KEPCO
Distribution Automation System

KEPCO
KOREA ELECTRIC POWER CORPORATION

KEPCO PROFILE (Forbes 2008)

Key financial performance : A1 by Moody's, A by S&P Fitch

- Sales Power : 368,605 GWh
- Total assets : USD 83.6 billion
- Revenues : USD 29.6 billion
- Net profit : USD 2.4 billion

Key management efficiency

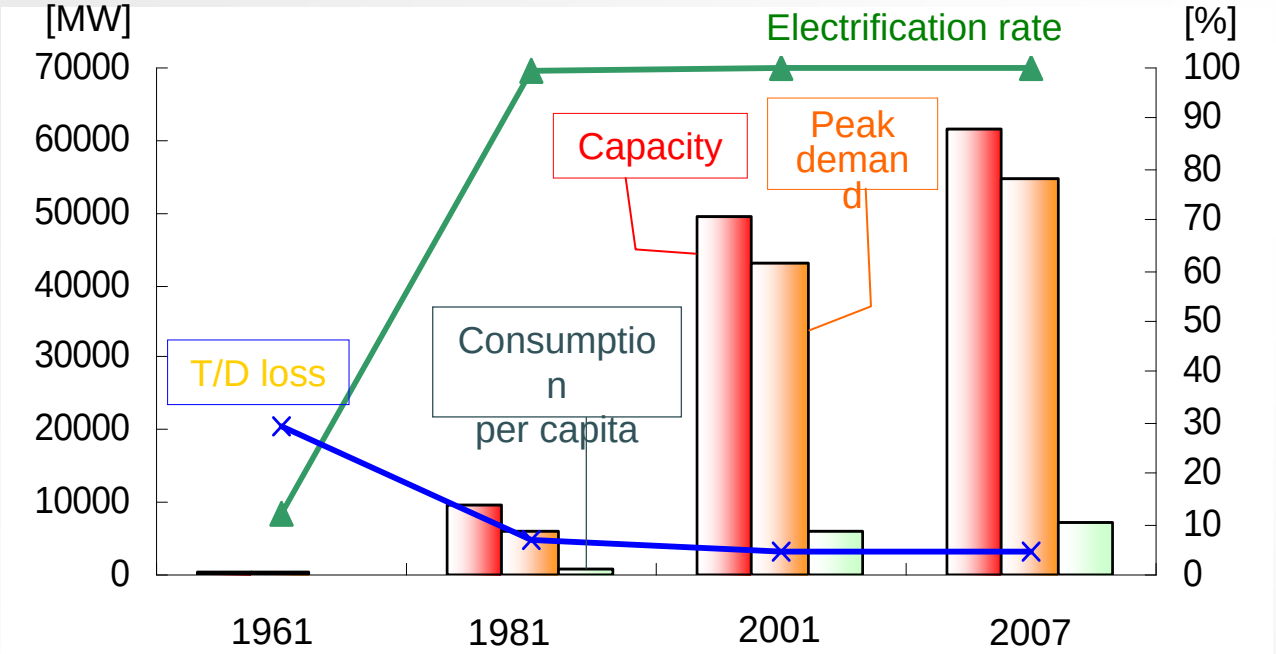
- Power loss in T & D : 3.99%
- Load factor : 73.9%
- Peak Demand : 62,285 MW (Power Gen Cap 68,286 MW)

North Korea Power Supply

KEPCO in Korean Power Market (As of 2007)

88%	100%	100%
		
Generation	**Transmission**	**Distribution**
Korea's Total Capacity: 68,268MW (100%)	Line Length: 29,979 C-km	Line Length: 401,485 C-km
KEPCO & Subsidiaries: 60,100MW (88%)	Supports: 39,937 Units	Support : 7,894,577 Units
IPPs & Others: 8,168MW (12%)	669 Substations	No. of Customers: 18,039 (Thousand Households)

