be gathered in consistent and sequential ways

15

B-2. Cause Analysis

- Multi-aspect cause analysis
  - To identify all considerable causes
  - Fishbone diagram
- Evaluation of significance of causes by using actual data
  - Frequency of occurrence
  - Magnitude of impact
- Refine root causes in order to require measures easily

16

B-3. Plan out Various Measures

- Measures corresponding with Causes from many aspects
  - Identify various potential solutions and measures. The solutions and measures are not only ONE.
  - Get rid of your prejudice or bias against the present situations.

17

B-4. Evaluation of Cost-Benefit Performance

- Evaluation of benefit
  - Expected timing of the benefit to arise
- Evaluation of cost
  - Expected timing of required payment
  - Possibility of budget procurement
- Consider time value
  - 1 Nu. (at present) ≠ 1 Nu. (1 year after)

18

B-5. Determination of Implementing Measure

- Comparison analysis & prioritization of several measures
  - Advantage/Disadvantage of application of measures
  - Cost-benefit performance
  - Difficulty
  - Amount of resource injection
  - Timing when implementation is possible

19

Formulate Implementation Plan

- Resource to be injected
  - Fund, manpower
- Timing and schedule of implementation
- Expected effect
- Other items to be considered
  - Confirm that any other problem will not occur by taking a solution/measure to be selected.
  - Have a viewpoint that a selected solution and measure will have large impacts if it is shared with other people. (lateral spreading)

20

C. Proposal to Higher Authority

- Preparation of presentation material
  - Easily understandable explanation
    - Easily understandable logic
    - Straightforward storyline
    - Short-time, limited main points
  - Easy-to-read documents
    - Effective use of figures & tables
    - What is the key message from figures/tables

21

When you carry out **PI Solving Activity**, Repeat **Self-Questionings** to achieve good performance

1. Are there still any other Causes that result in Badness?
2. Are there still any Alternative Solutions, that you have not yet found out?
3. Did you compare Solutions well enough in light of Cost and Effectiveness?
4. Did you prepare multiple Solutions and analyze them well enough, so that your Boss can compare and judge with your proposals?

22

Issue Solving Activity

- Work should not always be done only by yourself
  - Instructing Junior Staffs for Information gathering
  - Brain storming with other managers/officers
  - Discussion with higher authority
- Not special work (Routine work)
  - Always consider to improve current situation
- Make story and logic to convince higher authority using data & facts

23

Issue Solving Activity

- Not only beneficial for the company, but also for you
  - Save time
    - Family benefit; Enjoy private time
  - Save money
    - Money benefit; Increasing your wage
- Don't give up solving problems or issues.
  - There are many measures

24

Thank you for your kind attention

25

Issue Solving Activity

July 2013
Tokyo Electric Power Company

1

Future Schedule

- Next mission: the end of August
  - Discussion with each team (Seki, Fujitani)
- Last presentation session
  - 25th or 26th September
- Training in Japan: 2 weeks x 12 persons
  - The middle of November

2

Selection Criteria of Training in Japan

- Evaluation from Japanese Adviser (individual): max 10 points
- Evaluation of Output (team) : max 15 points
  - Final proposal
  - Third country survey report
- Others (individual): max 5 points
  - Participation to the discussion
  - Daily efforts

3

Judging Points of Proposal

- Analysis by using data & facts
  - Current badness, cause analysis
- Comparison with other measures
  - Selection of most appropriate measure
- Story of the Proposal
  - Easily understandable logic
- Implementation plan
  - What you want, how to do, when, who

4

Third Country Report

- By 9th August submit to Ms. Orui
  - By the end of July: Draft version
- What did you learn?
- How to use the things that you learnt for your PI solving activity?
- How to use the things that you learnt for your work in promoting BPC's business efficiency?

5

When you carry out **PI Solving Activity**, Repeat **Self-Questionings** to achieve good performance

1. Are there still any other Causes that result in Badness?
2. Are there still any Alternative Solutions, that you have not yet found out?
3. Did you compare Solutions well enough from Cost and Effectiveness?
4. Did you prepare multiple Solutions and analyze them well enough, so that your Boss can compare and judge with your proposals?

