
kepco
Reliability Improvement
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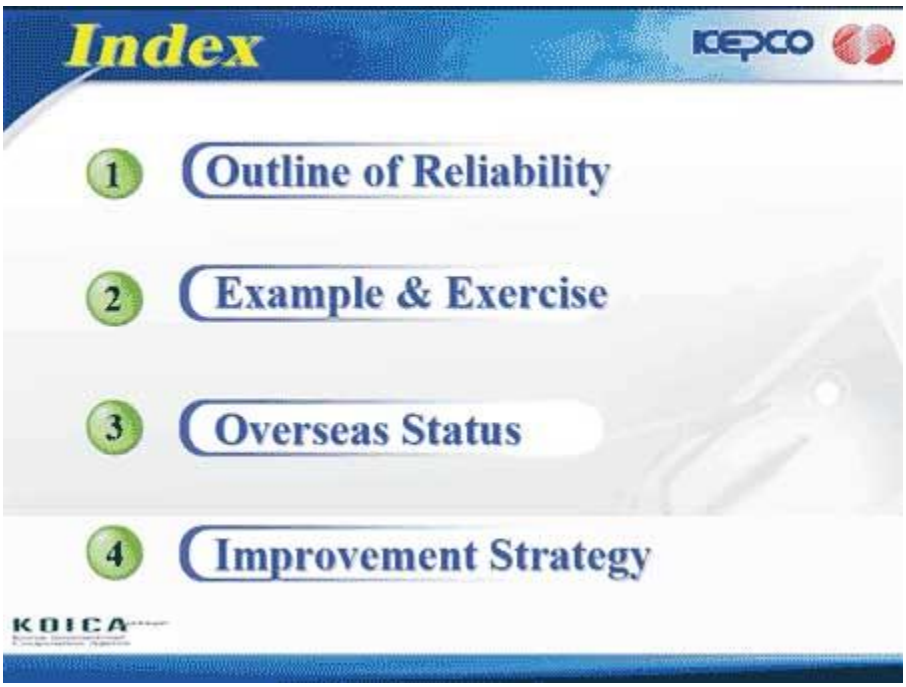
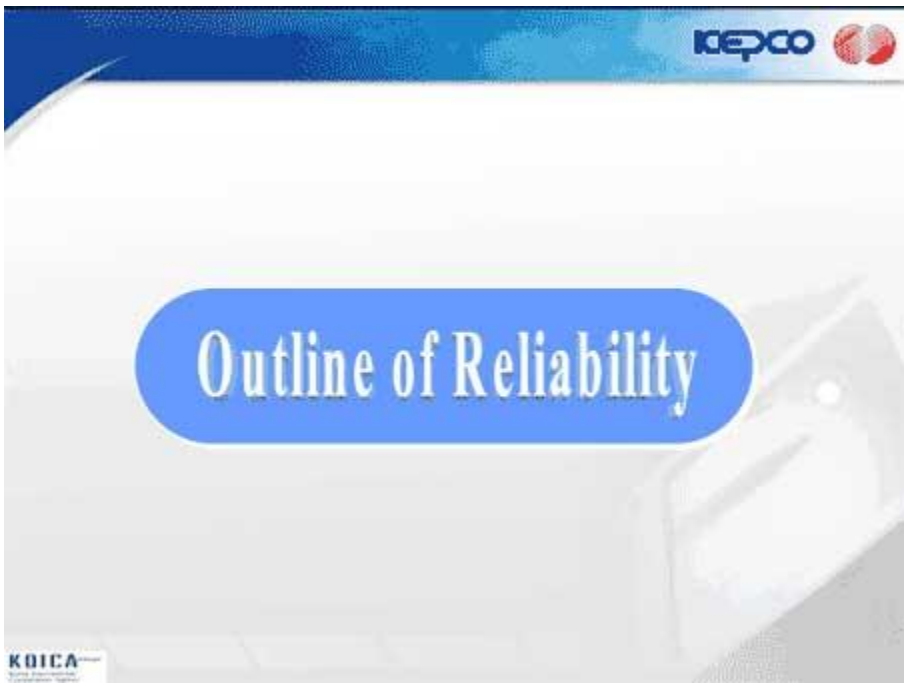

Index
KEPCO
1 Outline of Reliability
2 Example & Exercise
3 Overseas Status
4 Improvement Strategy
KOICA



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1. Outline of Reliability

KEPCO

Introduction

- **Feature of Electricity**
  - Just in time
  - Cannot save
- **Perception of Reliability**
  - Variable among customers and utilities
  - Change over the years
  - Load sensitivity of electrical equipment