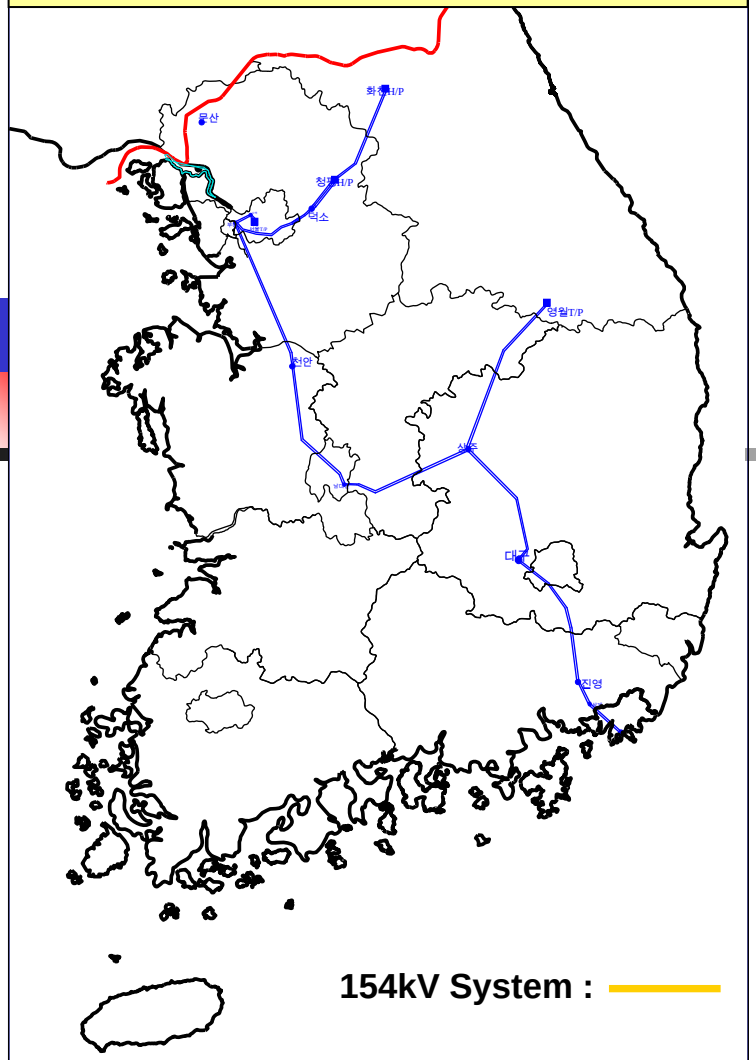
Major Changes over last 4 decades



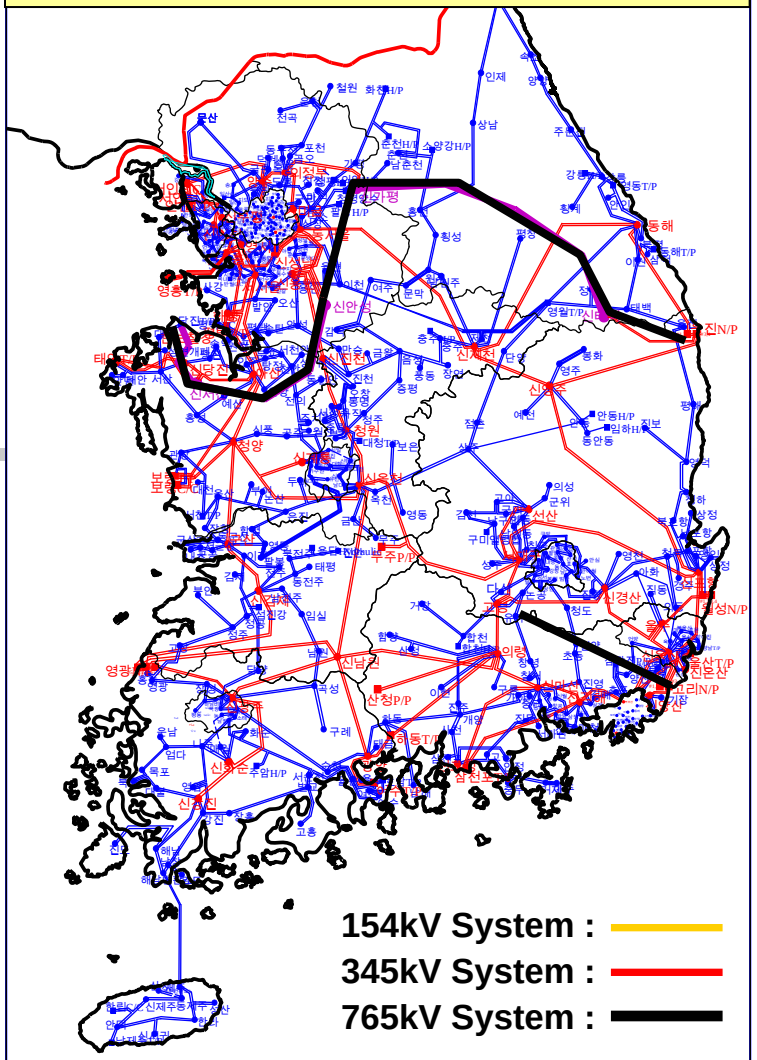
Year	1961	1981	2001	2007
Installed capacity (MW)	367	9,835	49,632	68,268
Peak demand (MW)	305	6,144	43,125	62,285
Consumption per capita (kWh)	46	927	5,965	7,524
Electrification rate (%)	12	99.3	99.9	99.9
T/D loss (%)	29.4	6.7	4.7	3.99

Korea's Power System

Power system (1965)



Power system (2007)




In Autumn….

Present DAS Status

		~'98	'99	'00	'01	'02	'03	'04	'05	'06	'07	Total
No. of control center	SDAS	18	66	60	29	0	-8	-13	-15	-15	-42	80
	TDAS	1	0	1	1	9	8	14	17	16	43	110
Ratio of automated feeder(%)		5	23	42	45	50	62	75	85	89	90	7,734 D/L
No. of automated switches		896	5,286	8,237	12,756	16,915	21,056	25,443	30,255	33,785	37,381	37,381 switches
Ratio of automated switch(%)		2	12	18	27	30	36	46	25	49	56	133,280 switches

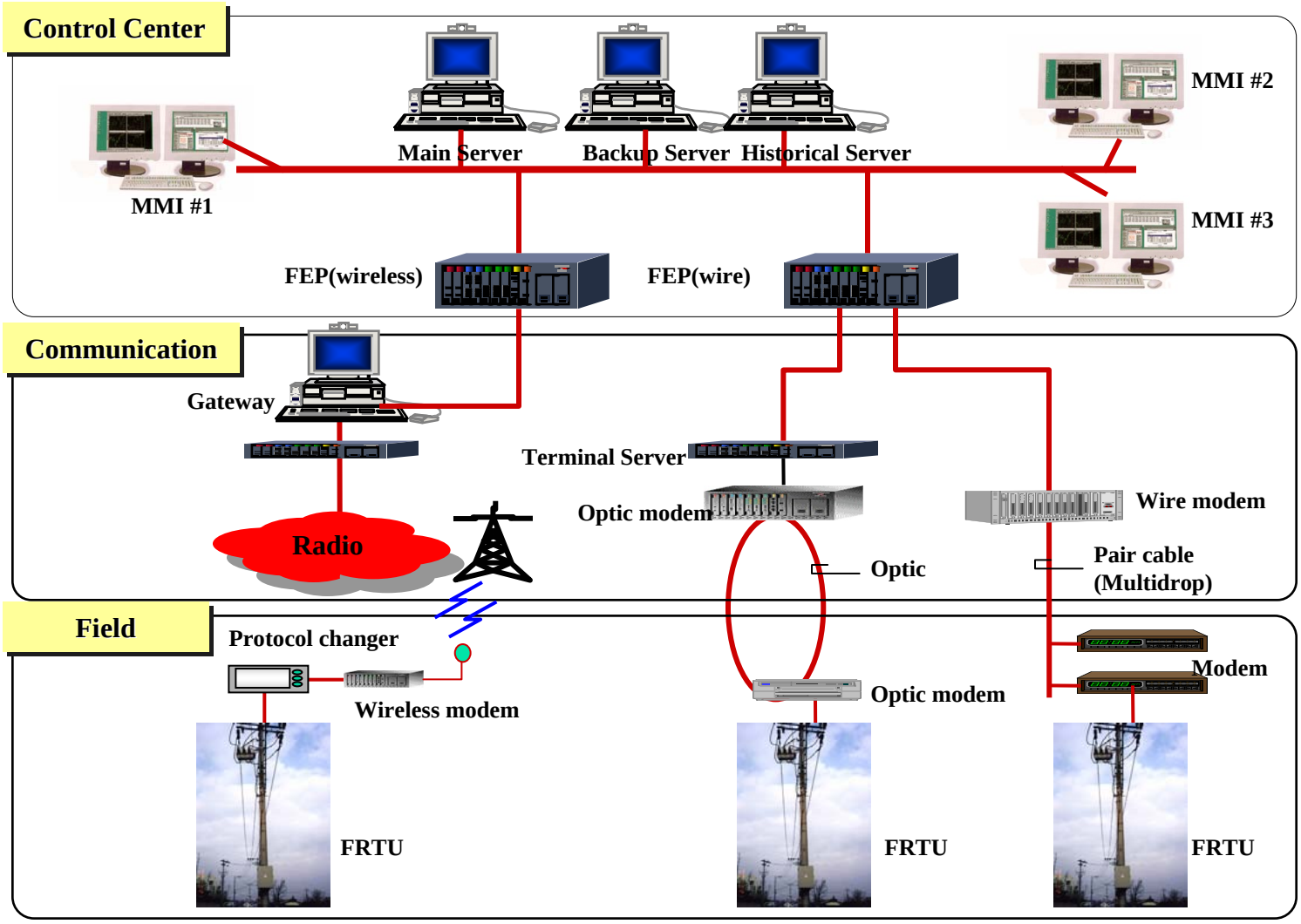
- GA/28,173, RA/4,699, PA/3,363, MCA/145 Total/36,380
- Section Switch/25,383, Link Switch/10,997

