

Loss Reduction & Reliability Improvement in Distribution System

January 2008

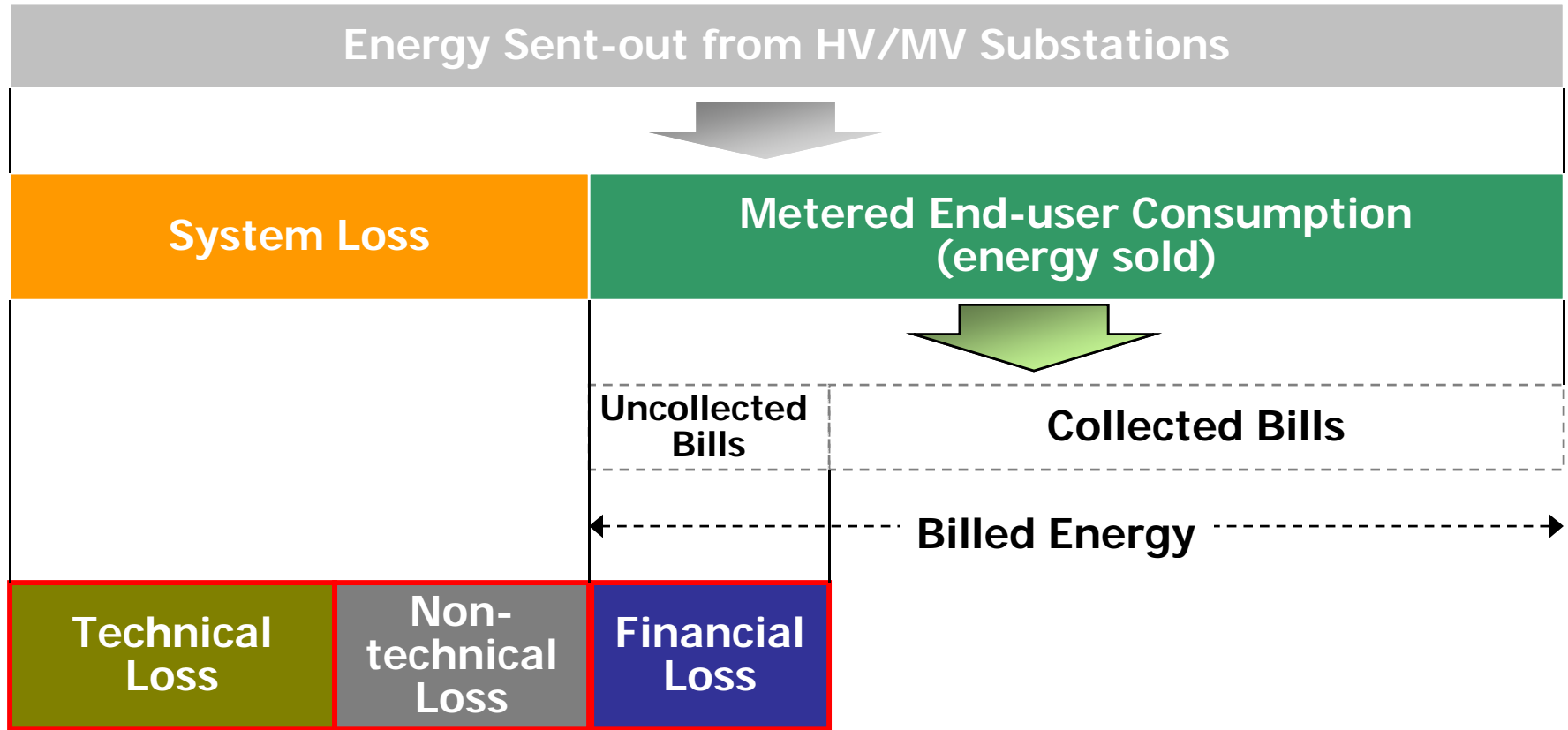
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THE TOKYO ELECTRIC POWER COMPANY, INC.