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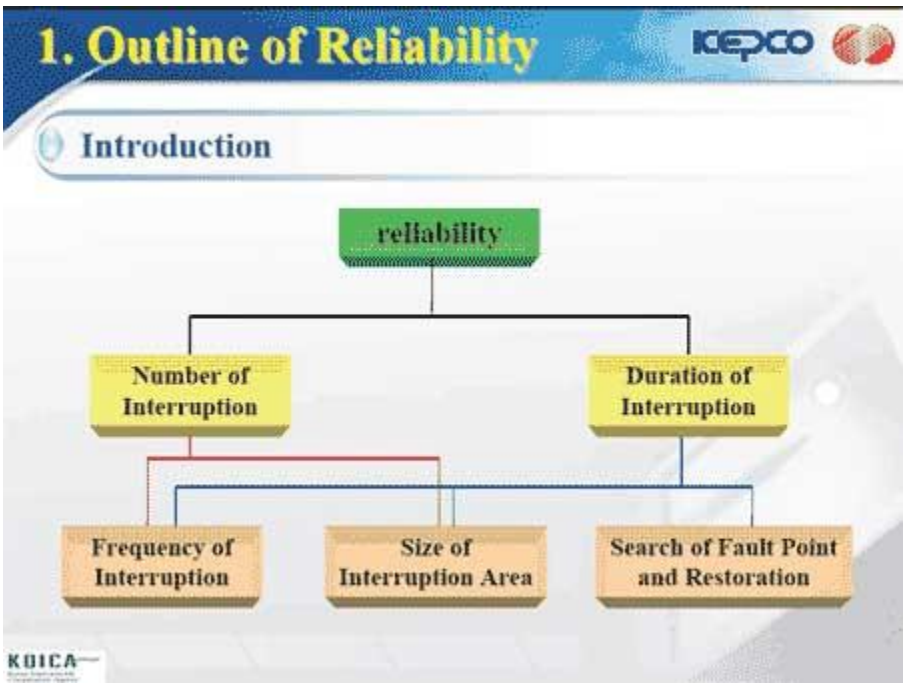
1. Outline of Reliability
KEPCO
Introduction
reliability
Number of Interruption
Duration of Interruption
Frequency of Interruption
Size of Interruption Area
Search of Fault Point and Restoration
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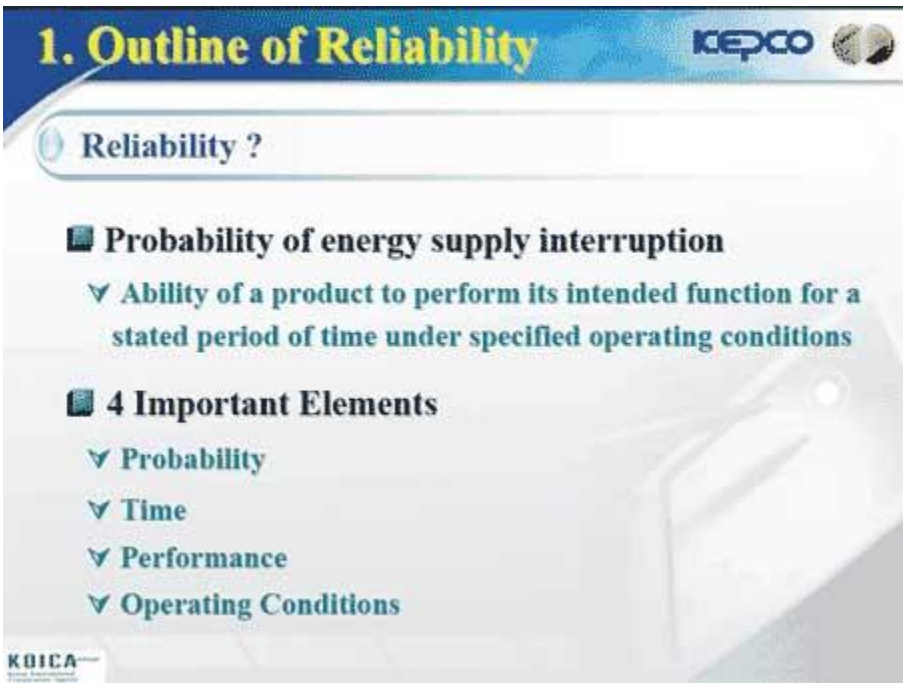
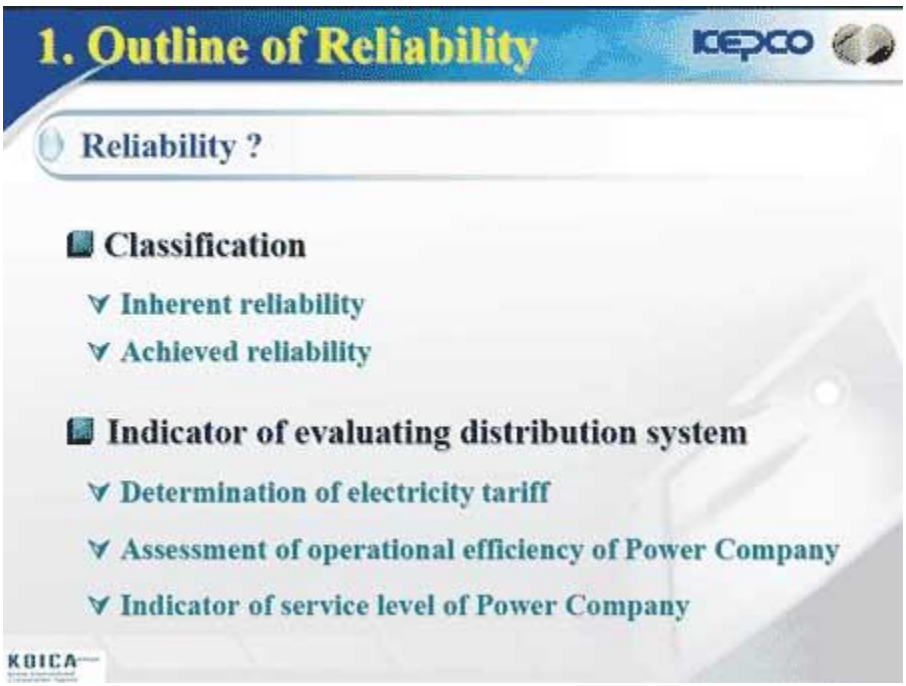
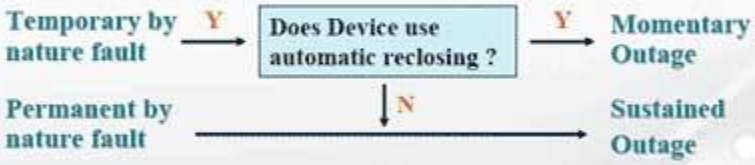




1. Outline of Reliability

Definition of Terminology

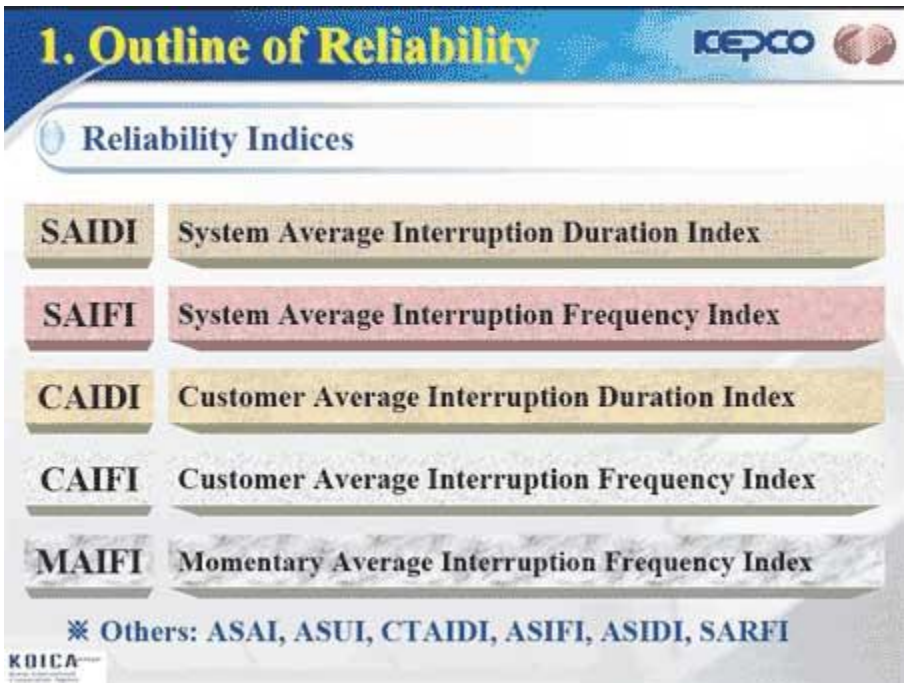
Temporary vs. Permanent Fault



Outage vs. Interruption

Interruption

- Instantaneous interruption : 0.5 ~ 30 cycles
- Momentary interruption : 0.5 ~ 3 s
- Temporary interruption : 3 s ~ 1, 3 or 5 min
- Sustained interruption : over 1, 3 or 5 min



