Presentation Materials of sixth Workshop

Earthing/Grounding in Japan

Earthing/Grounding in Japan

May 2014
Tokyo Electric Power Company

TOKYO ELECTRIC POWER COMPANY

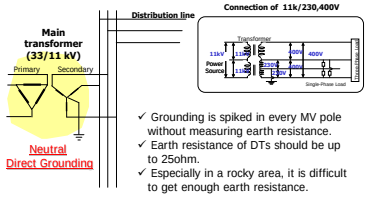
Agenda

§ .1 Current Situation of Earthing/Grounding in Bhutan
§ .2 Network Earthing/Grounding in Japan
§ .3 In-house Earthing/Grounding in Japan
§ .4 Recommendation

Chapter.1 Current Situation of Grounding in Bhutan

Network system in BPC

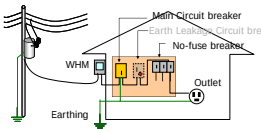
MV distribution line Grounding system in BPC



- ✓ Grounding is spiked in every MV pole without measuring earth resistance.
- ✓ Earth resistance of DTs should be up to 25ohm.
- ✓ Especially in a rocky area, it is difficult to get enough earth resistance.

Grounding system in house

Standard internal wiring in Bhutan

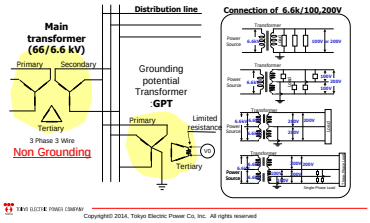


- BPC regulates a customer's grounding resistance in house at the time of application of electricity use. (good)
- ELCBs are installed in small number of households in Bhutan. (bad)

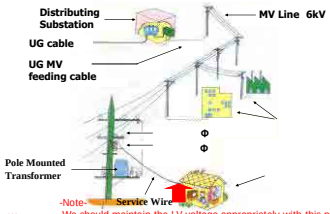
Chapter.2 Network Grounding in Japan

Network System in TEPCO

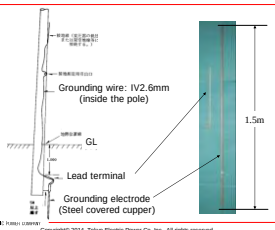
6.6kV-MV distribution line Grounding system



Overhead Distribution System



Earthing/Grounding of Poles



Chapter.2 Network Grounding in Japan

Rules, Regulation

Rules, Regulation for network grounding

➢ Regulation that Electricity Utilities must observe in Japan
"Electrical Equipment Technical Standards (EETS)"
by METI (Ministry of Economy, Trade, and Industry)
[objective] Ensuring pubic safety, Stable supply of Electricity

Earthing / grounding on EETS

Regulation about grounding is classified into 4 types.(⇒next slide)

[objectives of network grounding]

- ✓ To prevent damage to the human body in case abnormal voltage occurs at the time of network fault
- ✓ To minimize damage of network facilities in case of fault
- ✓ To protect network facilities and customers' equipments in case of lightening (grounding of arresters)

Rules, Regulation for network grounding

➢ Earthing / grounding on EETS

	Condition	Regulation value	Object (e.g.)
A class	For HV or MV equipment	10[Ω]	Lightening Arrester (LA) HV equip.
B class	For Voltage rise of LV equip. by a confused MV fault contact	150/Ig[Ω](*) Ig: primary-side current of one-line ground fault	DT
C class	For LV equip. over 300V	10[Ω](*)	LV equip.
D class	For LV equip. up to 300V	100[Ω](*)	LV metallic pole Messenger wire

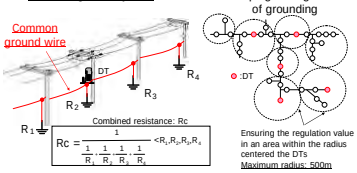
(*):These value are in TEPCO's case.
The values depend on the breaking time of network.

Regarding grounding of LA and B class grounding, **applying common ground system** is available.

Rules, Regulation for network grounding

➢ Common ground system

Grouping management of grounding



Ensuring the regulation value in an area within the radius centered the DTs
Maximum radius: 500m

Common ground system can make each resistance target high

Chapter.2 Network Grounding in Japan

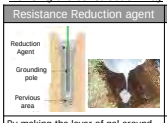
Problem and Countermeasures in Japan

Problem, Difficulties

TEPCO has mountainous & rocky area where it is difficult to get low grounding resistance. (We have the same problem as you!!)

Countermeasure (1)

➢ Devising the construction way

Resistance Reduction agent	Boring method
	
By making the layer of gel around the grounding pole, grounding resistance can be reduced. This agent reduces 50-70% of grounding resistance semipermanently.	By using special boring equipment, a grounding pole is spiked into 20m~70m depth. This method is very effective, but costs very high. (about 10,000USD)

Countermeasure (2)

➢ Proper management of grounding resistance

TEPCO measures all grounding resistance at the time of installation, and some of them regularly.

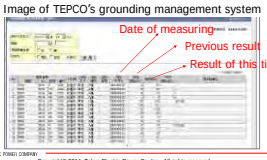
target	Period of measuring resistance
A class grounding B class grounding	• place with reduction agent - every 5 years • place where the previous measured value was more than 60% of regulation - every 5 years • the other - at any time In addition, at B class pole visual inspection is implemented every 5 years. After installing/repairing grounding, twice regular measuring must be implemented.
The other	at any time

Countermeasure (2)

TEPCO manages grounding resistance by the computer system.

This system can record the result of measuring and simulate the resistance to choose the proper way of installation.

Image of TEPCO's grounding management system



Countermeasure (3)

➢ Effort to ease the regulations

There is a third party "Japan Electric Association (JEA)" which consists in manufacturers and utilities in Japan

[JEA's role]

✓ Summary of the demand for revision of EETS

✓ Researching about electricity equipments

Electric utilities (included TEPCO) have implemented experiments about possibilities of making the regulations more rational. And they have realized that through JEA.

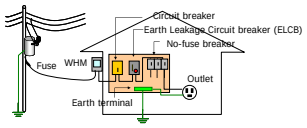
e.g. Mitigation of regulation resistance of A class grounding in the case when an arrester is in a B class grounding area

Chapter.3 In-house Grounding in Japan

In-house Grounding in Japan

Grounding system in house

Standard internal wiring in Japan



- Generally in-house earthing is separately installed (not connected to) network earthing in Japan.
- ELCB is installed in almost all new residence in Japan.(99.7%)

Chapter.4 Recommendation

Recommendation

Recommendation

✧ Network grounding

- Adoption of common grounding system
- Proper management of grounding resistance
  e.g. regularly measurement
- Use of new technology
  e.g. reduction agent

✧ In-house grounding

- Proper guidance on in-house grounding for customers
- Promoting of installing of ELCB

We recommend you above things with considering the pilot project which Begana training center has implemented.

Thank you for your attention!!

TOKYO ELECTRIC POWER COMPANY

Presentation Materials of seventh Workshop

Outline of Priority Issue Solving Activity

Issue Solving Activity

July 2014
Tokyo Electric Power Company

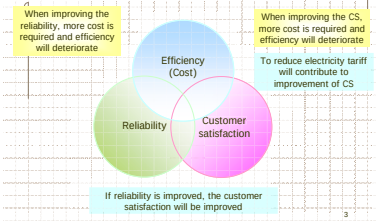
1

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



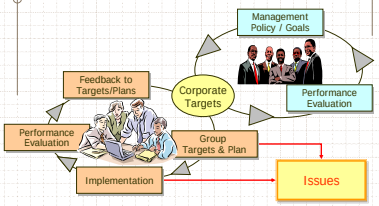
3

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

Manager's Role & Responsibility



5

What is Priority Issue (PI) Solving Activity?

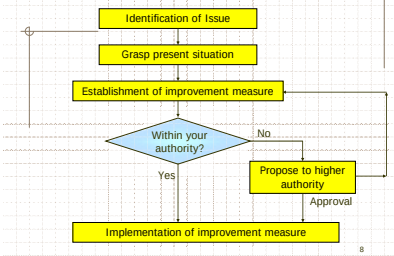
6

Objectives

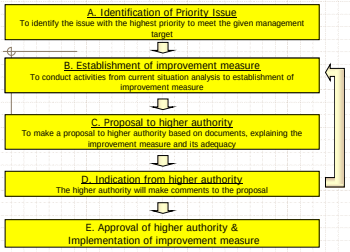
- The active and proper contributions of the middle-class managers are indispensable to improving the management situations at your office.
- The main objective is to enable the middle-class managers to tackle…
  - Issues/problems to achieve their group targets / the management goals
  - Issues/problems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

7

Flow of Issue Solving



8



9

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

10

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
6. Establishment of Implementation Plan

11

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.

12

How to handle the data

- The aim of using data is to solve problems, and to make people understand easily and correctly or to appeal to people.
  - Step 1: Think about what you want to describe, analyze, confirm, verify.
  - Step 2: Think about how you should handle or show the data.

13

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

14

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

15

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.

16

Examples of Various Measures

- Measures with less cost
- Measures which can be conducted instantly
- Measures with large effect
- Drastic measures, even though it might take a long time and high cost.

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 required resource to be injected
  - Timing when implementation is possible
  - Secondary (indirect) effects

19

B-6. Establishment of Implementation Plan

- Resource to be injected
  - Budget, 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 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 proposal?

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

QC Tools

Data Management and TQM Tools

July 2014

Tokyo Electric Power Company (TEPCO)

1

Contents

2

1. Significance of Data Management

3

Why *Data Management* is significant?

Data is necessary from viewpoints …

1. Survey actual conditions and Analyze phenomena

2. Establish Action Policies and Do Decision-making reasonably

3. Check the proceedings and Control the direction

4

Quality Management must be based on Facts

Bad Management
- based on **Experiences**, **Intuitions**
- impossible to reach Corporate Target

Good Management
- based on **Facts** (**Data**, **Actual Results**, **Information** or **Common words**)
- possible to reach Corporate Target

5

Advantages of Data Management

- Data Management enables you to quantify the Quality.
- Quantification helps you to deliver the information accurately to others.
- Quantification helps you to easily share problems and avoid others' subjectivities.
- Proposals established on Data have the power of persuasion.

6

2. Items of Useful TQM Tools

What are the TQM Tools?

1. TQM Tools are **techniques** applied in quality management activities.
2. They are applied in order to **identify problems**, compile information, get ideas, **analyze factors**, **devise solutions to problems**.
3. **Using the TQM Tools is not a Goal**. They just help us understand the problems.

TQM Tools (7 Tools)

- Pareto Diagrams
- Cause & Effect Diagrams
- Graphs
- Check Sheets
- Histograms
- Scatter Diagrams
- Control Charts

7 Tools

	Name	Purpose	Characteristics & Image
1	Pareto Diagrams	Select the Priority Issues. Grasp the importance of each item.	Bar charts of each item. Line plot of accumulated values
2	Cause and Effect Diagrams	Pursue the cause of the problem. Sort out the knowledge of causes and effects.	Final effect is linked by the associated causes.
3	Graphs	Facilitate to grasp the information of data through visualization.	Circular graph, Bar chart, Radar chart
4	Check Sheets	Facilitate the data collection and the data sorting.	Spreadsheet or records for easy data collecting and less-mistakable format.

7 Tools

	Name	Purpose	Characteristics & Image
5	Histograms	Grasp the data dispersion. Grasp the characteristics of distribution.	Bar charts of the frequency distribution table.
6	Scatter Diagrams	See the co-relation between two parameters. Study co-relation and recurrence.	Plot diagram of two parameters, each of which is allotted to X-axis and Y-axis.
7	Control charts	Facilitate to grasp the information of data through visualization. Manage the process. Analyze the problem in the process.	Line plot dependent on time, with regulated limits' lines.

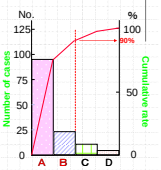
① Pareto Diagrams

- **Purpose is to find out dominant factors of the problems**

Example

"System Loss data"

Group	System Loss item	No. of cases	Cumulative No.	Cumulative %
A	Transformer Unbalance	90	90	72%
B	Power Theft	22	112	90%
C	Stopped Meters	10	122	98%
D	Loose connection	3	125	100%
	Total	125		

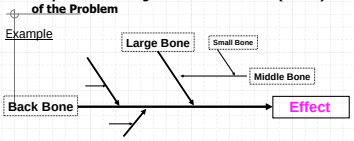


- **Put Simple Bar diagram in descending order, and draw a cumulative line plot**
- **Easy to grasp the "dominant factors" of the problem**

② Cause & Effect Diagrams

- **Purpose is to arrange "Causes" & "Effect (Result)" of the Problem**

Example



- **Write " Effect (Result) " on the right side of a "Back Bone"**
- **Write classification of "Causes" at the end of "Large Bones"**
- **Write "Causes" into "Middle" & "Small Bones"**

② Cause & Effect Diagrams

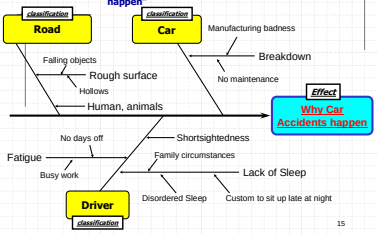
Points to Remember when constructing Diagrams

- **Brain storming session is a principle rules to list up "Causes"**
- **"Group thinking" is more effective than "Individual thinking"**
- **Repeat "Why" over and over again with all Participants**
- **Use as few words as possible**
- **Reach a team consensus**

② Cause & Effect Diagrams

Sample

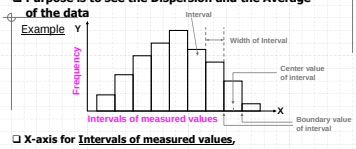
"Why Car Accidents happen"



③ Histograms

- **Purpose is to see the Dispersion and the Average of the data**

Example



- **X-axis for Intervals of measured values, Y-axis for Frequency within each intervals**
- **Histograms give information as below;**
  - **(1) Center of the Data (2) Amplitude of dispersion**
  - **(3) Shape of distribution**
  - **(4) Existence or non-existence of Abnormality**
  - **(5) Deviation from the Standard Ranges**

③ Histograms

How to Construct a Histogram

- **Step 1: Collect Data**
- **Step 2: Find Maximum and Minimum of Data**
  - **Arrange data in the Matrix style**
  - **Find Maximum and Minimum value in each column (row)**
  - **Find the Grand Max. and Min. from the marked values**

Dimensions of Products A [mm]

45.1	47.1	45.6	X 45.2	O 47.7	45.8	O 46.8	45.4	X 45.0	45.1
46.2	46.8	45.1	45.6	45.5	45.7	46.2	44.9	45.2	45.6
45.3	O 47.6	45.8	46.0	X 45.1	OO 48.0	46.1	45.4	O 47.3	45.2
45.8	45.7	O 46.1	46.4	45.3	45.7	46.7	O 46.8	45.2	O 45.7
45.7	46.8	45.9	O 47.5	45.8	45.9	46.6	46.1	45.6	X 44.5
O 46.9	45.7	45.2	46.7	47.5	46.0	45.7	46.5	45.7	45.5
44.5	X 45.2	45.3	45.5	47.3	46.1	45.9	46.1	45.5	44.6
44.6	45.3	45.7	X 45.2	45.7	45.3	X 44.8	X 44.2	45.1	45.0
XX 43.9	46.0	45.8	45.3	45.9	44.9	45.1	45.0	X 45.0	45.1
44.8	45.5	X 45.0	45.8	45.7	X 44.8	45.2	45.4	45.2	45.4

O: Maximum value of each column, X:Minimum value of each column

③ Histograms

Example to Construct a Histogram

- **Step 3: Make up a Frequency Table**

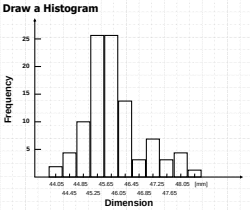
No.	Boundary of Interval	Center of Interval	Tick	Frequency
1	43.85 – 44.25	44.05	//	2
2	44.25 – 44.65	44.45	////	4
3	44.65 – 45.05	44.85	//// ////	10
4	45.05 – 45.45	45.25	//// //// //// //// /	26
5	45.45 – 45.85	45.65	//// //// //// //// /	26
6	45.85 – 46.25	46.05	//// //// ////	14
7	46.25 – 46.65	46.45	///	3
8	46.65 – 47.05	46.85	//// //	7
9	47.05 – 47.45	47.25	///	3
10	47.45 – 47.85	47.65	////	4
11	47.85 – 48.25	48.05	/	1
			Total	100

Example : Width of Interval = 0.4 mm

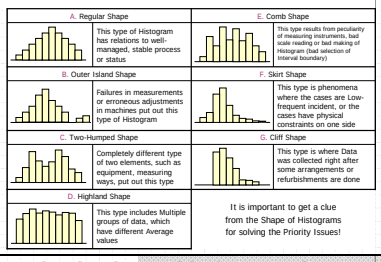
③ Histograms

Example to Construct a Histogram

- **Step 4: Draw a Histogram**



③ Histograms



It is important to get a clue from the Shape of Histograms for solving the Priority Issues!

④ Scatter Diagrams

- **Purpose is to examine the relationship between two variables**

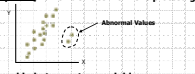
Example

- **Plot the points where X & Y intersects**

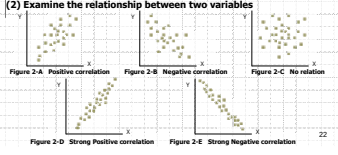
④ Scatter Diagrams

Estimation of Scatter Diagrams

- **(1) Examine Abnormal points, which deviate from the plotted group**



- **(2) Examine the relationship between two variables**



Tool Selection Guide for 7 Tools

No.	Sequence of procedure \ Tool	Graph	Control chart	Pareto Chart	Histo-gram	Cause-effect diagram	Scatter-ed diagram	Check sheet
1	Identification of issue	◎ Bar chart, line graph	○	●	○	◎		○
2	Understanding of the present status and goal setting	● Bar chart, line graph	○	◎	◎	○	○	●
3	Preparation of action plan	● Gantt Chart						
4	Analysis of element	● Bar chart, line graph	◎	○	●	●	●	●
5	Study on and implementation of the countermeasure	◎				●		
6	Confirmation of the effect	◎ Bar chart, line graph	●	◎	●		○	○
7	Standardization and establishment of control	○	●		○			●

Thank you for your attention

Exercise: QC Tools - Basic of Statistics

JICA Technical Cooperation Project
Improvement of Efficiency for Rural Power Supply Phase II

Lecturer

Exercise : QC Tools
- Basic of Statistics -

July 2014
Tokyo Electric Power Co.

4

Lecture

Table of Contents

5

Lecture

1. Items of Useful TQM Tools

6

Lecture

What are the TQM Tools?

1. TQM Tools are **techniques** applied in quality management activities.
2. They are applied in order to **identify problems**, compile information, get ideas, **analyze factors**, **devise solutions to problems**.
3. **Using the TQM Tools is not a Goal**. They just help us understand the problems.

7

Lecture

TQM Tools

7 Tools

- Pareto Diagrams
- Cause & Effect Diagrams
- Graphs
- Check Sheets
- ✓Histograms
- ✓ Scatter Diagrams
- ✓ Control Charts

Numeric Data Analysis

8

Lecture

7 Tools

Name	Purpose	Characteristics & Image
Pareto Diagrams	**Select the Priority Issues. Grasp the importance of each item.**	Bar charts of each item. Line plot of accumulated values
Cause and Effect Diagrams	**Pursue the cause of the problem. Sort out the knowledge of causes and effects.**	Final effect is linked by the associated causes.
Graphs	**Facilitate to grasp the information of data through visualization.**	Circular graph, Bar chart, Radar chart
Check Sheets	**Facilitate the data collection and the data sorting.**	Spreadsheet or records for easy data collecting and less-mistakable format.
Histograms	**Grasp the data dispersion. Grasp the characteristics of distribution.**	Bar charts of the frequency distribution table.
Scatter Diagrams	**See the correlation between two parameters. Study correlation and regression.**	Plot diagram of two parameters, each of which is allotted to X-axis and Y-axis.
Control charts	**Facilitate to grasp the information of data through visualization. Manage the process. Analyze the problem in the process.**	Line plot dependent on time, with regulated limits' lines.

Lecture

2. Exercise :Histograms

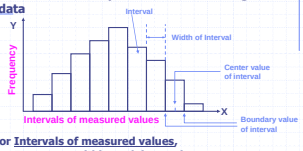
10

Lecture

① Histograms

❑ **Purpose is to see the Dispersion and the Average of the data**

Example



❑ **X-axis for Intervals of measured values, Y-axis for Frequency within each intervals**

❑ **Histograms give information as below;**

(1) Center of the Data
(2) Amplitude of dispersion
(3) Shape of distribution
(4) Existence or non-existence of Abnormality

11

Question

Exercise 1 Making histogram (1)

Make a histogram and explain your graph to your audience.

- 20 Men's heights (raw data)

No.	Heights (cm)	No.	Heights (cm)
1	158	11	166
2	163	12	154
3	139	13	165
4	157	14	148
5	156	15	172
6	144	16	156
7	152	17	162
8	176	18	167
9	154	19	181
10	149	20	159

Hints
- Min, and Max
- Class interval (10cm)
- Mid point
- Tally
- Frequency
- Relative frequency

12

Question

Exercise 1 Making histogram (1)

Make a histogram and explain your graph to your audience.

Max=__, Min=__, Range=Max-Min=__-__=__cm
Class interval=10cm

Class No	Class intervals	Midpoint	Frequency	Relative Frequency	Accumulative Frequency
1	130-140				
2	140-150				
3	150-160				
4	160-170				
5	170-180				
6	180-190				
Total					

13

Question

Exercise 1 Making histogram (2)

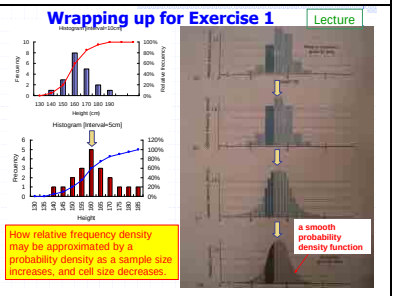
When class interval changes to 5cm from 10cm, make a histogram.

Class No	Class intervals	Midpoint	Frequency	Relative Frequency	Accumulative Frequency
1	135-140				
2	140-145				
3	145-150				
4	150-155				
5	155-160				
6	160-165				
7	165-170				
8	170-175				
9	175-180				
10	180-185				
Total					

14

Lecture

Wrapping up for Exercise 1



How relative frequency density may be approximated by a probability density as a sample size increases, and cell size decreases.

15

Lecture

Spread of Distribution

■**Variance**

❑Variance: $\sigma'^2 = \frac{1}{n-1}\sum_{i=1}^{n}(x_i - \bar{x})^2$

❑Standard deviation : σ'

❑Coefficient of variation: $C = \sigma' / \bar{x}$

Above the distribution (or data), mean, median, and mode are same, but different spread of distribution.

16

Lecture

Spread of Distribution

■**Variance**

❑Variance: $\sigma'^2 = \frac{1}{n-1}\sum_{i=1}^{n}(x_i - \bar{x})^2$

A random variable, probability distribution, or sample is a measure of statistical dispersion, averaging the squared distance of its possible values from the expected value (mean). Whereas the mean is a way to describe the location of a distribution, the variance is a way to capture its scale or degree of being spread out.

❑Standard deviation : σ'

A measure of the variability or dispersion of a population, a data set, or a probability distribution. A low standard deviation indicates that the data points tend to be very close to the same value (the mean), while high standard deviation indicates that the data are "spread out" over a large range of values.

❑Coefficient of variation: $C = \sigma' / \bar{x}$

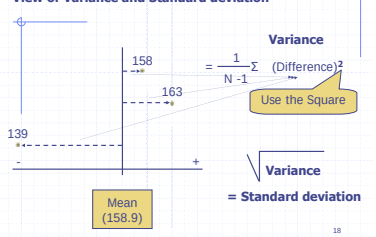
A normalized measure of dispersion of a probability distribution. It is defined as the ratio of the standard deviation to the mean.

17

Lecture

Spread of Distribution

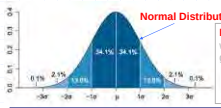
View of Variance and Standard deviation



18

Spread of Distribution

Lecture



Probability density function
which is the formula for the general normal distribution.

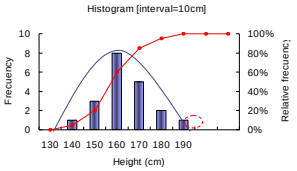
$$f(x) = \frac{1}{\sqrt{2\pi}\sigma} \exp\left(-\frac{(x-\mu)^2}{2\sigma^2}\right)$$

To understand standard deviation, keep in mind that variance is the *average* of the squared differences between data points and the mean. Variance is tabulated in units squared. Standard deviation, being the square root of that quantity, therefore measures the spread of data about the mean, measured in the same units as the data.

For the normal distribution, this accounts for **68.27 %** of the set; while two standard deviations from the mean (medium and dark blue) account for **95.45 %**; three standard deviations (light, medium, and dark blue) account for **99.73 %**; and four standard deviations account for 99.994 %.

Spread of Distribution

Lecture



20

Exercise 2 Variance (Spread of Distribution)

Question

(a) Calculate mean, variance, and standard deviation

(b) Find out abnormal (extraordinary) value

No.	Heights (cm)	No.	Heights (cm)
1	158	11	166
2	163	12	154
3	139	13	165
4	157	14	148
5	156	15	172
6	144	16	156
7	152	17	162
8	176	18	167
9	154	19	181
10	149	20	159

□ Variance $\sigma'^2 = \frac{1}{n-1}\sum_{i=1}^{n}(x_i - \bar{x})^2$

□ Standard deviation : σ'

21

3. Exercise : Scatter Diagrams

Lecture

22

② Scatter Diagrams

Lecture

□ **Purpose is to examine the relationship between two variables**

Example

□ **Plot the points where X & Y intersects**

23

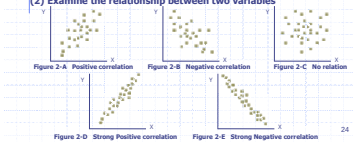
② Scatter Diagrams

Lecture

Estimation of Scatter Diagrams

(1) Examine Abnormal points, which deviates from the plotted group

(2) Examine the relationship between two variables

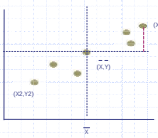


24

Correlation coefficient

Lecture

Covariance



$$\frac{1}{N-1}\Sigma\ (X_i - \bar{X})\ (Y_i - \bar{Y})$$

\+ \+

\- \-

\+ **Positive correlation**

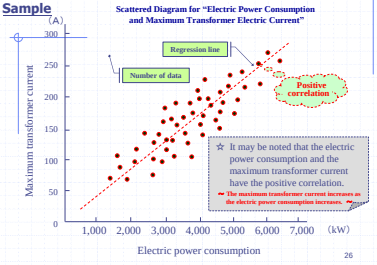
\- **Negative correlation**

25

② Scatter Diagrams

Lecture

Sample



26

Correlation coefficient

Lecture

$$\frac{1}{N-1}\Sigma\ (X_i - \bar{X})\ (Y_i - \bar{Y})$$

$$r^2 = \frac{(\Sigma\ XiYi - n \cdot Xmean \cdot Ymean)^2}{(\Sigma\ Xi^2 - n \cdot Xmean^2) \cdot (\Sigma\ Yi^2 - n \cdot Ymean^2)}$$

Coefficient of Correlation $r = \sqrt{r^2}$

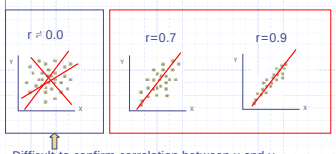
27

Scatter Diagrams

Lecture

What is Coefficient of Correlation r

There is correlation



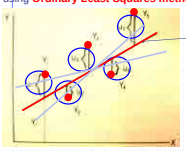
Difficult to confirm correlation between x and y

28

Regression Analysis
Ordinary Least Squares method (OLS)

Lecture

Regression Analysis is a technique used for the modeling and analysis of numerical data consisting of values of a dependent variable (response variable) and of one or more independent variables (explanatory variables). The dependent variable in the *regression equation* is modeled as a function of the independent variables, corresponding parameters ("constants"), and an *error term*. The parameters are estimated so as to give a "best fit" of the data. Most commonly the best fit is evaluated by using **Ordinary Least Squares method (OLS)**.