6

Thank you for your kind attention

Don't give up solving issues.
There are many measures

7

Smart Grid System

TEPCO's Challenges towards Smarter Grid

TEPCO will Establish the "SMART GRID" in Cooperation with Customers & Society

Following the Great East Japan Earthquake, amidst tremendous changes occurring in the energy supply and demand structure, TEPCO will implement energy reforms to realize efficient and optimal energy usage for our customers and greater society.

Position of TEPCO
- Service Area : 39,000 km² — One-tenth of Japan's land area
- Population : 45 million
- Electricity Sales : 270 billion kWh (FY 2011)
- Peak Demand : 64.3 GW (July 2001) — One-third of Japan's total demand; 70% of the demand within a 40km radius of Tokyo

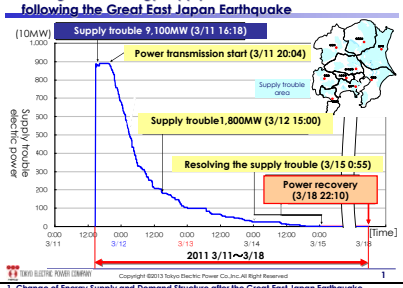
July 18, 2013

Masaki Iwama

TEPCO
Tokyo Electric Power Co.,Inc.

TOKYO ELECTRIC POWER CO.,INC.

1. Change in the Energy Supply and Demand Structure following the Great East Japan Earthquake

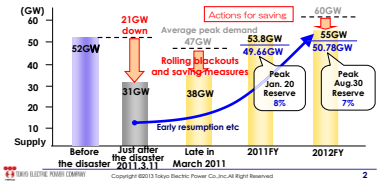


1

1. Large scale Change of Energy Supply and Demand Structure after the Great East Japan Earthquake

(1) Decreased supply capacity due to the earthquake

- About 21GW of Nuclear, Thermal and Hydro power plants were damaged.
- In spite of early resumption and emergency installation of facilities, demand was forcefully restricted via rolling blackouts and legal measures.
- Given the insufficient supply capacity, electricity saving measures has been required since autumn of 2011.



2

1. Change of Energy Supply and Demand Structure after the Great East Japan Earthquake

[Examples of Restored Disaster Equipment]

■Hirono Thermal Power Station

Shortly after disaster

3 months later

■Hitachinaka Thermal Power Station

Shortly after disaster

3 months later

3

1. Change of Energy Supply and Demand Structure after the Great East Japan Earthquake

[Measures to Secure Electric Power Supply Capacity]

■Re-start of aged power stations after a long term suspension

Re-started Yokosuka Thermal Power Station Unit 3&4 boiler

Operating Unit 3 turbine generator

■Urgent installation of new power supply facilities (284MW)

Chiba Power Station (PS) (3 gas turbines)

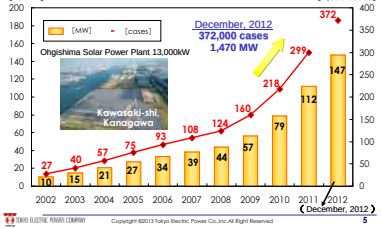
Sodegaura PS (102 sets of gas engines)

4

1. Change of Energy Supply and Demand Structure after the Great East Japan Earthquake

(2) Integration of Renewable Energy

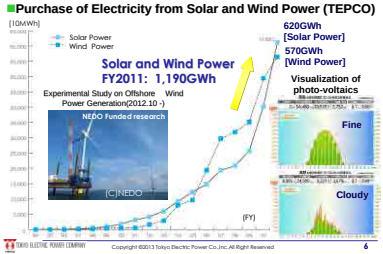
■Solar Power Generation installations (TEPCO)



5

1. Change of Energy Supply and Demand Structure after the Great East Japan Earthquake

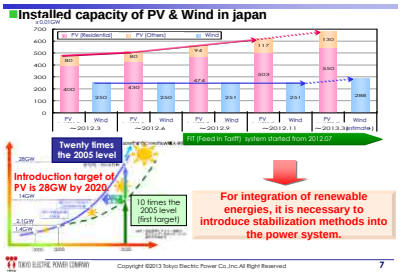
■Purchase of Electricity from Solar and Wind Power (TEPCO)