1. Outline of Reliability

Reliability Indices

System Average Interruption Frequency Index

- Designed to give information about the average frequency of sustained interruption per customer over a predefined area

$$\text{SAIFI} = \frac{\text{Total Number of Customer Interruptions}}{\text{Total Number of Customers Served}}$$

$$= \frac{\Sigma N_i}{N_T}$$

1. Outline of Reliability

Reliability Indices

System Average Interruption Duration Index

- Designed to provide information about the average time of sustained interruption per customer over a predefined area

$$\text{SAIDI} = \frac{\sum \text{Customer Interruption Durations}}{\text{Total Number of Customers Served}}$$

$$= \frac{\sum r_i \cdot N_i}{N_T}$$

1. Outline of Reliability

Reliability Indices

Customer Average Interruption Duration Index

- Average time required to restore service to the average customer per sustained interruption

$$\text{CAIDI} = \frac{\sum \text{Customer Interruption Durations}}{\text{Total Number of Customer Interruptions}}$$

$$= \frac{\sum r_i \cdot N_i}{\sum N_i} = \frac{\text{SAIDI}}{\text{SAIFI}}$$

1. Outline of Reliability

Reliability Indices

Momentary Average Interruption Frequency Index

- Very similar to SAIFI
- track the average frequency of momentary interruptions

$$\text{MAIFI} = \frac{\text{Total Number of Customer Momentary Interruptions}}{\text{Total Number of Customers Served}}$$

$$= \frac{\sum ID_i \cdot N_i}{N_T}$$

1. Outline of Reliability

Reliability Indices

Average Service Availability Index

- Represent the fraction of time that a customer has power provided during the defined reporting period

$$\text{ASAI} = \frac{\text{Customer Hours Service Availability}}{\text{Customer Hours Service Demand}}$$

$$= \frac{N_T \cdot (\text{No. Hours / Year}) - \sum r_i \cdot N_i}{N_T \cdot (\text{No. Hours / Year})}$$

$$= \frac{8760 - \text{SAIDI}}{8760}$$

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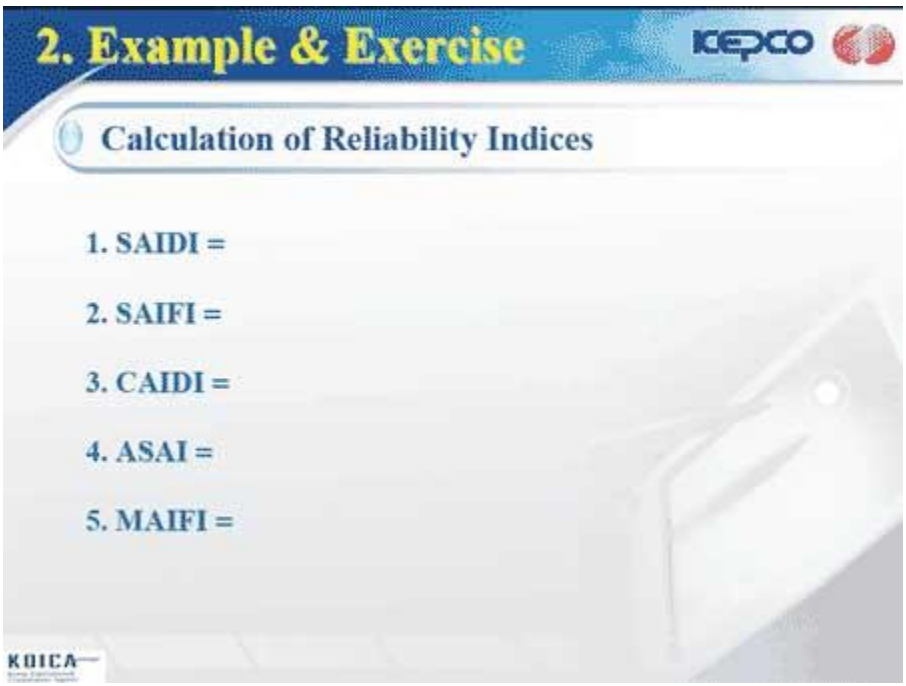
2. Example & Exercise

Calculation of Reliability Indices

- Total Customer : 10,000
- Sustained interruption : over 3 minutes

Date	Time of Outage	Time of Restoration	No. of Customer	Load (KVA)
Mar. 3	12:12:20	12:22:20	200	400
Apr.15	18:23:40	18:24:40	500	1600
May. 5	00:23:10	01:13:10	600	1500
Jun.12	23:17:00	23:47:00	200	700
Jul. 6	09:30:10	09:32:10	1000	2000
Aug.20	15:45:40	17:45:40	300	1000
Aug.31	08:20:00	09:20:00	500	1400
Sep. 3	17:10:20	17:30:20	1500	3000
Oct. 27	10:15:00	10:55:00	700	1500
Dec.10	20:30:20	20:33:20	500	1000


2. Example & Exercise
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Calculation of Reliability Indices
1. SAIDI =
2. SAIFI =
3. CAIDI =
4. ASAI =
5. MAIFI =
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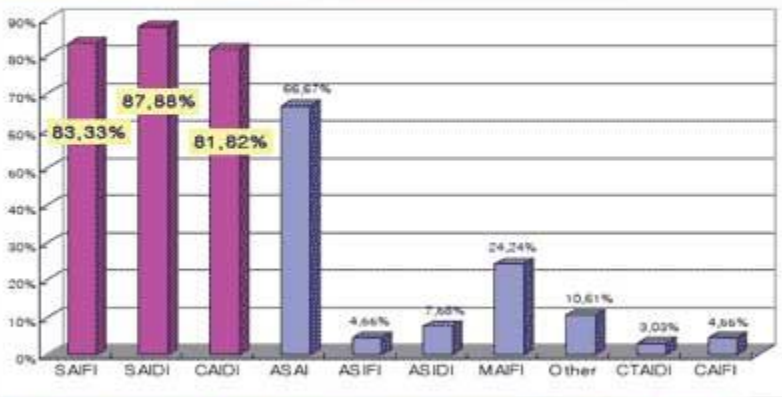
3. Overseas Status