Regression Equation

$$Y = a + bX + e$$

Best fit regression equation is determined when sum of error terms is the least. This is OLS.

29

Deviation of the Regression Equation

Lecture

Use the Square

$$Y = a + bX + e \rightarrow e = Y - a - bX \rightarrow e^2 = \Sigma\ (Y - a - bX)^2$$

Differentiate

times Σ X

$$\frac{\partial}{\partial a}\Sigma\ (Y - a - bX)^2 = \Sigma\ -2\ (Y - a - bX) = 0 \rightarrow \Sigma\ Y - na - b\Sigma\ X = 0$$

$$\frac{\partial}{\partial b}\Sigma\ (Y - a - bX)^2 = \Sigma\ -2X(Y - a - bX) = 0 \rightarrow \Sigma\ XY - a\Sigma\ X - b\Sigma\ X = 0$$

times n

$$a = (\Sigma\ Y - b\Sigma\ X)/n$$

$$a = Ymean - b \cdot Xmean$$

$$\Sigma\ X\Sigma\ Y - b(\Sigma\ X)^2 - n\Sigma\ XY + nb\Sigma\ X^2 = 0$$

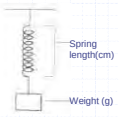
$$b = \frac{\Sigma\ XiYi - n \cdot Xmean \cdot Ymean}{\Sigma\ Xi^2 - n \cdot Xmean^2}$$

Exercise 3a (Regression Analysis)

Question

Calculate Regression Equation, and Coefficient of Correlation

No.	X	Y
	Wight (g)	Spring length (cm)
1	5	13
2	10	14
3	15	18
4	20	19
5	25	22
6	30	26



31

Exercise 3b (Regression Analysis)

Question

(1) Any correlation between Load factor and transformer temp?

(2) What is prediction of temperature when load factor is 100%?

32

4. Exercise : Control Charts

Lecture

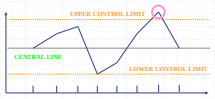
33

③ Control Charts

Lecture

□ **Purpose is to see whether the conditions are in preferable status or not**

Example



□ **UCL (Upper Control Limit) & LCL (Lower Control Limit) are statistically determined on either side of Center Line**

□ **No abnormality in dispersion, then condition is STABLE**

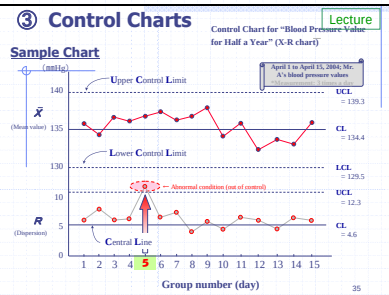
□ **If points are outside limits – indicates unusual causes**

34

③ Control Charts

Lecture

Sample Chart



35

Exercise 4 (Control Charts)

Question

Make Data Analysis and find out the extraordinary phenomenon to prevent major accident.

Standard Deviation = 2

36

Lecture

5. Attention

37

Lecture

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?

38

Lecture

The points are as below, when you wrap up your Achievement Report

- Quantitative description of your Issue
- Quantitative Verification of Adequacy of your proposed countermeasure
- Cost-effect comparison among several Countermeasures

39

Basic of Economic Analysis

JICA Technical Cooperation Project
Improvement of Efficiency for Rural Power Supply Phase II

Basic of Economic Analysis

July 2014
Tokyo Electric Power Co.

1

Lecture

Table of Contents

2

Lecture

Review of PI Solving Activity

A. Selection of Study Theme
To select the issue with the highest priority to meet the given management target

B. Establishment of improvement measures
To conduct activities from current situation analysis to establishment of improvement measures

C. Proposal to management class
To make a presentation to the management class based on documents, explaining the improvement measure and its adequacy

D. Indication from the management class
The management class will make comments to the proposal

E. Approval of management class & Implementation of improvement measure

3

Lecture

Review of PI Solving Activity

B. Establishment of Improvement Measures

1. Evaluation, Quantification of Current Badness
2. Cause Analysis
3. Establishment of Countermeasure Plans
4. Evaluation of Cost-Benefit Performance
5. Determination of Implementing Countermeasure

Lecture

Review of PI Solving Activity

4. Evaluation of Cost-Benefit Performance
(or Cost-effectiveness, Investment efficiency)

Economic analysis is an important tool for decision-making

5

Lecture

Introduction of Evaluating Methods

- When evaluating the economic efficiency among several countermeasure plans (or projects), the most commonly used methods (indicators) are: ROI, Payback Period, NPV and IRR.
- Both NPV and IRR are better techniques than ROI and Payback, because NPV and IRR favor long-term, and hence more risky projects that power utilities like BPC should be doing.

6

Lecture

Introduction of Evaluating Methods

Comparison of major methods

	Time value of money	Life-cycle cash flows	Risk considerations	Easy to understand
Return on Investment (ROI)	No	No	No	**Yes**
Simple Payback Period (SPP)	No	No	No	**Yes**
Net Present Value (NPV)	**Yes**	**Yes**	**Yes**	No
Internal Rate of Return (IRR)	**Yes**	**Yes**	**Yes**	No

7

Lecture

1. Return on Investment (ROI)

- Return on Investment (ROI) is the ratio of money gained on an investment relative to the amount of money invested.
- ROI refers to the rate of the profit against the amount of investment. It is thus usually given as a percent value.
- ROI = Return from investment / Cost of investment

8

Lecture

1. Return on Investment (ROI)

- For instance, a $1,000 investment that earns $50 per year generates more return than a $100 investment that earns $20. However, the $100 investment earns a higher ROI.

$50 / $1,000 = 5% ROI
$20 / $100 = 20% ROI

9

Lecture

1. Feature of ROI

Criteria	◆How profitable an investment is . ◆Higher ROI is preferable to lower ROI.
Advantages	◆Easy to understand ◆Simple calculation
Disadvantages	◆Time value of money (interest rate and risks) is not considered. ◆Does not indicate how long an investment is held. Indicates an annualized rate of return.

10

Lecture

Topic: Cash Flow (CF)

- Cash flow is a measure of cash inflow and outflow which generate from a income-generating project.
- Net cash flow refers to the excess of cash inflows over cash outflows (the amount of remaining money) in a given operation or a certain period of time.
- It is a measure of economic efficiency but does not coincide with the accounting term "profit".
- The table below is an example of cash flow statement:

Year	0	1	2	3	4	5	6
Investments	-$200mil.						
O&M Cost		-$20mil.	-$20mil.	-$20mil.	-$20mil.	-$20mil.	-$20mil.
Expected Revenue		$80mil.	$80mil.	$80mil.	$80mil.	$80mil.	$80mil.
Net cash flow at each year	-$200mil.	$60mil.	$60mil.	$60mil.	$60mil.	$60mil.	$60mil.

11

Question

Exercise (ROI)

Net cash flow on $1,000 investment

Year	0	1	2	3	4	5
Net Cash flow	-$1,000	$100	$90	$80	$50	$40

Calculate the ROI of each year:

Year	0	1	2	3	4	5
ROI	-	10%	9%	8%	5%	4%

12

Lecture

2. Simple Payback Period (SPP)

- Payback period (PP) refers to the period of time required for the return on an investment to "repay" the sum of the original investment.
- For example, a $1,000 investment which returned $500 per year would have a two year payback period.

13

Lecture

2. Feature of SPP

Criteria	How long it takes to pay for itself. Shorter payback period is preferable to longer payback period.
Advantages	Easy to understand. Simple calculation.
Disadvantages	Time value of money (interest rate and risks) is not considered. Ignores the cash flow after payback period.

14

Question

Exercise (SPP)

How long is the payback period?

Year	0	1	2	3
Net cash flow	- $3,000	+$1,500	+$1,000	+$1,000

3,000 = 1,500 + 1,000 + 500

➔ 2.5 years

15

Lecture

Time Value of Money

- Congratulations! You have won a cash prize. You have two options:

  Option A. Receive $10,000 now

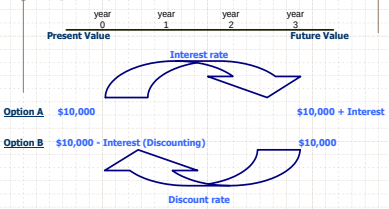
  Option B. Receive $10,000 three years later.
- You would choose to receive the $10,000 now. It is better to have it now rather than later. But why?
- Actually, although the amount is the same, you can do much more with the money if you have it now: over time you can earn more interest on your money.

16

Lecture

Time Value of Money

Image of Option A and B



17

Lecture

Time Value of Money (FV)

- For example,
  - Present value: $10,000
  - Interest rate: 10% per year
  - Future value (FV) becomes $11,000 (1 year later)

Present $10,000 = Future $11,000 (1 year later)

18

Question

Exercise (FV)

If you choose option A and invest the total amount at a annual rate of 10%, calculate the future value.

After 1 year : $10,000 x (1+10%) = $11,000

After 2 years: $11,000 x (1+10%) = $12,100

After 3 years: $12,100 x (1+10%) = $13,310

$10,000 x $(1+10\%)^3$ ➔ $13,310

Future Value = Cash x (1+Interest rate) No. years

$FV = Cash \cdot (1+r)^n$

19

Question

Exercise (FV for each Interest Rate)

Future value of $1 'n' year(s) later = 1 x $(1+r)^n$

	Interest rate (%)		
n	5%	7%	10%
1	1.050	1.070	1.100
2	1.103	1.145	1.210
3	1.158	1.225	1.331
4	1.216	1.311	1.464
5	1.276	1.403	1.611
6	1.340	1.501	1.772
7	1.407	1.606	1.949

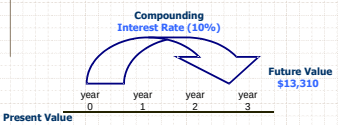
Assuming interest rate of 10%, what's the future value of $100 at year 7 (seven) ? ➔ $194.9

20

Lecture

Time Value of Money (FV)

Image of Option A



21

Lecture

Time Value of Money (PV)

- Present value (PV) is the current worth of a future money, discounted to reflect the time value of money by using a specified rate of return.
- Future money is discounted at the discount rate. The higher the discount rate, the lower the present value of the future money.
- Receiving $10,000 now (A) is worth more than $10,000 three years from now (B), because if you had the money now, you could invest it and receive an additional return over the three years.

22

Lecture

Time Value of Money (PV)

- For example,
  - Future value (1 year later): $11,000
  - Discount rate: 10% per year
  - Present value becomes $10,000

Future $11,000 (1 year later) = Present $10,000

23

Question

Exercise (PV)

If you choose option B with a discount rate of 10%, calculate the Present Value.

After 1 year : $10,000 / (1+10%) = $9,091

After 2 years: $10,000 / $(1+10\%)^2$ = $8,264

After 3 years: $10,000 / $(1+10\%)^3$ ➔ $7,513

Present Value = Cash / (1+Discount rate) No. years

$PV = Cash / (1+i)^n$

24

Question

Exercise (Discount Rate)

Present value of $1 'n' year(s) later = 1 / $(1+r)^n$

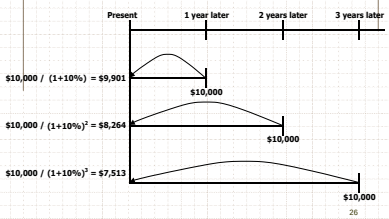
	Discount rate (%)		
n	5%	7%	10%
1	0.952	0.935	0.909
2	0.907	0.873	0.826
3	0.864	0.816	0.751
4	0.823	0.763	0.683
5	0.784	0.713	0.621
6	0.746	0.666	0.564
7	0.711	0.623	0.513

Assuming discount rate of 10%, what's the present value of $100 at year 7 (seven) ? ➔ $51.3

25

Lecture

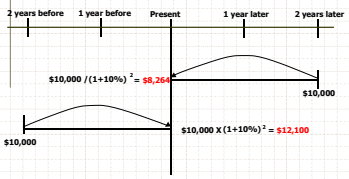
Time Value of Money (PV)



26

Lecture

Time Value of Money (PV)

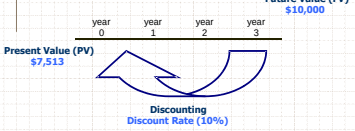


27

Lecture

Time Value of Money (PV)

Image of Option B



28

Lecture

Life-Cycle Cash Flow (LCC)

- Life-cycle cash flow (LCC) is an analysis of the total cash flow of an investment plan or project over its service life, allowing a comprehensive assessment of anticipated cash flow associated with the plan or project.
- Factors commonly considered in LCC analysis are initial investment, sales incomes, O&M costs, financing costs and expected life of project.

29

Question

Exercise (LCC)

- For example,
  - Construction : $300M
  - Electricity Sales : $80M
  - O&M : $20M
  - Life-cycle : 7 years

Calculate net cash flow of each year on the table below:

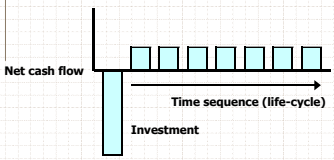
Year	0	1	2	3	4	5	6	7
Investment	300	0	0	0	0	0	0	0
Sales	0	80	80	80	80	80	80	80
O&M	0	20	20	20	20	20	20	20
Net cash flow	-300	60	60	60	60	60	60	60

30

Lecture

Life-Cycle Cash Flow (LCC)

Cash flow diagram of the said example



31

Lecture

Risk Consideration

- Risk is inseparable from return. Every investment involves some degree of risk.

	Present	Year 1	Year 2	Year 3	
Plan 1	-$1,000mil.	$105mil.	$95mil.	$100mil.	Not Risky
Plan 2	-$1,000mil.	$50mil.	$180mil.	$70mil.	Risky
Plan 3	-$1,000mil.	$0mil.	$250mil.	$50mil.	Too Risky

Net cash flow

- Risk is the possibility of a return being more different than expected.

32

Lecture

Topic: Discount Cash Flow (DCF) Analysis

- For power utilities, the investment efficiency evaluation (IEE) requires a long-term viewpoint, taking into account the life-cycle cash flow of projects or investments, which is inevitably accompanied by the time value of money and some degree of risks.
- Discounted cash flow (DCF) analysis is the one that takes into consideration all of the above three concerns. The DCF analysis consists of two methods: NPV and IRR.
- The process of investment decision-making by using DCF analysis is as follows:

1. All future cash flow (Life-cycle cash flow) → 2. Convert to PV with discount rate (Time value & Risks) → 3. Calculation (NPV or IRR)

- DCF analysis is widely used for power utilities to evaluate the economic efficiency of long-term investment.

33

Lecture

Topic: How to Set a Discount Rate?

- Theoretical definition of discount rate are:
  - Expected rate of return for investments
  - Time value of money + Risk-considered return
  - Cost of capital (financing cost for investments)
- In practice, we can appropriately set a discount rate by referring to:
  1) Interest rate charged by a Central Bank on a loan to a member bank (What is Bhutan's rate?).
  2) Interest rate of short-term Government bond distributing in the country.

34

Lecture

3. Net Present Value (NPV)

- Net Present Value (NPV) is the standard method for profitability analysis of long-term projects or investments.
- NPV refers to the present value of expected future cash flows (inflows), minus cash outflows (initial investment).
- Time value of money is taken into consideration by setting a certain discount rate.

35

Lecture

3. Feature of NPV

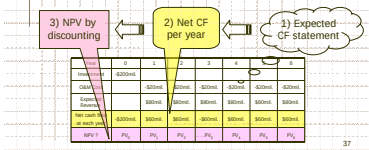
Criteria	NPV > 0 : Acceptable NPV < 0 : Not acceptable The larger the NPV, the better the project.
Advantages	Can be applied to compare two or more mutually exclusive projects. Takes into consideration the scale of investments.
Disadvantages	Setting a discount rate is difficult.

36

Lecture

3. Steps in Calculating NPV

1) Calculation of expected cash inflows and out flows
2) Calculate the net cash flow per year
3) Convert each cash flow by using discount rate, then summate each of obtained present value



37

Lecture

3. Formula of NPV

Net CF	CF_0	CF_1	CF_2	CF_3	••••	CF_n

$$NPV = CF_0 + \frac{CF_1}{(1+i)^1} + \frac{CF_2}{(1+i)^2} + \frac{CF_3}{(1+i)^3} + \bullet\bullet\bullet\bullet + \frac{CF_n}{(1+i)^n}$$

NPV	PV_0	PV_1	PV_2	PV_3	••••	PV_n

Where
i : Discount rate
CF_n: Net cash flow at year "n"
Net CF_n= $(\text{Cash inflow})_n$ - $(\text{Cash outflow})_n$

38

Question

3. Exercise (NPV)

Cash flow statement of an investment project, with a life-cycle of 3 years.

Year	0 (CF_0)	1(CF_1)	2(CF_2)	3(CF_3)
Net cash flow	-$5,000	+$2,000	+$2,000	+2,000

If the discount rate is 5%, calculate the NPV.

$$NPV = -\$5{,}000 + \frac{\$2{,}000}{(1+5\%)} + \frac{\$2{,}000}{(1+5\%)^2} + \frac{\$2{,}000}{(1+5\%)^3}$$

➔ $446 (NPV is positive : the project is acceptable)

39

Question

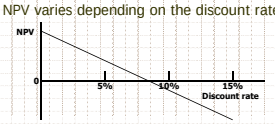
3. Exercise (NPV) Cont.

If the discount rate is 10%, the NPV will be…

$$NPV = -\$5{,}000 + \frac{\$2{,}000}{(1+10\%)} + \frac{\$2{,}000}{(1+10\%)^2} + \frac{\$2{,}000}{(1+10\%)^3}$$

➔ -$26 (NPV is negative : the project is not acceptable)

NPV varies depending on the discount rate.

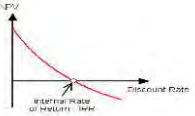


40

Lecture

4. Internal Rate of Return (IRR)

- Internal rate of return (IRR) refers to the discount rate at which the NPV is zero.



- A hurdle rate, the minimum required IRR that must be met to undertake a particular project, is set as the benchmark rate.
- If IRR is higher than a hurdle rate, a sort of go/no-go threshold (often same as capital cost or market interest rate), the investment may be accepted.

41

Lecture

4. Feature of IRR

Criteria	IRR > Hurdle rate : Acceptable IRR < Hurdle rate : Not acceptable The higher the IRR, the more profitable the project.
Advantages	Profitability can be easily ranked in terms of rate of return.
Disadvantages	Scale of investment/project is not considered.

42

Question

4. Exercise (IRR)

Year	Expected Cash flow	Present Value		
		i = 6%	i = 8%	i = 10%
0	- $1,000	- $1,000	- $1,000	- $1,000
1	$300	$283	$278	$273
2	$200	$180	$171	$165
3	$200	$168	$159	$150
4	$350	$277	$257	$239
5	$200	$149	$136	$124
NPV	+ $250	+ $57	+ $1	- $49

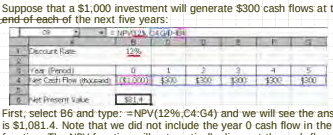
What is the IRR? ➔ IRR= 8%

43

Lecture

Topic: Microsoft Excel Functions – NPV

- Suppose that a $1,000 investment will generate $300 cash flows at the end of each of the next five years:



- First, select B6 and type: =NPV(12%,C4:G4) and we will see the answer is $1,081.4. Note that we did not include the year 0 cash flow in the function. The NPV function will automatically discount the cash flow of year 0, even if it shouldn't.
- Second, remember that the NPV, according to the actual definition, is calculated as the present value of the expected future cash flows, minus the cost of the investment.
- Then, we need to subtract the $1,000 of the investment. Therefore, the formula to calculate the net present value is: =NPV(B1,C4:G4)-B4 and the answer is $81.4.

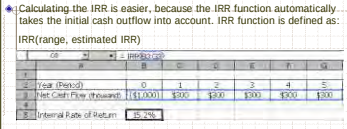
44

Lecture

Topic: Microsoft Excel Functions – IRR

- Calculating the IRR is easier, because the IRR function automatically takes the initial cash outflow into account. IRR function is defined as:

IRR(range, estimated IRR)



- Note that the "range" is a series of net cash flows, including the initial investment. The "estimated IRR" is optional and generally isn't needed. Thus the function in B6 is: =IRR(B3:B3).
- As seen above, the answer is 15.2%. This means that if we implement the investment for $1,000 now, the compound average annual rate of return will be 15.2% per year.

45

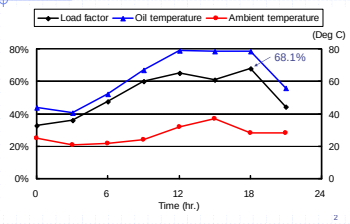
Data Management

Data Management

July 2014

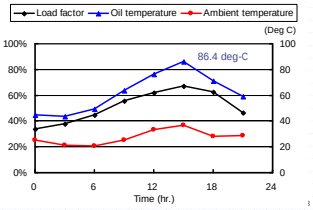
1

Maximum Load Factor: 68.1% (18th-June 18:00)



2

Maximum Oil Temp.: 86.4 deg-C (17th-June 15:00)



3

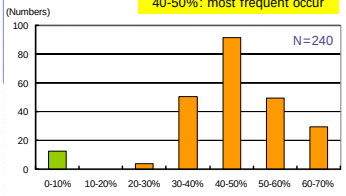
Information

- Maximum load factor: 68.1%
  - 18th-June 18:00
- Maximum oil temperature: 86.4 deg-C
  - Less than limit (90 deg-C)
  - 17th-June 15:00
- Peak hours: 12:00 - 18:00
- Off-Peak hours: 00:00 - 06:00

4

Histogram of Load Factor

40-50%: most frequent occur



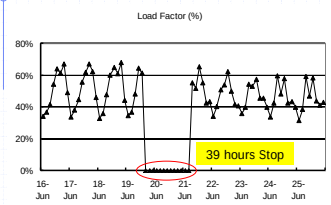
5

Information

- Average load factor: 44.9%
- Mode: 40% - 50%
- Minimum load factor: 26.6% (except stop)
  - 30th-June 00:00

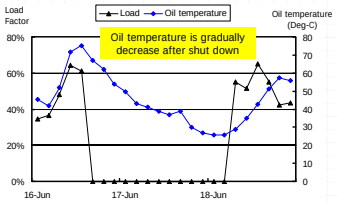
6

Outage



7

Load Factor and Oil Temperature



8

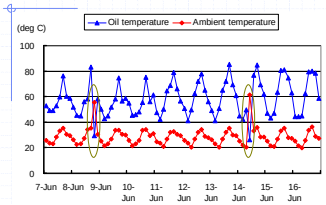
Recommendation & Information

- We should investigate the reason why this transformer stopped in detail.
- We should investigate the influence at customer in detail.
- Availability: 94.6%
  - 30days x 24hrs = 720hrs

$$\frac{720 - 39}{720} = 94.6\%$$

9

Doubtful Data



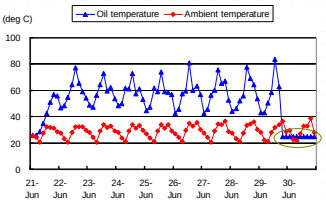
10

Recommendation

- We should check data logging procedure.
  - How to write data log sheet every day/hour by operators
  - How to check data by supervisor
  - How to make monthly report

11

Not Working Meter



12

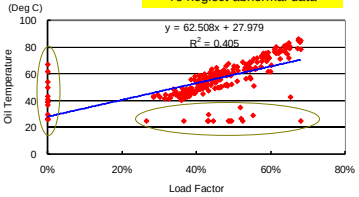
Recommendation

- We should check Oil temperature metering system immediately.
  - Meter
  - Connecting cable
  - Sensor
  - Mechanical system (at data conversion)

13

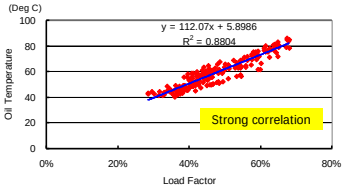
Relation between Load Factor and Oil Temperature

To neglect abnormal data



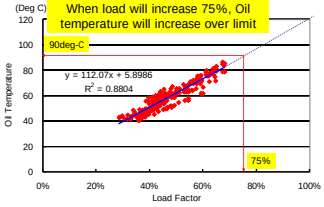
14

Relation between Load Factor and Oil Temperature



15

Relation between Load Factor and Oil Temperature



16

Recommendation

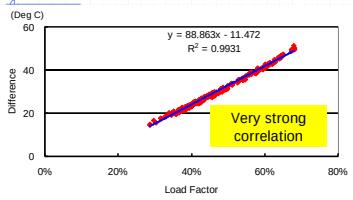
- We cannot supply electricity when load factor increase more than 75%.
- We should start to study for increasing supply capacity immediately.
  - To install cooling system (fan)
  - To install more transformer
  - To replace transformer to bigger one

17

Other Information

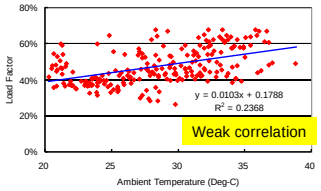
18

Relation between Load Factor and Temperature Difference



19

Relation between Ambient Temperature and Load Factor



Thank you for your kind attention

21

Exercise: How to use Excel effectively?

How to Use Excel Efficiently

(on the presentation)
(Review for more impressive Presentation)

15 July, 2014
JICA
TOKYO ELECTRIC POWER COMPANY

TOKYO ELECTRIC POWER COMPANY

Contents

1. Purpose for this Presentation.
2. Reviews of the previous presentation.
3. Explain for some Excel Function
5.Summary

1. Purpose for this Presentation.

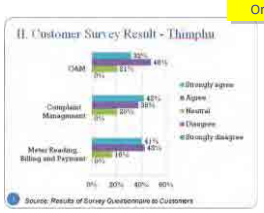
- Looking back presentation of the PI report meeting of September last year, and we think about more effective way for some figures (graph) on presentation today.
- Introduce some Excel function.

2. Reviews of the previous presentation
2.1 Case study 1

Case study 1
Theme 6b (at PI Final presentation)

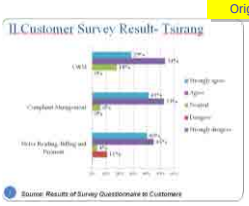
2. 1 Case study 1

Original



2. 1 Case study 1

Original



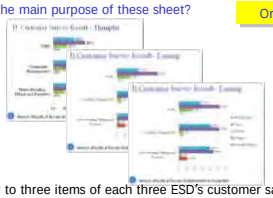
2. 1 Case study 1

Original

2. 1 Case study 1

What is the main purpose of these sheet?

Original

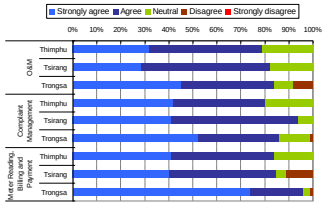


Compeer to three items of each three ESD's customer satisfaction about "O&M", "Complements Management" and "Meter reading, billing situation"

2. 1 Case study 1

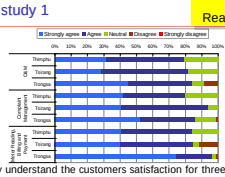
After Rearrangement

Countermeasures what we think...



2. 1 Case study 1

After Rearrangement



We can easily understand the customers satisfaction for three items, and easily to compare three ESD's situation
- ✓Almost all customer of these three ESD are satisfying tier service.
- ✓Tongsa ESD: Three item are hi compaired with other ESD.
- ✓These three items seems to related to each other.
- ✓Trongsa ESD seems has some trouble at O&M, Tsirang ESD seems has ploblam at meter Reading, Billing and paiment. Etc.

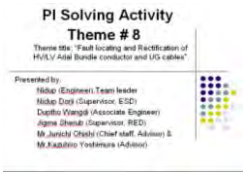
2. 1 Case study 2

Original

Good practice

2. 1 Case study 3 & 4

Case study 3 & 4
Theme 6b (PI Final presentation)



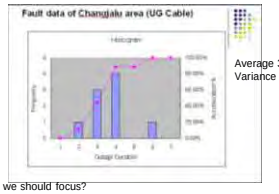
2. 1 Case study 3

Original

We can easily understand detail of the UG Cable fault.
But Presentation time is very short, so audience can't understand "causes of Outage".