Communication Media

[Communication Protocol : DNP 3.0]

Media	Modem Price(W)	Speed(bps)	Fee/month (W)	App. year	Portion
PLC	-	9,600	0	2006	test
Telephone wire	473,000	1,200	49,400	1998	15 %
Optical fiber	272,000	19,200	54,000	2000	68 %
Mobile Data	554,000	9,600	18,000	1998	8 %
TRS	1,285,000	9,600	0	2000	8 %
CDMA	900,000	9,600	17,000	2000	1 %

TDAS Configuration



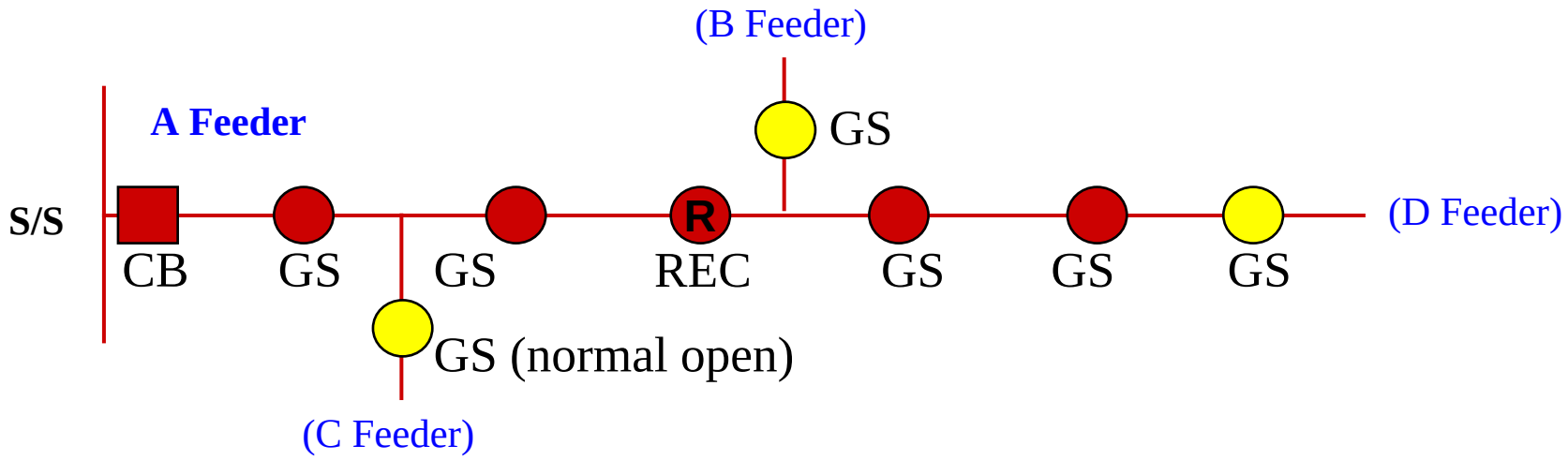
KEPCO IT Control Center

Distribution Automation

- Definition
  - The distribution automation system (DAS) provides an integrated technology that enables to remotely supervise and control breakers and switches on distribution network in real-time covering the distribution substations
- Functions
  - SCADA, FA, DMS, Optimal Operation of Distribution Network,
- Features
  - Extendable, Scalable, and Distributed Design
  - Open and Standardization
  - Reliable, Redundant Data Server
  - Diverse Lineup of RTUs Specified for Switches
  - Total Solution for Distribution Automation and Management