Reliability Indices Used Worldwide



☞ More than 80% of the electric power companies surveyed used


3. Overseas Status
KEPCO
United Kingdom
Reliability Index
SAIFI, SAIDI, MAIFI, Survey of public opinion
Standard
Interruption : over 3 minutes
Source side interruption
- SAIFI : not included
- SAIDI : included 10% of interrupted time
Survey of public opinion
Kindness of employees
Their willing to help
Accuracy of information provided
usefulness of information provided
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3. Overseas Status
KEPCO
Italy
Reliability Index
SAIFI, SAIDI, MAIFI
Standard
Instantaneous : below 1 second
Momentary : 1 second ~ 3 minutes
Sustained : over 3 minutes
CEER (Council of European Energy Regulators)
Survey the reliability status in European power companies
Trust
Fast recovery of interruption
Quick & Reliable information provided
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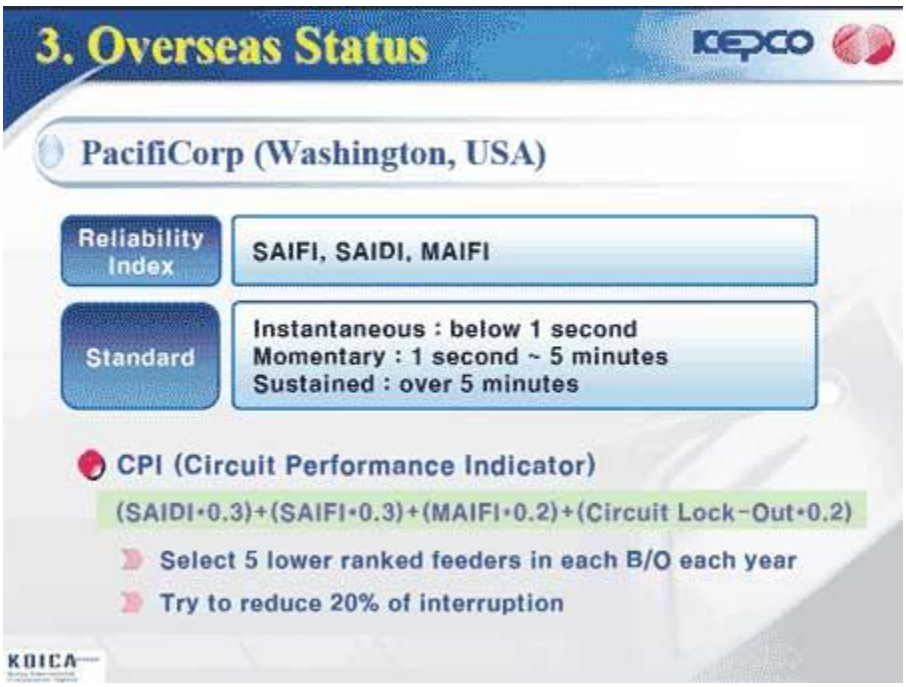
3. Overseas Status
KEPCO
PacifiCorp (Washington, USA)
Reliability Index
SAIFI, SAIDI, MAIFI
Standard
Instantaneous : below 1 second
Momentary : 1 second ~ 5 minutes
Sustained : over 5 minutes
CPI (Circuit Performance Indicator)
(SAIDI•0.3)+(SAIFI•0.3)+(MAIFI•0.2)+(Circuit Lock-Out•0.2)
Select 5 lower ranked feeders in each B/O each year
Try to reduce 20% of interruption