Image of Distribution Loss

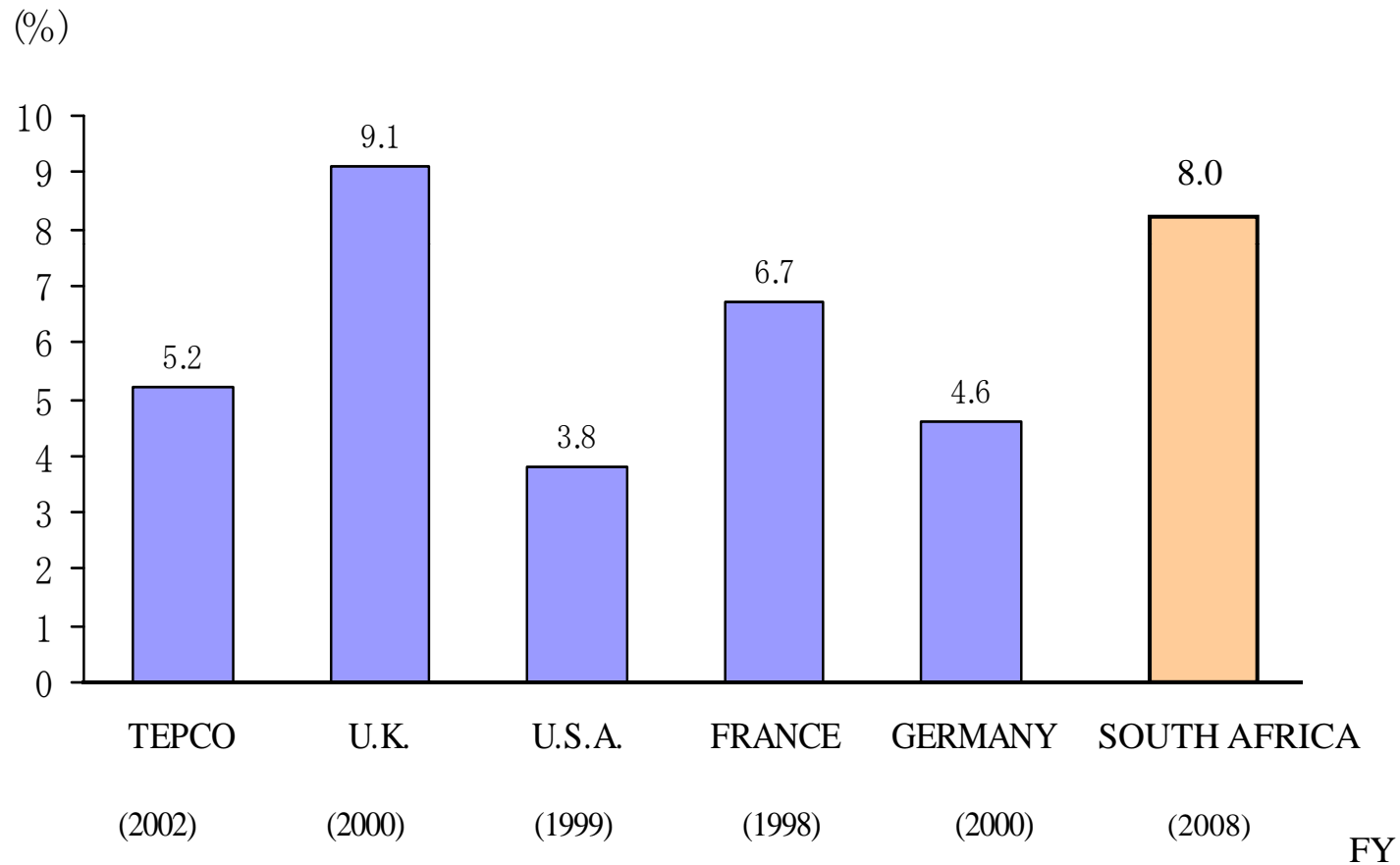


$$\left\{ \begin{array}{l} \text{(Energy Sent from S/S)} \\ - \text{Billed Energy} \\ - \text{Technical Losses} \end{array} \right\} \left\{ \begin{array}{l} \text{(Billed Energy)} \\ - \text{Collected Bills} \end{array} \right\}$$

Commercial Loss

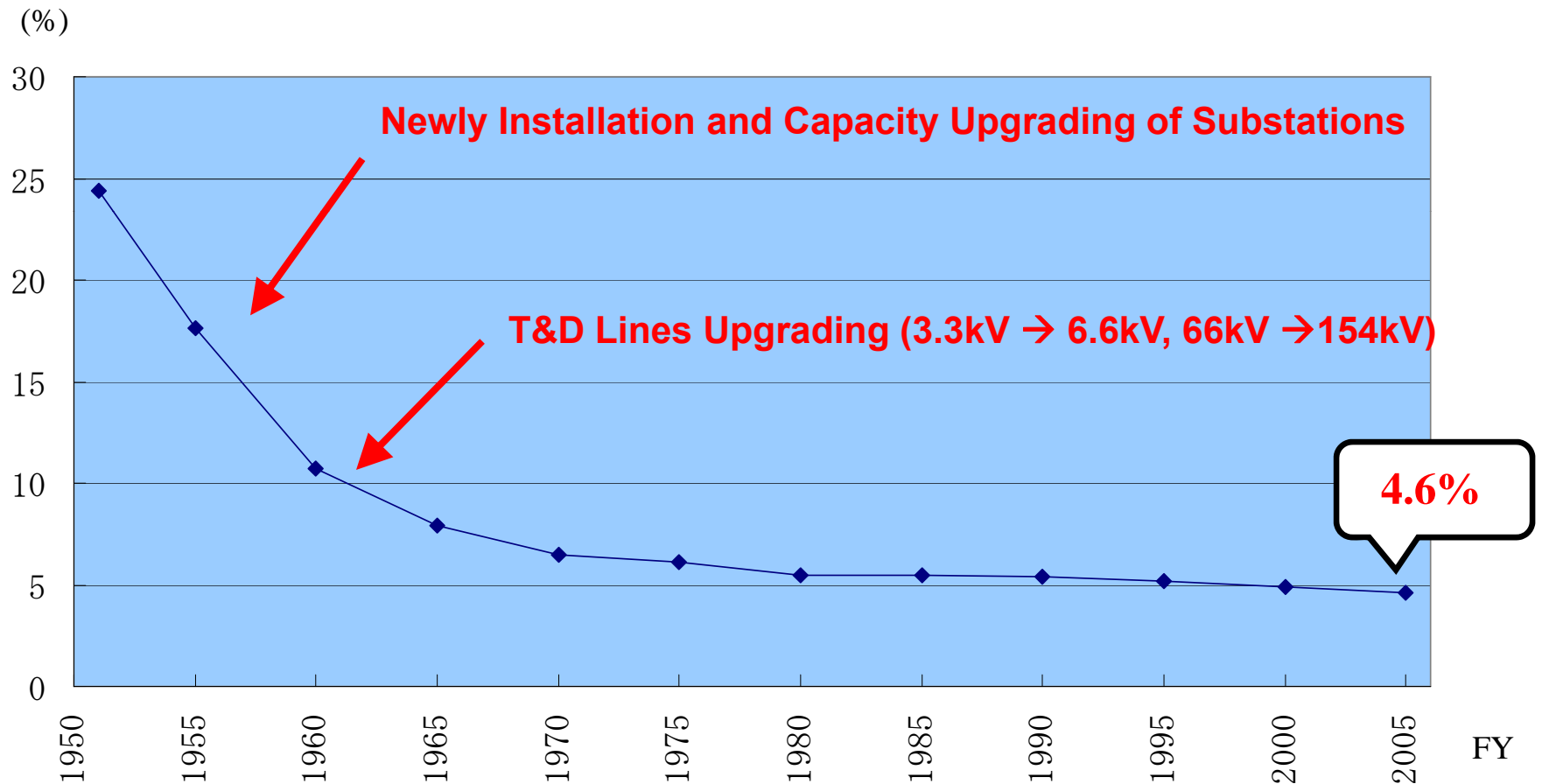
Transmission & Distribution Loss

International Comparison of Line Loss



Transmission & Distribution Loss

TEPCO's historical trend of Loss



Types of Distribution System Loss

Technical Loss

- ❑ Conductor
 - ❑ Resistance Loss
 - ❑ Corona Loss or Leakage (very few)
- ❑ Transformer
 - ❑ Core Loss
 - ❑ Copper Loss