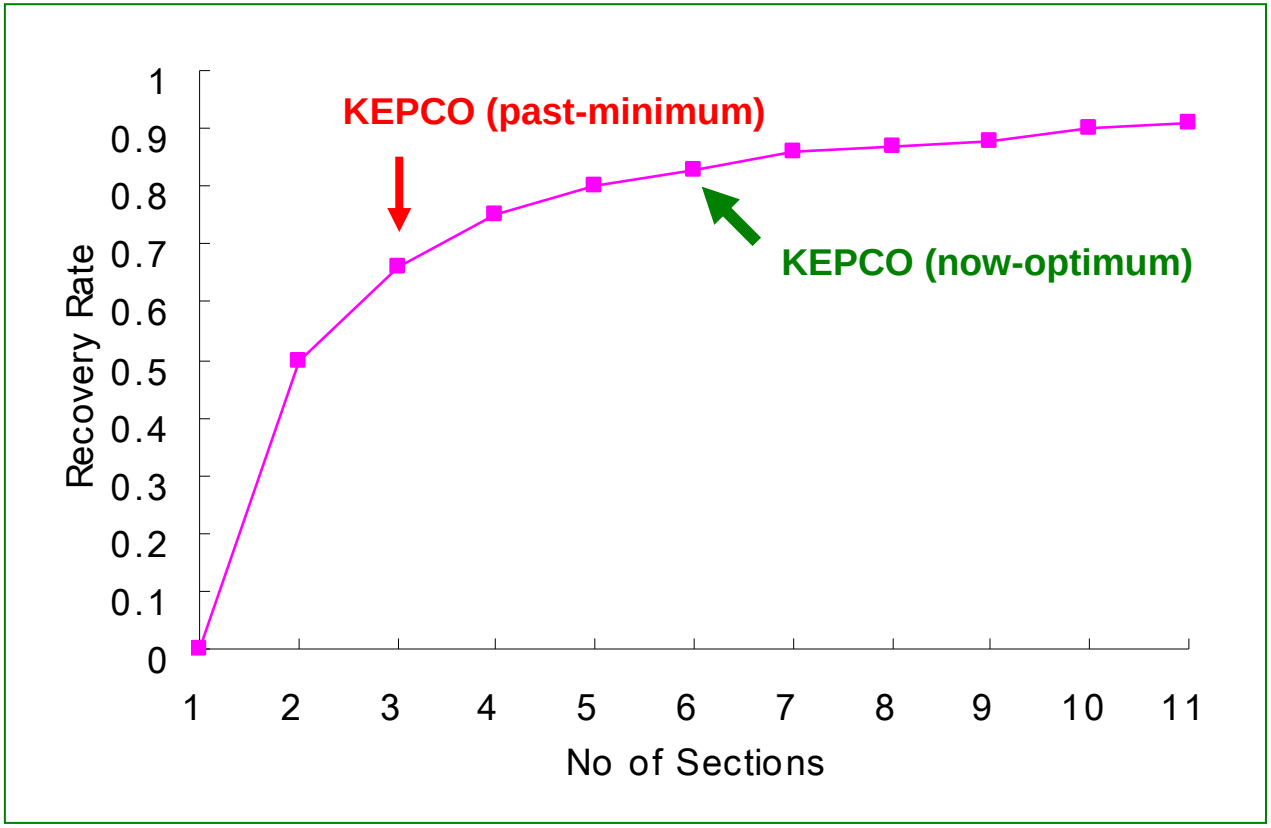
Feeder Standard of KEPCO

- Feeder power capacity
  - Normal : 10,000KVA (250A)
  - Emergency : 14,000KVA (350A)
- Standard : 6 section 3 link
  - Past : 3 section 3 link



Feeder Segmentation Effect

- Recovery Rate vs. No of Sections



Analysis the number of links

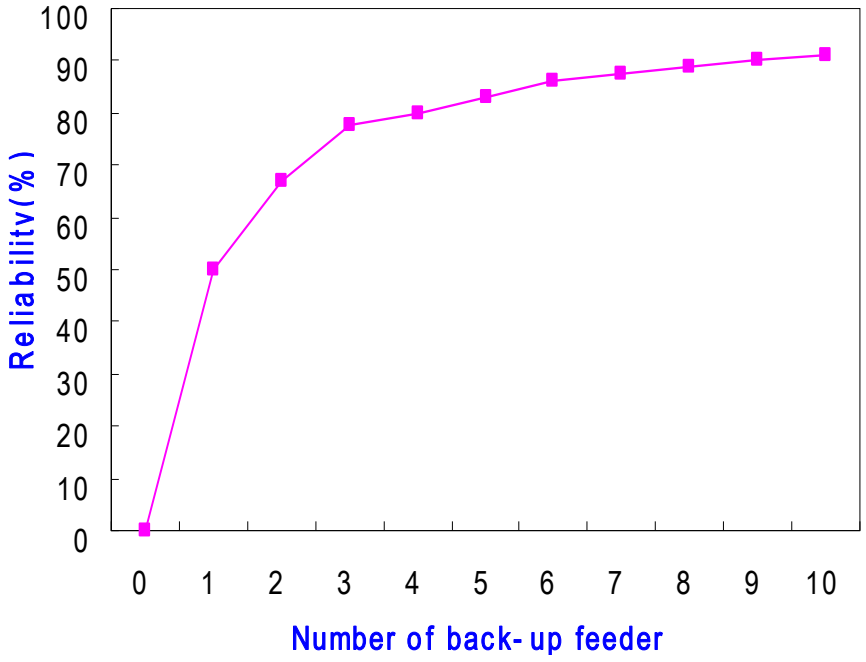
- Feeder capacity (normal/emergency)

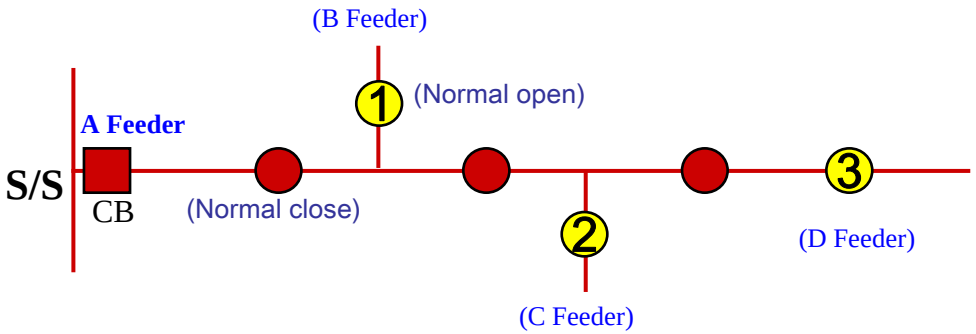
	KOREA	JAPAN	IRAN
Normal Capacity (Cn)	10MVA (250A)	6MVA	7MVA (200A)
Emergency Capacity (Ce)	14MVA (350A)	8MVA	10MVA (320A)
No of sections (Minimum)	2.5 → 3	3	3

- No of Links(n) = Cn/(Ce-Cn)
  - n ≥ 6/(8-6) = 3
  - No of links should be minimum three