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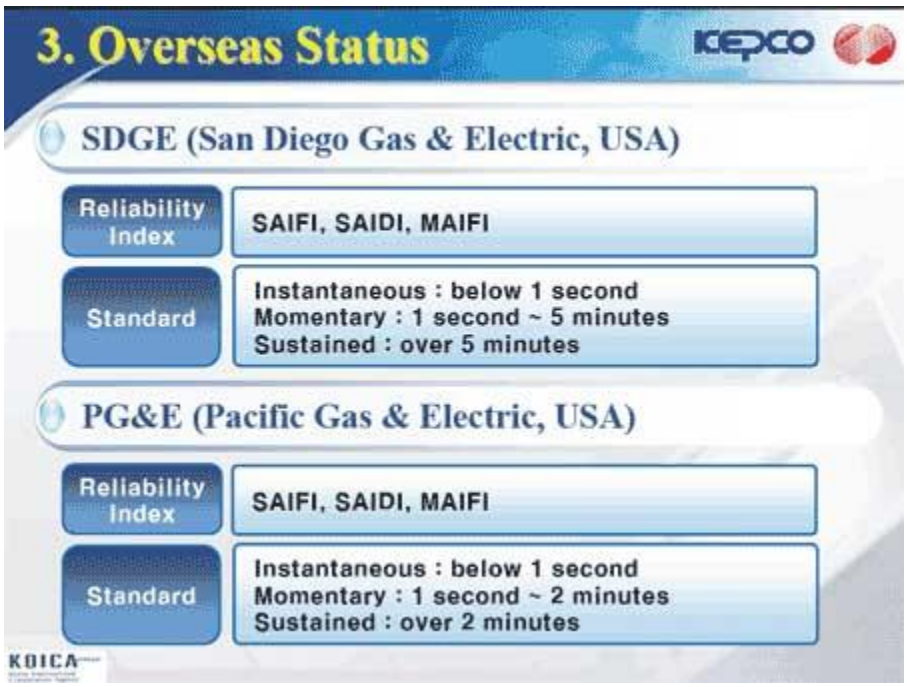
3. Overseas Status
KEPCO
SDGE (San Diego Gas & Electric, USA)
Reliability Index
SAIFI, SAIDI, MAIFI
Standard
Instantaneous : below 1 second
Momentary : 1 second ~ 5 minutes
Sustained : over 5 minutes
PG&E (Pacific Gas & Electric, USA)
Reliability Index
SAIFI, SAIDI, MAIFI
Standard
Instantaneous : below 1 second
Momentary : 1 second ~ 2 minutes
Sustained : over 2 minutes
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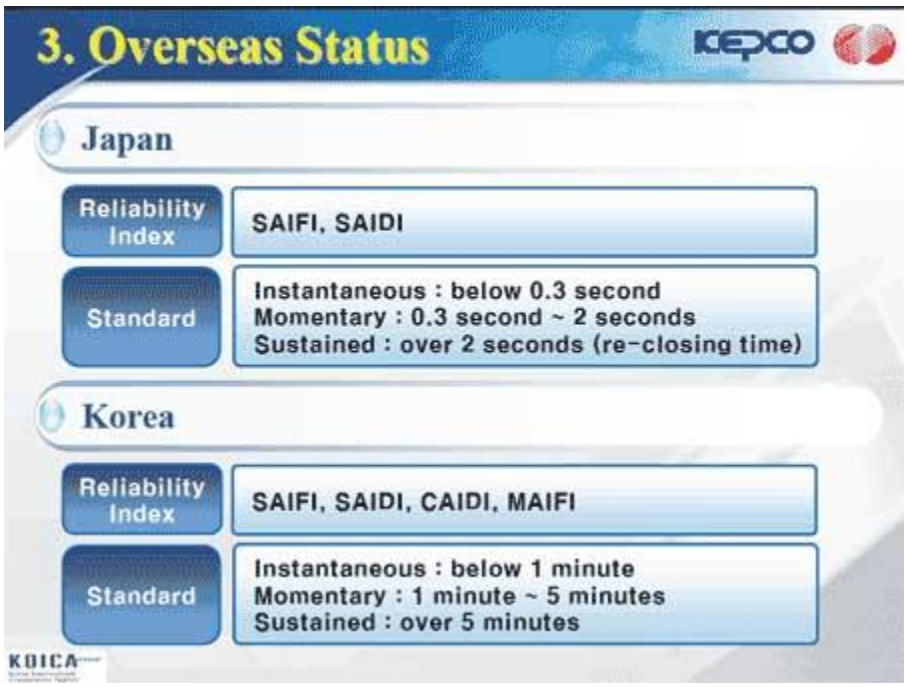
3. Overseas Status
KEPCO
Japan
Reliability Index
SAIFI, SAIDI
Standard
Instantaneous : below 0.3 second
Momentary : 0.3 second ~ 2 seconds
Sustained : over 2 seconds (re-closing time)
Korea
Reliability Index
SAIFI, SAIDI, CAIDI, MAIFI
Standard
Instantaneous : below 1 minute
Momentary : 1 minute ~ 5 minutes
Sustained : over 5 minutes
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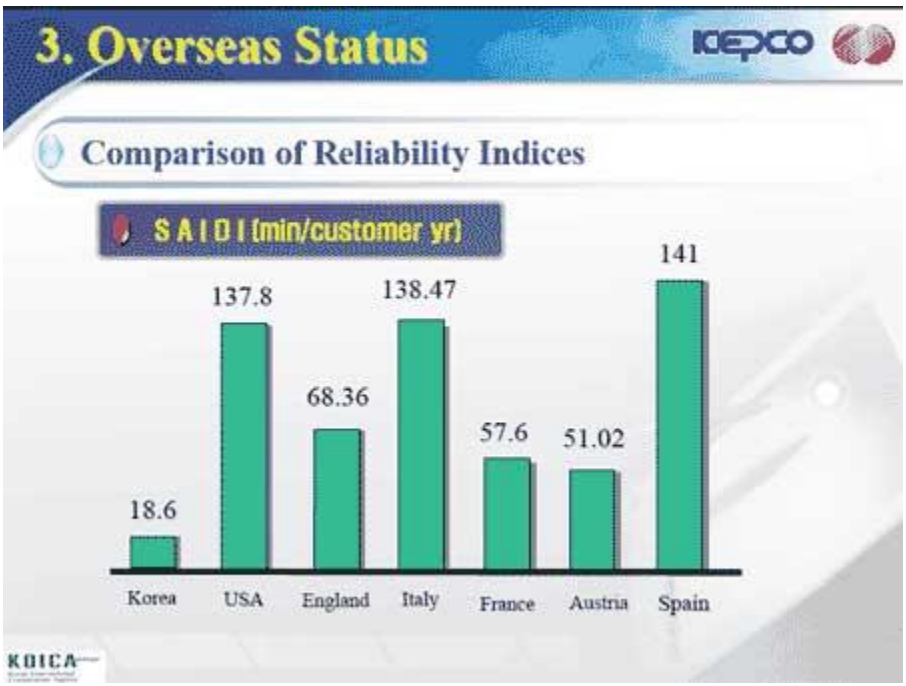
3. Overseas Status
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Comparison of Reliability Indices
S A I D I (min/customer yr)
18.6
137.8
68.36
138.47
57.6
51.02
141
Korea
USA
England
Italy
France
Austria
Spain
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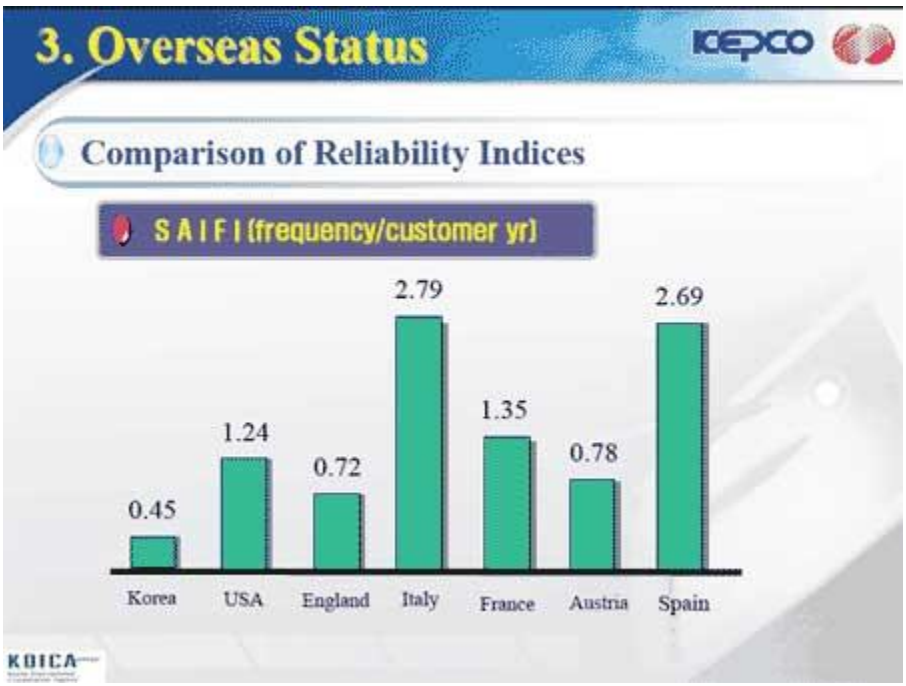
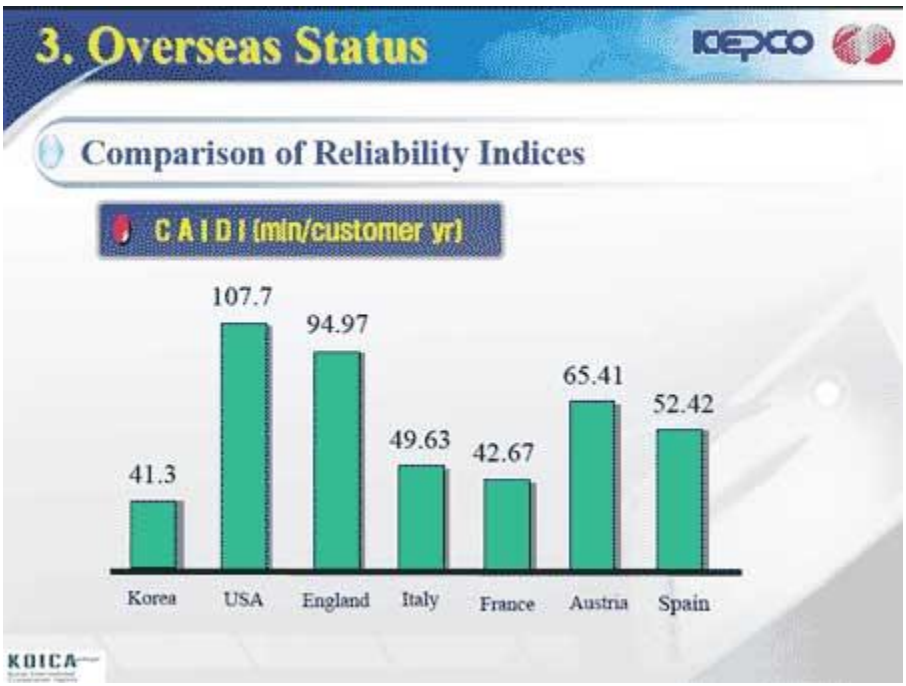