➔ Mostly losses come from conductor. Countermeasures advisable.

Non-technical Loss

- ❑ Non Technical Loss
 - ❑ Inaccurate Metering
 - ❑ Defective Meter
 - ❑ Tampering/Pilferage

Commercial Loss

Financial Loss

- ❑ Financial Loss
 - ❑ Uncollected Revenue

Countermeasures for Distribution Loss

(Focusing on the Technical Loss)

- Leveling distribution system loads by
network re-configuration(for MV, LV system)
- Power factor correction by capacitor placement
- Install new feeders
- Install new transformers
- Build a substation
- Re-conductoring
(Replace with larger cross section conductor)

Overview of Countermeasures

1. Leveling of distribution system loads by network re-configuration

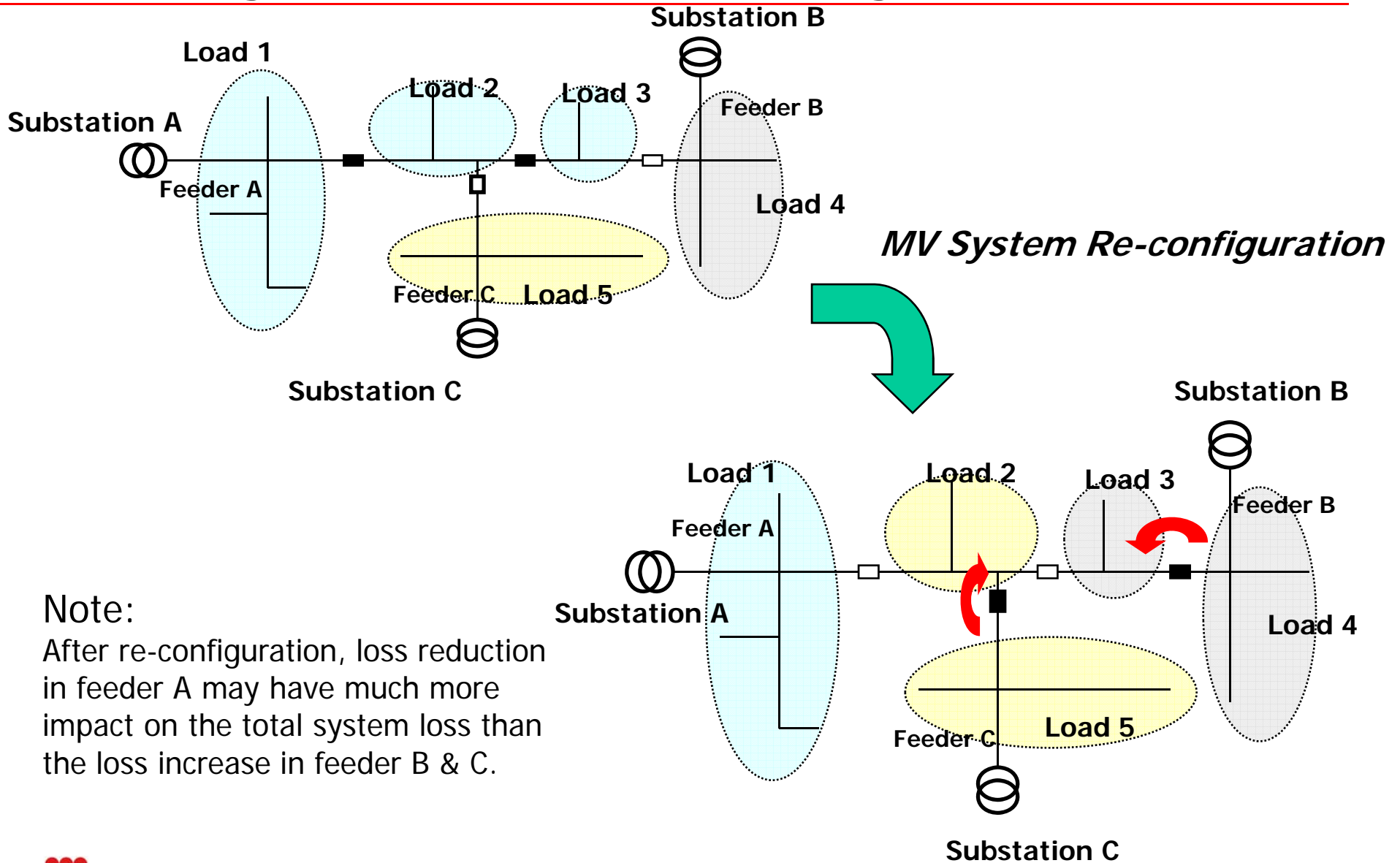
□ Basic Idea

- Some loads in the heavy loaded feeder shifted to another lightly loaded feeder
- Sectionalizing switchgear allocation for load shift (new interconnection between feeders may be required)
- Optimal switching allocation may be done by distribution system analysis software

□ Comments

- First step for loss reduction with less investment

Image of Load Leveling



Note:
After re-configuration, loss reduction in feeder A may have much more impact on the total system loss than the loss increase in feeder B & C.