6

1. Change of Energy Supply and Demand Structure after the Great East Japan Earthquake

■Installed capacity of PV & Wind in japan



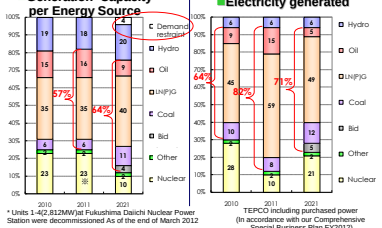
7

1. Change of Energy Supply and Demand Structure after the Great East Japan Earthquake

(3) Changes in Power Output Composition per Energy Source

■Generation Capacity per Energy Source

■Electricity generated



* Units 1-4(2,812MW)at Fukushima Daiichi Nuclear Power Station were decommissioned As of the end of March 2012

TEPCO including purchased power (In accordance with our Comprehensive Special Business Plan,FY2012)

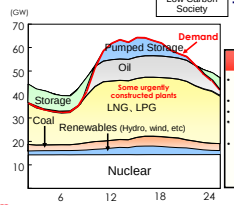
8

1. Change of Energy Supply and Demand Structure after the Great East Japan Earthquake

(4) Supply demand balance after the Great Earthquake

Before: Low Carbon Society

After the earthquake: Peak Shaving・Energy Efficiency; More use of IPP & Renewable Resources



Issues to be addressed

- Shortage and uncertainty in base load generation.
- Optimized usage of fossil fuel
- Integration of renewables
- Smart peak shaving and energy efficiency
- Diversified needs in energy usage of "prosumers" with distributed generation and storage.

2. Towards optimization of Energy Usage with our Customers and Society

"S"+Triple"E"s:
- Energy security
- Environmental conservation
- Economy
- Safety

①Supply Side
- Integration of RES DER
- New Supply Capacity

X

②Demand Side
- Various energy services
- Efficient energy usage

❸ Cope with changes in supply and demand side utilizing ICT flexibly

Towards optimization of energy usage with our customers and society.

2. Towards optimization of energy usage with our customers and society

◆Smart grid in Tepco

A Platform to innovate energy service with customers and society and to improve energy efficiency and optimize usage via the coordination of demand and supply

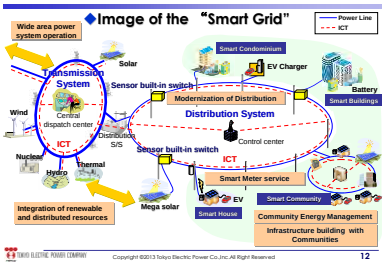
◆Objective

To establish an advanced "smart grid", in which both grid generators and customers are mutually coordinated, in order to realize the following objectives as "a network service integrator"

- ☐ Provision of more options for customers to meet diverse needs
  - ✓ Various tariff and energy management services via business alliances
- ☐ Additional reduction of peak demand and more efficient use of facilities
  - ✓ Developments and proposals for new services with smart meters, energy solutions and so on.
- ☐ Grid Integration of a large amount of renewable resources and coordination with on-site generation systems
  - ✓ Enhancement of neutrality and fairness in network service divisions establishment of a network, in which efficiency and the reliability of facilities are improved by ICT

2. Towards optimization of energy usage with our customers and society

◆Image of the "Smart Grid"



3.Efforts in realize "Smart Grid"

(1) Key concepts

1. Efficient & optimized energy usage with customers and society.

❶ Active adoption of Smart Meters. / Expansion of new services.
❷ Construction of Demand-Response program for efficient energy usage with demand side & supply side.
❸ Realization of Smart Communities/Towns with customers & areas.

2. Integration of renewable and distributed resources with the help of the modernization of power networks.

❶ Upgrading distribution network by taking advantage of ICT.
❷ Widening of power system operation.
❸ Development of next-generation transmission & distribution network system concerned with integration of residential PV.
❹ Development of integrated control of battery energy storage.