3. Overseas Status
kepco
Comparison of Reliability Indices
S A I F I (frequency/customer yr)
0.45
1.24
0.72
2.79
1.35
0.78
2.69
Korea
USA
England
Italy
France
Austria
Spain
KOICA



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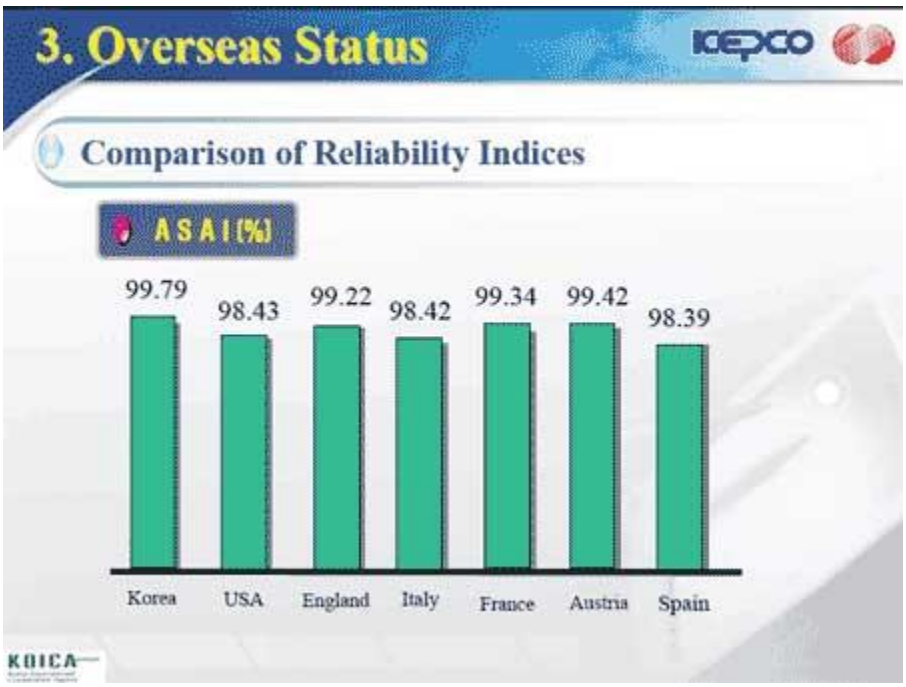
3. Overseas Status
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Comparison of Reliability Indices
ASAI(%)
99.79
98.43
99.22
98.42
99.34
99.42
98.39
Korea
USA
England
Italy
France
Austria
Spain
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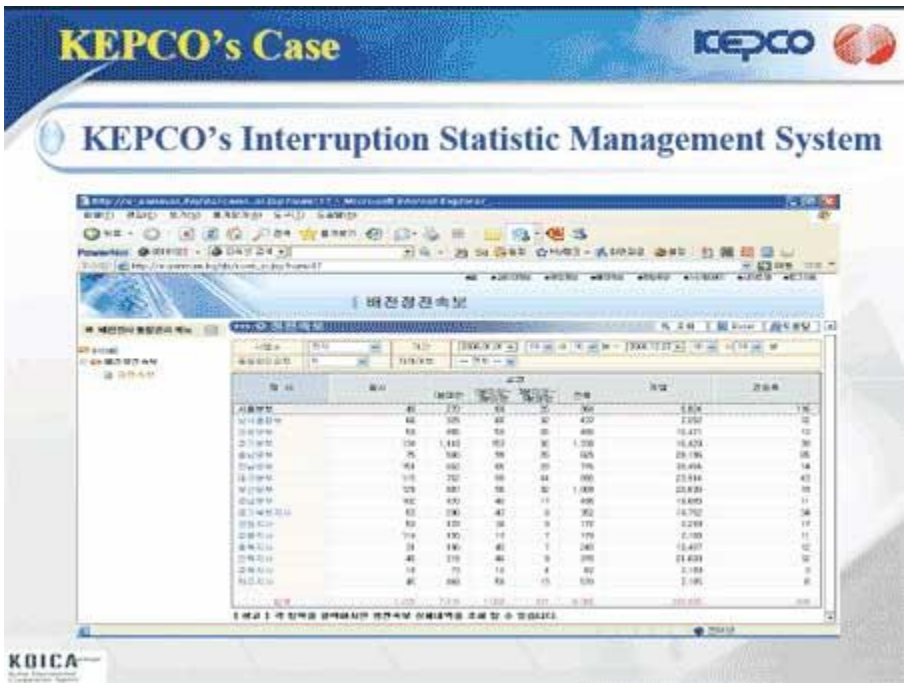

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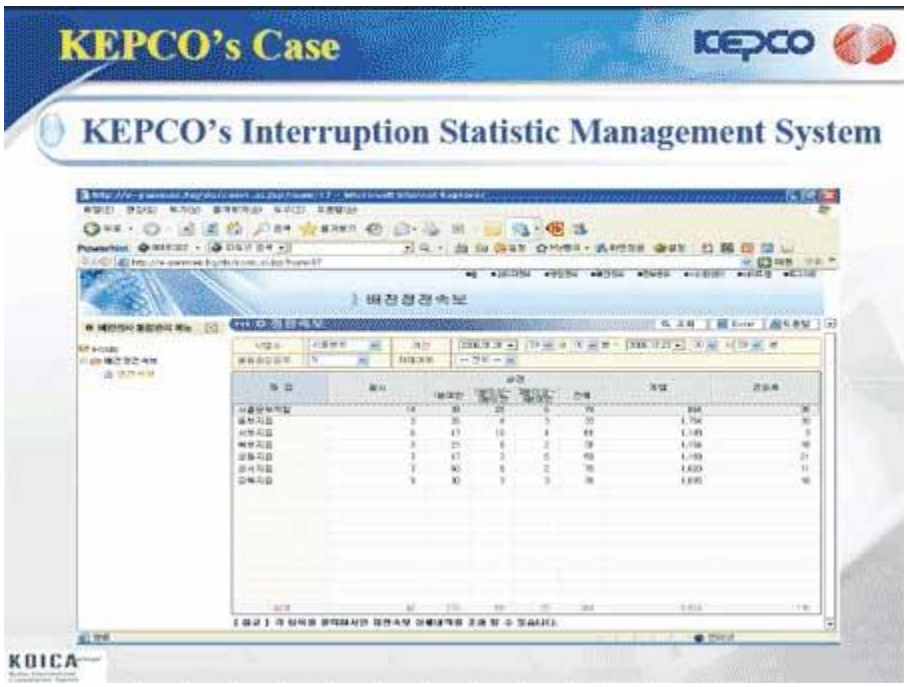
KEPCO's Case
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KEPCO's Interruption Statistic Management System
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KEPCO's Case