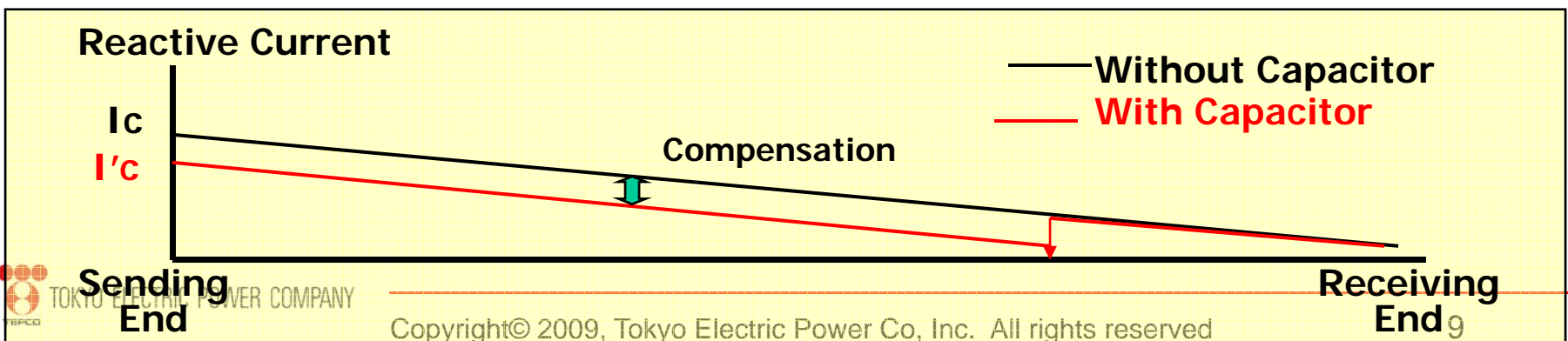
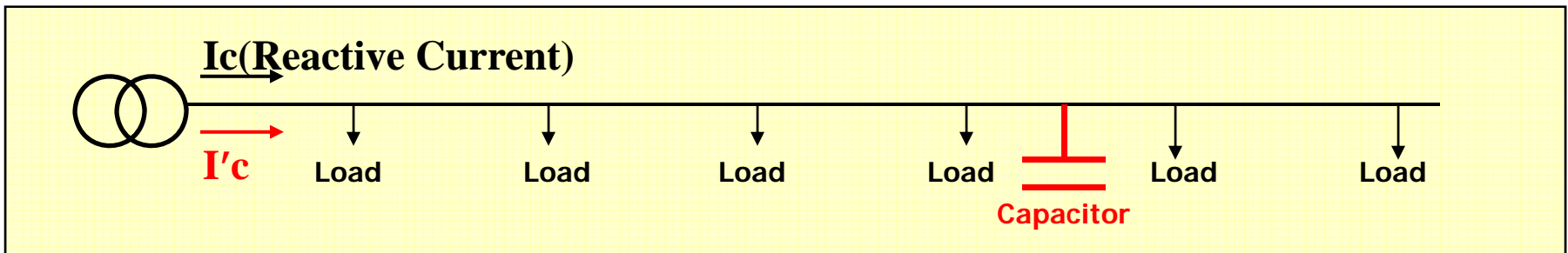
Overview of Countermeasures

2. Power factor correction by capacitor placement

□ Basic Idea

- Improvement of power factor reduces power flow in a feeder. Thus, system loss reduction achieved
- Power factor improved by compensating the reactive power