2. 1 Case study 3

After Rearrangement



Average 3.450
Variance 1.3583

What point we should focus?
We think outage duration of the UG Cable is most important point.
In this case, Histogram of Outage Duration is more impressive for audiance.

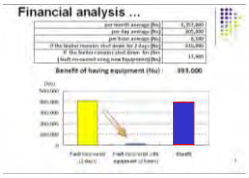
2. 1 Case study 4

Original

The size of the pie chart is related to the amount of money.
More effective to explain the amonut of money when using a bar graph.

2. 1 Case study 4

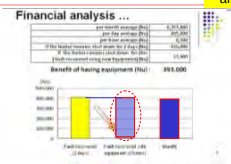
After arrangement



More effective to explain the amonut of money when using a bar graph.

2. 1 Case study 4

After arrangement



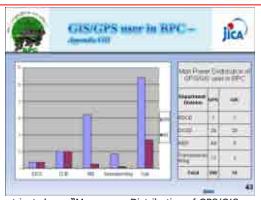
We can easily understand the benefit what introduce new equipments and use it.
✓If will use new fault detecting equipment, There is a possibility to ensure the interests of 393 thousand Nu as abenefit. Etc.

2. 1 Case study 5

Case study 5
Theme 9 (at PI Final presentation)

2. 1 Case study 5

Original



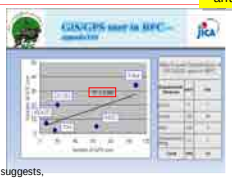
This bar chart just shows "Man power Distribution of GPS/GIS user in BPC".
But if we use scatter chart (rearrangement) ...

2. 1 Case study 4

After arrangement

2. 1 Case study 4

After arrangement



Scatter chart suggests,
✓Whether are there existing correlation between two values?
✓Validity of the asymptotic curve .
In this case
✓There are no relation GPS user and GIS user in BPC each division.

3. Explain for some Excel Function
3.1 Economic analysis(IRR, NPV)
3.1.1 NPV: Net Present Value

Case study : Purchase of UG Faulty point detector

Table 3.1 Assumptions sheet

UG Faulty point detector	5,000,000	Nu
Incidence of UG Fault (Assumption)	0.25	per month
Benefit having/using new equipment	400,000	Nu
Benefit having/using new equipment per Year	1,200,000	Nu
Interest Rate	10.0%	percentage

How much is Present value at the time of the consideration of the 7 years after of this investment?

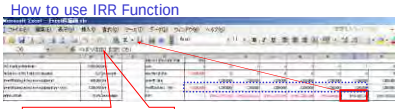
BTN 206,000 (Appx.)

Table 3.2 NPV Calculation sheet

Interest (Discount) Rate	10%									
year	1	2	3	4	5	6	7	8	9	10
Investment (Nu)	5,000,000	0	0	0	0	0	0	0	0	0
Benefit (Nu)		1,200,000	1,200,000	1,200,000	1,200,000	1,200,000	1,200,000	1,200,000	1,200,000	1,200,000
Profit and loss (Nu)	5,000,000	1,200,000	1,200,000	1,200,000	1,200,000	1,200,000	1,200,000	1,200,000	1,200,000	1,200,000
NPV		BTN -3,553,719	BTN 2,852,161	BTN 1,832,525	BTN 1,087,420	BTN 410,051	BTN 205,739	BTN 765,548	BTN 1,274,465	BTN 1,737,117

3.1.1 NPV: Net Present Value

How to use IRR Function



=NPV($I$1,$I$5:N5)

1st step : make a NPV Function sheets
take a quote of equipment, Calculation of benefit about every year
2nd step : calculate NPV used by the function of Excel
3rd step : Management judgment/Proposal to the higher authority

3.1.2 IRR: Internal Rate of Return

Case study : Purchase of UG Faulty point detector

Table 3.1 Assumptions sheet

UG Faulty point detector	5,000,000	Nu
Incidence of UG Fault (Assumption)	0.25	per month
Benefit having/using new equipment	400,000	Nu
Benefit having/using new equipment per Year	1,200,000	Nu

How much is the Benefit will return at the 6 years later?

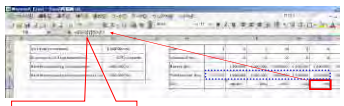
6%

Table 3.2 IRR Calculation sheet

year	1	2	3	4	5	6	7	8	9	10
Investment (Nu)	-5,000,000	0	0	0	0	0	0	0	0	0
Benefit (Nu)		1,200,000	1,200,000	1,200,000	1,200,000	1,200,000	1,200,000	1,200,000	1,200,000	1,200,000
Profit and loss (Nu)	-5,000,000	1,200,000	1,200,000	1,200,000	1,200,000	1,200,000	1,200,000	1,200,000	1,200,000	1,200,000
IRR		#NUM!	-38%	-15%	-2%	6%	12%	15%	17%	19%

3.3.2 IRR: Internal Rate of Return

How to use IRR Function



=IRR($I$5:N5)

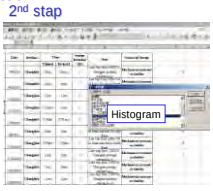
1st step : make a IRR Function sheets
take a quote of equipment, Calculation of benefit
2nd step : calculate IRR used by the function of Excel
3rd step : Management judgment/Proposal to the higher authority

3.2 Statistic analysis
3.2.1 How to make histgram

Calucutated by Excel function

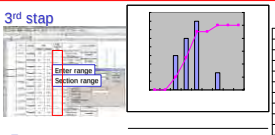
1st stap

2nd stap

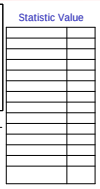


3.2.1 How to make histgram

3rd stap



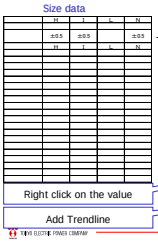
Statistic Value

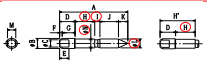


Easy to get
histogram and datas.

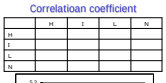
3.2.2 Correlation coefficient

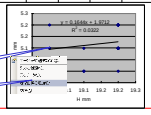
Size data





Correlation coefficient



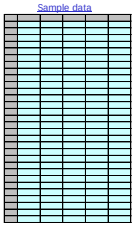


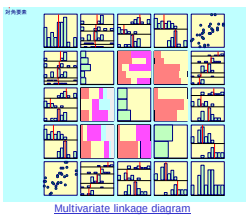
Right click on the value

Add Trendline

Appendix.
Example of the statistical software calculation output

Sample data





Multivariate linkage diagram
We can get relation of the data easily!!

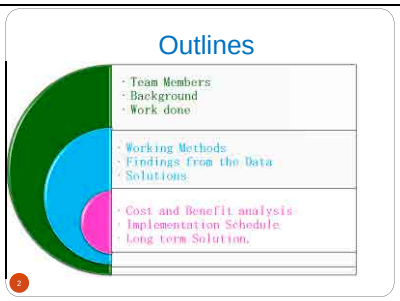
4. Summary

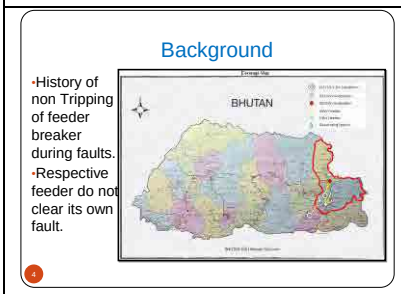
When you use the Excel chart in a presentation, consider what you want to express.
If effective use of the various functions of Excel, and lead to simplification of your work.
If you want to make a more complex statistical analysis, we recommend the use of statistical software.
We are expecting further development of BPC, and we will support from Japan.

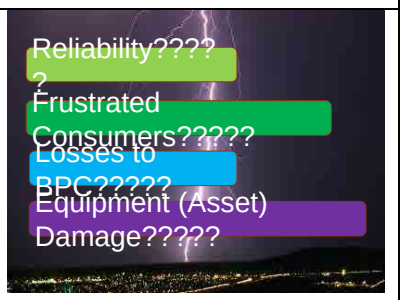
Appendix 11
PI Activities Final Presentation

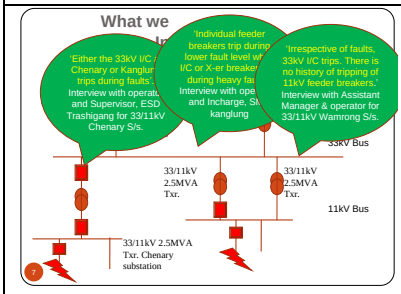
Presentation Materials

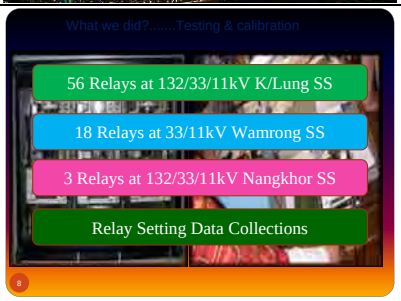
Theme 1

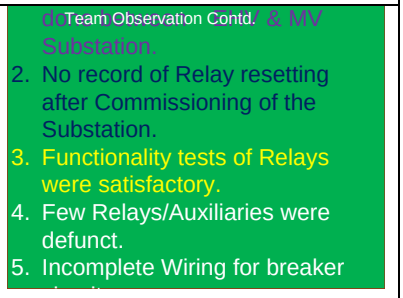


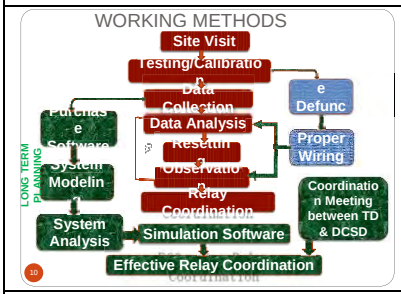


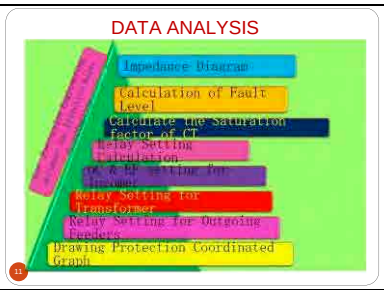


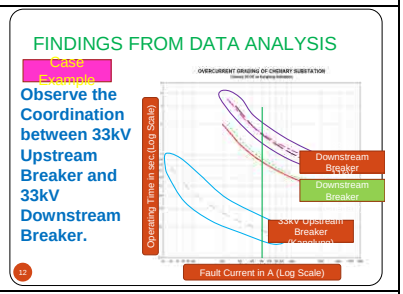


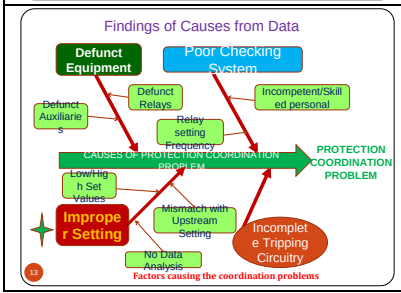


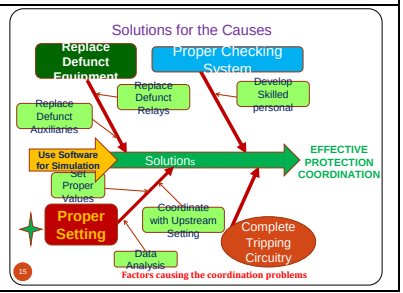








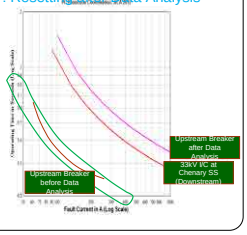




Main Solution : Resetting and Relay Coordination Analysis

Case Example

After data analysis, resetting was done and shifted the curve of Chenary (Upstream) Feeder at Kanglung (Downstream) as per the



16

Cost Analysis for Relay Setting and Coordination

Particulars	Cost	Total
Resetting of the relays for proper coordination	3 Engineers x 700 x 10days = Nu. 21,000 Vehicle expense = Nu.10,000 1 Driver x 500 x 10 days = Nu. 5,000 Miscellaneous materials = Nu.20,000	Nu.56,000
Replacement of defunct E/F relays and O/C relays CDG 31 and auxiliaries	7 x 16,440 = Nu. 115,080. Lump sum Nu.50,000	Nu.165,080
Complete check of wiring, mechanical problems	3 Engineers x 700 x 7days = Nu. 14,700 Vehicle expense = Nu.10,000 1 Driver x 500 x 7days = Nu. 3,500 Miscellaneous materials = Nu.20,000	Nu.48,200

CAPE Software for Protection Engineering

The power that protection engineers need

CAPE (Computer-Aided Protection Engineering) software is built for engineers responsible for protection of high voltage transmission systems and distribution systems within electric power utilities

- Detailed modeling capabilities based on a single open source database
- Support for analysis and simulation to solve data management issues, uncover potential network and protective device problems, and evaluate alternatives
- Support for networks of any size
- Support for setting complex modern digital relays
- Support for relay coordination functions and wide-area studies

We believe CAPE is simply the best of its kind anywhere in the world today, whether you define "best" based on productivity improvement, ease of use, flexibility, comprehensiveness, technical detail, or price.

Numerical Cost Analysis(Sample, Wamrong Substation)

Income for April : Nu.248052.0

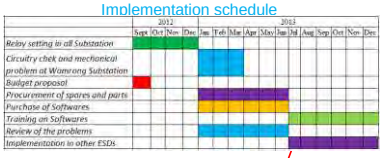
Assuming outage of 5hrs due to poor Relay Coordination;

If all feeders trips, loss =(248052x5)/(30x24)=Nu.1723.0

If Thungkar feeder trips, loss=(12061x5)/(30x24)=Nu.83.75

Here, in this case we save by almost 20 times the revenue.

Implementation schedule



In all other ESDs works will be done by engineers trained on Protection.

20

Long Term Solutions. ….Sustainability

1. The protection coordination team suggests a dedicated protection and control unit to start with a dedicated engineer under O&M Manager at DCSD Head office. He/she must guide and facilitate other trained engineers in the regions (preferably in RM offices). In future it can become a division under a /department or wing.
2. Succession Training has to be done.

21

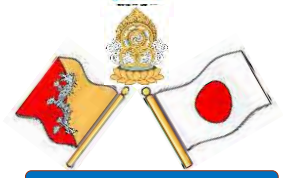
ACKNOWLEDGEMENT

PI Protection Coordination Team would like to acknowledge the following ;

- All the JICA experts who contributed in the progress of the teams work, through feedback, etc.
- Sr. Consultant, DNCD, BPC for providing guidance and for sparing your valuable time with teams queries.
- Ton La, P.E, LA Engineering. "Relay Coordination Study", 2005.
- Varadarajan,M. "Protection of Non Grid feeders". TNEB, 2001.
- Authors of "Transformer and Transformer-Feeder protection". NPAG, 2007.
- To all those who helped us directly or directly in this Endeavour.

22

'Tashi JICA You'



ARIGATO GOZAIMASU

23

Theme 2

OUTLINE

1. Members/Theme
2. Background for selecting this theme
3. Selection of feeder and reasons
4. Current badness in this feeder
5. Causes of badness
6. Counter Measures (ARCB,LBS&Fault Indicators)
7. Implementation plan

1

Theme & Members

Standard/Guideline on Installation of Fault Locating and Switching Devices/Equipments in MV Distribution System

Sonam Gyeltsen- Advisor | Chejay Wangdi- Coordinator | Ngawang Norbu-Team Leader | Dorji Tshewang- member | Ugyen Tshering- Coordinator

2

Background/Reasons for selecting this theme

- **Operational Problem:**
  - -Difficulties in locating and isolating fault
  - -Excessive "trip/close" operation of SS breaker
  - -Taking too long to restore the supply (lowers SAIFI/SAIDI)
  - -Low customer satisfaction
- **Lack of proper standard for installing different distribution equipments**
  - -No uniformity in installing switching and protection devices
  - -Difficulties in preparing BoQ

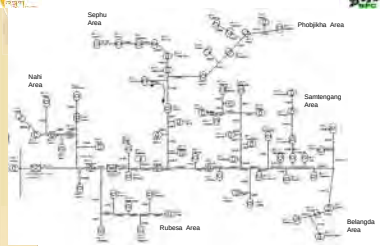
3

Identified area:
ESD, Wangdue

Identified system:
33 kV feeder No-II

4

Single Line Diagram



5

Reason for selecting 33 kV feeder

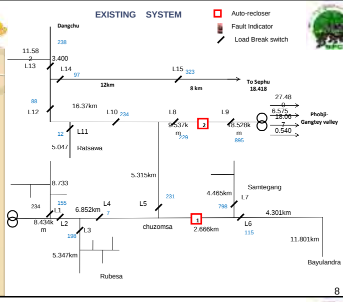
Sl. #	Name of Feeder	Line Length	Line Length in %	No. of Customer	No of Customer in %
1	33 kV Fdr-II 177 kM Sha	177.00	67.00	3620	48.93
2	11 kV Fdr- IV 35.261 kM Gaselo	35.261	14.00	1242.00	16.79
3	11 kV Fdr-IV 17.316 kM Ruricha	17.316	7.00	105.00	1.41
4	11 kV Fdr-III 16.407 kM Jalla Ulla	16.407	7.00	475.00	6.42
5	11 kV Fdr-V 12.953 kM Omtekha	12.953	5.00	1889.00	25.53
6	11 kV Fdr-I 7.329 kM Hebesa	7.329	3.00	66.00	0.892
	Total	266.26		7397.00	

- Longest line length (scattered lines)
- Highest customer base
- The most affected feeder (Interruption)
- Most difficult geographical terrain
- Most of the 33 kV feeders in other ESDs are similar to this feeder in terms of terrain, vegetation, line length, switching/protection equipments etc.

6

Current Badness

1. When ever there is fault, breaker at the source will trip and all the consumers fed from this feeder are affected
2. Fault location is not known
3. Restoration has to do on prediction basis by operating LBS time and again and frequency of interruption is high
4. More Duration of interruption

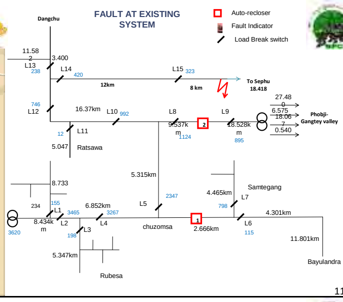


Time taken to travel from office to LBS switches

LBS	ESD office to LBS Time (Min)	Place	Type of road
L1	20.00	Wangdue	feeder road
L2	7.00	Bridge	Highway
L3	25.00	Rubesa	Highway
L4	20.00	Raguna	feeder road
L5	30.00	chuzomsa	feeder road
L6	50.00	chungseykha	feeder road
L7	40.00	Samtengang	feeder road
L8	60.00	Wachey	Highway feeder road
L9	150.00	Khotokha	feeder road
L10	90.00	Khelekha	Highway
L11	120.00	Rachawa	Highway/ no road
L12	150.00	Dungdungesa	Highway
L13 &l14	180.00	Dangchhu	Highway
L15	210.00	Rukhubji	Highway/ feeder road

LBS to LBS travel time

LBS to LBS		Mode of travel	Type of road
G.O	Time(min)		
L1-L2	7	by vehicle	Feeder road
L2-L3	28	by vehicle	Highway/Foot path
L3- L4	42	by vehicle	Feeder road/highway/fppt path
L4-L5	7	by vehicle	Feeder road
L5-L6	25	by vehicle	Feeder road/Foot path
L6-L7	10	by vehicle	Feeder road
L7-L8	40	by vehicle	Highway/feeder road/Foot path
L8-L9	80	by vehicle	feeder road (cannot go during raining) by walk 6 hours
L8-L10	45	by vehicle 30 mins and walk 15 mins	Highway/ footpath
L10-L11	60	by vehicle 30 mins and walk 30 mins.	Highway/ feeder road/ foot path
L11 - L12	60	by vehicle	Highway/ feeder road



Fault locating Exercise/Time (Existing)

Date	Time	Duration (min)	LBS	CB	Cust Affected	Fault Loaction	Remark
04-08-12	2:10		All LBS closed	Open	3620	Not Known	Test charged within 1min
04-08-12	7:00	4:50	Started from office				
04-08-12	7:30	0:30	L5 open	closed	3620	Not Known	Charged upto L5
04-08-12	8:00	0:30	L8 open &L5 Closed	tripped	2347		
04-08-12	8:10	0:10	L5 open & L8 closed	closed	3620		
04-08-12	9:10	1:00	L10 open L5 closed	closed	2347		Fault is downsteam of L10
04-08-12	10:10	1:00	L11 open L10 closed	tripped	992		
04-08-12	10:20	0:10	L11 closed & L10 open	closed	3620		
04-08-12	11:20	1:00	L12 open & L10 closed	closed	992		Fault is downsteam of L12
04-08-12	11:35	0:15	L14 open& L12 closed	closed	746		Fault is downsteam of L14
04-08-12	12:20	0:45	L15open & L14 closed	closed	420		Fault is downsteam of L15, thus it is kept open and started line patrolling
Located fault in Sephu area where two DP and two single structures were damaged by fallen trees. There was heavy rain on that day. It was restored after 3 days.							
06-08-12	7:10	54:50:00	L15 closed	closed			

Reliability Indices at present situation

- fault at Sephu area
- Breaker at the source tripped
- All the 3620customer will be affected

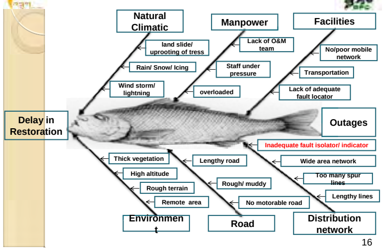
Sl. #	Reliability Indices	SAIFI	SAIDI	
1	Under ESD Control	6.17	7.33	
Total number of customer in the feeder				3620.00
Sum of customer interruption duration (Customer interrupted * Duration)				24595.33
Total number of customer interrupted				18324

Causes of current badness

As per practical experiences

- Inadequate testing equipments
- Inadequate fault isolator/ indicator in the system
- Longer the line distance, difficult to trace the fault
- Scattered system, most difficult to detect the faulty line.
- No access road leads to delay in line patrolling/ restoration and transportation of Crews, equipments & materials
- Bad weather condition
- Bad road condition
- Difficult environment and terrain

Fish bone Cause Analysis



Cause Analysis

A. Beyond our control
   i. Natural Climatic
   ii. Environment
   iii. Road
A. Within Our Control
   i. Manpower
   ii. Facilities
   iii. Distribution System

These will have limited improvement

Distribution System

i. Lengthy Lines
ii. Too Many spur lines
iii. Wide Area network

These are existing system and cannot be changed. Moreover, the counter measure for number iv will address all these problems

iv. Inadequate fault isolators/indicators
(solvable cause)

Counter Measures

A. By Installing Auto-reclosers
B. Installing Fault Indicator
C. ARCB and Fault Indicator

A. Auto-Recloser

Installed on 6th Sept 12

Protection Functions/Features

- Over current
- Earth fault
- Under and over voltage
- Under and over frequency
- Inrush Restraint
- Negative Phase Sequence (NPS)
- Cold load pick up
- Live Load Blocking
- Loop Automation

Metering Functions/Features

i. Voltage
ii. Current
iii. Frequency
iv. Kilowatt (kw)
v. Energy(kwhr)-Weekly, Monthly
vi. Apparent Power(KVA), Reactive power (KVAR)
vii. Power factor
viii. Outage recording

Generally Used for:

i. Clearing transient faults to reduce frequency of outage experienced by customers at source end of long feeders
ii. Used to prevent urban consumers being affected by faults in rural areas in situation where feeder serves both urban and rural customers
iii. Used to segregate lines which has high fault frequency-Eg. Dagachhu project line

Generally used for….

iv. Segregating faults between two areas or ESDs.
v. Generator control
vi. Loop Automation in tie lines
vii. Can be used for switching station or substation

33 kV Switching station at Duksum, Trashiyantse

-Two Incomer, four Outgoing

25

Channel Mounted 33 KV Breakers (33/11 kV SS)

26

33 KV breaker in 33/11 KV S/S with 33/11 KV transformer

27

33KV Pole Mounted Breaker protecting a 10 MVA 33/11 KV Transformer

28

Cost Comparison between conventional substation and substation with Auto-Reclosers

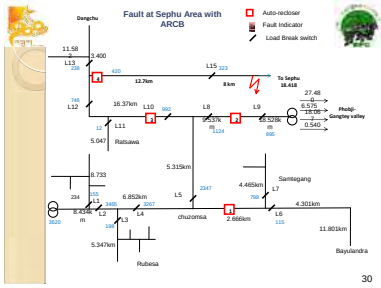
i. With Auto-Reclosers

SL#	Particular	No	Unit Price	Total
1	33 kV Auto-Reclosers	6	1,000,000	6,000,000
2	10 Meter Poles	16	10,000	16,000
3	Channels, fittings etc			50,000
				6,210,000
	Total			

ii. Conventional Substation

SL#	Particular	No	Unit Price	Total
1	33 kV switchgears with CT,PT,Relays, commissioning	6	1,797,867	10,787,202
2	Civil Works			7,015,480
3	Earthing, LV ac system, etc			361,278
	Total			18,163,960

29



30

Outage time with ARCB

Date	Time	Duration (mins)	LBS	CB	ARCB	Cust affected	Fault Loaction	Remark
For same date	0:00		All LBS closed	closed	ARCB-4 open	420	Not Known	Downstream of ARCB4. Test charge through online
	2:00	4:50	started from office					
	02:00	3:00	All LBS closed	closed	ARCB-4 open	420	Not Known	Check the type of fault and event log and test charges
	02:10	All closed	L15 Closed	closed	Closed but tripped	420		
	03:15	3:45	L15 open	closed	closed	420		Fault is downstream of L15

31

Reliability Indices with ARCB

- Fault at Sephu area
- ARCB-4 tripped
- 420 Customers

Reliability Indices without ARCB

Sl. #	Reliability Indices	SAIFI	SAIDI	
1	Under ESD Control	0.12	1.02	
Total number of customer in the feeder				3620.00
Sum of customer interruption duration (Customer interrupted * Duration)				3675
Total number of customer interrupted				420

32

Reliability Indices Comparison

Sl.#	Reliability Indices	SAIFI	SAIDI
1	Existing System	6.17	7.33
2	With ARCB	0.12	1.02
	Improvement with ARCB	**98.1%**	**86.1%**

33

Cost Implication for this feeder

SL#	Equipment	Nos	Unit Rate	Total(Nu)
1	Auto-reclosers	2	1,000,000	2,000,000
				2,000,000

34

Where to use Autoreclosers?

1. if the line length is more than 20 km from the T-off or Mid point (more customers, passes through similar terrain, possibility of more transient faults etc)
2. Use if it is for Loop Automation
3. Use if it is for substations
4. For others short lines where there is possibility of transient faults, tie lines between two ESDs, urban-rural segregating line etc. it can be used case by case.