New Distribution Information System (NDIS)

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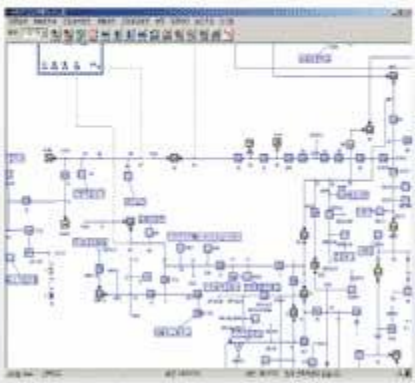
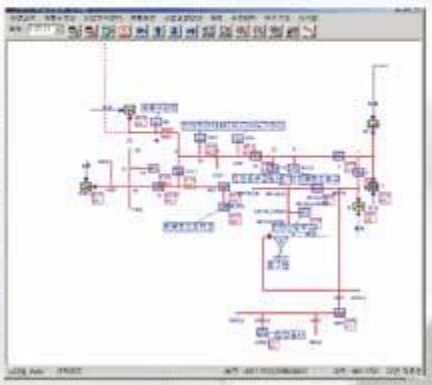
KEPCO's Case

New Distribution Information System (NDIS)



System circuit diagram



Single line diagram

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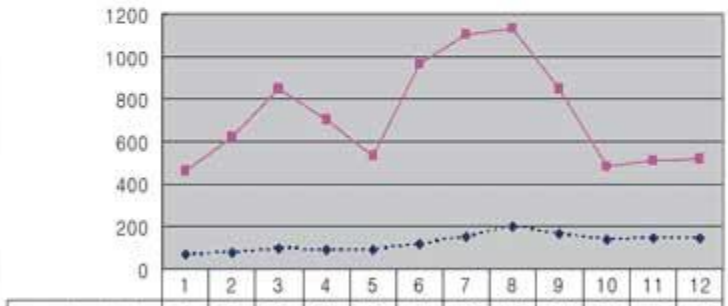
KEPCO's Case

KEPCO's Interruption Analysis

Interruption status of KEPCO by month



	1	2	3	4	5	6	7	8	9	10	11	12
Sustained	71	75	96	90	93	119	152	200	163	135	146	147
Momentary	464	621	849	706	530	966	1103	1128	851	482	508	519

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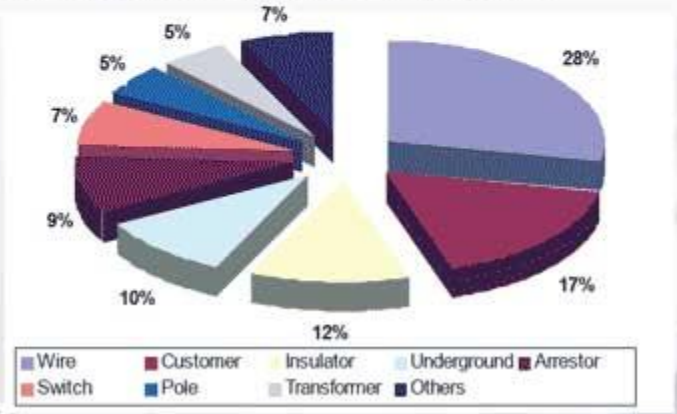
KEPCO's Case

KEPCO's Interruption Analysis

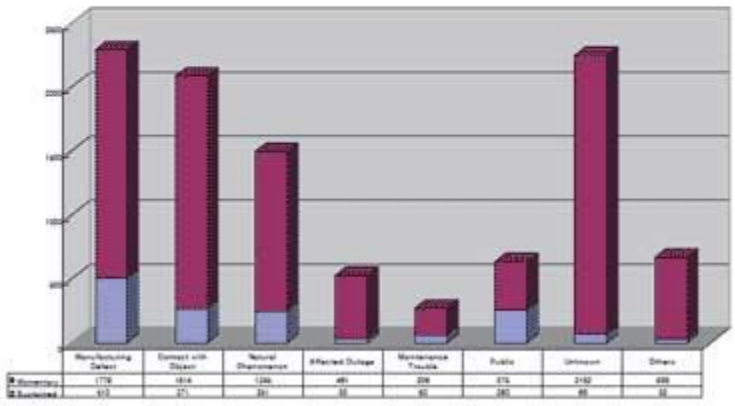
Interruption status of KEPCO by facility



KEPCO's Case

KEPCO's Interruption Analysis

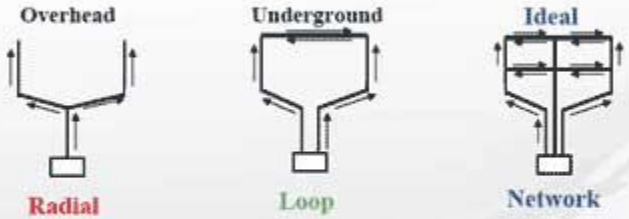
Interruption status of KEPCO by cause



4. Improvement Strategy

Improvement of the Fault Prevention System

System interconnection and division



System interconnection and division

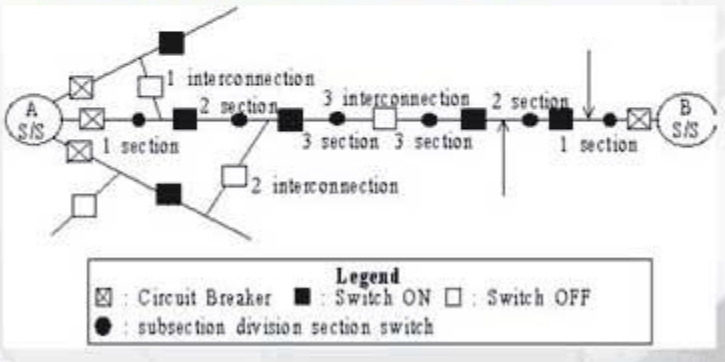
Tokyo Electric	Kyushu Electric	Texas Electric	KEPCO
General : 3/3 Large capa : 6/6 Underground : 2/2	3/3	3/3	3/3