□ Image of Reactive Current Compensation



Overview of Countermeasures

3. Install new feeders/transformers/substations

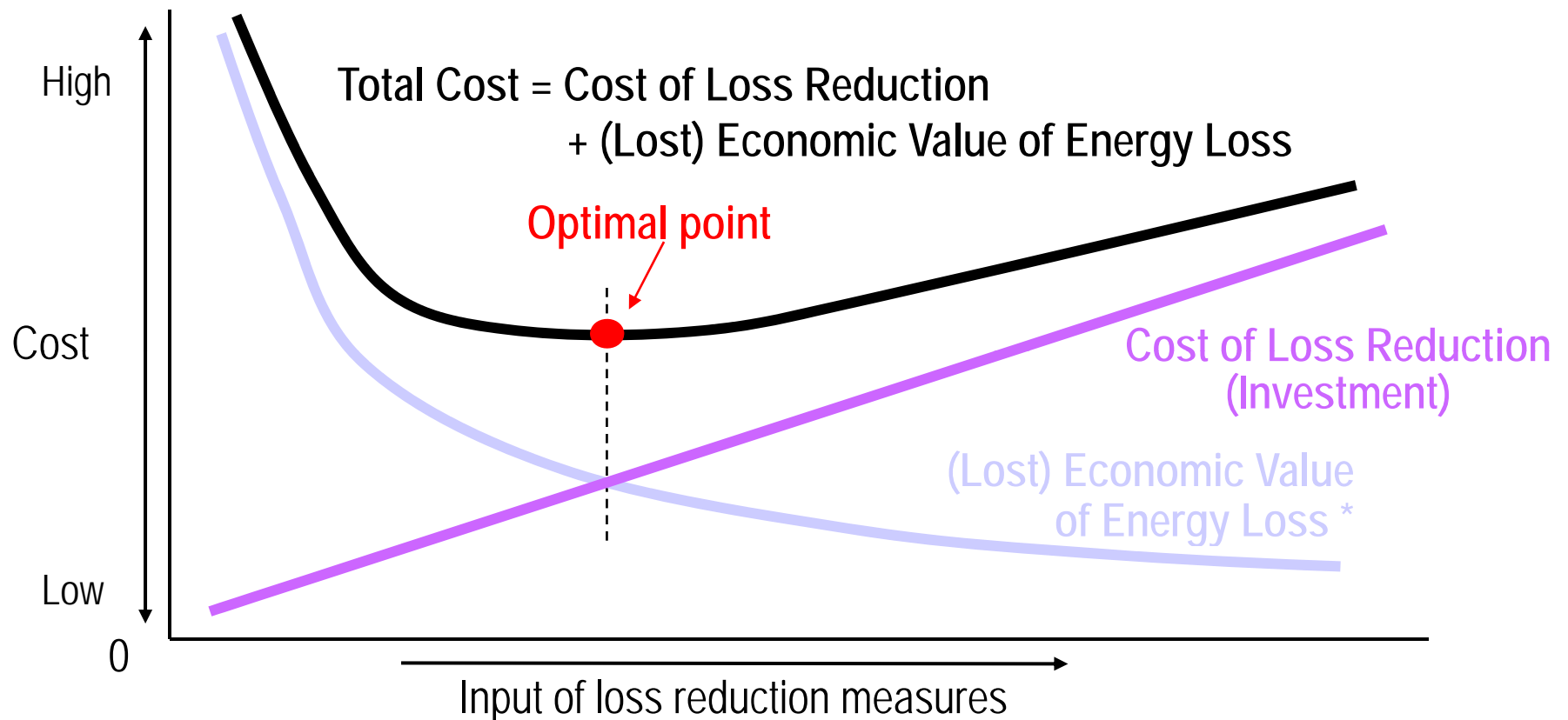
□ Basic Idea

- Heavy loaded area to be supplied by new feeder so that existing feeder supplies less loads (for new feeder install, sometimes new HV/MV transformer needed)
- New substation to be built in the center of high load density area so that existing feeder supplies less loads

□ Comments

- Building new facilities (feeders, transformers, substations) requires a certain level of investment. Impact of loss reduction and investment must be carefully considered.

Evaluation of Loss Reduction Measures



- When “Cost of Loss Reduction” > “Economic Value of Reduced Energy Loss”, the loss reduction measure is considered feasible
- **Determine the most effective measures and their respective input**

TEPCO Loss Reduction Experiences

- Loss Reduction & Reliability Improvement in Jamaica
 - Client: Marubeni, Jamaica Public Service (JPS)
 - Period: Aug 2007 – July 2008
- Power Distribution System Loss Reduction(Phase II)
 - Client: Electricite du Laos/World Bank
 - Period: Mar 2007 – Dec 2008 (Phase II)
 - Period: Mar 2004 – Mar 2005 (Phase I)
- Feasibility Study on Loss Reduction of Distribution Network
 - Client: National Electric Power Co. Jordan/JICA
 - Period: Sep 1999 – Oct 2000

Reliability Indices

SAIDI : System Average Interruption Duration Index
(Annual Average Interruption Duration per Customer)

$$\text{SAIDI} = \frac{\sum (\text{Interruption Duration} \times \text{Number of Interrupted Customers})}{\text{Total Number of Customers}}$$

TEPCO = 3 minutes

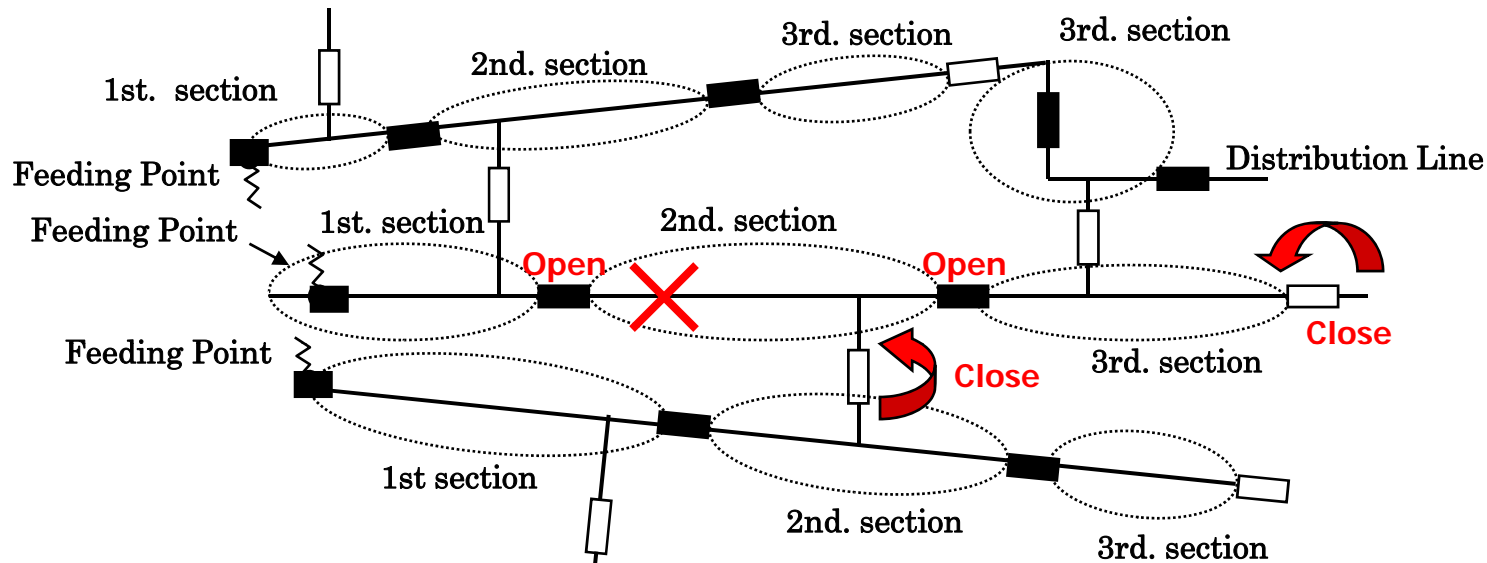
SAIFI : System Average Interruption Frequency Index
(Annual Average Interruption Frequency per Customer)

$$\text{SAIFI} = \frac{\sum (\text{Total Number of Interrupted Customers})}{\text{Total Number of Customers}}$$