Feeder Linkage Effect

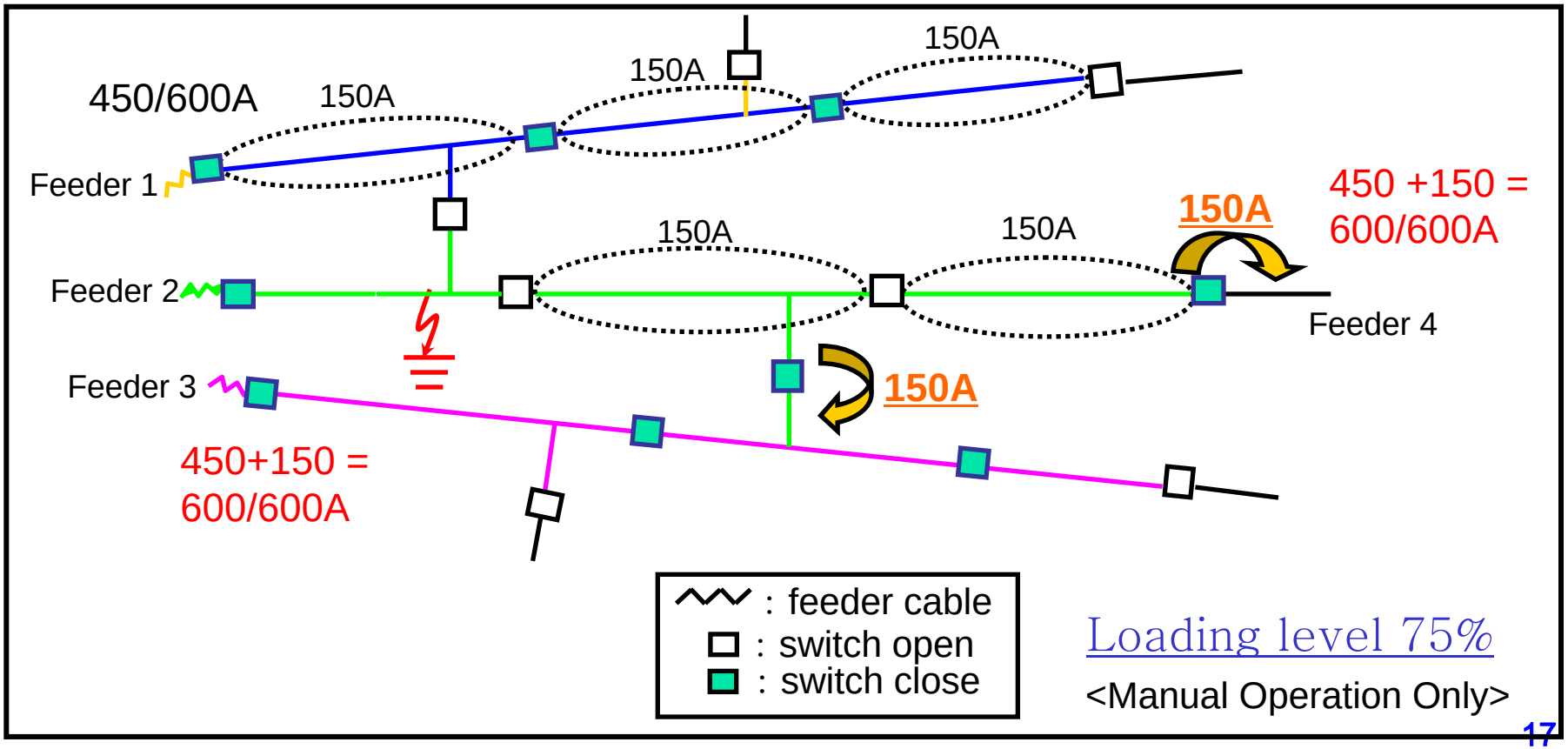
- Reliability vs. Number of linked back-up feeder





Effective Use of Facilities

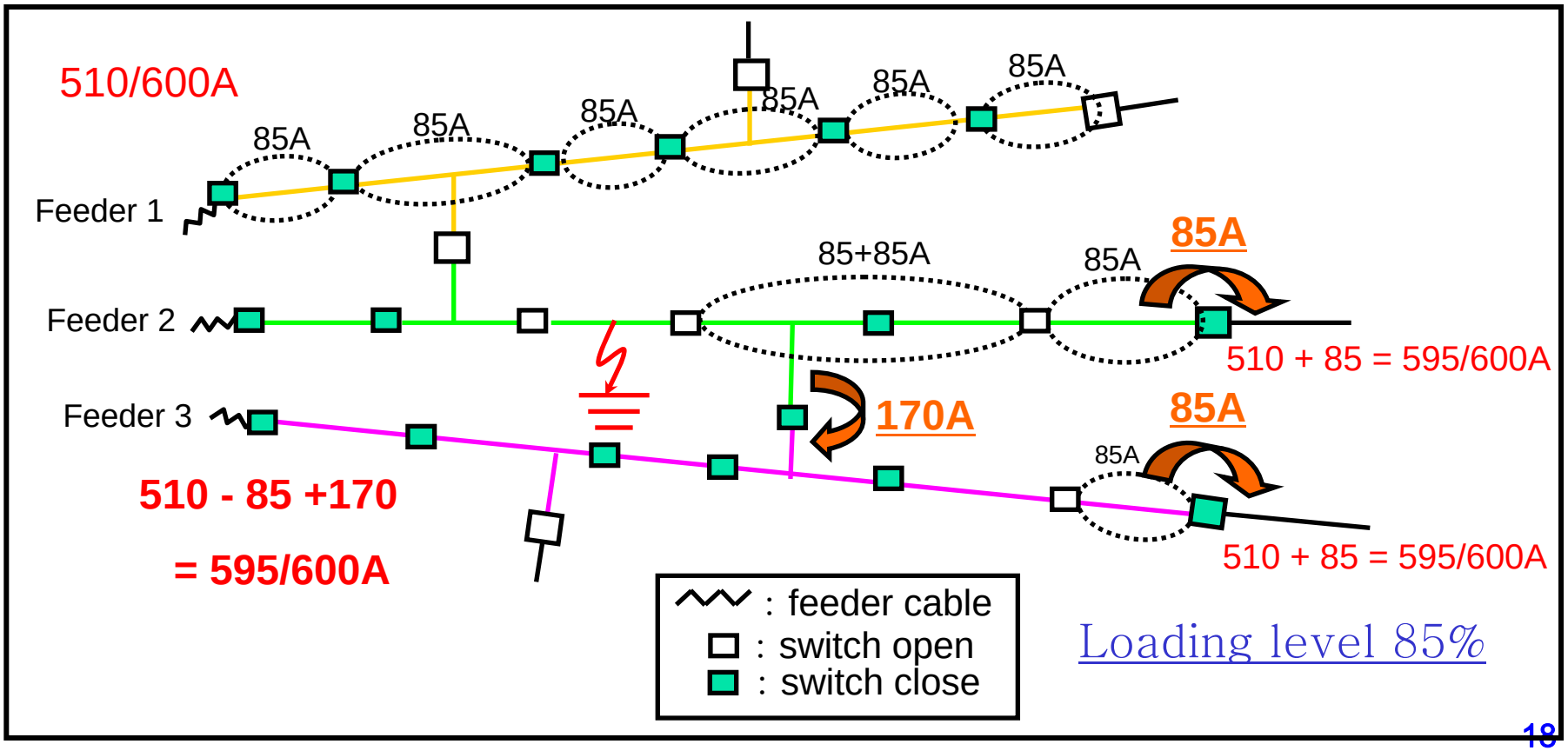
- Single Step Switching to Adjacent Distribution Line
- Conductor capacity; 600A
- Operating Rating ; 450A
- Loading Level ; 75% (450 / 600A)