35

B. Line Fault Indicator and LBS

FLA3 Fault Indicators
1. Ring of six LEDs indicates line fault
2. Orange flag also indicates line fault (se

36

Technical Index	Overhead earth & short-circuit fault indicator	Overhead earth & short-circuit fault indicator	Overhead short-circuit fault indicator	Overhead short-circuit fault indicator
Model	HESI-FG	HESI-FLG	HSFI-FS	HSFI-FLS
Applicable voltage	6-35 kV	6-35 kV	6-35 kV	6-35 kV
Applicable wire cross-section	16-400 sq mm	16-400 sq mm	16-400 sq mm	16-400 sq mm
Times of actuating	Over 5000	Over 5000	Over 5000	Over 5000
Maximum elevation	4000 m	4000 m	4000 m	4000 m
Indication mode	Red flag	Red flag + LED flash	Red flag	Red flag + LED flash

37

Advantages of using Fault Indicator

- It will indicate faulty section of the line
- Cheap
- Easy for Installation

Disadvantages

- It will not isolate the faulty area
- Crew has to do visual inspection

38

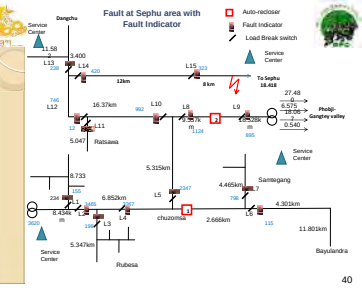
Advantages of using Load Break Switch

- Faulty section of the line can be further narrowed by isolating with LBS
- Cheap
- Easy for Installation

Disadvantages

- Have to operate manually

39



40

Travel time from Service centers to Fault Indicators

Service Center	Fault Indicator/LBS	Travel Time(Min)
Dangchhu Service Center	L13 and L14	15
Sephu Service Center	L15	30
Samtengang Service Center	L6 and L7	25
Wangdue Service Center	L5	30

41

Outage time with Fault Indicator

Date	Time	Duration (mins)	LBS	CB	ARCB	Cust affected	Fault Loaction	Remark
04-08-12	2:30		All LBS closed	Open	ARCBs Closed	8620	Not Known	Test charged within 1min
04-08-12	7:00	4:50	At 7 am, Service centers at Dangchu area, Sephu Area and Samtengang area to check the status of Fault indicator at their area. At the same time, ESD Wangdue will check the local area.It should be able to inform and locate the fault within the maximum time of 30 minutes.					
04-08-12	2:30	2:30	L15 open	closed		8620	Not Known	Charged upto L5

42

Reliability Indices Comparison

Sl.#	Reliability Indices	SAFI	SAIDI
1	without Fault Indicator (Existing)	5.06	6.79
2	with fault Indicator	1	5.33
	Improvement with fault Indicator	**80.23%**	**21.5%**

43

Cost Implication for this feeder

SL#	Equipment	Nos	Unit Rate	Total(Nu)
1	Fault Indicator	15	45,000	675,000
				675,000

44

Recommendation for LBS and Fault Indicator

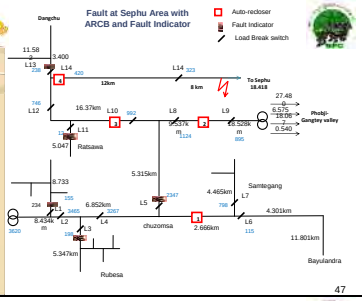
- Install LBS after every 10 kms (Existing standard)
- Install LBS & Fault Indicator on spur lines having more than 5 km
- No fault indicator after ARCB
- depend on the probability of faults
- As per customer base
- Fault Indicators must be installed in the visible areas

45

C. ARCB and Fault Indicator

- Install two ARCBs
- Install 5 fault indicators

46



47

Reliability Indices Comparison

Sl.#	Reliability Indices	SAIFI	SAIDI
1	Existing System	6.17	7.33
2	With ARCB & Fault Indicator	0.12	1.02
	Improvement with ARCB	**98.1%**	**86.1%**

48

Cost Implication for this feeder

SL#	Equipment	Nos	Unit Rate	Total(Nu)
1	Auto-reclosers	2	1,000,000	2,000,000
2	Fault Indicator	5	45,000	225,000
				2,225,000

*** Since Auto-Reclosers have been already purchased through RE, actual cost implication is less than Nu. 0.225 million

49

Comparison

Reliability Indices	Existing (Only LBS)	With ARCB	With Fault Indicator	With ARCB & Fault Indicator
SAIFI	5.06	0.12	1	0.12
SAIDI	6.79	1.02	5.55	1.02
Cost	0	2 M	0.675M	2.225 M

50

Proposal

A. By Installing Auto-reclosers
B. Installing Fault Indicator
C. ARCB and Fault Indicator(Selected)

51

Implementation Plan

- ARCB is already purchased by RE. Can be installed this year itself
- Fault Indicator-ESD Punakha already purchased fault indicators, can be used for this pilot project.

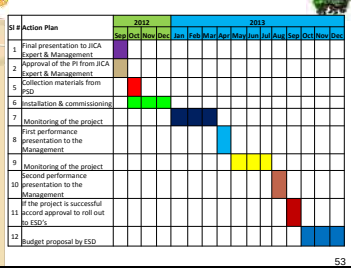
***Thus, should be able to implement this year itself!

-Study with other feeders from different regions.

-Present during review presentation

52

Implementation Plan: 1

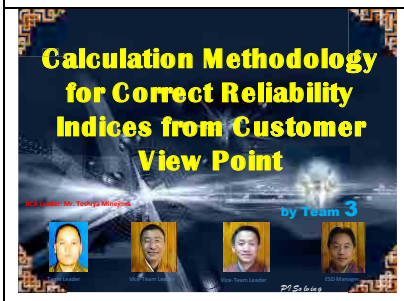


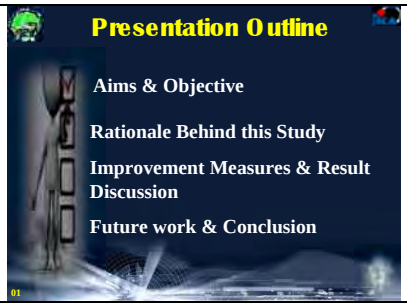
53

Thank you

54

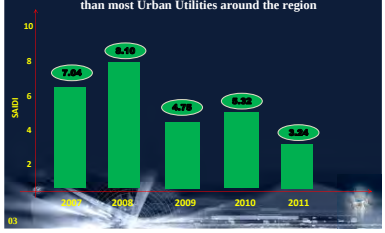
Theme 3





Rationale

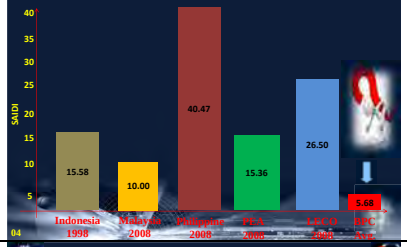
✓ SAIDI achieved in BPC are better than most Urban Utilities around the region



03

Rationale

✓ SAIDI Comparison

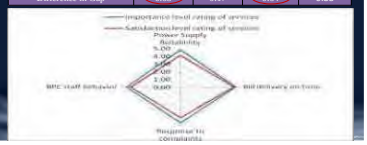


04

Rationale

✓ Review of Customer Satisfaction Survey

Particulars	Power Supply Reliability	Bill delivery on time	Response to complaints	BPC staff behavior
Importance level rating of services	4.79	4.60	4.60	4.48
Satisfaction level rating of services	4.11	4.43	3.96	4.13
Difference in Gap	0.68	0.17	0.64	0.35



05

Current Badness (Systemic Error)

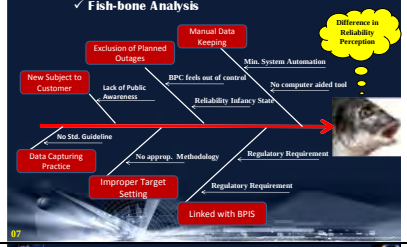
- ✓ Present practice of Outage Data Keeping/Reporting seems improper
- ✓ Reliability performance is linked with PBIS without proper tool for its improvement
- ✓ Exclusion of Planned Outages in Reliability Computation & 'Major Events' are not well defined
- ✓ Improper Target Setting Process/Methodology

Difference in Perception of Reliability between Utility & Customer

06

Cause Analysis

✓ Fish-bone Analysis



07

Improvement Measures

- ➢ Design of New Format for Data Keeping/Recording
- ➢ Data Management Process
- ➢ Defining of Planned outage and Major Events
- ➢ Formulation of Reliability Improvement Guidelines
- ➢ Reliability Target Setting/Benchmarking

08

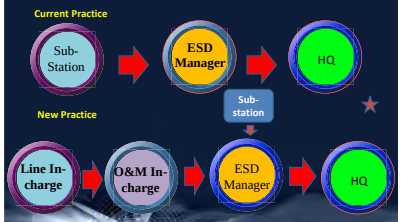
Improvement Measures #1

✓ Design of New Format for Data Keeping/Recording

09

Improvement Measures #2

✓ Data Management Process



10

Result Discussion

✓ "Near to Accurate" (real) SAIDI can be captured from new system

SAIFI Comparison

Month	SAIFI (Current Practice)	SAIFI (New Practice)
April 2012	2	2
May 2012	0.91	4.44
June 2012	1	2.78
July 2012	1	7.43

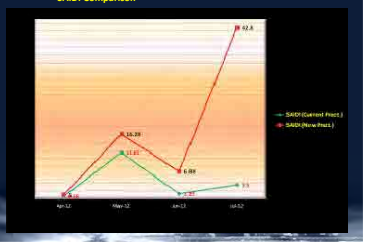
SAIDI Comparison

Month	SAIDI (Current Practice)	SAIDI (New Practice)
April 2012	0.66	1
May 2012	11.60	16.28
June 2012	1.25	6.88
July 2012	3.5	42.8

11

Result Discussion

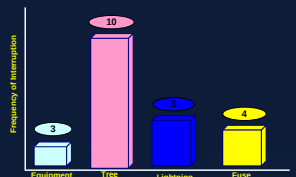
SAIDI Comparison



12

Result Discussion

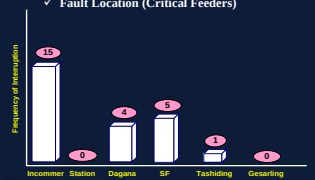
✓ Cause of Fault can be known



13

Result Discussion

✓ Fault Location (Critical Feeders)



✓ Can link Lineman's Incentive to SAIDI Improvement

✓ Computationally Demanding

14

Improvement Measures #3

✓ Reliability Improvement Guidelines

- ➢ Identify and Target Critical Circuits
- ➢ Identify the Major Causes of Faults & apply Mitigation measures
- ➢ Application of Protection and Switching Devices
- ➢ Automation
- ➢ Restoration Practices
- ➢ Maintenance and Inspection

15

Improvement Measures #4

✓ Planned Outage & Major Events

- Major Event Days needs to be well defined (under process)
- Planned Outages need to be computed separately with separate Reliability Index
  - SAIDI for planned outages are almost equal to unplanned outages (as per past reports)
  - ESDs style of handling planned outages seems disorganized and also asymmetric among ESDs
  - **CAIDI will be used as a Index to measure the performance for each ESDs (internally)**
- Develop planned outage handling procedure in more organized format (under Process)

16

Improvement Measures # 5

- Reliability Target Setting and Benchmarking (2 options)
  - ✓ Targets Based on 'Acceptable' past performance
  - ✓ Targets based on budget constraints
- However Target Setting /Benchmarking will be done as per our action plan

17

Action Plan

Activities	April 2012 to Dec.2012	Jan.2013 to Dec.2013	Jan.2014
Data Collection for Dagana			
Awareness to ESD Managers			
Rollout to other ESDs			
Data Review			
Target Setting/ Benchmarking			

18

Conclusion/Recommendation

- New format is proposed since current format captures only about 50% of the total interruptions.
- Our aim is to capture outages till DT level, but it might be difficult with present manpower strength . Therefore, we have two options:
  - Meter all DTs through Smart meters???
  - Track outage data till 33/11kV s/st. or identify ESD-wise point of data recording, like till ARCB or feeder LBS point.
- "We forecast, reliability will further decrease for few years due to more infrastructure , customer, "increase in distribution voltage level". Hence target setting has to done considering all these factors.

19

Conclusion/Recommendation

- Till proper target setting is done and reliability improvement guidelines are formulated, it may not be wise be link with incentives (PBIS).
- Planned outages needs to recorded and computed separately with planned outage handling procedure that needs to be formulated and practiced.

20

Theme 4

PI SOLVING ACTIVITY

TO IDENTIFY REAL TECHNICAL LOSS OF DISTRIBUTION SYSTEM

Team - 4

1

TEAM MEMBERS

1. Ghana Shyam Tamang, DCSD (Team Leader)
2. Lobzang Yeshi, TD (Member)
3. Kinzang Lhamo, EDCD (Member)
4. Kinley Gyem, EDCD (Member)
5. Sushil Pradhan, FAS (Member)
6. Sangay Wangdi, FAS (Member)

JICA EXPERT: JUNICHI OHISHI

2

PRESENTATION OUTLINE

- Background
- Present Problems with regards to energy loss
- Current methodology for calculating loss
- Case Study - ESD Lhuentse
- Causes of High & Inconsistent Energy Loss
- Fish Bone Analysis – Causes of Loss
- Approach adopted for Determination of REAL TECHNICAL LOSS
- Relevant Formulas for Numerical Calculation of Technical Loss:
- Identification of Pilot Feeder
- Single Line Diagram of Pilot Feeder
- Determination of Technical Loss using Numerical Method
- Results
- Conclusion/Recommendation
- Future plans and benefits

3

BACKGROUND

1. Energy Loss is REVENUE LOSS to BPC.
2. In 2011, Energy (MV & LV) loss: 31,393,773.27 kWH
   Loss (MV & LV) in Percentage : 6.38 %
   Approx. Revenue loss: Nu. **53.400** million
3. 1% reduction in loss (6.38% → 5.38%)
   Revenue saving : Nu. **8.4** million!
   0.38% reduction in loss (6.38% → 6.00%)
   Revenue saving opportunity: Nu. **3.2** million!!
4. BPC needs to reduce energy loss to reduce revenue loss.

4

---

5. System of loss target setting tied up with the PBIS was introduced and the concept of ratcheting helped to reduce the loss (MV& LV) significantly from 16% in 2004 to 6.38% in 2011.
6. For further reduction of loss, it has become necessary to set **REALISTIC** YEARLY LOSS TARGETS for different ESDs.
7. BPC should determine the allowable Technical Loss in the Distribution System.

5

---

1. Determination of Technical Loss of the Distribution System requires a detailed study of power loss that take place in the electrical DISTRIBUTION network mainly due to the flow of current.

Electrical Distribution Network consists of:

- MV and LV Lines (both overhead and underground)
- Distribution Transformers
- Service Wires

Difficulties involved:

1. Current flowing in the network is not constant and assumptions are necessary
2. Distribution network is very vast and difficult to map

6

Revenue Savings with 1% Loss Reduction- excluding ESDs with loss less than 5%

DIVISIONS	Loss % (2011)	Revenue loss (millions Nu.)	Revenue loss with 1% reduction in loss	Savings (millions Nu.)
Bumthang	12.41%	1.78	1.64	0.14
Dagana	10.00%	1.80	1.62	0.18
Gelephu	8.48%	2.38	2.10	0.28
Haa	4.42%	0.73	0.73	-
Lhuentse	14.12%	0.76	0.70	0.05
Mongar	11.82%	1.90	1.74	0.16
Paro	6.84%	4.19	3.57	0.61
Pemagatshel	11.28%	0.82	0.75	0.07
Phuntsholing	0.33%	0.67	0.67	-
Punakha	6.58%	1.44	1.22	0.22
Samtse	3.41%	2.63	2.63	-
S Jongkhar	15.42%	3.68	3.44	0.24
Trashigang	12.72%	2.77	2.55	0.22
Thimphu	9.86%	25.42	2.84	(2.58)
Trongsa	11.56%	0.73	0.67	0.06
Tsirang	6.96%	0.49	0.42	0.07
Trashi Yangtse	7.95%	0.53	0.46	0.07
Wangdue	1.34%	0.55	0.55	-
Zhemgang	2.17%	0.11	0.11	-
% Loss (6.38%)	6.38%	53.37	48.41	(4.96)

7

Present Problems with regards to energy loss:

- BPC's distribution network has grown in size over the years. Its distribution lines is over 9,500 km and the total number of distribution transformers installed stands at 3,233 as on Dec'11.
- Yearly Aggregate Technical & Commercial (AT&C) Loss of different ESDs - very inconsistent
- BPC is not able to set REALISTIC YEARLY LOSS TARGET for different ESDs.
- No system of monitoring energy loss feeder wise.
- BPC lacks strategy to reduce distribution system loss further.

8

CURRENT METHODOLOGY
for determination of monthly AT&C loss

$$\text{Loss\%} = \frac{\text{Energy Input} - \text{Energy Sold}}{\text{Energy Input}} \times 100$$

Where, **Energy Input** = Total energy billed by TD +BPC's Internal Generation
Energy Sold = Energy billed to customers

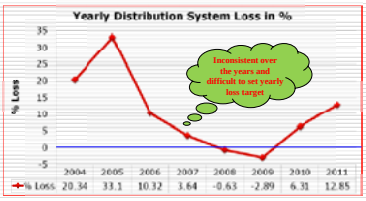
Problems with the current methodology:

1.Not possible to pin point the section which is contributing to high loss

2.As a result, difficult to work out any suitable counter measures for reduction of loss

9

CASE STUDY – ESD LHUENTSE



1

Feeder-wise loss analysis

Abstract

Sl. no	Feeder	Purchase (May'11– March'12)	Sale (May'11-March'12)	(%) Loss
1	Lhuentse	1,653,402.00	1,411,904.80	14.61%
2	Tangmachu	404,660.00	220,620.80	45.48%
3	Minjey	204,860.00	179,462.00	12.40%
4	Gorgan	847,114.00	685,364.12	19.09%
5	Colony	35,911.20	11,012.00	69.34%
	Total	**3,153,407.60**	**2,515,824.12**	**20.22%**

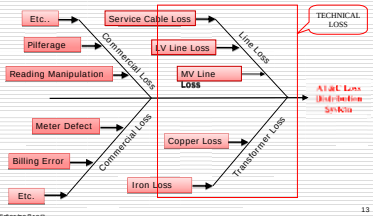
1

Causes for High and Inconsistent Energy Loss :

- Not reading energy meters every month
- Reading manipulation
- Inaccurate or defective meters
- Reading time difference
- Pilferage

12

FISH BONE ANALYSIS - CAUSES OF LOSS



13

Approach adopted for determination of REAL TECHNICAL LOSS of DISTRIBUTION SYSTEM

- Identify a feeder for the pilot study
- Map the details of the identified feeder (poles, conductors, transformers and customers)
- Draw single line diagram of the pilot feeder
- Determine Technical Loss using various techniques
- Weigh pros and cons of various methods and recommend the most suitable option

14

Relevant Formulas for Numerical Calculation of Technical Loss:

1. Power Loss in the MV/LV LINES & CABLES

Power Loss in the MV/LV lines and Cables takes place due to the electric current that flows through them. Basically, power loss can be determined by: **$W = I^2 r L$ [W]**

Where;
W: Power Loss in Watt
I : Current [A]
r : Resistance per Unit Length [Ω /m]
L : Length of Distribution Line [m]

15

---

2. Concentrated load method:

$W = N(r\ I^2\ L)/1000$

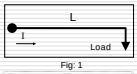
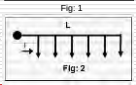


Fig: 1

3. Equally distributed load method:

$W = N(r\ I^2\ L)/(3*1000)$

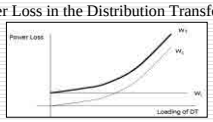


Where;
W : Power Loss [w]
N : Coefficient
N = 2 : Single Phase Two Line
N = 3 : Three Phase Three Line
L : Length of Distribution Line [m]
I: Current [A]
r : Resistance of line per km line [Ω /km]

16

---

4. Power Loss in the Distribution Transformer



$W_T = W_c + W_i$

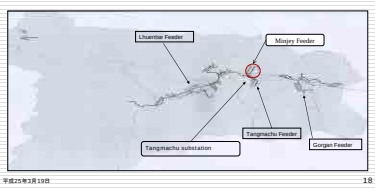
$W_c = (P/T)^2\ W_{cr}$

W_T : Total Power Loss of DT [W]
W_{cr} : Copper Loss at Rated Output [W]
W_c : Copper Loss (Changed by Loading) [W]
W_i : Iron Loss (Constant Value) [W]
Each coefficient is specified by manufacturer
P : Output [kVA]
T : Rated Output [kVA]

17

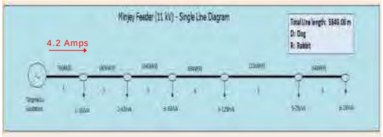
Identification of Pilot Feeder

ESD Lhuentse has 4 feeders and 2 generators and Minjey Feeder was identified for the pilot study because of simple system.



18

Single Line Diagram of the Pilot Feeder



DETERMINATION OF TECHNICAL LOSS BY NUMERICAL CALCULATION

Parameters considered :

Feeder Parameters (Minjey Feeder)		
1	Maximun Current [A]	4.20
2	Average Current [A]	2.63
3	Load Factor	0.63
4	Loss Factor	0.44
5	Annual Hour [h]	8760.00
6	Power Factor	1.00

Line Parameters

		Resistance [Ω /km]
1	Dog	0.2745
2	Rabbit	0.5449
3	LV ABC 95sq.mm	0.3200
4	LV ABC 50sq.mm	0.6410
5	Service Cable 6sq.mm	2.6820

Transformer

KVA Rating	Iron Loss [W]	Full load Cupper Loss [W]
16 kVA	75.00	300.00
25 kVA	125.00	425.00
63 kVA	175.00	1300.00
125 kVA	300.00	1700.00

LV System

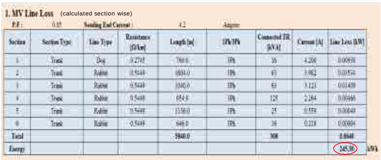
Maximum Line length [m]	1,500.00
Average Length [m]	800.00
Average number of Feeder	2.00

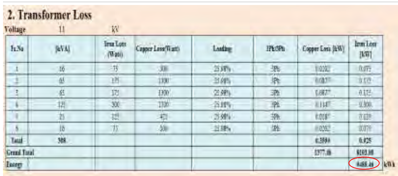
Service Cable (4, 6 & 10 Sq mm) generally used in rural areas

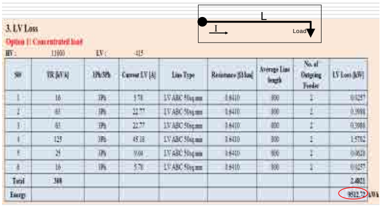
Resistance of 6 sq mm (Copper) cable considered for the study	2.682	Ohms/km
Total customers of Minjey feeder	183	Numbers
Average length of service cable	30	Meters

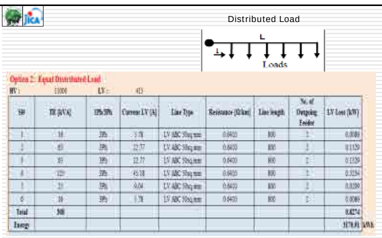
Results of the Numerical Calculation

OPTION - A









ABSTRACT

1

MV Loss	[illegible]
TR Loss	9480.46
LV Loss (concentrated load)	[illegible]
Total	20096.74

2

MV Loss	[illegible]
TR Loss	[illegible]
LV Loss (distributed load)	[illegible]
Total	15694.95

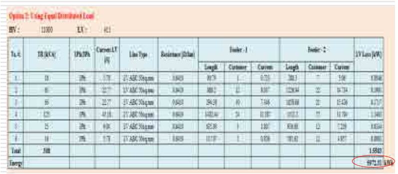
Option - A

Loss Comparison

Loss Comparison	Loss (%)
Concentrated load	9.24%
Distributed load method	6.32%
Average	7.78%

Option : B

1. MV Line Loss : Same as Method A — 288.59 kWh
2. Transformer Loss: Same as Method A — 9480.46 kWh

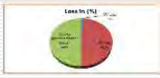


4. Service Cable Loss : Same as that of Method A — 798.26 kWh

ABSTRACT

1

MV Loss	245.30
TR Loss	9480.46
LV Loss (concentrated load)	9758.73
Total	10482.49



2

MV Loss	245.30
TR Loss	9481.48
LV Loss (distributed load)	6771.57
Total	16496.35

Option - B

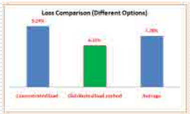
Loss Comparison

Concentrated load meth	8.99%
Distributed load mehod	7.61%
Average	8.30%

Option - A

Loss Comparison

Loss Comparison	Loss (%)
Concentrated load	9.24%
Distributed load method	6.32%
Average	7.78%

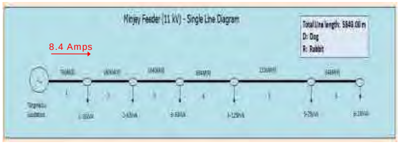


Option - B

Loss Comparison

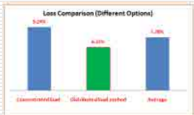
Concentrated load meth	8.99%
Distributed load mehod	7.61%
Average	8.30%

Loss - when the load is doubled



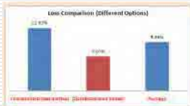
Loss Comparison (Option : A)

Loss Comparison	Loss (%)
Concentrated load	9.24%
Distributed load mehod	5.32%
Average	7.78%



Loss Comparison (Load doubled)

Concentrated load method	12.92%
Distributed load	7.07%
Average	9.99%



Conclusion/Recommendation

Technical loss of the pilot feeder was calculated using Numerical Technique. Two options were explored; Option-A: Assuming average length of LV lines and Option-B: Assuming actual length of LV lines.

Option –A is simple to understand and easier to implement. The result of both the options are comparable. Thus, considering the complexity of the network than the pilot feeder , Option-A with distributed load method is recommended for computing technical loss of the distribution system.

Future Plans and Benefits

1. All the DTs of the pilot feeder can be metered . This will help to compare the computed loss with that of the actual loss recorded by these meters.
2. Ask all ESDs to properly map the distribution facilities.
3. Once the distribution facilities are mapped by all ESDs, compute technical loss.
4. Set yearly energy loss targets based on the loss so computed.
5. Loss targets can be revised depending upon the load
6. ESDs would be able to monitor energy loss feeder wise, narrow down and pin point problematic areas so that effective loss reduction measures can be implemented.