3. Efforts in to realize "Smart Grid"

(2) Positive introduction and practical use of a smart meter system

I. Active adoption of Smart Meters / Expansion of new services

●The advantage of smart meter implementation (27 million sets)

- Operation cost reduction
- Wider Tariff choices
- The visualization of power consumption data
- Demand control by two- way communication
- Creation of new value-added service

→ ■Operational reforms ■Better customer service ■Cut back on investments by DSM

●The deployment prospect of smart meters

RFP : Request For Proposal

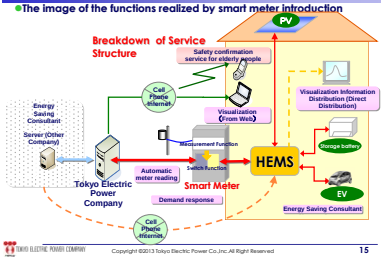
	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Meter installation	Mechanical meter										
	About 2 million sets	About 5 million sets		About 14 million sets						About 27 million sets	

Smart Meter installation

Deployment of new service

3. Efforts to realize a "Smart Grid"

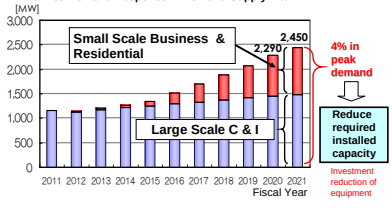
●The image of the functions realized by smart meter introduction



3. Efforts in to realize "Smart Grid"

II. Construction of Demand-Response program for efficient energy usage with demand side & supply side

●Planned Demand Response in Demand-Supply Plan



4% in peak demand

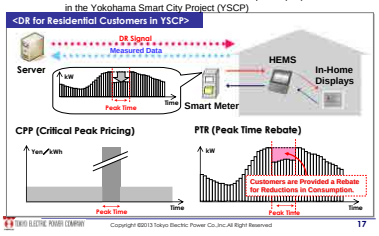
Reduce required installed capacity

Investment reduction of equipment

3. Efforts in to realize "Smart Grid"

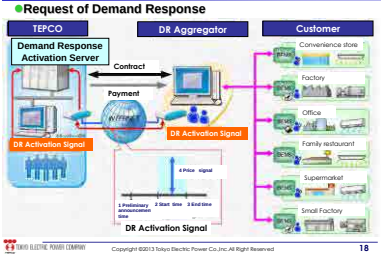
●Research on Introducing Dynamic Pricing for Residential Customers
- Measurement and Verification of Demand Response (DR) in the Yokohama Smart City Project (YSCP)

<DR for Residential Customers in YSCP>



3. Efforts in to realize "Smart Grid"

●Request of Demand Response



3. Efforts in to realize "Smart Grid"

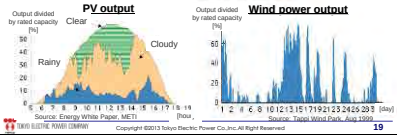
(3) Integration of renewable and distributed resources by modernizing power networks

■Grid Intermittent output of PV and wind Power

- Intermittent output of PV and wind power is subject to weather condition

☐ Network Reinforcement is required for more RE integration to realize interactive coordination between grids and generators
→Smart Grid with interactive communication

☐ Much discussion is needed to decide who should pay the reinforcement costs



3. Efforts in realization of "Smart Grid"

■Integration of Renewable Energy

	Challenges	Solutions
Voltage (Developed)	**Overvoltage on distribution system** ● Voltage rises at the end of the distribution lines due to renewable energies	・Additional transformers ・Installation of voltage regulators
Frequency (Developing)	**Absorption of surplus power** ● PV output causes surplus power during off peak demand period	・Curtailment of PV ・Electrification ・Widening of power system operation
	Improvement in output estimation ● How to estimate intermittent output	・Estimation of intermittent output
	Sufficient frequency control capability ● Insufficient frequency control of generation system due to renewable energies	・Integrated system of batteries for generation control ・Widening of power system operation