Effective Use of Facilities

- Multi-step switching
- Operating Rating ; 450A → **510A**
- Loading Level ; 75% → **85%**

Enhance Loading Level



Current & Voltage Sonsors

- Sensors
  - Measure single/three phase line currents and voltages and reports these measurements to RTU
  - Accuracy + or – 3%
  - Suitable for measuring fault current
  - May be incorporated in the switch
  - Must detect fault before it's cleared
  - Korean products have the CTs & PTs inside all switches

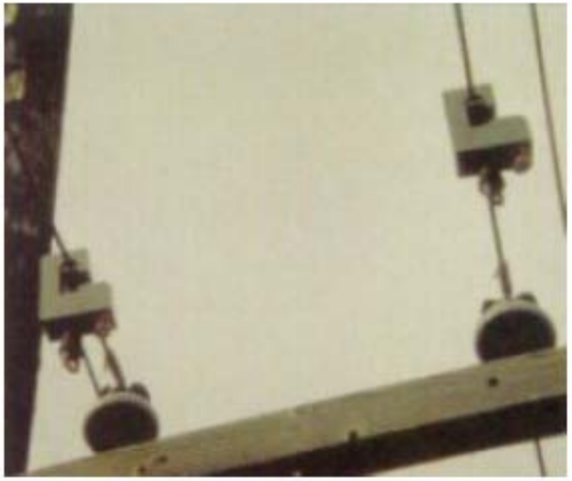
Fisher Pierce Line Post Sensor

Fault Indicators

- Fault Indicators
  - Clamp on style or built-in function on Feeder RTU
  - Current inrush restraint
  - Fault settings
  - Bi-directional
  - Detect fault before clearing
  - Reset conditions
    - Time
    - Restoration of voltage or current
  - Output signal to feeder RTU
    - Radio signal
    - Fiber optic/metallic cable
  - Local indicator visible from ground level or displayed in the control box

- Korean products have the function of fault Indicator in all Feeder RTUs

Fisher Pierce



Edison Controls FCI

Present Function

- SCADA Function
  - Primary substation
  - Switching station & Switches
  - MV customer
  - MV/LV Transformer
- DMS Function
  - Facility management
  - Work management
  - Fault management
  - Topology management
  - Network & protection management
  - Switching planning
  - Outage DATA management

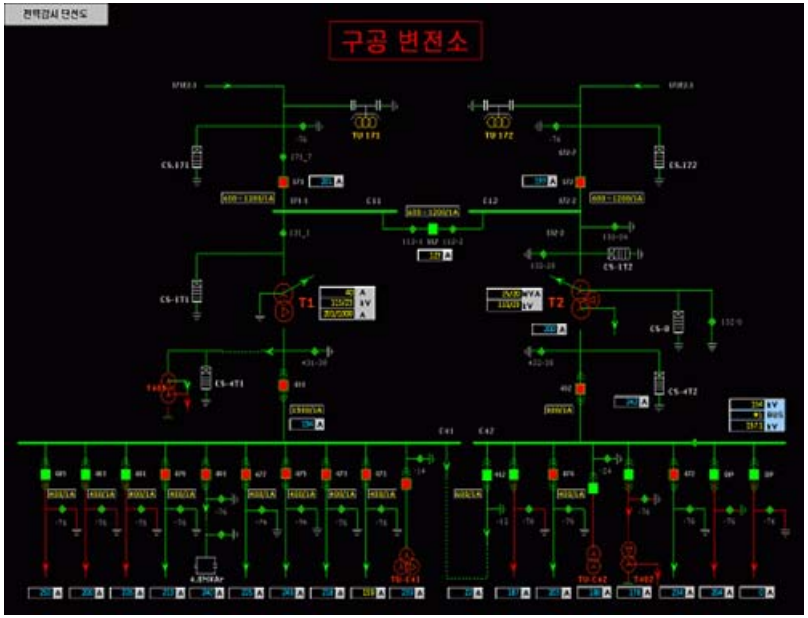

Between spring and summer....

SCADA Function

- Primary Substation
- Switching Station
- HV Customer
- MV Transformer
- Automated Switch
- History management
- Trend Graph
- Report

SCADA for Substation

- Abstract
  - Real-time monitoring and control on equipment in primary substation
  - Topology coloring
- Main function
  - Real-time control
  - Status & analog data monitoring
  - Relay operation monitoring
  - Live/Dead line coloring
  - Integrated DAS and SCADA

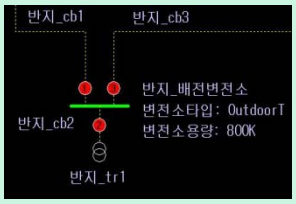
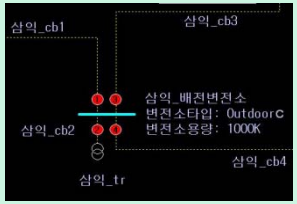
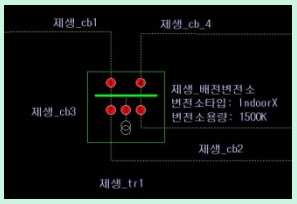
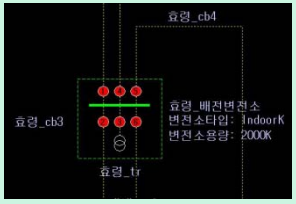


<SCADA Monitoring>

Switching Station

- **Abstract**
  - **Monitoring and control for switching station or distribution substation**
- **Main function**
  - **Remote control and monitoring of facilities in distribution substation**
  - **Analog data acquisition such as voltage and current**
  - **Remote parameter setting of RTU**
  - **Topology coloring as live line, dead line and loop line**
  - **Covering 3 switches to 6 switches in house**