Thank you for your patience

Theme 5

PI Activity on Improvement of Billing and Collection System in Rural Areas
Team 5

Bhutan Power Corporation Limited

OUTLINE

- Team Members
- Reasons for Prioritizing
- Objective of PI
- Result of Site Survey
- Current Situation
- Causes
- Problems
- Options Available
- Conclusion
- Implementation Schedule

Bhutan Power Corporation Limited

Team Members







Mr. Akihiro Hayashi

Bhutan Power Corporation Limited

Reasons for prioritizing

- B&C is the core functions of BPC
- The present cost of MB&C is high
- To maintain CSI of 3.7
- Within threshold of 3% for Distribution for O&M (Employee Cost, O&M & Administrative and Other Expenses)
- Need to come up with cost effective solutions to improve profitability and better customer services

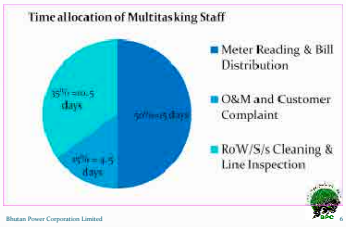
Bhutan Power Corporation Limited

Result of Site Survey

- Monthly average bill : 61% below Nu. 100
- 79% of customers prefer on the spot payment
- 42% of customers are facing problems for making payment (especially due to long distance)
- 61% is non holders of bank account (Those who are non holders, 40% of them are willing to open an account)
- 70% prefers to pay using mobile voucher and the rest with bank account
- 97% of customers agrees to send meter reading via SMS
- 99% of customers are interested to use POS facility for bill payment

Bhutan Power Corporation Limited

Current Situation



Bhutan Power Corporation Limited

Contd…

MBC Cost

ESD Tsirang

Sl #	Service Center	No. of Customers	Revenue Collected	Unit Consumed	Total Expenses	Cost of Metering & Billing / customer	Cost of Collection/ customer	Expenses/ kwh
1	Kilkhorthang/Rangthangling	1,574	491,826	327,884	15,231	9.68	0	0.05
2	Tsirangtoe	69	31,430	20,953	8,512	94.38	28.99	0.41

Bhutan Power Corporation Limited

Contd…

MBC Cost

ESD Thimphu

Sl #	Service Center	No. of Customers	Revenue Collected	Unit Consumed	Total Expenses	Cost of Metering & Billing / customer	Cost of Collection/customer	Expenses/kwh
1	Lanjophaka	439	497,169	280,332	16,550	37.7	0	0.06
2	Genekha	630	27,399	222,573	16,689	23.84	2.65	0.07

Bhutan Power Corporation Limited

Causes

- **Scattered Customers (1 KM – 41 KMs from ESD)**
- **Low consumption**
- Limited Manpower
- Higher cost of Electrification
- Tariff regulated by Bhutan Electricity Authority
- Have to do Site Collection (Nu.70 – Nu.300)

Bhutan Power Corporation Limited

Problems

- Meter reading & billing takes time due to limited resources
- Meter reading and billing is done manually
- Not many options available for customers for payment
- Cannot do site collection at all Geogs
- Cost of making the payment is high compared to the bill amount

Bhutan Power Corporation Limited

Options Available

Meter Reading & Billing

1. Send meter reading by customer by SMS or e mails
   - Sign an agreement with the customers
   - Customer submits the reading
   - Bill sent back to customer via SMS
   - Provide incentive for sending message

Bhutan Power Corporation Limited

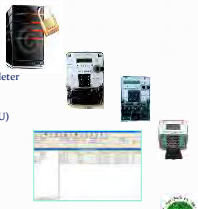
2. Read Meters once in 3 months

a. MT staff will get time for O&M works
b. Difficult to calculate monthly loss figure

Bhutan Power Corporation Limited

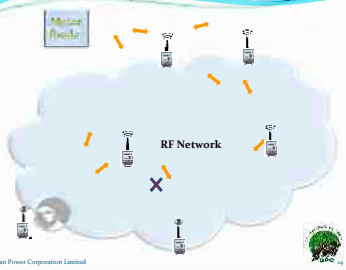
3. Prepaid Meters

1. Centralized Vending Server
2. Smart Pre Payment Energy Meter
3. Consumer Interface Unit (CIU)
4. Base Computer Software



Bhutan Power Corporation Limited

4. RF Network (other technologies)



Bhutan Power Corporation Limited

Collection

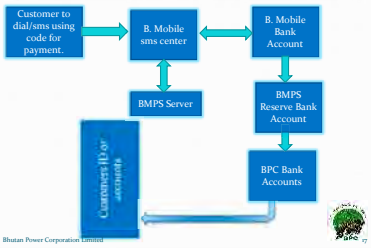
1. Direct Debit from Bank
   a. Need to have Bank Account
   b. Sign agreement with BPC and Bank
   c. Monthly bill sent to Bank
   d. Deduction done by Bank on behalf of the registered customer

Bhutan Power Corporation Limited

2. Mobile Payment (BT)

- Very convenient for the customers
- Customers are willing to opt this
- Cost sharing / Transaction

3. Proposal from Indo Group



4. Proposal from BDBL

- Has 29 branches (out of which 3 are offline)
- Offering the following services
  - Internet Banking
  - SMS Banking
  - PDA Banking
  - Over the counter

5. Point of Sales (BoB)

6. Counter Sharing

- Utilities
- Geog Offices
- Banks
- Connectivity
- Additional Manpower

Options Available

1. Meter Reading & Billing

Sl.No	Options Available	Criteria for Selection					Total	Ranking
		Cost	Benefit	Customers Convenience	Implementing Issues	Technology		
1	Through SMS or E-mails	7	7	8	9	5	36	1
2	Read Meters once in 3 months	8	6	5	4	8	31	3
3	Pre Payment Meters	2	9	5	7	7	30	4
4	RF meters (Other Technologies)	5	8	8	7	6	34	2

Rating
1 – Very Low
10 – Very High

2. Collection

Sl. No	Options Available	Criteria for Selection						Total	Ranking
		Cost	Benefit	Customers Convenience	Implementing Issues	Technological difficulty	Dependence on other Utilities		
1	Direct Debit from Bank	7	8	7	7	7	5	41	1
2	Mobile Payment (BT)	5	8	8	6	6	4	37	2
3	Mobile Payment (Indo Group)	6	8	8	6	6	2	36	3
4	Through BDBL	6	6	8	6	5	3	34	5
5	Point of Sales	7	5	8	6	5	4	35	4
6	Counter Sharing	7	7	6	4	5	5	34	5

Rating
1 – Very Low
10 – Very High

Conclusion

Meter Reading & Billing

- Through SMS or E mails

Collection

- Direct debit from Bank

Other options will be implemented together with the above options

Implementation Cost

Meter Reading & Billing

1. Send meter reading by customers/representative by SMS or e mails
   - Nu. 100,000 annually as AMC for SMTP server
   - Nu. 10, 000 per month for 10, 000 SMS. Additional charges for more than 10, 000 SMS
   - Approx Nu. 50, 000 for additional lease line
   - Approx Nu. 30, 000 per month as bandwidth service charge
   - Total Cost: Nu. 630,000

Works to be Initiated

Meter Reading & Billing

1. Send meter reading by customers/representative by SMS or e mails
   - Have additional lease line pulled to the SMS gateway server
   - Select the vendor and carry out the detail blueprinting based on requirements
   - Sign an agreement with the customers/representative
   - Provide incentive for sending message

Works to be Initiated

Collection

1. Direct Debit from Bank
   - Sign tri party agreement between BPC, Banks and Customers
   - Work on Integration
   - BPC to send the bills to Banks
   - Banks to deposit that amount in BPC account

Sl.#	Work Details	Sept, 2012	Oct, 2012	Nov, 2012	Dec, 2012	Jan, 2013	Feb, 2013	Mar, 2013	Apr, 2013	May, 2013	Jun, 2013	Jul, 2013	Aug, 2013	Sep, 2013	Oct, 2013	Mar, 2014
1	Presentation to the Management	2nd week														
2	Finalize the report based on feedback		1st week													
3	Propose for budget for pilot project		2nd week													
4	Discuss with other stakeholder for integration			3rd week												
5	Finalize if integration is feasible or not				2nd week											
6	Initiate the work and start implementation					2nd week										
7	Receive materials						2nd week									
8	Installation									2nd week						
9	Monitoring/Testing															
10	Propose for budget for integration if it is found feasible.													1st week		
11	Complete integration															2nd week

Thank You
&
Tashi Delek

Cost

Meter Reading & Billing

2. RF meters (Other Technologies)
   - Single phase meter – Nu. 2,000 per meter
   - Data concentrator with RF and GPRS communication – Nu. 20, 000
   - Central Server Software – Nu. 500, 000
   - Data Acquisition Server – Nu. 485, 000
   - AMC – Nu. 150, 000
   - Training – Nu. 700, 000

Theme 6a

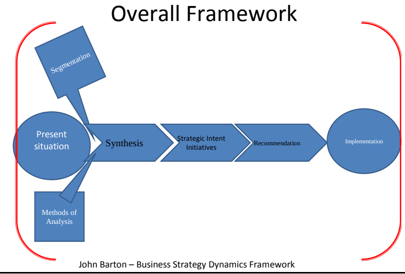
PI Solving Activity 2013

Group 6A:
"Study on existing manpower and management of existing facilities under DCSD"

Members:
1.Dilli Ram Adhikari, Manager, ESD Punakha.
2.Kinlay Wangmo, Asst. Manager, HRD.
3.Sangay Tenzin, Manager, DCSD,HQ.
4.Tal Man Pradhan, Manager, Finance Department.

Team Advisor: Mr. Nobor Seki, JICA/TEPCO

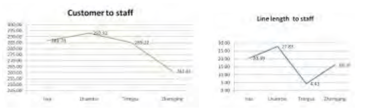
Overall Framework



John Barton – Business Strategy Dynamics Framework

Current Badness

- Manpower distribution unequal.
- Overstaffing and understaffing
- Heavy work load and light work load.
- Budget proposal for facilities increasing every year.
- No benchmark in distribution of manpower and facilities.

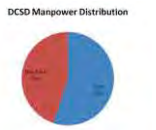


Objectives

- Optimal distribution of manpower & facilities.
- Efficient & effective utilization of manpower & facilities.
- Get the best practice of other electric utilities.
- Reduce the unnecessary cost.

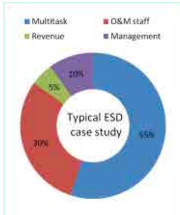
Manpower Analysis

- Job Analysis.
- Use of statistical & mathematical models in manpower Analysis.
- Judgement(managerial) Analysis -Thomas D, Murray State University.
- Trend Analysis
- For future studies: Multiple Regression Analysis, Data Envelopment Analysis.

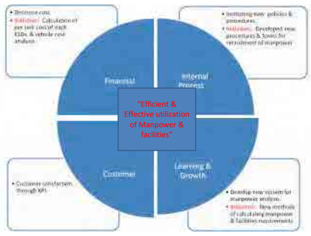


Segmentation of Manpower

- Management
  - Manager
  - Office Asst Cum Dispatcher
  - Finance Officer/Accountant
  - Sweeper cum Gardner
  - Supervisor/In-charges
- Concentrate more on Multitask, O&M & Revenue staff



Balanced scorecard



Adapted from Kaplan & Norton 1996. The Balanced Scorecard.

1. Internal Procedure Proposal

- Strict manpower recruitment process.
- Review overall manpower planning every three years(includes all stakeholders).
- Every Employee to have the JD/JA(*Third country survey*).
- Managers - Accountability & Responsibility for manpower planning.
- New manpower requisition form, Job analysis form(*Third country survey*).

Requisition Form

Position Title:

Reporting Manager:

Salary Range:

Job Description: Attach as a separate Sheet (download the form from the BPC Website)

State key drivers for creating this new position or critical business issues being addressed	
Outline the tangible benefits/savings and quantify if possible	
Describe any intangible benefits	
Existing staff strength of the same designation	
Requirement type: Replacement/additional requirement / new requirement	

Submitted by the Manager:

Comments & Recommendation by General Manager:

Comments & Recommendation by CFO:

Comments & Recommendation by HRAD:

Approved by CEO:

Job Analysis

The Job Analysis should comprise of detailed Job Description of the post, Job Specification (Knowledge, skills and abilities required to carry out the Job) and roles and responsibilities of the person going to hold that post.

The Job analysis has to be provided for each individual.

Job title:

Job Description and Roles & Responsibilities:

The job description is basically an outline of how the job fits in to the company. First, it should point out in broad terms the job's goals, responsibilities and duties. Next, develop a job statement or summary describing the position's major and minor duties. Finally, define how the job shall help the company/department achieve its goal.

Job Description:

Roles/duties and Responsibilities:

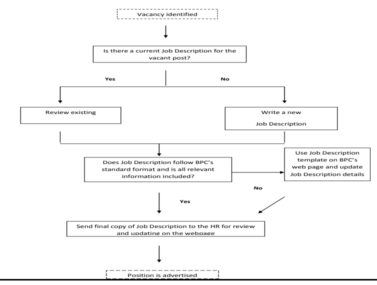
Job Specification:

The job specification describes the personal requirements you expect from the employee. List any educational requirements, desired experience and specialized skills or knowledge required. Also any physical or other special requirements associated with the job, as well as any occupational hazards.

Knowledge (Qualification):
Skills:
Abilities:

Any Other Matter:

Process The flow diagram below shows the process used to review and create a job description.



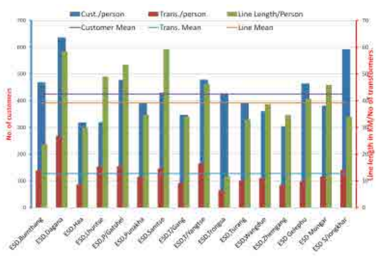
2. Learning & growth

a) Multi-Task Staff
  -Line length
  -Number of Customers
  - Number of transformers
  - Segregate ESD:
    - Rural
    - Urban

b) O&M Staff
  -Line length
  -Number of Customers
  - Number of transformers
  - Segregate ESD:
    - Rural
    - Urban

c) Revenue staff
  - Number of customers

Multitask staff analysis



Multitask staff Analysis

Dimensions	Mean	Weight	STDEV.[σ']	ESD,B/thang	% Variance	Wtg. Variance	ESD,Dagana	% Variance	Wtg. Variance	ESD,Haa	% Variance	Wtg. Variance
Customer/staff	424.00	58%	94.00	468.50	-47%	-27%	636.33	-226%	-130%	318.56	112%	65%
Transformer/staff	13.00	21%	5.00	13.88	-18%	-4%	26.83	-277%	-59%	8.67	87%	18%
Line length/staff	39.00	21%	13.00	23.78	117%	25%	58.46	-150%	-32%	29.89	70%	15%
		100%			52%	-6%		-652%	-220%		269%	98%
Result				Optimum			4 Less			2 More		

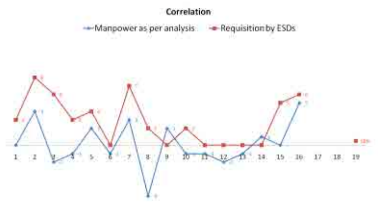
Analysis in detail

Particulars	ESD,Bumthang	ESD,Dagana	ESD,Haa
Vehicle	4.00	3.00	2.00
Manpower	38.00	24.00	23.00
Customers	3,748.00	3,818.00	2,867.00
No. of transformers	111.00	161.00	78.00
Line length	190.25	350.75	268.98
Asset	459,470,254.60	358,463,850.63	105,351,684.92
Revenue	13,046,664.44	30,176,924.50	18,454,917.63
Expenses	15,002,710.88	10,061,609.43	8,347,984.96
No. of s/centers	4.00	6.00	5.00
No. of s/center staffs	8.00	6.00	9.00
Customer/staff	468.50	636.33	318.56
Transformer/staff	13.88	26.83	8.67
Line length/staff	23.78	58.46	29.89

Multitask staff Analysis Result

Division	Cust./person	Trans./person	Line Length/Person	Manpower as per analysis	Requisition by ESDs
ESD,Bumthang	468.50	13.88	23.78	-	3.00
ESD,Dagana	636.33	26.83	58.46	4.00	8.00
ESD,Haa	318.56	8.67	29.89	- 2.00	6.00
ESD,Lhuntse	319.55	15.45	48.99	- 1.00	3.00
ESD,P/Gatshel	477.63	15.50	53.47	2.00	4.00
ESD,Punakha	391.21	11.50	34.76	- 1.00	-
ESD,Samtse	430.82	14.64	59.24	3.00	7.00
ESD,T/Gang	346.97	9.25	34.08	- 6.00	2.00
ESD,T/Yangtse	478.56	16.56	46.14	2.00	-
ESD,Trongsa	427.83	6.5	11.82	- 1.00	2.00
ESD,Tsirang	392.00	10.08	32.92	- 1.00	-
ESD,Wangdue	360.11	11.06	38.66	- 2.00	-
ESD,Zhemgang	305.00	8.50	34.66	- 1.00	-
ESD Gelephu	464.83	9.83	40.75	1.00	-
ESD Mongar	381.65	11.59	45.85	-	5.00
ESD S/Jongkhar	592.38	14.13	33.95	5.00	6.00
STDEV.[σ']	94.20	4.77	12.58		
Mean	424.49	12.75	39.21		
Correlation Co-efficient [r]					50%
- means excess					

Correlation (Actual Required Vs requisition put up by ESDs)



Other Analysis Result:

O&M staff

Division	Cust./staff	Trans./staff	Line Length/Person	As per analysis	Requisition
ESD,Bumthang	937.00	27.75	47.56	-1	0
ESD,Dagana	1,272.67	53.67	116.92	2	5
ESD,Haa	716.75	19.50	67.25	-1	3
ESD,Lhuntse	1,171.67	56.67	179.62	2	1
ESD,P/Gatshel	955.25	31.00	106.95	0	0
ESD,Punakha	684.63	20.13	60.83	-3	1
ESD,Samtse	592.38	20.13	81.45	- 4.00	-
ESD,T/Gang	1,850.50	49.33	181.76	5	4
ESD,T/Yangtse	430.70	14.90	41.53	-5	0
ESD,Trongsa	285.22	4.33	7.88	-6	1
ESD,Tsirang	1,568.00	40.33	131.68	1	0
ESD,Wangdue	1,296.40	39.80	139.19	2	0
ESD,Zhemgang	140.77	3.92	15.99	-10	2
ESD Gelephu	1,195.29	25.29	104.80	0	0
ESD Mongar	926.86	28.14	111.34	0	0
ESD S/Jongkhar	3,159.33	75.33	181.08	3.00	2
STDEV.[σ']	720.25	19.58	56.13		
Mean	1,073.96	31.89	98.49		

Revenue Staff

	Cust./staff	As per analysis	Requisition
ESD,Bumthang	3,748.00	0	0
ESD,Dagana	3,818.00	0	1
ESD,Haa	2,867.00	0	0
ESD,Lhuntse	3,515.00	0	1
ESD,P/Gatshel	3,821.00	0	0
ESD,Punakha	5,477.00	1	0
ESD,Samtse	4,739.00	0	1
ESD,T/Gang	2,775.75	-1	1
ESD,T/Yangtse	4,307.00	0	0
ESD,Trongsa	2,567.00	0	0
ESD,Tsirang	4,704.00	0	0
ESD,Wangdue	6,482.00	1	0
ESD,Zhemgang	1,830.00	0	0
ESD Gelephu	2,789.00	0	0
ESD Mongar	2,162.67	-1	0
ESD S/Jongkhar	4,739.00	1	1
ESD Thimphu	5,185.20	2	1
ESD Paro	2,950.33	0	0
ESD Pling	2,321.40	-1	0
STDEV.[σ']	1,262.17		
Mean	3,726.23		

3. Financial

- Factors Considered:
  - Three years data
  - O&M Cost (TADA, R&M of material/services, stores & spares, R&M of office equipment, consumables)
  - Employee Cost
  - Depreciation on fixed assets.
  - Power Purchase.
  - Energy Import, Export, DG, Mini/Micro Hydel.

Cost of Supply (per kwh)

District	2010	2011	2012
Thimphu	0.88	0.84	0.75
Trashigang	5.16	5.11	4.9
Chukha	0.27	0.18	0.18
Mongar	2.77	3.4	3.3
Paro	1.23	1.13	1.13
Punakha	1.87	1.86	0.53
Samtse	0.5	0.5	0.53
Sarpang	1.87	2.2	1.89
Samdrup Jongkhar	0.37	0.31	0.4
Tsiring	3.47	3.37	4.61
Wangdue Phodrang	1.19	0.76	0.92
Bumthang	4.67	4.04	4.27
Dagana	4.31	2.14	2.02
Pema gatshel	3.71	3.8	4.24
Trashi Yangtse	5.07	4.65	5.68
Haa	1.32	1.21	1.35
Lhuntse	5.05	6.53	6.44
Trongsa	2.93	3.31	2.55
Zhemgang	5.77	5.28	5.46

3. Financial

- Objectives:
  - The concept developed from third country survey.
  - To reduce cost by setting targets and benchmarking within each ESDs.
  - Compare the cost of supply each year.
  - To introduce the concept of 'Profit Center' in each ESDs.
  - To be competitive.

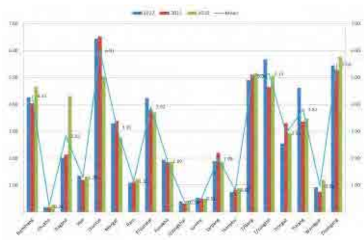
Cost of Supply Analysis

For 2012: (Datas for analysis)

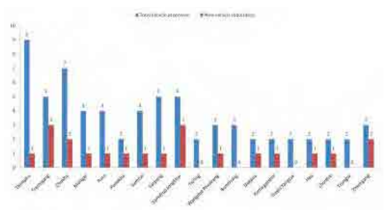
Particulars	Bumthang	Chukha
Power purchase (unit)		
Mini/Micro Hydel	3,397,017.00	-
Diesel Generation	11,554.00	58,863.00
Energy Import	6,463,442.87	-
Energy Export	- 661,094.58	-
Purchase from Gencos as per TD bill	-	1,209,108,995.50
HV purchase	-	1,084,945,500.00
Total (kWh)	9,210,919.29	1,209,167,858.50
Cost of Supply:		
Power Purchase (Nu)	1,197,419.51	157,191,821.61
Sale of units (kwh)	8,124,895.30	1,197,793,744.40

	Bumthang	Chukha
O&M cost	4,113,186.07	7,485,679.03
Employee cost	10,297,430.93	29,525,471.92
Depreciation on fixed assets	19,044,763.61	22,448,158.38
Power Purchase in Nu..	1,197,419.51	157,191,821.61
Total	34,652,800.12	216,651,130.94
Sale in units	8,124,895.30	1,197,793,744.40
Cost of Supply(per unit)	4.27	0.18

Cost of Supply



Facilities: Vehicles Allocations



Vehicles Allocations

- Medium Vehicles per ESD – 1 nos.
- Light Vehicles per ESD – 1 nos.
- Medium/Light vehicle per ESSD –1
- Sharing of resources among different Department/Division/Units. *(From Third Country survey).*
- Hire vehicles for planned work and planned O&M works *(From Third Country survey)*.

Present Vehicle Distribution

ESD Office	Type of Vehicles							Total
	Eicher truck	Hilux	Bolero	Scorpio	Tata truck	Crane	EECO Van	
ESD,Bumthang	1	2	0	0	-		-	3
ESD,Chukha	3	3	1	0	-	-	-	7
ESD,Dagana	1	1		0	-	-	-	2
ESD,Haa	1	1	0	0	-	-	-	2
ESD,Lhuntse	1	1	0	0	0	0	0	2
ESD,Mongar	1	1	1	1	0	0	0	4
ESD,Paro	2	1	1	0	0	0	0	4
ESD,Pemagatshel	1	1	0	0	0	0	0	2
ESD,Punakha	1	2	0	0	0	0	0	3
ESD,Samdrupjongkh	2	1	2	0		0	0	5
ESD,Samtse	1	1	2	0	0	0	0	4
ESD,Sarpang	2	2	1	0	0	0	0	5
ESD,Thimphu	2	2	2	1	0	1	1	9
ESD,Trashigang	0	1	3	0	1	0	0	5
ESD,Trashiyangtse	1	1	0	0	0	0	0	2
ESD,Trongsa	1	1	0	0	0	0	0	2
ESD,Tsirang	1	1	0	0	0	0	0	2
ESD,Wangdue	1	1	1	0	0	0	0	3
ESD,Zhemgang	1	2	0	0	0	0	0	3
								69

Cost Benefit analysis

Vehicle analysis(Hilux)		Driver's salary		Vehicle analysis(Eicher)	
Cost of vehicle	20,51,312.00			Cost of vehicle	10,38,319.00
Depreciation	307,696.80	Salary	98,592.00	Depreciation	155,747.85
O&M	125,048.00	TA/DA	90,000.00	O&M	123,105.00
Fuel	143,892.88	LTC	7,825.00	Fuel	145,178.11
Blue book renewals	1,500.00	Leave Encashmen	7,825.00	Blue book renewals	3,800.00
Insurance	1,200.00	PBIS	15,650.00	Insurance	2,400.00
Emission test	100.00	PBVA	9,390.00	Emission test	100.00
Fitness	60.00	Gratuity	7,825.00	Fitness	75.00
Driver Salary	247,436.00	PF	10,329.00	Driver Salary	247,436.00
Total Amount (Nu)	826,933.68	Total Amount (Nu	247,436.00	Total Amount (Nu)	677,841.96

Hiring of Vehicles(Hilux)

No. of Days	Local Rate	Total Amount (Nu)
90	5,000.00	450,000.00

Hiring of Vehicles(Hilux)

No. of Days	Local Rate	Total Amount (Nu)
90	5,000.00	450,000.00

Minimum saving from Hilux (Nu.) 376,933.68

Minimum saving from Eicher (Nu.) 227,841.96

Saving from 21 vehicles per year(Nu.) = 7,915,607.28 **OR** Saving from 21 vehicles per year(Nu.) = 4,784,681.16

Recommendation

- Continuous consultation & discussion with all the stakeholders.
- Implement new manpower requisition and Job Analysis form.
- Involve CFO in new manpower recruitment and analysis.
- Review overall manpower planning(once in three years).
- Use manpower analysis methods.
- Freeze purchase of new vehicles(time being).
- Sharing of resources among department/division/units.
- Create awareness on "Profit Center" concept through cost of supply.
- Encourage use of private vehicles for travel(ESDs).
- Monitor the benchmarking annually.

Implementation Plan

Action Plan	2013 Oct	Nov	Dec	2014 Jan	Feb	Mar	April	May	June	July	Aug	Sep	Oct	Nov	Dec	Responsibility
Implementation of new forms and guidelines																HRD
Freeze the purchase of new vehicles																FAD
Involve CFO in manpower recruitment and analysis																Management
Sharing of resources among department/division/units																Management
Creat awareness on "profit center" concept																DCSD
Encourage the use of pvt. Vehicles for travel.																DCSD,FAD
Monitor the benchmarking annually																DCSD
Review the manpower planning once in three years																HRD,DCSD & ESDs
Use manpower analysis methods																HRD & DCSD
Continious consultation & discussion with all the stakeholders.																DCSD

References:

- Morisawa,T 2002, 'Building performance measurement systems with the balance scorecard approach ', *NRI Papers*, Nomura Research Institute, No. 45, Nomura Research Institute, "
- Thompson, A, Strickland,A & Gamble, J 2010, '*Crafting and Executing Strategy*', McGraw Hill, New York.
- Butwal Power Company Limited,2013, '*Annual Report*' kathmandu.
- Nepal Electricity,2013, '*27th Anniversary Report*' Kathmandu.
- Provincial Electricity Authority,2013, '*PEA Power System Development Plan*', Bangkok.
- North Power Limited, 2013,'*Company Presentation to BPC Report*', Auckland.
- Orion Energy, 2013, 'Company Presentation to BPC Report', Christchurch.
- Unison Energy, 2013, ' Company Presentation to BPC Report', Napier.
- Bhutan Power Corporation Limited, 2013, 'Data Report', Thimphu.
- Department of Power,2013, 'Asset Report' Government of Arunachal Pradesh.
- Department of Power,2013, 'Resource Assessment Report' Government of Arunachal Pradesh
- Tallapragada, P,Shkaratan,M,Izaguirre,AK,Helleranta,J,& Rahman,S2009, '*Monitoring Performance of Electric Utilities: Indicators & benchmarking in Sub-Saharan Africa*', The World Bank http://www.esmap.org/sites/esmap.org/files/P099234_AFR_Monitoring%20Performance%20of%20Electric%20Utilities_Tallapragada_0.pdf
- Pacific Power Association, 2012, '*Power Benchmarking Manual: Performance Benchmarking for Pacific Power Utilities*', Sydney.http://www.theprif.org/sites/theprif.org/files/POWER%20BENCHMARKING%20MANUAL%202012.pdf
- Travaglione M 2010, 'Organisational Behaviour', Mc Graw Hill, Sydney.

Thank you

Theme 6b

PI SOLVING ACTIVITY

Theme#6b
Effectiveness of existing Service Centers

Members:
1. Ms. Dechen Dema, Sr. Manager, UED (Team Leader)
2. Ms. Tashi Lhamo, Asst. Manager, HRAD
3. Mr. Talman Pradhan, DFO, FAS

Date: 25th September, 2013

1

Outline

- Background
- Methodology
- Current Situation
- Cause Identification
- Improvement Measures
- Improvement Possibilities
- Conclusion
- Action Plan

2

Background

- 19 Electricity Services Division (ESD)s are divided into geographical areas and Service Center (SC) staff look after the areas designated.
- The Service Center concept initiated in 2007 & was launched in 2008
  - Mainly initiated to cope with the pressing demand for additional meter readers and linemen
  - Enhance productivity of staff
  - Improve customer satisfaction
- Presently, 183 Service Center with 289 staff
  - No proper procedure or written document to set up SC
- Staff working are called Multi-Task with the following roles and responsibilities.

3

Roles and responsibilities

Metering Billing & Collection	Operation and Maintenance (O&M)	Complaint Management
• Meter Reading & Billing • Collection for remote areas • Disconnection and Reconnection, new meter issue • Checking in case of high bills/illegal connection	• Cleaning of Substation • Clearing of Bush mainly Low Voltage (LV) • Maintaining Distribution Pillars (DP) and Mini Pillars (MP) • Operation and Maintenance in micro hydel	• Attend to no supply complaints • Rectify problems if possible otherwise inform the O& M Team in ESD • Reporting the status of High Voltage (HV) line and Transformer

4

Merits and Demerits of SC

Merits of Service Centre	Demerits of Service Centre
Faster and prompt service delivery to customers	Manager unable to control or monitor the services provided by the SC staff
One staff performing multiple task	In some cases with more than one staff, work are divided among themselves and information is not shared properly
Adequate knowledge about infrastructure and customers in their designated areas	Lack of coordination between SC staff and ESDs
The SC staff can advice the customers on proper house wiring or safety measures.	Risk of SC staff taking up customer's internal wiring or other electrical related works.
SC Staff who collects the billed amount from the customers helps the customer from saving time to pay the bills.	The risk of misappropriation of the bill amount by SC staff is probable.