TEPCO = 0.04 times

Distribution Network in TEPCO

Typical Multi-Divided and Multi-Connected System(Standard Configuration)



- ⚡ : Feeding Cable from Substation
- : Section Switch (Closed)
- : Section Switch (Open) = Interconnection Switch
- : Distribution Line

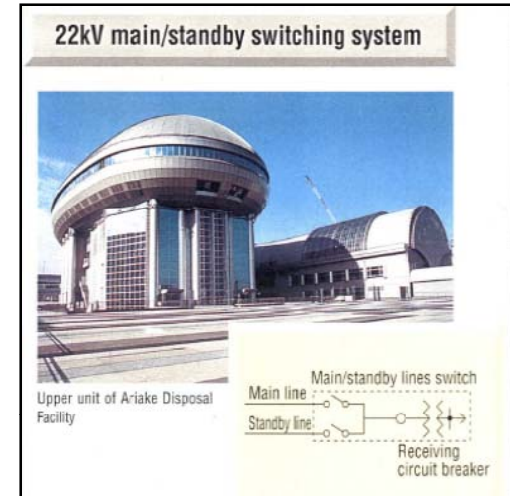
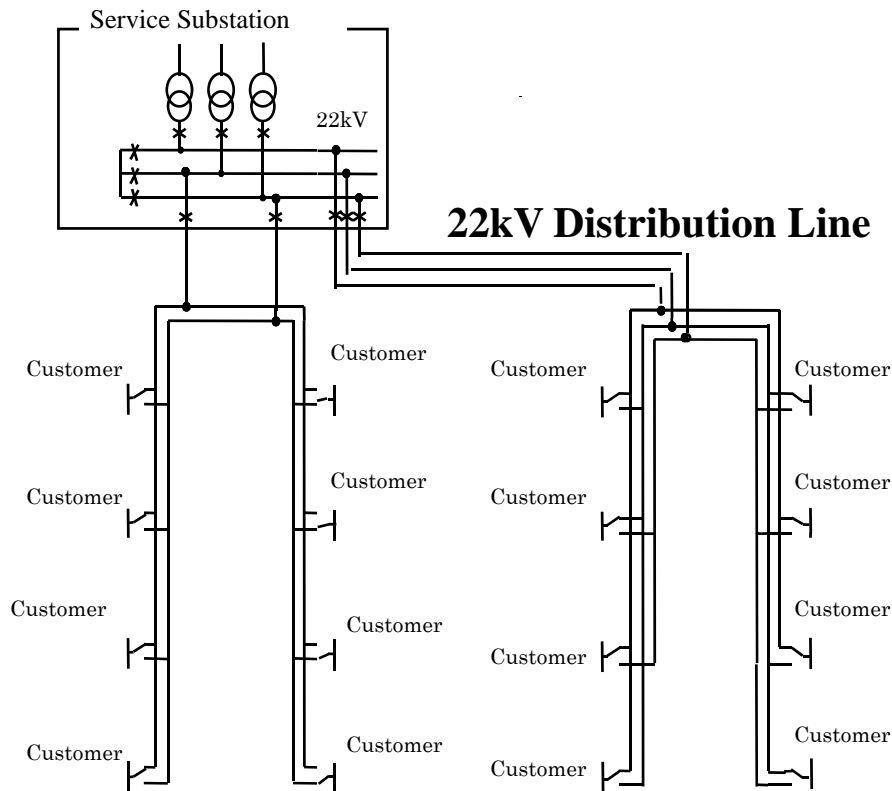
- Flexible network to demand growth
- Restored automatically (Distribution Automation System(DAS))
- Section switch remote operation capability