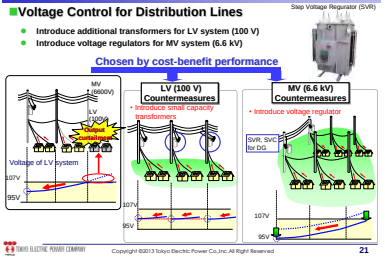
3. Efforts in realization of "Smart Grid"

I. Upgrading distribution network by taking advantage of ICT

■Voltage Control for Distribution Lines

- Introduce additional transformers for LV system (100 V)
- Introduce voltage regulators for MV system (6.6 kV)

Chosen by cost-benefit performance

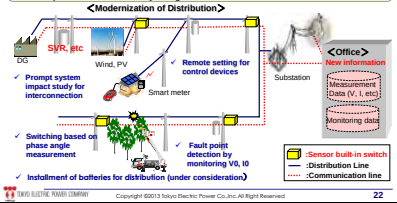


3. Efforts in realization of "Smart Grid"

■Optimization of Distribution Network

Merits of monitoring and control system with sensor built-in switch

- Securing power quality using measurement data (V, I) for RE integration study
- Quick fault detection and prompt restoration to prevent faults
- Improvement of efficiency using the remote control



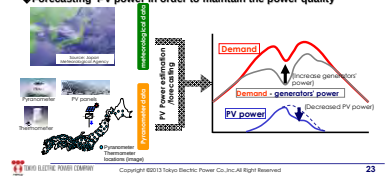
3. Efforts in realization of "Smart Grid"

II. Development of next-generation transmission & distribution network system concerned with integration of residential PV

■Demonstration project of forecast technologies for photovoltaic generation

- Development of a method to estimate the current photovoltaic power generation output from weather data or sunlight data
- Develop method to forecast the photovoltaic power generation output

◆Forecasting PV power in order to maintain the power quality

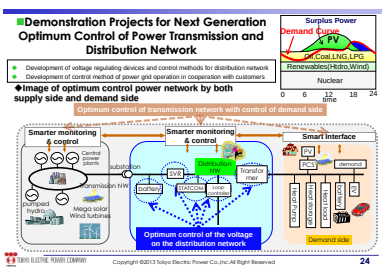


3. Efforts in realization of "Smart Grid"

■Demonstration Projects for Next Generation Optimum Control of Power Transmission and Distribution Network

- Development of voltage regulating devices and control methods for distribution network
- Development of control method of power grid operation in cooperation with customers

◆Image of optimum control power network by both supply side and demand side



4. Conclusions

Change in Demand-Supply Structure

1. Efficient & optimized energy usage with customers and society
2. Integration of renewable and distributed resources with the help of the modernization of power networks

S+3E Achievements

①Supply Side
- Integration of RES DER,
- New Supply Capacity

X

②Demand Side
- Various energy services,
- Efficient energy usage

Flexible & Robust "Smart Grid"

- Innovate our energy services with our customers and society
- Realize a platform that enables efficient and optimized energy usage with a demand and supply side perspective

- Neutral and non-discriminatory operation
- Improvement and modernization of the O&M of facilities

● Amidst current restoration efforts, TEPCO will work towards the establishment of the SMART GRID in cooperation with our customers and society to achieve efficient and optimized energy usage leading to maximization of social benefits.

事故点探査の結果報告

ブータン電力公社（BPC）における事故点探査結果について

東京電力株式会社
2013年7月

TOKYO ELECTRIC POWER COMPANY

1．背景

- ✓ ブータン地方電化推進プロジェクトフェーズ2実施中
  2013年の電化率100%を目指し，地方電化展開中
  プロジェクト期間：2012年3月～2014年7月
- ✓ 優先課題解決活動（PI活動）の実施でブータン電力公社（BPC）職員の課題解決能力向上を支援
- ✓ 5～6テーマを選定し，課題解決にむけ活動を展開
- ✓ 1テーマとして事故点探査手法の改善をピックアップ