5

Increasing SC and Staff

Particulars	2010	2013	Addition
No. of Service Center	138	183	45
No. of staff	250	289	39

6

Effectiveness- Assessment?

7

Methodology

8

Target Study Area

Sl. #	ESD Category	ESD	Reason	Survey Questionnaire
1	I	Electricity Services Division, Thimphu	1. Most of the area would represent a urban services 2. Road connectivity is good	- 1,000 customers/ 25, 926 customers - All 33 SC staff
2.	II	Electricity Services Division, Tsirang	1. The area would represent a rural setting 2. Road connectivity only through farm roads	- 500 customers / 4714 customers - All 14 SC staff
3.	III	Electricity Services Division, Trongsa	1. Typical rural setting 2. Less road connectivity	-300 customers/ 2567 customers - All 6 SC staff

Survey Questionnaire for Managers to all 19 ESD managers

9

CURRENT SITUATION

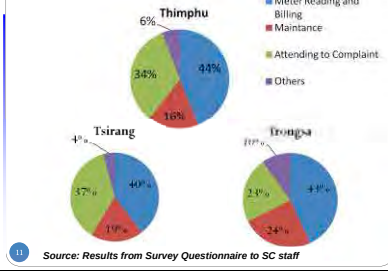
I. Work Load
Average number of days / month / staff

Tasks	Thimphu	Tsirang	Trongsa
Meter Reading and Billing	6	10	11
Operation and Maintenance	2	5	6
Attending to Complaint	5	10	6
Others (Reconnection, Disconnection, Support to O&M, B&CU)	1	1	3
Total	14	26	25

Source: Results from Survey Questionnaire to SC staff

10

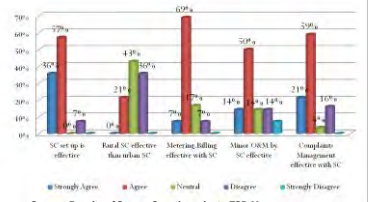
I. Task Allocation



Source: Results from Survey Questionnaire to SC staff

11

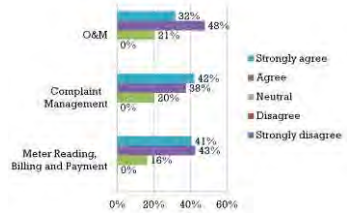
II. Manager's view



Source: Results of Survey Questionnaire to ESD Managers

12

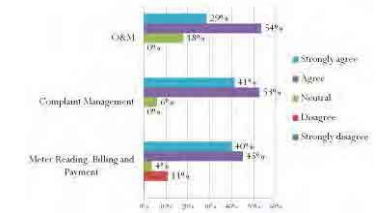
II. Customer Survey Result - Thimphu



Source: Results of Survey Questionnaire to Customers

13

II.Customer Survey Result- Tsirang



Source: Results of Survey Questionnaire to Customers

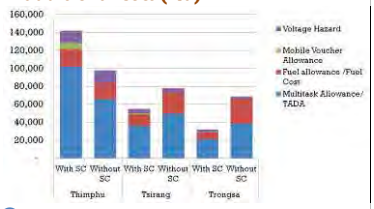
14

II. Customer Survey Result- Trongsa

Source: Results of Survey Questionnaire to Customers

15

III. Cost Implications- Monthly additional cost (Nu)



Source: With SC cost from ERP-SAP system
Without SC cost: Analysis by Theme 6b

16

Cost calculations (monthly)

With SC

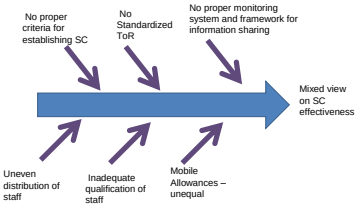
- Multitasking allowance - Nu. 3000
- Fuel allowance –
  - Nu. 1000 for BPC owned
  - Nu. 1500 for self owned
- Mobile Voucher allowance – Nu. 100- Nu 200
- Voltage Hazard Allowance- Nu. 400

Without SC

- *Travel Allowance/Daily Allowance of Nu. 500/day for SC staff and driver*
  - *Distance more than 25 km*
  - *11 days cap*
- *Fuel cost for the distance travelled (Diesel cost considered)*
- Voltage hazard allowance of Nu. 400

17

Cause Identification



18

Selection of Major Improvement Measures

1. Problem with increasing number of SC and recruitment of Staff for SC
   a) Selection of criteria to establish SC important
   b) Even distribution of staff
2. Implement standardized ToR
   a) clarity in responsibility and accountability
3. Proper monitoring and information sharing
   a) Availability of record and information

- Inadequate qualification of staff – BPC recruitment procedure will resolve
- Different mobile allowances- to propose to competent authority to approve equal allowance

19

Improvement Measure # 1

Criteria for setting up Service Center

Parameters	BPC present level/ per SC staff	Weightage
Customer Base (Numbers)	456	42%
Line Length (LV) (km)	21	26%
Distribution Transformer (Numbers)	12	26%
Other factors (geographical terrian, distance)	Distance more than 25 km	7%

Calculated from the existing BPC infrastructure as per Power Data Book 2012

20

Improvement Measure # 2

- Draft Terms of Reference for SC

Improvement Measure # 3

- Register to record the activities in log book
  - To be submitted monthly to ESD
  - Help keep history of the type of complaints
  - ESD Thimphu initiated from August 2013
  - First month report submitted
- Third Country Survey to Provincial Electricity Authority, Thailand
  - Have advanced recording system

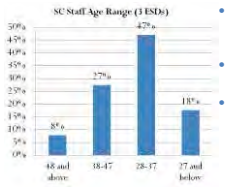
21

Improvement Possibilities

- PEA, Thailand - Outsourcing of non-core technical works such as Meter Reading, Tree trimming
- BPC can have strategic plan to have VEEET instead of SC in future
- Village Electrical Entrepreneurs & Electrical Technician (VEEET) first batch of 40 people trained out of total 120 people
- VEEET presently paid Nu.8000 per month, BPC's SC staff currently paid Nu.14,960 per month

22

Challenges



- Outsourcing of work of present SC staff as they retire will be **slow**
- Recruit VEEET in new RE areas
- Replace the present SC in places where present VEEET is trained
  - SC staff to be transfered to O&M

23

Conclusions

- SC effective for rural areas (ESD, Tsirang and Trongsa)
- Reshuffling of staff and re-allocation of areas for urban areas (ESD, Thimphu)
- Follow SC set up criteria to open new SC
- Follow proper recording system for effective monitoring purposes and proper communication
- Future Recommendation: BPC to outsource non-core technical works and emphasize more on technical works

24

Action Plan

Actions	Activities	Deadline	Responsible
Implementation of ToR	Discussion with ESD, Managers	30 November, 2013	Theme 6 b members and DCSD HQ
Implementation of proper monitoring and recording system	-Sensitization on the data to be entered in log book -Log Book to SC to be circulated to all ESDs -Documentation on the system to monitor and record	30 October , 2013 30 November, 2013 30 December 2013	O&M Managers & ESD Managers DCSD HQ and ESD, Managers Theme 6b members and DCSD HQ
Finalization of criteria to set up SC	In consultation with ESD, Managers and GM, DCSD	30 April, 2014	Theme 6 b members and DCSD HQ and ESD Managers

25

Thank you.
Any Questions?

26

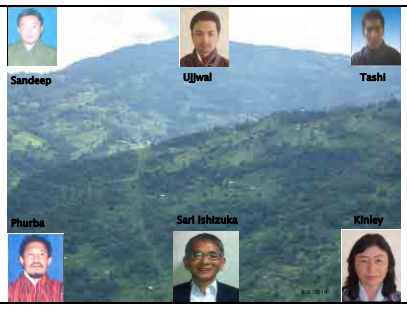
Theme 7

JICA PI Solving Activity

Theme # 7

Study on metering, billing, collection procedures, process and technologies and prepare road map for implementation including cost benefit analysis

8/6/2014 1



Outline

- Background
- Studies conducted
- AS IS PROCESS – Metering, Billing & Collection
- GAP ANALYSIS
- TO BE PROCESS
- Implementation plan
- Conclusion

8/6/2014 3

BACKGROUND

Background

- Study on metering, billing, collection procedures, process and technologies and prepare road map for implementation including cost benefit analysis.
- Metering, Billing & Collection : Core functions of DCSD.
- Annual compact of 2013.
- PBIS of DCSD 2013.
- JICA PI solving activity 2013.
- ESD, Tsirang as the sample ESD

STUDIES CONDUCTED

Studies conducted

AS IS PROCESS

AS-IS-PROCESS : Metering

- Need for documented procedures & policies
1. Inventory policy
2. Replacement policy

AS-IS-PROCESS : Billing

- ESDs have limited Spot Billing Machines (SBM), therefore it has to be shared
- Due to the urgency of the work (since the SBM has to reach another in waiting), the billing function is prone to many reading errors.
- SBMs prone to failure -Hard ware failure , battery failure
- In some cases, the customer reaches the billing section of ESD to pay their bills before the SBM has actually reached the office for downloading purpose.

AS-IS-PROCESS : Billing

- The reading and billing is spread over the month - the loss calculated by each ESD is not accurate and realistic.
- The billing cycle currently followed does not give a customer a minimum of 30 days grace period to pay his bills.
- 50 % time spent on MB function.

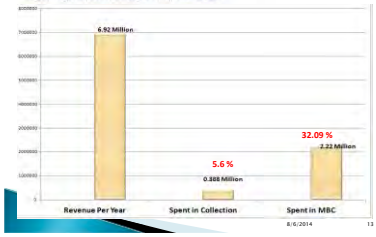
Total Multi tasks in ESD Tsirang	Total costs incurred by BPC (Salary and all allowances) in the year 2012	Total costs on Metering and Billing alone (50%)	Number of Customers as of Dec. 2012	MB costs on multitask/customer/year
14	3,671,374.80	1,835,687.40	4,825	380.45

AS-IS-PROCESS : Collection

- Conventional payment method (99.63%)
- Internet online Banking (0.36%)
- Point of Sales (POS)

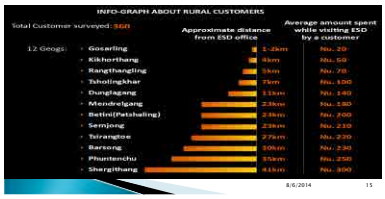
2012 data

AS-IS-PROCESS : Collection
EXPENDITURE IN MBC



AS-IS-PROCESS : Collection

AS-IS-PROCESS : Collection
Average expenditure by customers



THE GAP ANALYSIS

The Gap Analysis

- Third country visit to TNB, Malaysia
- Best practices followed shall be adopted
- Metering policies - replacement
- Lessons learnt from TNB – SMS reading

TO BE PROCESS

The TO-BE-PROCESS : Metering

- Policy decision to procure static meters taken in 2010.
- Meter specification frozen in 2012 only during CTC meeting on 26 January 2012.
- Decision to replace meters every after 10 years taken.
- Inventory of 10 % of meters .

The TO-BE-PROCESS - Billing

- Options studied

(A) Process improvement for rural

- 4 % of the total energy sales
- About 3 % of revenue
- Hence, process improvement schemes and not high investment in introduction of technology

(B) Introduction of new technology for urban

The TO-BE-PROCESS - Billing

(A) Process improvement

- 3 Monthly advance payment scheme
- 3 Monthly Post paid scheme
- Yearly advance payment scheme

(B) Introduction of new technology

- Advanced Metering Infrastructure
- Automatic Meter Reading (AMR)
- SMS reading & Billing
- Group metering

The TO-BE-PROCESS - Billing

- 3 Monthly Post Paid Scheme

Cost	Benefit	Risks	Remarks
1.320M : No meter replacement 4.837 M : With meter replacement	Cost savings to BPC = 0.941 M per year for ESD, Tsirang.	Theft cases going unnoticed for a period of 3 months	This scheme can be implemented without any change of meters as monthly consumption of a rural customer is seen to be much lesser than 100 units/month. 1.320 M Ngultrums is for software change requests. Rebate of Nu. 19.86 per customer per month. Savings on travel by customer (only 4 times in a year).
	Customer saves on the monthly visit to ESD Cash counter.	Bill date for Oct, Nov, Dec consumption will be available by 15 Jan. The actual consumption of all the customers can be made only in March.	
	Every customer gets 30-45 days period to pay the bills		
	MB costs cut down by 66 %.		

The TO-BE-PROCESS - Billing

- 3 Monthly advance payment scheme

Cost	Benefit	Risks	Remarks
1.320M : No meter replacement 4.837 M : With meter replacement	Cost savings to BPC = 0.950 M per year for ESD, Tsirang	Theft cases going unnoticed for a period of 3 months	Rebate of Nu. 20.78 per customer per month. Savings on travel by customer (only 4 times in a year).
	Customer saves on the monthly visit to ESD Cash counter	Bill date for oct, nov, dec consumption will be available by 15 Jan. The actual consumption of all the customers can be made only in March.	
	Every customer gets 30-45 days period to pay the bills		
	MB costs cut down by 66 %.		

The TO-BE-PROCESS - Billing

- Yearly Advance Payment Scheme

Cost	Benefit	Risks	Remarks
1.320M : No meter replacement 4.837 M : With meter replacement	1. Cost savings to BPC = 1.141 M per year for ESD, Tsirang	Theft cases going unnoticed for a period of 3 months	The billing will be done every 3 months. Rebate of Nu. 28.9 per customer per month. Savings on travel by customer (only 1 time in a year).
	Customers can pay after yearly harvest	Bill date for oct, nov, dec consumption will be available by 15 Jan. The actual consumption of all the customers can be made only in March.	
	Every customer gets 30-45 days period to pay the bills	Accumulated advance is high. Paying capacity??	
	MB costs cut down by 66 %.		

The TO-BE-PROCESS

- Comparison between the schemes

Parameters	3 monthly post paid	3 monthly prepaid	1 year advance
Cost	1.320M : No meter replacement 4.837 M : With meter replacement	1.320M : No meter replacement 4.837 M : With meter replacement	1.320M : No meter replacement 4.837 M : With meter replacement
Benefit	0.941 M per year	0.950 M per year	1.141 M per year
Rebate	Nu. 19.86 per customer per month	Nu. 20.78 per customer per month.	Nu. 28.90 per customer per month.

One year advance scheme not recommended as the risk of accumulated advance can affect the paying capacity.
The 3 monthly post paid is preferred over 3 monthly prepaid because no advance billing is required.

The TO-BE-PROCESS

- The schemes can be implemented without any change of meters as monthly consumption of a rural customer is seen to be much lesser than 100 units/month. 1.320 M Ngultrums is for software change requests.
- The estimated amount of 4.837 M is for replacement of meters to static/digital which BPC as per the policy would anyway invest over time and also this will only make the scheme more robust even if the consumption increases over 100 units over the period of time.
- The scheme would be more robust if the meters would be replaced in the initial phase so that snap shots of monthly energy sales will be mapped every month, thereby providing accurate & realistic monthly system performance.
- The risks with yearly closing (if at all) will be done away with enough SBMs. DCSD has recently made a breakthrough on the SBMs, andriod based machines can now be used for the purpose of billing and the costs of each andriod machine is 19,000 as compared to 70,000 for traditional SBMs. The new andriod based machines shall be rolled out from July 2014 on a pilot basis.

The TO-BE-PROCESS - Advanced Metering Infrastructure Automatic Meter Reading (AMR)

Cost	Benefit	Risks	Remarks
P1 : 1.9 M P2 P3	Reduced Billing costs for BPC.	Technology upgrades and dependence on communication networks	P1: HV MV P2: LV Bulk & Thimphu P3: All customers (ADSS & OPGW leverage) Co-ordination & integration with DMS & other technologies
	This will also result in better energy management.	Sustenance of technical expertise	
	Every customer gets 30-45 days period to pay the bills		
	Faster as travel time is reduced.		

78.63 % of the energy sales are from HV/MV, hence accurate & realistic data capture is a must. Therefore, BPC should invest in this option

The TO-BE-PROCESS - Advanced Metering Infrastructure Group Metering (For Thimphu)

Cost	Benefit	Risks	Remarks
91.375 M Meter costs + Server + Software change requests	Reduced Billing costs for BPC.	Technology upgrades and dependence on communication networks	This could be considered for as AMR P2 and P3.
	Accurate & realistic data capture. Better energy management.	Sustenance of technical expertise	
	Every customer gets 30-45 days period to pay the bills		
	Faster as travel time is reduced.		

The costs are very high and cannot be implemented

The TO-BE-PROCESS - Advanced Metering Infrastructure SMS Reading & Billing (For Thimphu)

Cost	Benefit	Risks	Remarks
0.35 M + 0.720 M + 0.15 M = 1.22 M Sunk + Software Change Request + Contingency	Cost savings to BPC = 1.9 M per year for ESD, Thimphu	Theft cases going unnoticed for a period of 3 months	Rebate of Nu. 7.28 per customer per month. The above rebate is calculated considering that 100 % customers send sms
	Reduced Billing costs for BPC.	The customers do not have fixed address and keep moving houses	
	100 % network connectivity in urban part of the country.	Readings can be wrong or manipulated	
	All the urban people can read and send SMS.		

Costs is low, the benefits are tangible and can be easily implemented.

IMPLEMENTATION PLAN

Implementation plan documenting metering policies

	Responsibility	Jan-14	Feb-14	Mar-14	Apr-14	May 14' onwards
Documentation of policies	DCSD					
Presentation to management for approval	DCSD					
Distribute to ESDs for implementation	DCSD & Respective ESDs					

Implementation plan for 3 monthly schemes

	Responsibility	Jan-14	Feb-14	Mar-14	Apr-14	May-14	Jun-14	Jul-14	Aug-14	Sep-14	Oct-14	Nov-14	Dec-14	Jan15' onwards
Change request for ISU/ERP	ISU, DCSD & ITD													
Replace existing meters with static	ESD, Tsirang													
Train the meter readers & Managers	ISU, DCSD													
Pilot Study in ESD Tsirang	DCSD & ESD, Tsirang													
Roll out in other ESDs	DCSD & Respective ESDs													

Implementation plan for SMS Reading & Billing

	Responsibility	Jan-14	Feb-14	Mar-14	Apr-14	May-14	Jun-14	Jul-14	Aug-14	Sep-14	Oct-14	Nov-14	Dec-14	January 15' onwards
Change request for ISU/ERP	ISU, DCSD & ITD													
User training	ISU, DCSD & ITD													
Pilot study in ESD, Thimphu	DCSD & ESD, Thimphu													
Roll out in other ESDs	DCSD & Respective ESDs													

Implementation plan for AMR

	Responsibility	Jan-14	Feb-14	Mar-14	Apr-14	May-14	Jun-14	Jul-14	Aug-14	Sep-14
Scoping & Tendering	DCSD									
Evaluation & award	DCSD									
Implementation for 62 customers (HV/MV)	DCSD & Respective ESDs									

Conclusion

Metering policy shall be documented.

For rural customers

3 monthly Post paid scheme as a pilot study in ESD, Tsirang

For HV MV

Automatic meter reading

For Urban customers

SMS as a pilot study in ESD, Thimphu

Theme 8

PI Solving Activity
Theme # 8

Theme title: "Fault locating and Rectification of HV/LV Arial Bundle conductor and UG cables".

Presented by:
Nidup (Engineer),Team leader
Nidup Dorji (Supervisor, ESD)
Duptho Wangdi (Associate Engineer)
Jigme Sherub (Supervisor, RED)
Mr.Junichi Ohishi (Chief staff, Advisor) &
Mr.Kazuhiro Yoshimura (Advisor)

Over view…..

1. Why this issue was selected?
2. Current situation
- Cause analysis
3. Measures taken
- Fault locator equipment from Togami.
- Work carried out and its result
4. Comparison between Fault Locating Equipment of Togami and Megger
5. Cost benefit analysis
6. Recommendation
7. Formation of fault locator team and it's training
8. Action plan

Reason for selecting this Issue

UG Cable

- 10 to 15 years back, cables were laid with route markers. But with rapid development taking place, route markers were not found (may be buried or stolen), loosing its cables route. Due to this it's difficult to locate the fault for Under ground cables.

ABC Cable

- When fault occurs, it's very difficult to locate/pinpoint the fault. BPC do have equipment(MTDR300/100) but no one is confident enough to operate in a correct way.

Current situation

1. **Underground Cable**
- Difficult to trace the route of cables.
- No one is confident to use the equipment in a correct way

Fault data of Changjalu area (UG Cable)

Date	location	Time		outage duration(Hr)	Note	Causes of Outage
		Tripped	Restored			
3/4/2010	Changjalu	10am	12noon	2	Line trip from 750KVA Changjalu package substation A	Mechanical excavator or similar
4/26/2010	Changjalu	3pm	6pm	3	Line trip from 220kv S/S at Semtokha due to Earth Fault	Mechanical excavator or similar
5/29/2010	Changjalu	11am	1pm	2	Line trip from 750KVA Changjalu package substation A	Mechanical excavator or similar
6/3/2010	500KVA old PWD S/S near Kelki School	5:15pm	Not yet restored	-	Line trip from DPH Substation due to earth fault	Unknown
7/15/2010	Changjalu	11:30am	3pm	3.5	Line trip from 750KVA Changjalu package substation A	Mechanical excavator or similar
7/18/2010	Changjalu	8:30am	2:30:pm	6	Line trip from 220kv S/S at Semtokha due to Earth Fault	Mechanical excavator or similar
9/6/2010	Changjalu	10am	2pm	4	Line trip from 220kv S/S at Semtokha due to Earth Fault	Mechanical excavator or similar
11/11/2010	Changjalu	4:30pm	7:30pm	3	Line trip from 220kv S/S at Semtokha due to Earth Fault	Mechanical excavator or similar
11/23/2010	Changjalu	11am	3pm	4	Line trip from 750KVA Changjalu package substation A	Mechanical excavator or similar
12/23/2010	Changjalu	7am	10am	3	Line trip from 750KVA Changjalu package substation A	Mechanical excavator or similar
12/28/2010	Changjalu	1pm	5pm	4	Line trip from 750KVA Changjalu package substation A	Mechanical excavator or similar

Causes of fault (UG Cable)

- As per the above data, most of the cable were damaged by external force/excavator. (due to developmental activities)
- As per our third country survey findings, fault occurs mainly through cable jointing

2. HV/LV ABC (OH)

Besides having equipment no one is confident enough to operate in a correct way.

When ever a fault occurs in ABC line, site people inspect visually to locate the fault which takes a lot of time increasing the recovery time.

Data collection

Phobjikha, Wangdue. Jan to March, 2013

Date	location	Trip Time	Restored time	Outage duration(Hr)	Remark/11kV/LT Line
6-9/12/12	kIlkhorthang/Gangphel feeder	3:30pm	4pm	72.5	LT fault/11kV cable sparking
1-6/01/13	Gangphel feeder . Zhizi	5am	4pm	131	line fault from indoor and outdoor tapping
2-3/01/13	Gangtey feeder. Gakiling /BHU	6:30pm	5:30pm	23	line fault from cable
7-8/01/13	**Gangphel feeder/Tangchey**	**5pm**	**3pm**	**22**	**HV ABC indoor and outdoor tapping sparking**
18-21/01/13	**Gangphel to Ramechen**	**3am**	**5:57pm**	**82**	**HV ABC cable sparking through it**
30-31/01/13	Gangtey feeder above Druk seed	10:20am	-	-	line sparking through cable jointing
02-4/02/13	Gangtey feeder behind BHU	2:21pm	3:45pm	49	line sparking through cable jointing
06-7/02/13	Gangtey feeder behind BHU	8:24pm	4:42pm	20	line sparking through cable jointing
9-10/03/13	Station between Dewachen , Gantey feeder	2:15pm	3:50pm	25	line fault due to snow fall
12-16/03/13	Gangtey feeder near Bayta school.Ganghu feeder Zhizi/soba	5:41pm	4:47pm	95	underground cable spark , LT fault and cable sparking
21-25/03/13	Gangphel feeder, Khamdro/Tangchey	7pm	3:34pm	92	line fault through cable it due to rain fall
25-28/03/13	Gangphel feeder, Tangchey	3:34pm	12:51pm	69	line fault through T-joint
29/03/13	Gangtey feeder/koombu	3:17pm	-	-	LT line fault through cable

Causes of fault (ABC)

- Based on the data collected, most of the faults occurred through cable jointing.
- Faults occurred through natural calamities
- May be the Cables could have been damaged during the construction phase.

Summary on current situation

- Being a developing country, use of underground cables will be more in the near future.
- As per the studies carried out, there are more issues in case of underground cable comparing with ABC line. (Site people are facing problems in locating fault in case of UG cable)
- Based on the above issues, more importance has been given to underground cables.

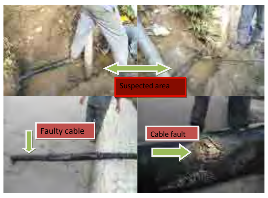
Fault locator equipment(UG Cable) T2LUPIN & HV BRIDGE

Procedure for fault locating(UG Cable)

1. Identifying fault cable
2. Measuring resistance of fault cable: Determines cable Length
3. Applying HV-Bridge : Estimation
4. Applying T^2 LUPIN : Detail investigation
5. Finish

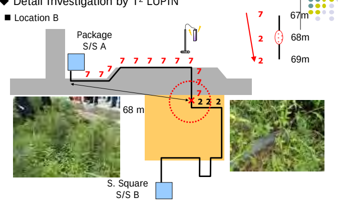
Work carried out by JICA
Carried out in three location.
1. Changjalu area..

1. Result in location A



1. Fault location B

- Detail Investigation by T^2 LUPIN
- Location B



1. Result location B

1. Fault location at C

Result at location C

Comparison between UG FLE of Togami & Megger.

Fault locator equipment	T2LUPIN & HV BRIDGE	PFL40A(Megger)
Portability	its portable, so site people wont face difficult regardless of its location.	If the Site is not accessible to road, site people will face difficulty in carrying the equipment
Route and depth trace	Route is traceable without UG GIS data Mapping	Difficult to trace route As per the previous records
Accurate fault point detection	Although not 100%, Witnessing three fault point location, the team are convinced about its accuracy.	As per previous record, while conducting training they couldn't locate the fault.

Comparison between FLE of Togami & Megger.

Fault locator equipment	T2LUPIN & HV BRIDGE	PFL40A(Megger)
Usability	Technician people will be able to understand its working principle.	As per it's manual, different methods are there but no one is confident to operate in correct way.