Image of Control Center with DAS

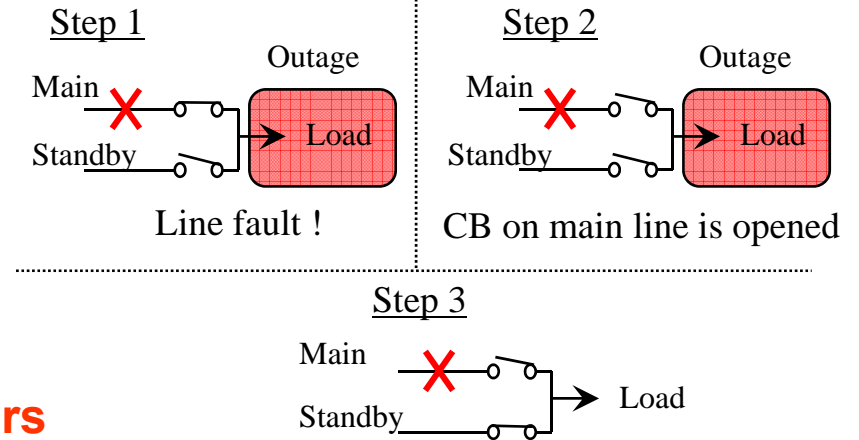


Distribution Network in Urban Area

22kV Main/Stand-by Switching System for Urban Area



Steps to Restore

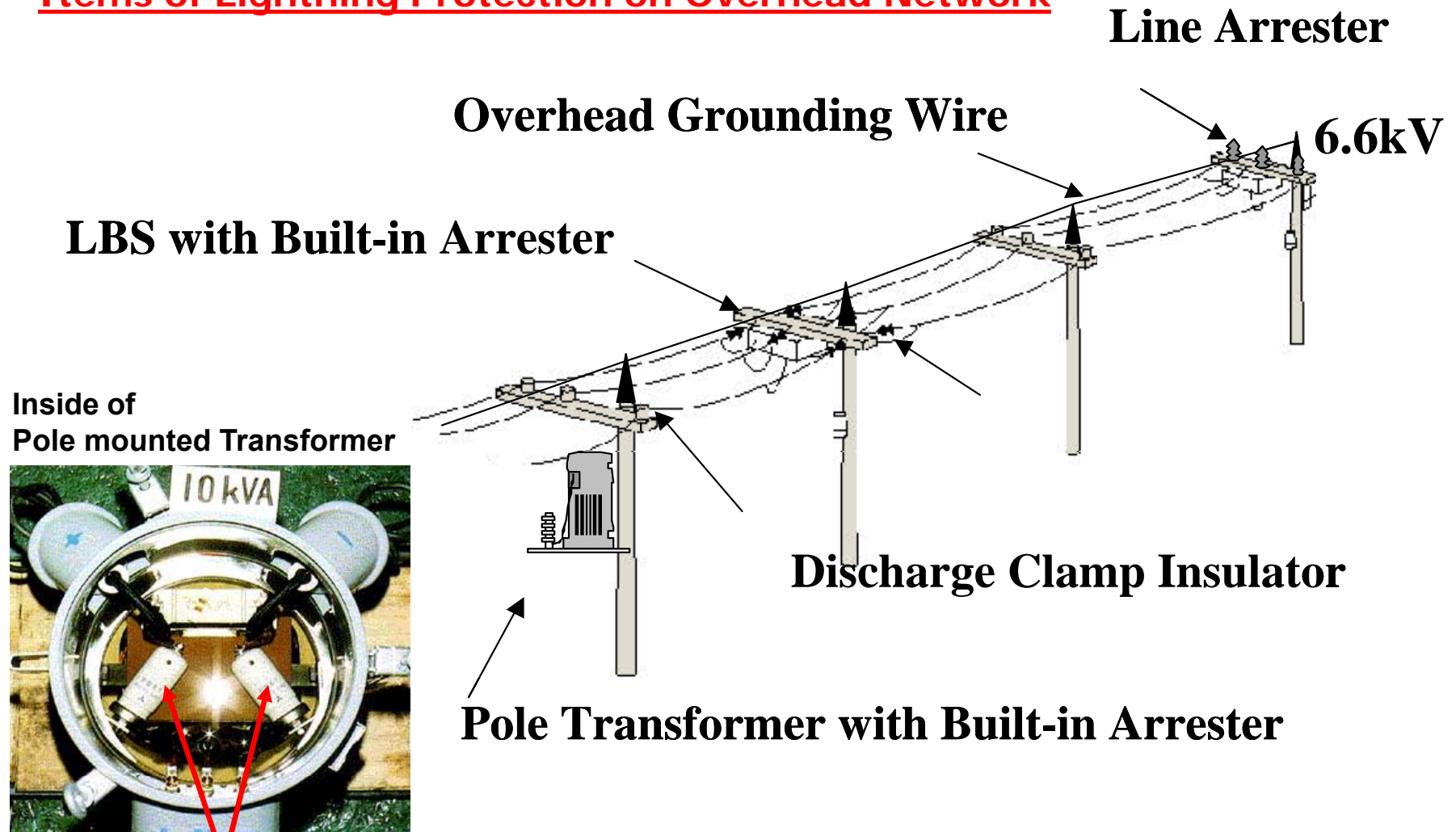


After 4 sec, CB on standby line is closed

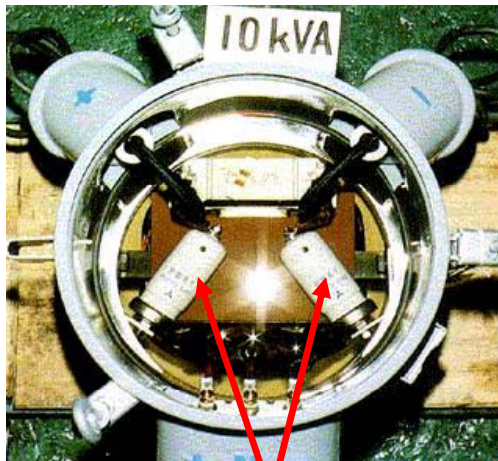
- Applied in urban area with large customers
- 2 line service drops
- Automatic switching when one line contingency

Equipment for Reliability Improvement

Items of Lightning Protection on Overhead Network



Inside of Pole mounted Transformer



Built in Arrester



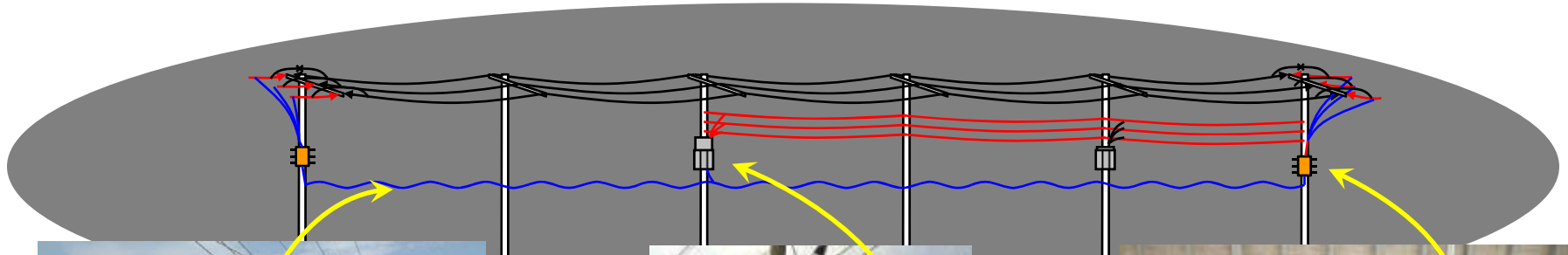
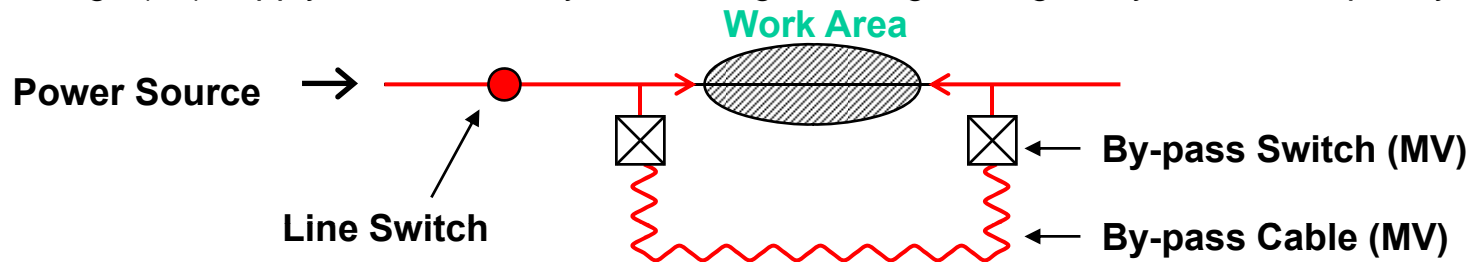
Non-interruption Work Method