2．課題（事故点探査の改善）について

■ BPCの現状

- 適切な事故点探査機材がない
  （機材はあるがうまく扱えない） ⇨ ✓ **探せない** ✓ **事故設備放置**
- 設備マップが存在しない
- 事故点探査に時間がかかる
- 多くの人員を配置 ⇨ ✓ **非効率** ✓ **サービス低下**

課題の解決により，

- ✓ 効率化（地方電化へ人員配分，設備の改修利用）
- ✓ 信頼度向上（設備信頼度，供給信頼度向上）
- ✓ 顧客満足度向上（早期送電）

事故点探査手法の改善を目指して取り組む

3．派遣概要

■ 目的
- 一手法の紹介としてLUPINにて現地探査を実施
  （BPC技術者の理解向上，解決支援）
- 日本製機材（LUPIN）の紹介

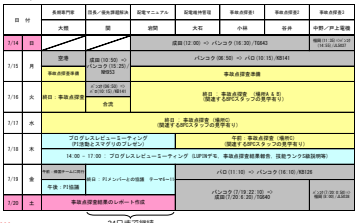
■ 要員
- 東電配電保守員 2名 ＋ 戸上電機 1名
  東京電力　東京支店　小林
  東京電力　埼玉支店　谷井
  戸上電機　中野氏
- プロジェクトメンバー
  関，岩間，大石

■ 内容
- ✓ 事前準備（現場確認と機材準備）（1日）
- ✓ 事故地中配電線の事故点探査（2.5日）
- ✓ 事故点探査に関するBPCとの協議（0.5日）

} 現地調査 計4日

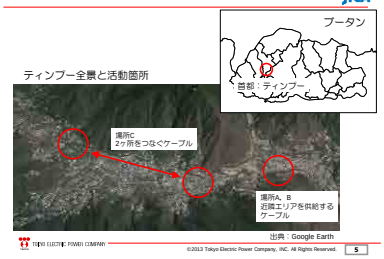
3．派遣概要

■ スケジュール



24日まで継続

4．ブータン位置情報



ティンプー全景と活動箇所

出典：Google Earth

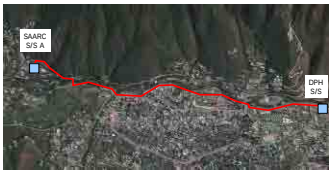
5．事故点探査現場情報

■ 場所AおよびB

出典：Google Earth

5．事故点探査現場情報

■ 場所C



出典：Google Earth

6．事故点探査の流れ

1. 事故ケーブルの特定
2. 事故ケーブルの絶縁測定
3. ケーブル導体抵抗測定: ケーブル長算出
4. 高圧プリッジ測定：事故点距離の算出
5. LUPINによる探査：詳細な事故点探査
6. 終了

6．事故点探査結果

◆ ケーブル事前情報（場所AおよびB）

ケーブル	サイズ	長さ	埋設深さ	分岐有無	使用電圧
3core XLPE	300mm²	A:600m B:500m	Over 1m	No	11kV

◆ 絶縁測定による事故状況

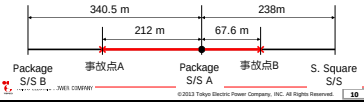
場所A	相	絶縁抵抗
対地	赤相	7.6M Ω
	黄相	< 5000M Ω
	青相	**< 15k Ω**
線間	赤－黄	< 5000M Ω
	黄－青	< 5000M Ω
	赤－青	< 5000M Ω

場所B	相	絶縁抵抗
対地	**赤相**	**3k Ω**
	黄相	< 5000M Ω
	青相	< 5000M Ω
線間	赤－黄	< 5000M Ω
	黄－青	< 5000M Ω
	赤－青	< 5000M Ω

6．事故点探査結果

◆ 高圧プリッジによる事故点距離の測定結果

場所	事前情報 ミリオームテスタおよびLUPINによる現地測定	%値	事故点までの距離
A	600 m	62.3 %	373 m
	340.5 m		**212 m**
B	500 m	28.4 %	142 m
	238 m		**67.6 m**