Cost benefit analysis
Cost of equipment

Cost of fault locator equipment

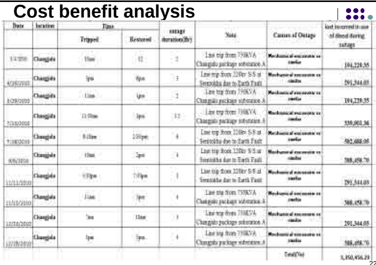
Qty	Description of goods	unit price USD	amount USD
1 set	UG Distribution line Fault Locator Type: SLUT-A-Y50	36,100	36100
1 pac	Export packing,all courier & handling charges	6500	6500
	Total		42600
1 set	HV BRIDGE MEASUREMENT Type: 1011,L610, and step down transformer	24500	24500
1 pac	Export packing,all courier & handling charges	2100	2100
	Total		26600
	UG Distribution line Fault Locator Training Training is joint operation with Tepco Purchase of two sets of equipment shall be the condition of this training price	3060	3060
	Total	3060	3060
1 set	Mili Ohm meter	777	777
	Total amount (USD)	73037	
	Total amount (NGULTRUM)	4747405	

Cost benefit analysis

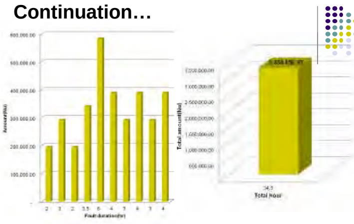
Generator capacity	125KVA
Starting time	10:57AM
stopping time	11:57AM
Connected load	5.5kW
Initial diseal in tank	197ltr
Diseal in tank at the end	188ltr
fuel consumption in 1hr of 5.5kW	9 ltrs
fuel consumption in 1hr of 1kW	1.64ltrs
prize of diseal per ltr	Nu 51
Cost of diseal used per hr(Nu) per hr	83.64

	customer		Billed Qty	Bill mount
		KW	KWh	Nu
2018/01	2431	1310	948,246.00	1,620,579.50
2018/02	2431	1217	876,124.00	1,488,227.40
2013/03	2431	956.4	638,613.00	1,100,333.76
	2431	1161	2,507,983.00	4,204,130.66
Cost on 1KW per hr				83.64
Average cost on 1161KW per hr				97,114.68

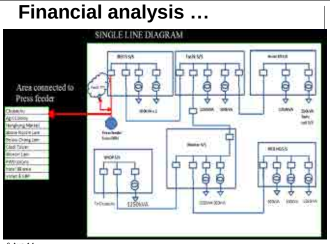
Cost benefit analysis



Continuation…



Financial analysis …

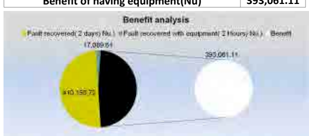


Customer connected and it's bill

Route #	Area	No of Customer	Summer 3months consumption qty(KWH)	Summer 3months consumption Amount(Nu)	Winter 3 months Consumption qty(KWH)	Winter 3 months Consumption Amount(Nu)
P10_21	Chubachu	534	76,912.00	138,697.04	1114792.645	2,000,078.00
P10_23	Agri Colony	236	527,380.00	921,365.47	390,224.00	700,110.86
P10_25	Hongkong Market	593	309,109.00	519,608.93	877,645.00	1,555,823.51
P10_31	above Norzin Lam	727	383,521.00	633,940.26	1,170,256.00	2,103,566.42
P10_32	Below Chang Lam	877	641,971.00	1,036,874.23	1,051,238.00	1,823,690.06
P10_33	Clock Tower	455	706,602.00	1,123,268.16	1,380,146.00	2,733,648.13
P10_34	Wonzin Lam	426	824,975.00	1,579,654.35	1,089,508.00	2,070,175.68
P10_41	PWD colony	180	292,021.00	531,900.17	557,083.00	1,095,981.31
P10_42	hotel 89 area	622	347,955.00	651,244.63	951,675.00	1,730,172.66
P10_46	imtart & RBP	42	555,147.00	800,730.87	1,534,234.00	3,258,761.85
		4692	4,665,593.00	7,937,284.11	10,116,801.65	**19,072,008.48**

Financial analysis …

per month average(Nu)	6,357,336.16
per day average(Nu)	205075.36
per hour average	8544.806667
If the feeder remains shut down for 2 days(Nu)	410,150.72
if the feeder remains shut down for 2hrs(fault recovered using new Equipment)(Nu)	17089.61333
Benefit of having equipment(Nu)	**393,061.11**



Recommendation from fault locating team

UG fault locator

Based on

- **Comparison done between Fault Locator Equipment of Megger & Togami**
- **Witnessing fault location using Fault Locator Equipment of Togami.**
- **Cost benefit analysis**

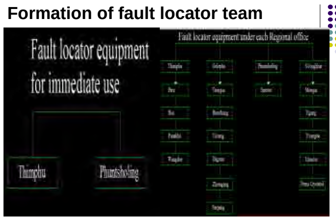
The fault locator team would strongly recommend to buy Fault Locator Equipment of Togami as it serves both as a route tracer and fault locator.

The team would like to propose two sets of equipment.

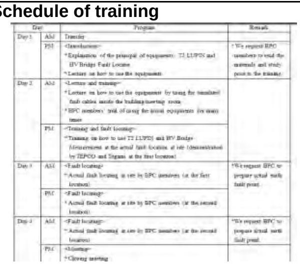
UG fault locator

Equipment	Unit price(USD)	Qty	Amount(USD)	Training cost(USD)
T2LUPIN(SLUT-A-Y50)(Togami)	42600	2	85200	3060
HV BRIDGE(Mitsubishi)	26600	2	53200	
MILI OHM METER(HIOKI)	777	2	1554	
TOTAL		6	139954	3060

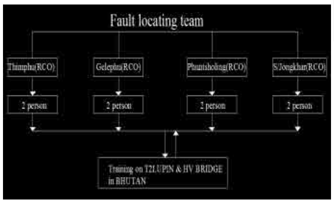
Formation of fault locator team



Schedule of training



Members for training



Recommendation from fault locating team

HV/LV ABC fault locator

- **In present situation, fault occurs frequently incase of overhead line but when it occurs it is difficult to locate the fault point.**
- **Training is already finalized for the fault locating equipment(30th September -3rd October)**
- **If trainees are satisfied with the equipment then the team would recommend to purchase the equipment.**
- **As per third country survey, while visiting manufacturing company, their recommendation was to handle the cable properly during construction phase, so to reduce occurrence of fault in near future.**

Action Plan

No	Action	Sept.	Oct.	Nov.	Dec	Jan	Feb.	Mar.	Apr.
01	Hands on training for fault locating equipment **(Megger Company)**								
02	Review and approval for purchasing of fault locator equipment **(Management)**								
03	Giving supply order to Togami Mfg.Co Ltd. **(PSD)**								
04	Delivery of equipment by Togami Mfg.Co Ltd. To BPC & Payment. **(Togami & BPC)** Formation of fault locator team **(DCSD)**								
05	Hands on Training to Fault locator team by expert from Togami. **(Togami)**								

Acknowledgement

The team would like to thank :

- BPC Management for selecting and letting the team to study on this important issue.
- JICA team including the advisor for guiding till date in carrying out the activities in a proper way.
- All ESD offices for providing relevant data.
- PT. Jembo Cable Company and State Electricity Company (Indonesia) for their warm welcome and support which was useful in doing the comparative studies.

Thank you

Theme 9

PRIORITY SOLVING ACTIVITY - 2013

Theme: 9

Effective Utilization of Geographical Information System (GIS) in BPC

September 25, 2013

Team Members.
1.Mr. Dorji Tshewang, DCSD.
2.Mr. Pema Wangchuk, EDCD.
3.Mrs. Kesang Choden, DCSD.
4.Mr. Nima Dorji, RED.
5.Mr. K.B. Gurung, ESD, Zhemgang.
6.Mr. Masaki Iwama, JICA Expert, TEPCO.

Outline

Brief Background

- Introduced in the beginning of 2003 through JICA project during the study of integrated master plan for Dzongkhag-wise electrification in Bhutan.
- The GIS was started to provide various spatial data for:
  - preparing the master plan.
  - updating the master plan.
  - implementation of RE Projects.
- GIS related works are carried out by Environment & GIS Division (EGD), Engineering Design & Contracts Department (EDCD).

Reason for Theme Selection

- The usage of GIS is very marginal and its benefit not appreciable as of today.
- The GIS unit is largely unorganized and lacks capacity.
- No GIS Base map in place. (Appendix II)
- No proper system of GIS data reporting.
- Underutilization of GIS Data. (Appendix I)
- The state of GIS still stands at where it was first initiated in 2003.
- Lack of awareness of GIS application in BPC.

Objective

- To optimize the use of GIS data for overall improvement of efficiency in BPC.
- To strength the capacity of existing GIS users in BPC.
- To create awareness on the importance of GIS in BPC.

Concept of GIS, GPS & Google Earth

- **Geographical Information System (GIS)**
  - Computer based tool for mapping and analyzing features on earth.
  - System used for land planning, Environmental Management, Mapping of Roads, Railway Lines, Electrical Transmission and Distribution Network.
  - It helps in collecting every information.

GIS Components: Hardware | Software | Data | People | Methods

- **Global Positioning System (GPS).**
  - Satellite based navigation, timing and positioning system.
  - Applications in GIS data collection, surveying and mapping.
- **Google Earth.**
  - A virtual globe, map and geographical information program.
  - It is simply based on 3D maps, with the capability to show buildings and bridges in 3D.

Current Situation

Hardware
- One or more GPS in every ESD's. (Appendix II)
- Type of GPS. (Appendix III)
- No dedicated computers. (Appendix IV)
- No GIS Database Server.
- One Plotter in Head Office.

Software
- Lack of Original Software. (Appendix V)
- Usage of Open source GIS software.

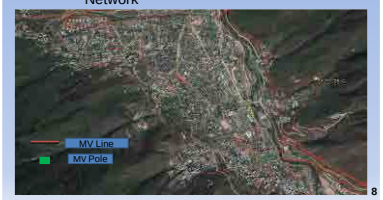
Data
- GIS Database of Distribution and Transmission Network. (Appendix VII)
- No Customer Database and Mapping.
- Data Error. (Appendix VIII)

People
- GIS/GPS user in BPC. (Appendix VIII)
- Inadequate manpower.
- Lack of GIS Expertise.
- Lack of Training. (Appendix IX)

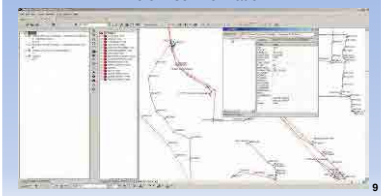
Method
- Procedure. (Appendix X)
- No proper system of GIS data reporting. (Appendix XI)

GIS Data not Effectively Utilized.

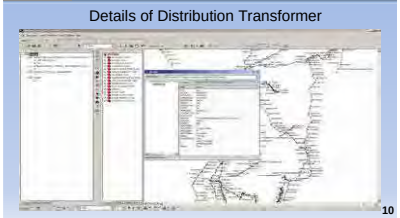
Sample Geographical view of the Network



Pole wise Information



Details of Distribution Transformer



Third Country Visit

As a part of the Study Tour, the JICA provided an opportunity to visit two Power Utilities such as Provincial Electricity Authority (PEA) and Metropolitan Electricity Authority (MEA), Bangkok, Thailand including one of the well known manufacturing companies know as Thai-Yazaki Manufacturing Company.

Summary of Day wise Report.

June 24, 2013	Travelled to Bangkok, Thailand.
June 25, 2013	Visit to PEA Head Quarter (HQ) and GIS Center in HQ at Bangkok, Thailand.
June 26, 2013	Visit to PEA Area 2 Central Region (Chonburi Province) and Chachoengsao Province.
June 27, 2013	Visit to Thai Yazaki Manufacturing Company.
June 28, 2013	Visit to MEA Head Quarter, Bangkok, Thailand.
June 29, 2013	Return to Bhutan.

Learning Outcome

- GIS system is so advanced and fully established.
- They have GIS Database Server.
- They have their own GIS Map with their infrastructure details.
- Everyday data update is very important.

- Their GIS personal are from different background;
  1. Electrical Engineer,
  2. Survey Engineer and
  3. Computer Engineer.
- They are trained for a year on GIS and other related applications.
- GIS has made their work more easy and reliable in the management of power outage and customer services due to the integration of GIS with other applications.

Application of GIS in BPC

GIS offers power organizations a method of quickly accessing and producing maps. Using GIS streamlines daily workflow and improves decision making.

Application of GIS in BPC

- Distribution & Customer Services Department
- Rural Electrification Department (RED).
- Transmission Department.
- Environment & GIS Division, EDCD.
- Infocomm Services Division.
- National Load Dispatch Center.

Distribution & Customer Department (DCSD) & Rural Electrification Department (RED)

- Extension of new line.
- Installation of meter.
- Distribution Transformer Metering Mapping.
- Operation and Maintenance.
- Customer Service.

15

Extension of new line.

16

Installation of new meter.

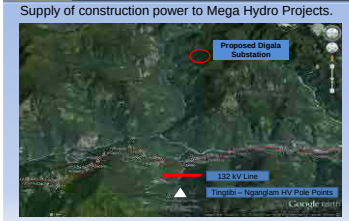
17

Transmission Department (TD).

- For routine maintenance.
- Initial GPS survey for the selection of suitable sites for Transmission route.
- Supply of construction power to Mega Hydro Projects.
- GIS in Right of way (ROW) issues like land easement and acquisition.

18

Supply of construction power to Mega Hydro Projects.



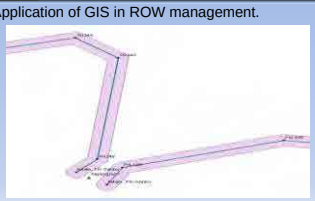
19

Environment & GIS Division, EDCD.

- GIS applications can manage the power company's environmental compliance.
- Manage right-of-way activities including planning and management, property acquisition, vegetation management and corridor preservation.
- To buffer and overlay right-of-way requirements for tower placements, query features to identify property owners and other land information.

20

Application of GIS in ROW management.



21

Infocomm Services Division

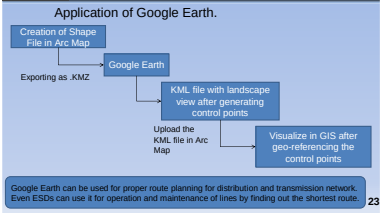
- GIS mapping of OPGW and ADSS network.
- GIS in extension of new network to any center.(Appendix XX)
- Maintenance of the cable.

National Load Dispatch Center (NLDC)

- GIS integration with SCADA.

22

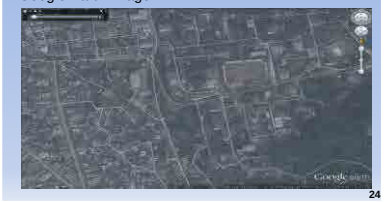
Application of Google Earth.



Google Earth can be used for proper route planning for distribution and transmission network. Even ESDs can use it for operation and maintenance of lines by finding out the shortest route.

23

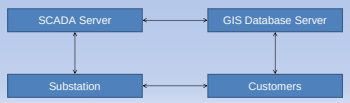
Google Earth Image



24

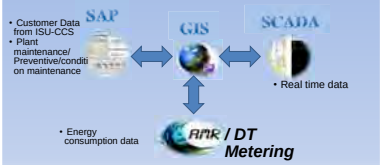
GIS & SCADA

- Supervisory Control & Data Acquisition (SCADA) is used to monitor and control the electrical utility.
- **Advantage** : Visualize the SCADA events in GIS and help identify consumers within the affected areas.



25

Ideal Situation for BPC



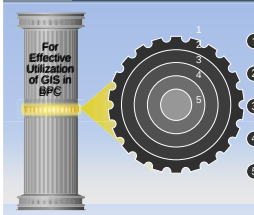
26

Ideal Situation Contd...

- Provide Complete geographical based network data map which can be used for the management of following:
  - Asset Management/Monitor.
  - Dynamic map production, visualization and understanding real scenario.
  - Efficient Planning of Maintenance.
  - Location of Faults including UG.
  - Effective network extension/augmentation.
  - Right of way issues.
  - Customer Management viz. attending complaint, releasing new service connection etc.
  - Energy Auditing.
  - Provide analytical tool such as distance calculation, shortest path etc.
  - Load forecasting.
  - Substation locating and sizing.
  - Feeder routing.
  - Transformer and feeder optimization.
  - Possibility of data sharing between different users simultaneously.
  - Easy and speedy retrieval of information.

27

Counter Measure



1. Develop a clear guideline for GIS management.
2. Reorganize existing GIS system in BPC.
3. Purchase of hardware and software resources.
4. Update incomplete data.
5. Build manpower competency.

28

Implementation Plan

- Proposal of Consultancy Firm.
- Formation of GIS core Group.
- Prepare Actual Road Map with the help of consultant.
- Purchase of GIS and Google Earth Software.
- Capacity building/training.
- Data update and
- Customer Mapping.
- Purchase of computer for ESD's GPS/GIS focal person.
- Set up GIS server.
- Training.
- Creation of BPC map.
- Integration of GIS with SCADA and SAP.

29

Cost Analysis

Particular	Budget
Computer (45,000.00*19)	855,000.00
GIS Software (Appendix XIII)	1,431,457.41
Google Earth Software (Appendix XIV)	103,740.00
Training (Appendix XV)	1,825,000.00
Consultant (PEA GIS Specialist)	1,000,000.00
GIS Server (Appendix XVI)	690,000.00
Total	5,905,197.41

30

Action Plan

Action Plan - 2014

Sl.No.	Activities	January - April	May - June	July - August	September - December
1	Proposal of Consultancy Firm and formation of GIS Core Group.				
2	Prepare actual Road Map with the help of Consultant and Purchase of GIS and Google Earth software.				
3	Training and formulation of proper guideline.				
4	Data update and collection of spatial data.				

DCSD, EGD (EDCD) and Infocomm Services Division should be responsible.

31

Conclusion

- GIS provide a solutions for comprehensive and effective distribution and transmission management.
- GIS is used to spatially analyze network congestion and determine site feasibility.
- GIS Specialist and capacity development is very important.
- Using GIS will make it more efficient and reliable organization in simplifying daily workflow and improving the decision making.

32

Reference

- Patty,.McGray. “GIS Education Solutions from ESRI, Building Geodatabse – II”.
- De By,. Rolf A. “Principles of GIS“.
- www.esri.com.
- www.itc.nl.

33

Thank You

34

Theme 10

STUDY ON SUSTAINABILITY & EFFECTIVE USAGE OF EXISTING MINI / MICRO HYDELS OF BPC

TEAM MEMBERS:

1. Sonam Phuntsho, CMTD, DCSD (Team Leader)
2. Kezang Lhazom, CWD, EDCD
3. Gyeltshen, ESD, Bumthang
4. Yeshey Tshering, ESD, Mongar

ADVISORS:

1. Keiichi Fujitani, JICA Expert
2. Tshewang Rinzin, Manager, ESD, Thimphu

OUTLINE

1. REASONS FOR SELECTING THIS THEME AS A PRIORITY ISSUE
2. SCOPE OF THIS STUDY
3. MINI HYDELS OF BPC
4. MICRO HYDELS OF BPC
5. PRESENT SCENARIO OF MINI/MICRO HYDELS OF BPC
6. O&M COST INCURRED IN THE PAST 5 YEARS (2008-2012)
7. REVENUE GENERATED IN THE PAST 5 YEARS (2008-2012)
8. RETURN ON INVESTMENT
9. NPV, IRR & PAY BACK PERIOD ANALYSES OF CONNECTING MICRO HYDELS TO GRID
10. CONCLUSION
11. RECOMMENDATION
12. ACTION PLAN

2

REASONS FOR SELECTING THIS THEME AS A PRIORITY ISSUE

- No study on sustainability and effective usage of MHPs of BPC
- No detailed status report on the current health of the MHPs (Civil structures, E&M components, Electrical components, etc.) is available
- Although grid supply is available in most of the areas where the MHPs are located, no financial analysis on grid connection of micro hydels has been carried out.

3

SCOPE OF THIS STUDY

Following are included in this study:

- Present scenario of the MHPs
- Cost of O&M of the MHPs (including renovation / rehabilitation / overhauling) between 2008-2012
- Revenue generated between 2008-2012 from the MHPs
- Cost-Benefit Analysis of all MHPs together and for individual plant between 2008-2012
- NPV, IRR and Pay-back period analyses for grid connection of 7 Micro HPs and Gangzur Mini Hydel

The following plant is not included in the study:

- Hesothangkha Mini Hydel falls under the submergence area of PHPP-I and shall no longer be operated by BPC once the PHPP is operational

4

MINI HYDEL PLANTS OF BPC

Sl. No.	Plant	Installed Capacity (kW)	Year of commissioning	Automation	No. of Operators
1	Gangzur Mini Hydel	2x60	Upgraded in 2000 (1986-1x20kW)	Manually operated	02
2	Changchey Mini Hydel	2x100	1992	Semi-automated	01
3	Darachhu Mini Hydel	2x100	1992	Semi-automated	01
4	Rongchu Mini Hydel	2x100	2001	Semi-automated	01
5	Tingtibi Mini Hydel	2x100	1992	Semi-automated	02
6	*Hesothangkha Mini Hydel*	*3x100*	1969	Manually operated	04
7	Thimphu Mini Hydel	4x90	1967	Manually operated	07
8	Khalanzi Mini Hydel	2x200	1975	Manually operated	02
9	Chenary Mini Hydel	3x250	1973	Manually operated	-
10	Gidakom Mini Hydel	5x250	1972	Manually operated	07
11	Chumey Mini Hydel	3x500	1989	Manually operated	07
12	Rangjung Mini Hydel	2x1100	1996	Semi-Automated	04

5

MICRO HYDEL PLANTS OF BPC

Sl. No	Plant	Installed Capacity (kW)	Year of commissioning	Remarks
1	Kekhar Micro Hydel	1x20	1986	•All Micro hydels are semi-automated & hence unmanned. •A multi-task operator visits the plant once a week to checks & clean. •Run in isolated mode (no grid connection)
2	Kuengarabten Micro Hydel	1x30	1992	
3	Tamshing Micro Hydel	1x30	1992	
4	Tangsibji Micro Hydel	1x30	1992	
5	Rukubji Micro Hydel	1x40	1992	
6	Sherubling MicroHydel	1x50	1992	
7	Ura Mirco Hydel	1x50	1992	

6

PRESENT SCENARIO OF MINI HYDELS

Sl.	Plant	Particulars	Condition	Remarks
1	Rangjung (2x1100 kW), Trashigang	Civil structures	Good	➢ Commissioned in 1996 ➢ Both units are running
		Electro-Mechanical	Good	
		Electrical panels	Good	
2	Chumey (3x500kW), Bumthang	Civil	Good	➢ Commissioned in 1989 ➢ Only one unit is currently running. ➢ Study to overhaul E&M equipments is under way by DCSD.
		E&M	Good	
		Panels	Protection System not functioning	
3	Gidakom (5x250kW), Thimphu	Civil	Cracks in the water channel	➢ Commissioned in 1972 ➢ Repair of water channel required. ➢ Repair/replacement of Unit V panel is required. ➢ Study on automation underway by DCSD.
		E&M	Good	
		Panels	Problem with Unit V panel	
4	Chenary (3x250kW), Trashigang	Civil	Penstock & water conductor (hume pipes) are removed	➢ Commissioned in 1973 ➢ Major over-hauling b/w 1997-2002 ➢ Shutdown for rehabilitation since 2004 flood caused major damage ➢ Renovation of civil intake structures, etc. done ➢ Procurement of penstock & water conductor system (by DCSD) is underway.
		E&M	Good	
		Panels	Good	
5	Khalanzi (2x200 kW), Mongar	Civil	Upgraded to 2x200 kW with new E&M parts	➢ Commissioned in 1975 (3x130kW) ➢ Shutdown for rehabilitation since 2011 ➢ Procurement of penstock bifurcation pipes underway.
		E&M		
		Panels		
		Civil	Cracks in power channel	➢ Commissioned in 1967

7

PRESENT SCENARIO OF MINI HYDELS

Sl.	Plant	Particulars	Condition	Remarks
7	Changchey (2x100kW), Tsirang	Civil	Problem in water channel	➢ Commissioned in 1992. Connected to grid recently. ➢ Power channel (110m) has to be reconstructed. ➢ Maintenance required at Intake ➢ Replacement of runners required in near future
		E&M	Runners worn out in both machines	
		Panels	Good	
8	Darachhu (2x100kW), Dagana	Civil	Good	➢ Commissioned in 1992 ➢ Shutdown b/w 2010-2012 to reconstruct power channel. ➢ Recently connected to grid. ➢ Replacement of runners required in near future
		E&M	Runners worn out	
		Panels	Good	
9	Rongchhu (2x100kW), Lhuntse	Civil	Minor cracks in the power channel	➢ Commissioned in 2001 ➢ Connected to grid ➢ Power channel repair required. ➢ Replacement of runners required in near future.
		E&M	Runner worn out in both machines	
		Panels	Good	
10	Tingtibi (2x100kW), Zhemgang	Civil	Good	➢ Commissioned in 1992 ➢ Connected to grid ➢ Replacement of runners required in near future.
		E&M	Runners worn out in both machines	
		Panels	Good	
11	Gangzur (2x60kW), Lhuentse	Civil	Cracks in water channel	➢ Commissioned in 1992. Not connected to grid. ➢ Water channel repair required. ➢ E&M equipment need to be overhauled. ➢ Problem with protection system ➢ Plant recently under shutdown due to battery
		E&M	Generators & Runners worn out	
		Panels	Governor worn	

8

PRESENT SCENARIO OF MICRO HYDELS

Sl	Plant	Particulars	Condition	Remarks
1	Kekhar (1x20kW), Zhemgang	Civil structures (Intake, fore-bay, penstock pipes, water channels)	Water channel washed away	➢Running ➢HDPE pipes are used as a temporary measure to conduct water ➢Reconstruction of water channel and minor maintenance at Intake required.
		Electro-Mechanical parts (Generator/ turbine/ governor)	Good	
		Electrical component / panels	Good	
2	Kuenga Rabten (1x30kW), Trongsa	Civil	Power channel washed away	➢Plant is under shutdown. ➢Water channel gets frequently washed away; unstable stretch of land
		E&M	Good	
		Panels	Good	
3	Tamshing (1x30kW), Bumthang	Civil	Water channel washed away	➢Plant is under shutdown since May 2012. ➢Reconstruction of water channel and minor maintenance at Intake required.
		E&M	Good	
		Panels	Good	
4	Tangsibji (1x30kW), Trongsa	Civil	Minor cracks in the water channel	➢Running ➢Minor repair required in the power channel
		E&M	Good	
		Panels	Good	
5	Rukubji (1x40kW), Wangdue	Civil	Cracks in the water channel	➢Running ➢Minor repair required in the power channel
		E&M	Good	
		Panels	Good	
6	Sherubling (1x50kW), Trongsa	Civil	Cracks in the water channel	➢Flash flood near powerhouse this year has caused shutdown. ➢Repair of water channel needed.
		E&M	Good	
		Panels	Good	

9

O&M COST OF MHPs FROM 2008-2012

Sl. No.	Plant (Capacity in kW)	MTNC COST (in Mil Nu.)	OPERATION (PERSONNEL) COST (in Mil Nu.)	COST OF SPARES (in Mil Nu.)	Total for each Plant (in Mil Nu.)
1	**Rangjung (2x1100)**	1.524	10.484	2.424	**14.432**
2	**Chumey (3x500)**	0.616	4.053	3.284	**7.953**
3	**Gidakom (5x250)**	0.842	14.778	0.888	**16.507**
4	**Chenary (3x250)**	6.621	-	-	**6.621**
5	**Khalanzi (3x130)**	20.583	3.101	0.198	**23.882**
6	**Thimphu (4x90)**	0.291	8.261	0.668	**9.220**
7	**Changchey (2x100)**	0.960	1.860	0.068	**2.888**
8	**Darachhu (2x100)**	2.857	1.152	0.446	**4.455**
9	**Rongchu (2x100)**	0.068	1.120	0.339	**1.528**
10	**Tingtibi (2x100)**	1.419	1.120	0.106	**2.646**
11	**Gangzur (2x60)**	0.156	2.001	0.785	**2.943**
12	**Sherubling (1x50)**	0.460	0.150	0.083	**0.693**
13	**Ura (1x50)**	0.210	0.150	0.125	**0.486**
14	**Rukubji (1x40)**	0.531	0.150	0.037	**0.718**
15	**Kuenga Rabten (1x30)**	0.165	0.150	-	**0.315**
16	**Tamshing (1x30)**	0.359	0.150	0.084	**0.593**
17	**Tangsibji (1x30)**	0.162	0.150	0.212	**0.524**
18	**Kekhar (1x20)**	0.012	0.150	0.022	**0.183**
		37.836	**48.981**	**9.769**	
	TOTAL COST (in Million Nu.)				**96.586**

Maintenance cost is inclusive of grid connection & major rehabilitation works.