- **MV Non-interruption Methods**
 - Temporary switch method
 - MV by-pass method
 - Temporary interconnection method
- **LV Non-interruption Methods**
 - Temporary switch method
 - Temporary transformer method
- **Generating Vehicle (Generator) Method**

Various Methods for reduction of outage time

Introduction of Live Line Distribution Work

- By using “By-Pass Cables” & “By-Pass Switches”, “Planned Outage” is avoided. (Work Area is by-passed.)
- Low voltage (LV) supply is continued by connecting to a neighboring LV system or temporary transformers.



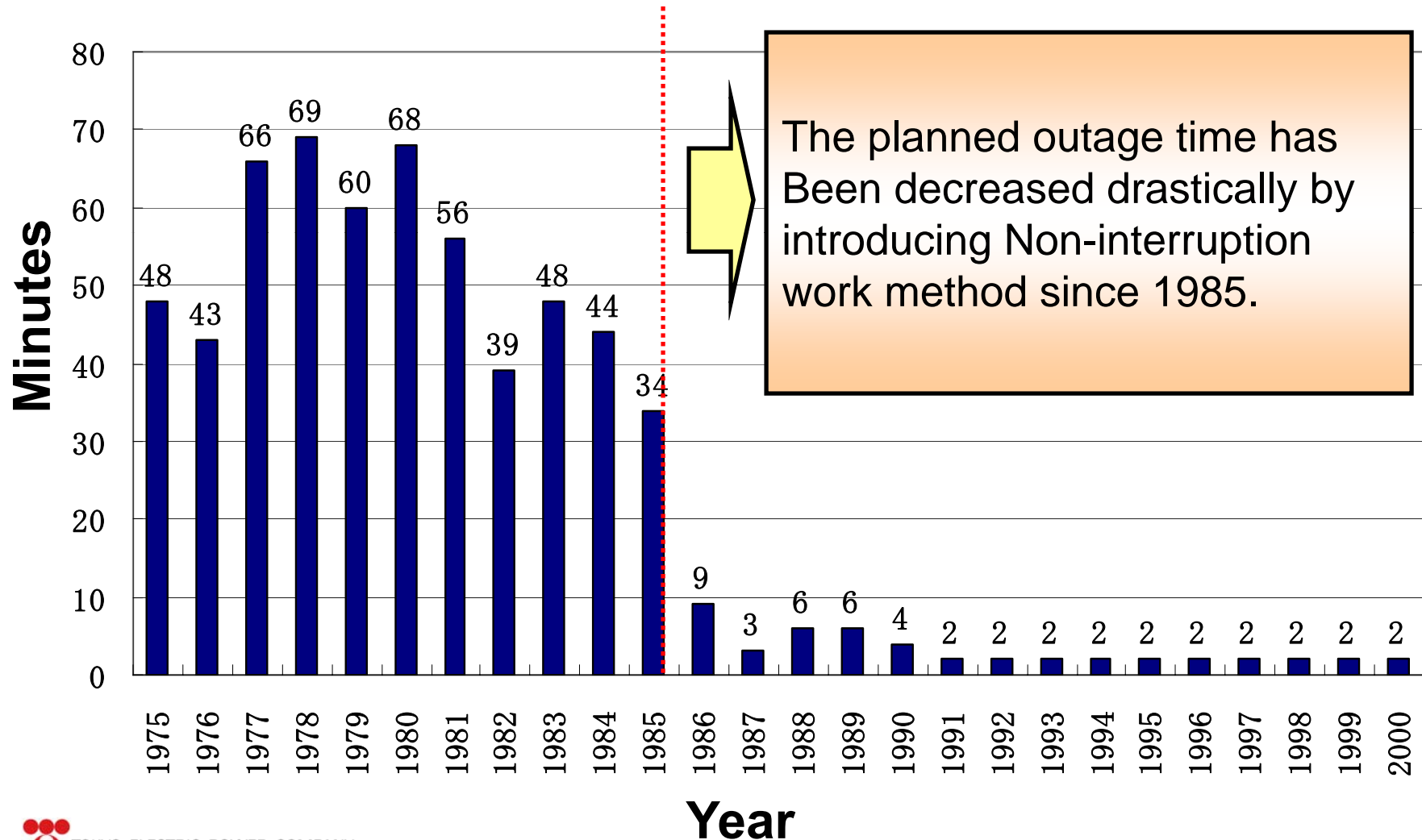
By-Pass Cable

Temporary Transformer

By-Pass Switch

Effect of Non-interruption Work Method

Reduction of “Planned Outage” Duration



TEPCO's Power Supply Reliability