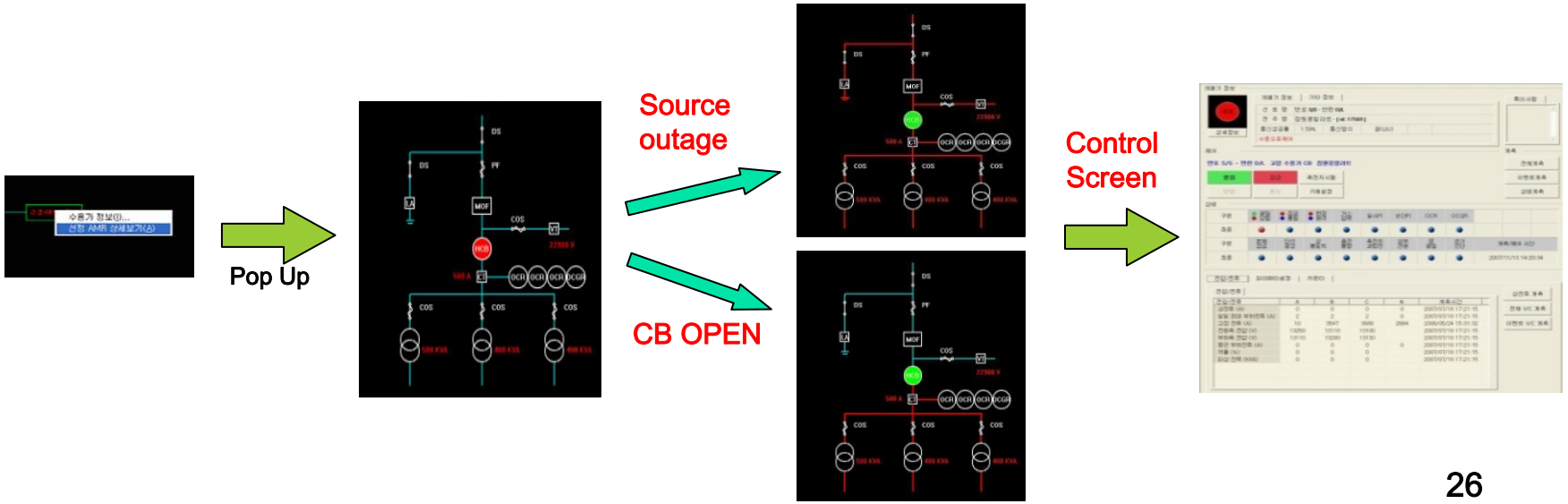
Switching Station

OutDoor T (3 switches & Tr)	OutDoor C (4 switches & Tr)	InDoor X (5 switches & Tr)	InDoor K (6 switches & Tr)
			

<Types of switching station in Vietnam>

HV Customer

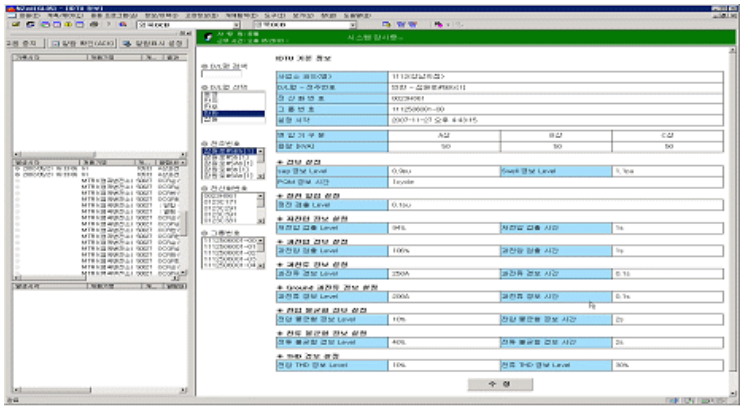
- **Abstract**
  - **Monitoring and control on CB of HV customer**
- **HV Customer SCADA**
  - **Support the standard single line diagrams of HV customer**
  - **Topology coloring**
  - **Remote control of CB**
  - **Give the Relay operation info**

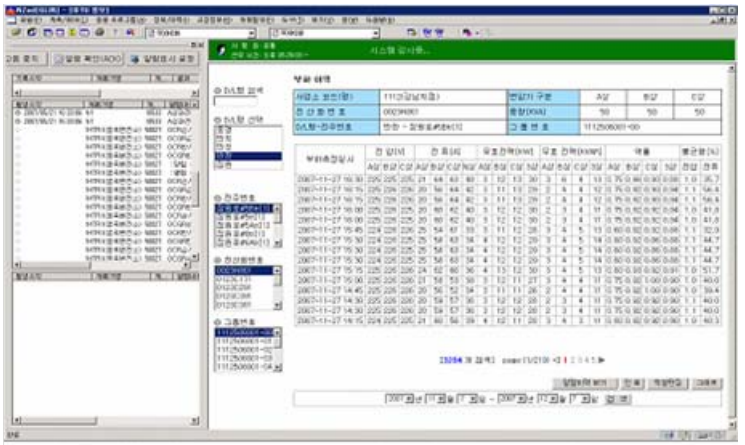


Monitor the pole transformer

- **Abstract**
  - Monitoring of distribution transformer information
  - Display the historical data of transformer

- **Main function**
  - Web interface
  - Remote data acquisition
    - Voltage & Current
      - PQM
      - Outage
      - Temperature
  - Load trend graph
  - Printout supporting
  - Alarm and event