10

REVENUE GENERATED FROM 2008-2012

Sl. No.	Plant (Capacity in kW) / YEAR	2008	2009	2010	2011	2012	SUB TOTAL
		REVENUE GENERATED (IN NU.)					
1	**Rangjung (2x1100)**	11,577,170.00	15,967,861.80	15,401,597.10	15,062,724.81	6,696,746.70	64,706,100.41
2	**Chumey (3x500)**	6,285,254.20	6,919,169.40	7,604,480.80	4,683,252.24	5,466,126.48	30,958,283.12
3	**Gidakom (5x250)**	7,968,421.00	10,637,731.50	9,564,982.00	10,270,294.20	9,282,552.00	47,723,980.70
4	**Chenary (3x250)**	*Under rehabilitation*					
5	**Thimphu (4x90)**	2,140,944.44	2,203,779.60	2,430,265.60	2,515,239.00	2,319,195.54	11,609,424.18
6	**Khalanzi (2x200)**	645,395.14	790,754.25	873,460.00	351,170.73	-	2,660,780.12
7	**Darachu (2x100)**	1,330,846.05	772,587.75	-	-	-	2,103,433.80
8	**Changchey (2x100)**	1,338,584.80	916,476.00	544,285.60	240,494.40	191,365.20	3,231,206.00
9	**Rongchu (2x100)**	1,099,521.60	1,292,181.00	1,221,875.00	825,588.00	923,748.60	5,362,914.20
10	**Tingtibi (2x100)**	229,369.00	373,395.00	249,356.00	167,614.20	57,855.00	1,077,589.20
11	**Gangzur (2x60)**	157,936.94	196,937.40	229,483.00	151,172.55	94,610.76	830,140.65
12	**Sherubling (1x50)**	183,896.86	93,348.75	69,836.00	80,188.74	73,250.52	500,520.87
13	**Ura(1x50)**	239,667.20	249,920.55	286,314.00	318,179.70	374,187.00	1,468,268.45
14	**Rukubji (1x40)**	72,072.30	94,239.75	121,329.00	133,927.20	132,518.40	554,086.65
15	**Kuenga Rabten (1x30)**	215,144.80	232,362.90	207,575.10	150,866.46	15,997.56	821,946.82
16	**Tamshing (1x30)**	110,897.42	163,163.55	186,425.40	153,263.88	70,496.10	684,246.35
17	**Tangsibji (1x30)**	65,917.54	75,376.95	82,900.50	81,466.11	40,340.16	346,001.26
18	**Kekhar (1x20)**	36,729.24	45,817.20	48,359.90	56,602.71	60,795.60	248,304.65
	TOTAL (in Nu.)						**174,887,227.43**

TOTAL REVENUE GENERATED FROM THE 18 MINI/MICRO PLANTS B/W 2008-2012 AMOUNTS TO NU. 174.887 MILLION

GENERATION DATA FROM 2008-2012 Sept 2013 Fin Analyses.xlsx

11

RETURN ON INVESTMENT

Sl. No.	Plant (Capacity in kW)	COST INCURRED (in Mil. Nu.)	REVENUE EARNED (in Mil. Nu.)	Gross Income (in Mil. Nu.)	30% Coporate Income Tax (in Mil. Nu.)	Net profit (in Mil. Nu.)	Return on Investment
1	Rangjung (2x1100)	14.432	64.706	50.274	15.082	35.192	**243.85%**
2	Chumey (3x500)	7.953	30.958	23.006	6.902	16.104	**202.50%**
3	Gidakom (5x250)	16.507	47.724	31.217	9.365	21.852	**132.37%**
4	Chenary (3x250)	6.621	-	(6.621)	(1.986)	(4.635)	**-70.00%**
5	Khalanzi (3x130/2x200)	3.882	2.661	(21.221)	(6.366)	14.855)	**-62.20%**
6	Thimphu (4x90)	9.220	11.609	2.390	0.717	1.673	**18.14%**
7	Changchey (2x100)	2.888	3.231	0.343	0.103	0.240	**8.32%**
8	Darachhu (2x100)	4.455	2.103	(2.352)	0.705)	(1.646)	**-36.95%**
9	Rongchu (2x100)	1.528	5.363	3.835	1.150	2.684	**175.68%**
10	Tingtibi (2x100)	2.646	1.078	(1.568)	(0.471)	(1.098)	**-41.49%**
11	Gangzur (2x60)	2.943	0.830	2.113)	(0.634)	(1.479)	**-50.25%**
12	Rukubji (1x50)	0.718	0.554	(0.164)	(0.049)	(0.115)	**-15.97%**
13	Sherubling (1x50)	0.693	0.501	(0.193)	(0.058)	(0.135)	**-19.45%**
14	Ura (1x50)	0.486	1.468	0.983	0.295	0.688	**141.61%**
15	Kuenga Rabten (1x30)	0.315	0.822	0.507	0.152	0.355	**112.65%**
16	Tamshing (1x30)	0.593	0.684	0.092	0.027	0.064	**10.81%**
17	Tangsibji (1x30)	0.524	0.346	(0.178)	(0.053)	(0.125)	**-23.80%**
18	Kekhar (1x20)	0.184	0.248	0.065	0.019	0.045	**24.72%**
	Total	96.586	174.887	78.301	23.490	54.811	**750.55%**

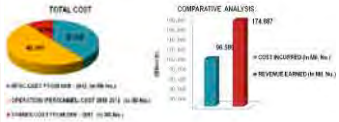
12

RETURN ON INVESTMENT CONTD..

PROFIT CONTRIBUTION BY THE MHPs

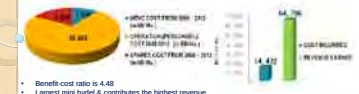
Year	Profit before tax (whole BPC) in Mil. Nu.	Profit from Plants in Mil. Nu.	Percentage
2008	927.13	34.00	3.67%
2009	986.45	41.68	4.22%
2010	1,353.20	38.56	2.85%
2011	1,209.01	34.88	2.88%
2012	1,212.32	24.70	2.04%

TOTAL O&M COST OF MHPs BETWEEN 2008-2012



-Total revenue generated from MHPs is higher than the cost incurred on MHPs.
-Benefit to cost ratio is 1.81
-Personnel cost in the O&M of MHPs is very high especially for the Mini Hydels which are not automated

1996

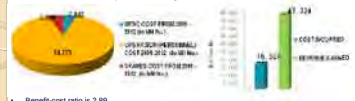


- Benefit-cost ratio is 4.48
- Largest mini hydel & contributes the highest revenue

CHUMEY MHP (3X500kW), BUMTHANG - 1989

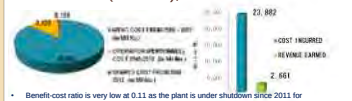
- Benefit-cost ratio is 3.89
- E&M equipment are old; Two units are under shutdown
- Study to rehabilitate & automate the plant is underway by DCSD

GIDAKOM MHP (5X250kW), THIMPHU -1972



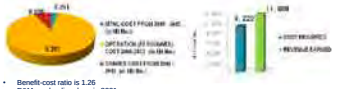
- Benefit-cost ratio is 2.89
- Study to automate the plant is underway by DCSD

KHALANZI MHP (2X200kW), MONGAR - 1975



- Benefit-cost ratio is very low at 0.11 as the plant is under shutdown since 2011 for rehabilitation
- Plant is upgrade to 2x200 kW from 3x130 kW
- Rehabilitation is expected to complete this year.

THIMPHU MHP (4X90kW), THIMPHU - 1967



- Benefit-cost ratio is 1.26
- E&M overhauling done in 2001
- Two units are under shutdown due to problems with generator & trip coil
- Penstock pipes are worn out and thickness reduced.
- Plant needs to be considered for rehabilitation & automation

CHANGCHEY MHP (2X100 kW), TSIRANG - 1992

- Benefit-cost ratio is 1.12
- Problem with 110 m of power channel which needs to be reconstructed.
- Plant connected to grid in 2013

DARACHHU MHP (2X100 kW), DAGANA - 1992

- Benefit-cost ratio is only 0.47
- Plant was shut down between 2011-2012 for major renovation of civil structures viz. power channel
- Connected to grid in 2013

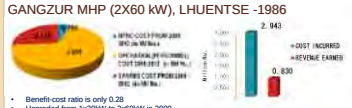
RONGCHHU MHP (2X100 kW), LHUENTSE – 2001

- Benefit-cost ratio is 3.51
- Repair of power channel required
- Runners are worn out and needs to be replaced in near future.
- Connected to grid.

TINGTIBI MHP (2X100 kW), ZHEMGANG - 1992

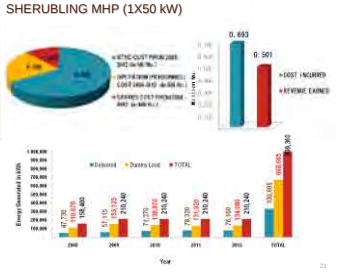
- Benefit-cost ratio is only 0.41
- Frequent breakdown of E&M
- Runners are worn out and needs to be replaced in near future.
- Connected to grid in 2013

GANGZUR MHP (2X60 kW), LHUENTSE -1986

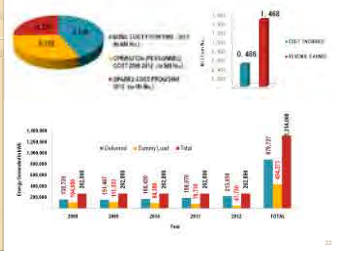


- Benefit-cost ratio is only 0.28
- Upgraded from 1x20kW to 2x60kW in 2000
- E&M parts are already worn out and needs to be replaced in near future.
- Repair of water channel is required.
- Not connected to grid.

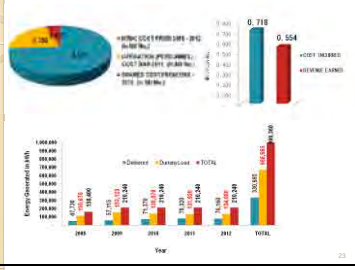
SHERUBLING MHP (1X50 kW)



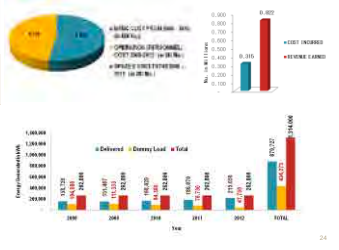
URA MHP (1X50 kW)



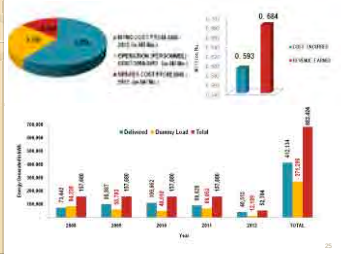
RUKUBJI MHP (1X40 kW)



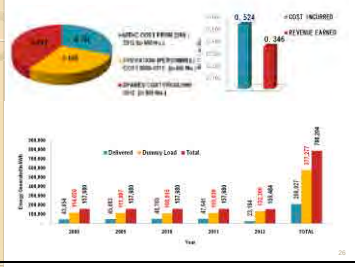
KUENGA RABTEN MHP (1X30 kW)



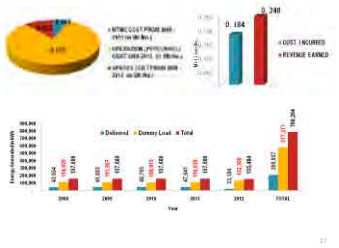
TAMSHING MHP (1X30 kW)



TANGSIBJI MHP (1X30 kW)



KEKHAR MHP (1X20 kW)



SUMMARY OF NPV, IRR FOR GRID CONNECTION OF MICRO HYDELS & GANGZUR MINI HYDEL

Sl. No.	Plant (Capacity in kW)	NPV	IRR	Payback period (in years)
1	Gangzur (2x60)	-1.16	-8 %	28.2
2	Sherubling (1x50)	1.772	28%	3.5
3	Ura (1x50)	1.02	21%	5.7
4	Rukubji (1x40)	0.75	4%	8.7
5	Kuenga Rabten (1x30)	0.08	-8%	17.7
6	Tamshing (1x30)	0.63	8%	7.1
7	Tangsibji (1x30)	0.91	13%	5.6
8	Kekhar (1x20)	0.11	-8.2%	16.9

Investment on Gangzur Mini Hydel includes the cost of connection to grid and rehabilitation of the plant.

ADDITIONAL REVENUE GENERATION AFTER GRID CONNECTION

Sl. No.	Plant (Capacity in kW)	Revenue generated b/w 2008- 2012 (in Mil. Nu.)	Revenue generation from 2014-2018 (in Mil. Nu)	Increase by (in Mil. Nu)	Percentage increase
1	Gangzur (2x60)	0.830	5.400	4.57	84.6%
2	Sherubling (1x50)	0.501	2.290	1.79	78.1%
3	Ura (1x50)	1.468	3.050	1.58	51.9%
4	Rukubji (1x40)	0.554	2.290	1.74	75.8%
5	Tamshing (1x30)	0.684	1.380	0.70	50.4%
6	Tangsibji (1x30)	0.346	1.380	1.03	74.9%
7	Kekhar (1x20)	0.248	0.920	0.67	72.9%
8	Bubja (1x30)	0.822	1.370	0.55	40.0%

- Estimated cost for Grid connection =Nu. 20.631 Mil.
- Revenue generation shall be enhanced in the next 5 years by Nu. 12.62 Mil

CONCLUSION:

1. Overall, revenue generated in the past 5 years is more than the cost incurred.
2. However, if we look at the plants individually, it is apparent that only some plants viz. Rangjung, Chumey, Gidakom, Thimphu, Changchey, Rongchu, Ura, Tamshing, *Kuenga Rabten* are sustainable, with the present situation.
3. Since the Micro HPs are not connected to the grid, any energy generated beyond the connected load is transferred to dummy load. If connected to grid, except for Kekhar, Kuenga Rabten, Gangzur the remaining hydels will be sustainable.
4. Operation Cost (HR) of the plants is high.
5. Standard operation procedure (SOP) and standard check list for monitoring and preventive maintenance of MHPs is not available.
6. Plant operators are not trained to carry out breakdown maintenance. Restoration period of plant breakdown is longer as maintenance team has come from CMTD, Begana.
7. MHPs serve as a back-up service incase of grid supply failure and provide power to essential services / organizations, thus improving reliability/energy security.
8. Every single unit generated from MHPs helps meet the internal energy demand and thus equivalent energy generated from large HPs can be exported.

RECOMMENDATION

1. If the Micro HPs are connected to grid, surplus energy (currently diverted to dummy loads) can be injected into the grid and hence increase revenue generation. Therefore, it is recommended that some of the micro hydels viz. Sherubling, Ura, Rukubji, Tangsibji and Tamshing be considered for grid connection.
2. High operation cost (HR) can be reduced by going for automation. Therefore, it is recommended that study for automation of plants be carried out.
3. It is recommended that a study be carried out to check the feasibility of availing carbon credit for the MHPs so that part of the O&M cost may be met from the credit earned.
4. Standard operation procedure (SOP) and standard check list for monitoring and carrying out preventive maintenance of plants are required. The standard check list similar to that used by power plants in Indonesia (3rd country survey) may be adopted in our MHPs. Weekly Inspection Check List.pdf

31

ACTION PLAN

Sl. No	Action	Scheduled Start Date	Scheduled End Date	Responsibilities
1	Drafting of SOP	January 2014	March 2014	To be prepared by PI Team, CMTD & DCSD
2	Study for automation of plants	November 2013	March 2014	To be initiated by DCSD
3	Grid Connection	January 2014	December 2014	To be budgeted & carried out by CMTD in coordination with ESDs
4	Study on carbon credit eligibility for MHPs	April 2014	June 2014	To be initiated by DCSD/PI Team

32

EXIT STRATEGY

33

WHY EXIT STRATEGY

- Recent directive from the DHI Board that BPC's mandate is in transmission and distribution of electricity
- BPC is directed to prepare a proposal on how to exit from the mini and micro HPP.

34

EXIT STRATEGY

Option I: Create subsidiary company

- If BPC has plans for investing in additional embedded generation viz. solar, wind, hydro power plants

Option II: Outsource

a. Asset to BPC, O&M to private companies
b. Both asset and O&M to private companies

Recommended that a team be constituted with the following members immediately to carry out the study:

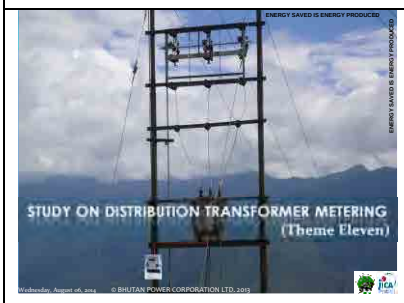
1. Tariff Officer, MDO, BPC
2. Asset Manager, FAS, BPC
3. Technical engineers (Mechanical, Electrical,Civil)
4. PI Team

35

TASHI DELEK

36

Theme 11



ENERGY SAVED IS ENERGY PRODUCED

Presentation Contents

- ✓ What is distribution transformer (DT) metering ?
- ✓ Why is it required in BPC distribution network ?
- ✓ Cost benefit analysis
- ✓ Pilot study proposal
- ✓ Cost analysis for pilot study
- ✓ Recommendations

Wednesday, August 06, 2014 © BHUTAN POWER CORPORATION LTD, 2013

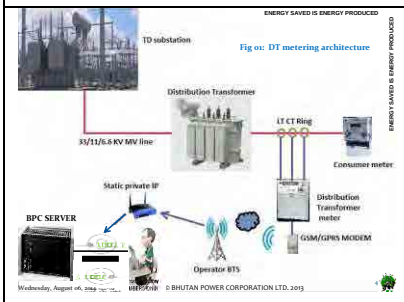
ENERGY SAVED IS ENERGY PRODUCED

What is Distribution Transformer metering?

A distribution transformer meter (DT Meter) is a "link meter" between the sub-transmission substation and the LV system. Its' application covers the following.

- Load flow analysis, energy auditing and accounting.
- Distribution network reliability (History of outage/event log including date and time)
- To monitor the loading condition of the distribution transformer

Wednesday, August 06, 2014 © BHUTAN POWER CORPORATION LTD, 2013



ENERGY SAVED IS ENERGY PRODUCED

Why in BPC?

- ✓ Energy auditing and accounting
- ✓ Supply reliability
- ✓ To monitor the operating condition of DT
- ✓ To meet up the requirements of regulatory bodies

Wednesday, August 06, 2014 © BHUTAN POWER CORPORATION LTD, 2013

ENERGY SAVED IS ENERGY PRODUCED

1. Energy Accounting and Auditing

Current scenario:

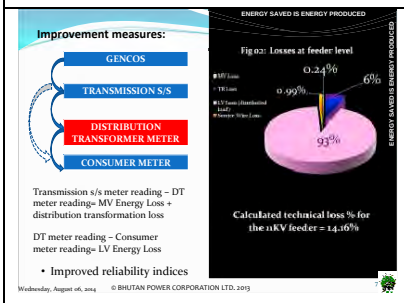
GENCOS → TRANSMISSION S/S → DISTRIBUTION S/S → CONSUMER METER

GENCOS meter reading – Transmission meter reading = Transmission Energy Loss

Transmission S/S meter reading – Submission of customer meter reading = Distribution Loss

- Absence of strategy in place to identify loss at each section of the network

Wednesday, August 06, 2014 © BHUTAN POWER CORPORATION LTD, 2013



ENERGY SAVED IS ENERGY PRODUCED

2. Supply reliability

Current scenario:

TRANSMISSION S/S → DISTRIBUTION TRANSFORMER → CONSUMER METER

Distribution outage is recorded only at Transmission s/s.

No outages is recorded at any point in distribution network.

- Room for manipulation for calculating SAIFI and SAIDI
- Outage period and duration not known unless consumer informs leading to low Customer Satisfaction Index.

Wednesday, August 06, 2014 © BHUTAN POWER CORPORATION LTD, 2013

ENERGY SAVED IS ENERGY PRODUCED

Improvement measures:

TRANSMISSION S/S → DISTRIBUTION TRANSFORMER → CONSUMER METER

Distribution outage is recorded at Transmission s/s i.e., upstream reliability.

Distribution outages also recorded at every DT metering point in distribution network i.e., downstream reliability.

- Can avoid room for manipulating reliability indices.
- Reduction in customer call volume and improve CSI.

Wednesday, August 06, 2014 © BHUTAN POWER CORPORATION LTD, 2013

3. To monitor the loading condition of DT

Current scenario:

- Reasons of distribution transformer failures not exactly known
- Overloading and under loading of distribution transformers not precisely recorded
- Increased outage period

Improvement measures:

- Failure reasons can be outlined using more detailed information from DTM along with the data obtained from the maintenance team and identify under-used and overloaded transformers and properly size transformers.
- Enable BPC to more accurately forecast load growth and evaluate system investments resulting in improved asset/distribution system planning.

4. To meet up the requirements of regulatory bodies

Parameters	% Loss	% Voltage drop
Medium Voltage Line	2.50	± 10
Distribution Transformer		
Low Voltage	12.0	± 6
Service Wires		
Commercial loss	5% of LV sales	

Table 01: Permissible losses and voltage drop as per BEA guidelines

Cost benefit analysis

General assumptions made

- The cost benefit analysis is based on Genus, India LT CT meter
- Time value of money is not considered
- 18 % targeted revenue savings every year keeping the loss figure constant
- Meter depreciation time (useful life) period used in the model is 10 years
- Meter growth rate is not considered
- Depreciation cost is Nu. 44.22m @3.33% as per BPC asset depreciation codes
- Assumes full implementation of DTM technologies with 100% deployment of DTM over a period of 2.26 years
- The model analysis period is 10 years ending in 2023, with DTM deployment commencing in year 2014

Specification	Genus India make		EDMI Singapore make
	LT CT Meter	Whole Current Meter (Direct)	
System type	Three Phase Four Wire AMR Compatible Metering System. (Dual processor)	Three Phase Four Wire. (Direct) Through Metering System.	3P3W/3P4W AMR compatible electronic revenue meter
Applicable standard	IEC 62053-22 & IEC 62054		IEC62052-11, 62053-21, 62053-22, 62052-11, 62053-23, 62053-24 and EN50470-1, 50470-3
Electrical parameters			
Voltage & Current rating	3x240Volt, WC= (10-100A), CT = x/1Amps	3x240Volt, 40-200Amps	480V - 240V, CT Range: 1/5A, 5/20A, WC Range - 5/100A, 10/100A.
Class of accuracy	0.5s		0.2s - 2
Power factor	Zero (lag)-Unity-Zero(lead)		Zero (lag)-Unity-Zero(lead)
Frequency	50Hz ± 5%		50Hz ± 5%
Communication Protocol	DLMS compliance		Non-DLMS compliance
1. Local data downloading	Galvanically Isolated Optical Port for Data Downloading, RJ45		Optical Port for Data Downloading
2. Remote data downloading	Compatible for Remote Communication through GSM/GPRS/3G communication		Compatible for Remote Communication through GSM/GPRS/3G communication
Anti-tamper features	Self-Diagnostic and various tamper detection & event storing facility		Self-Diagnostic and various tamper detection & event storing facility
Installation & mounting	Compact design, pole mounting/C-Channel Mounting		Compact design, pole mounting/C-Channel Mounting
Modem	Separate Modem to be purchased		Separate Modem to be purchased
Software	Data Software that can handle up to 200-4000 meters		Tod-view and multi drive, can handle up to 30000 meter by Ed-view software.
	Can be integrated with other meters		Cannot read other meters of different make
	Can be integrated with SAP/ERP		Cannot be integrated with SAP, ERP directly
	Connected through, Direct, Modem & IP address		Connected through, Direct, Modem & IP address
Quantity to be procured	50 to 100 Nos.		200 Nos
Accessories	Not available		Optional with additional cost
Approximate cost	**Rs/Nu. 12,120.00 / meter**	**Rs/Nu. 26,280.00/meter**	**Rs/Nu. 13,333.00/meter**

Table 02: Cost comparison of DT meters

Source: Genus Power and EDMI

Fig 04: LT CT operated and Sampoorna static DT meter Source: GENUS Power , Jaipur India

Fig 05: LT CT EDMI Singapore make meters

Source: EDMI/PT PLN

Payback Period

Payback period in capital budgeting refers to the period of time required for the return on an investment to "repay" the sum of the original investment.

Description	% Cumulative reduction in revenue loss	Loss figure for every year (Nu. Mn)	Savings every year (Nu. mn)	Cost reduction every year (Nu. mn)
Year 0	0%	63.95	0.00	-98.28
Year 1	18%	63.95	11.51	-86.76
Year 2	18%	63.95	11.51	-75.25
Year 3	18%	63.95	11.51	-63.74
Year 4	18%	63.95	11.51	-52.23
Year 5	18%	63.95	11.51	-40.72
Year 6	18%	63.95	11.51	-29.21
Year 7	18%	63.95	11.51	-17.70
Year 8	18%	63.95	11.51	-6.19
Year 9	18%	63.95	11.51	5.32
Year 10	18%	63.95	11.51	16.83
Payback period = 9 YEARS				

Table 03: Payback period

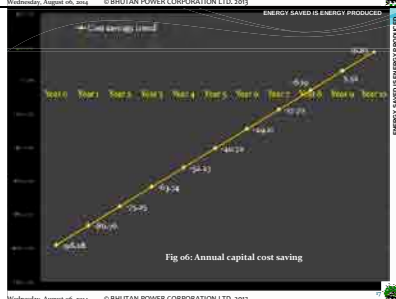


Fig 06: Annual capital cost saving

Salvage value & depreciation

Year	Depreciation Rate	Depreciation Expense	Accumulated Depreciation	Book value at end year
Year 0			Original Cost	98.28
Year 1	3.33%	3.27	3.27	95.01
Year 2	3.33%	3.16	6.44	88.57
Year 3	3.33%	3.06	6.22	82.35
Year 4	3.33%	2.96	6.01	76.33
Year 5	3.33%	2.86	5.81	70.52
Year 6	3.33%	2.76	5.62	64.90
Year 7	3.33%	2.67	5.43	59.46
Year 8	3.33%	2.58	5.25	54.21
Year 9	3.33%	2.50	5.08	49.13
Year 10	3.33%	2.41	4.91	44.22

Table 04: Depreciation & salvage value calculation

Calculation of useful life of the system

Total No of meters	3295	Sets
No of meters installed in a day	4.00	Sets
No of days required	823.75	Days
No of years required	2.26	years
Meters installed in 1st year	1460	Sets
Meters installed in 2nd year	1460	Sets
Meters installed in 3rd year	375	Sets
% of meters with 1.26 years useful life	56	%

Table 05: Useful life of the system

Cost savings abstract

Descriptions	Amount (Nu. mn)
Cost savings through ten years with 18% revenue loss reduction	16.83
Cost savings during the useful life of 1.26 years	14.50
Salvage value	44.22
Total savings in 11.26 years	**75.56**

Table 06: Cost savings from the system

Capital cost abstract

Descriptions	Amount (Nu. mn)
Cost of Meter	39.935
Cost of Installation	9.885
Accessories	9.045
Add 5% contingency cost	2.943
Add 2% maintenance cost	1.236
Add recurring cost for 10 years	35.230
Grand total	98.274

EDMI Singapore make – 102.35 million

Table 02: Capital cost

Pilot study outline

- ✓ To study the achievement of 18% targeted reduction in revenue loss within the annual O&M cost.
- ✓ One No. 11KV MV feeder under Paro ESD has been identified as pilot feeder.
- ✓ Adequate No. of customers (3826 Nos with average connected load of 0.8 KW per household) with 24 DTs (6488KVA installed capacity) to study loading profile of DTs
- ✓ The line length of 19.67Km for loss analysis purpose.
- ✓ The number of DTs (24 Nos. with 6488 installed KVA) is adequate for load profile analysis as well as reliability indices.
- ✓ The line covers both urban and rural sites (semi urban)
- ✓ Easily accessible by the team who are based in Thimphu
- ✓ Requires minimum of four months including installation, data analysis and generation of DT health report

Capital cost for the pilot study

Descriptions	Amount (Nu. mn)
Cost of meter	11.290
Installation charges	0.072
Accessories	0.773
Communication charges	0.035
Contingency cost 5%	0.057
Grand total	1.197

Table 07 : Cost abstract

Cost with LT CT and sampoorna mixed is more by Nu. 0.131 than only LT CT type

Recommendations

- ✓ BPC should target to reduce 18% revenue loss annually within the same annual O&M cost
- ✓ To study the achievement of ±18% targeted reduction in revenue loss, a pilot study may be necessary
- ✓ Can be foundation stone for migration to latest energy saving techniques and improvement of distribution system efficiency such as DMS
- ✓ One of the arms in achieving BPCs vision/mission

Way forward

- Purchase, Inspection and testing of meters and accessories
- Hands on training and installation of meters for the pilot study
- Data capture and analysis
- Generate report and submit the findings