6．事故点探査結果

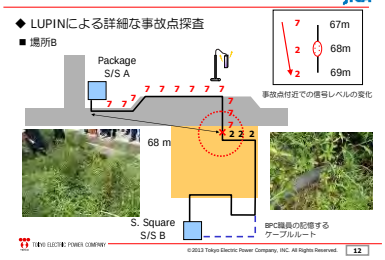
◆ LUPINによる詳細な事故点探査

■ 場所A

6．事故点探査結果

◆ LUPINによる詳細な事故点探査

■ 場所B



6．事故点探査結果

◆ ケーブル事前情報（場所C）

ケーブル	サイズ	長さ	埋設深さ	分岐有無	使用電圧
3core XLPE	300mm²	4000m	Over 1m	No	11kV

◆ 絶縁測定による事故状況

場所C	相	絶縁抵抗
対地	赤相	470M Ω
	黄相	56M Ω
	青相	200M Ω
線間	赤－黄	270M Ω
	黄－青	310M Ω
	赤－青	740M Ω

高圧プリッジ適用前の状況

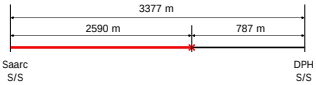
場所C	相	絶縁抵抗
対地	赤相	480M Ω
	黄相	70M Ω
	青相	**6k Ω**
線間	赤－黄	320M Ω
	黄－青	50M Ω
	赤－青	450M Ω

最終的な状況（プリッジ数度適用）

6．事故点探査結果

◆ 高圧プリッジによる事故点距離の測定結果

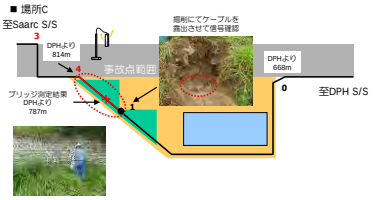
場所	事前情報 ミリオームテスタおよびLUPINによる現地測定	%値	事故点までの距離
C	4000 m	76.7 %	3068 m
	3377 m		**2590 m**



6．事故点探査結果

◆ LUPINによる詳細な事故点探査

■ 場所C



7．事故点探査結果のまとめ

◆ 場所AおよびBについて

場所	全長	高圧ブリッジ	LUPIN	差	探査時間
A	340.5 m	212 m	210 m	2 m	2時間
B	238 m	67 m	68 m	1 m	2.5時間

- 高圧ブリッジとLUPINの結果に大きな差はなくそれぞれの測定器が精度の高い結果を残した
- ただし、高圧ブリッジは全長データが重要であり正確なルート探査ができるLUPINとの併用が必要である
- LUPINより先に高圧ブリッジを実施することで絶縁抵抗の低抵抗化とLUPIN探査範囲の絞り込みができ、作業の効率化が図れる

LUPINと高圧ブリッジの併用により短時間で精度の高い結果を得られた
長距離が多い高圧ケーブルへの事故点探査手法の一例を示せた

7．事故点探査結果のまとめ

◆ 場所Cについて

- 絶縁抵抗が安定せず，LUPIN探査が困難を極めた
- 高圧ブリッジでは0.2~0.3kVまで昇圧すれば安定した電流の確保が可能
- しかし，LUPINではケーブル静電容量の影響で，160V程度でアンプが過負荷となってしまう
- よって，安定した信号電流を確保できず，難しい事故点探査となった
- 事故点抵抗がもう少し低抵抗化させられたらLUPIN探査は可能

（調査時間の関係から，低抵抗化の時間をあまり確保できなかった）

- LUPIN側の接地極を配電塔側で取ると事故点手前の水道管等に戻り信号が発生し、対地に接地極を打ち込むと事故点以降のケーブルに事故電流が確認できた。高圧ケーブル探査では遮蔽層、アーマー層の影響があるため探査状況によっては接地極を替えて確認する必要ある。

高圧ブリッジの低抵抗化によってLUPIN探査可能な状況へ進展できた
LUPIN単独で難しい事故様相への打開策の一例を示せた

8．事故点探査風景


TBM-KY

ブリッジ測定

LUPIN調整中


LUPIN探査中


信号確認のため掘削


営業所にて