4. Improvement Strategy

Improvement of the Fault Prevention System

System interconnection and division of KEPCO

☞ Reduce fault recovery duration & area



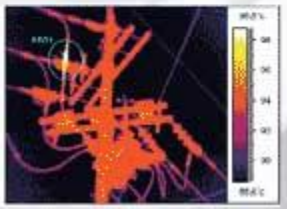
4. Improvement Strategy

Improvement of the Fault Prevention System

Use Infrared light Camera for Facility Diagnosis

- Portable Instruments & Diagnosis Vehicle

- Analysis Program



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4. Improvement Strategy

Improvement of the Fault Prevention System

Introduce Fault Indicators

- Underground Line Fault Indicator

- Overhead Line Fault Indicator

4. Improvement Strategy

Prevention of the Underground Cable Fault

Diagnosis of Underground Cable Deterioration

- Diagnosis and then replace bad condition cable
- RVM (Return Voltage Method) for paper insulated Cable

DC 1 kV → Cable → Return Voltage → PC Analysis

electrified　discharged　measured

- Deterioration Determination Criteria

Deteriorated	Cautionary	Good
Less than 1.65	1.65~1.86	Over 1.87

4. Improvement Strategy

Prevention of the Underground Cable Fault

Non-Contact Infrared Thermometer

- Deterioration Determination Criteria

Deteriorated	Cautionary	Good
Over 15 ℃	± 10 ℃	0 ~ 5 ℃

Prevent Damage to Cable by External Shock

- Underground line mark & marking post
- Cable protection plate & Protective cable alarm sheet




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4. Improvement Strategy

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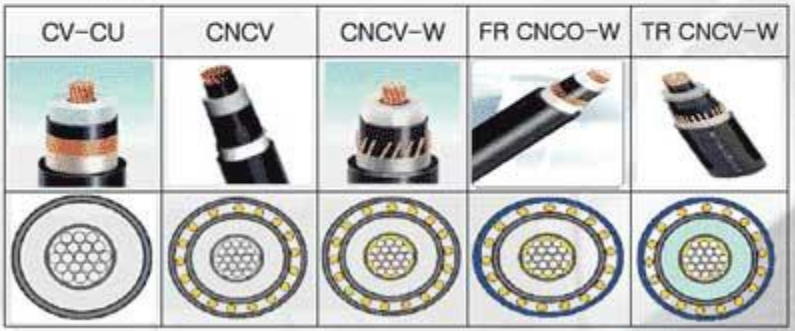
Prevention of the Underground Cable Fault

- **Strengthen the Patrol of Excavation Site**
  - Hold a periodic conference with other utilities
- **Use highly Reliable & Endurable Cable**



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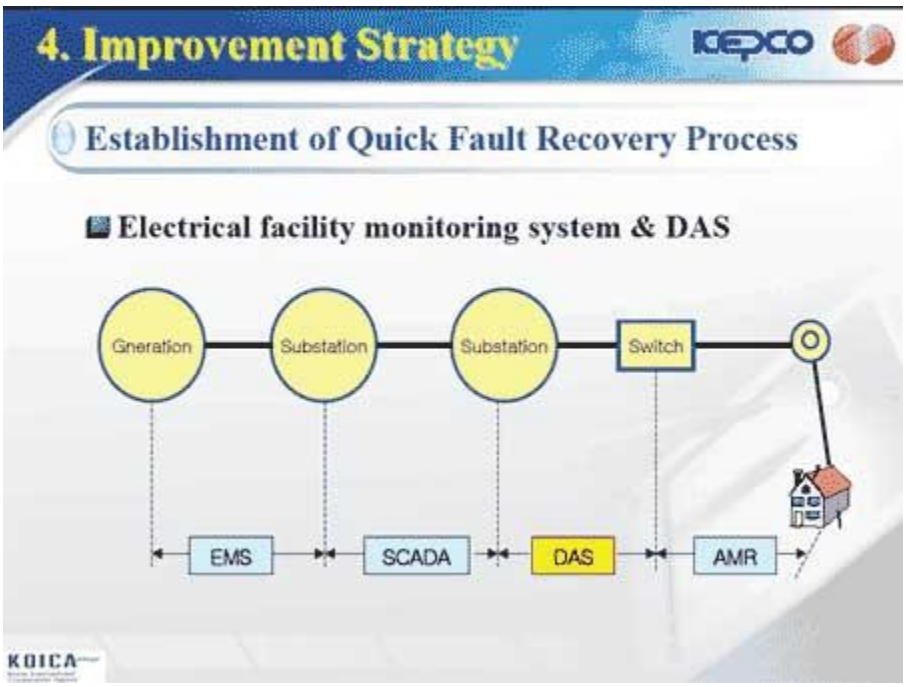
4. Improvement Strategy

Prevention of Tree Contact

- Tree Trimming

- Insulated Wire & Aerial Bundled Cable

- Curved pole


4. Improvement Strategy
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Establishment of Quick Fault Recovery Process
Electrical facility monitoring system & DAS
Gneration
Substation
Substation
Switch
EMS
SCADA
DAS
AMR
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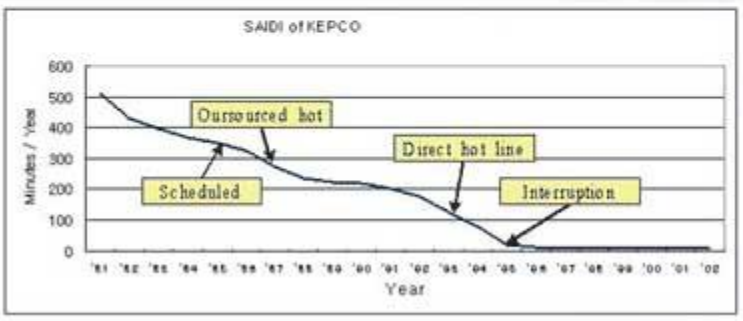
4. Improvement Strategy

KEPCO's New Work Process

- Hot line work
- maintenance techniques without power interruption



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4. Improvement Strategy
KEPCO
Miscellaneous
Introduce internal competition
Permanent emergency mobilization process
Secure major materials for emergency
Prevent Faults Attributable to 3rd Party-owned Facilities
refer to fault propagated from electrical facilities owned by customers or other 3rd party
ask to improve their old facilities and take appropriate measures
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4. Improvement Strategy
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Reliability Improvement
Power Companies
Customers
Provide high quality power by technology development and devices
Better Service Satisfaction
Eliminate elements causing reliability problem
High Reliability
Competitiveness Confidence
Highly reliable Equipment
Develop equipment with longer life and stronger against reliability problem
Device Manufacturers
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