DMS Function

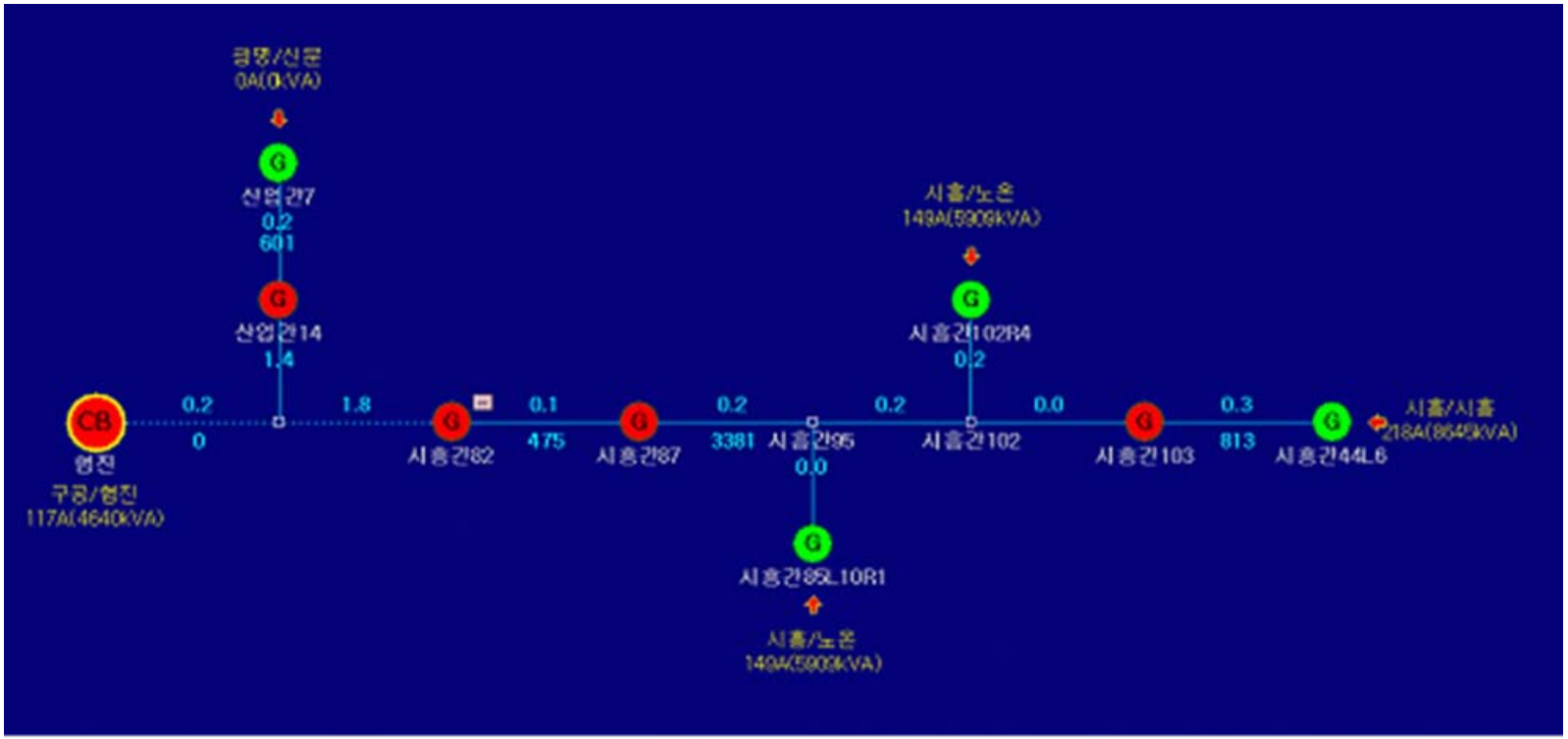
- Facility management
- Work Management
- Low voltage management
- Power outage management(TCS)
- Change schematic and skeleton diagram

Advanced application function

- Section load management
- FLISR (fault location isolation & service restoration)
- Short fault calculation
- Voltage drop calculation
- Distribution loss calculation
- Feeder reconfiguration
- Protection analysis
- Switching planning

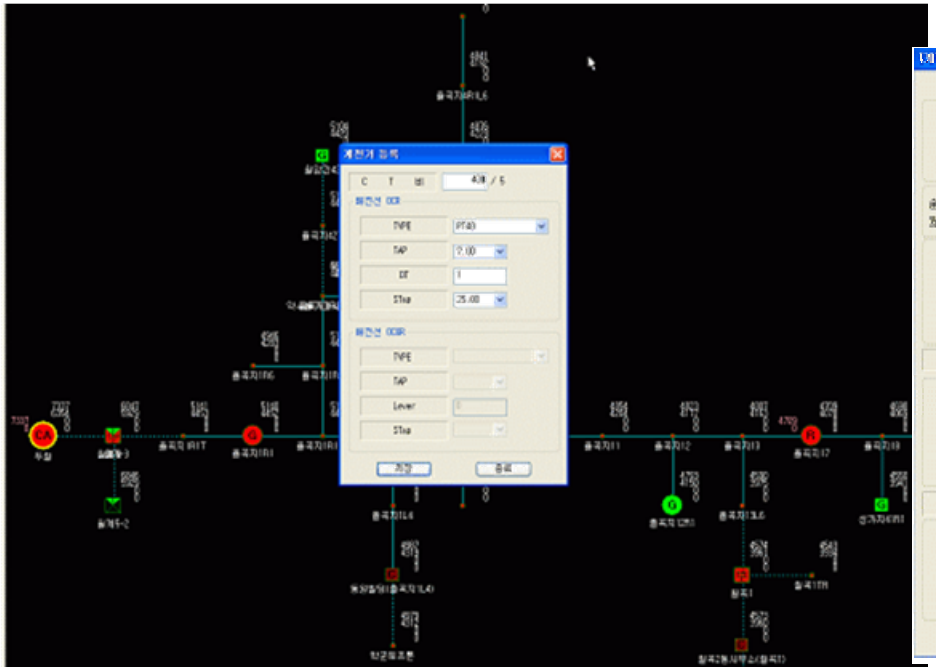
Section load management

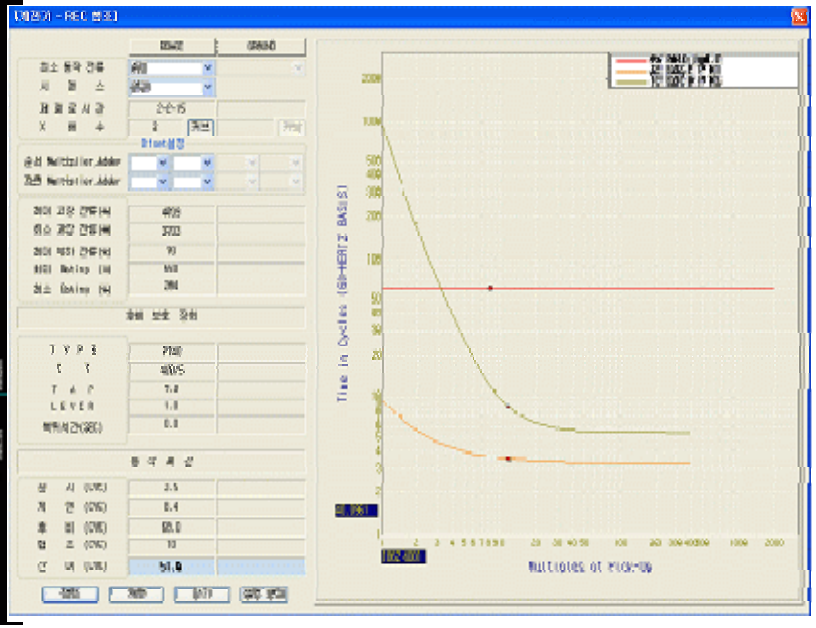
- **Calculation of section load everyday**
  - Section load calculation using the load of passed 7 days
  - Display the section length and section load on single line diagram



Protection analysis

- **Relay protection**
  - Calculation the current in short fault or earth fault
  - Input the setting data of relay or recloser
  - Display the protection analysis results

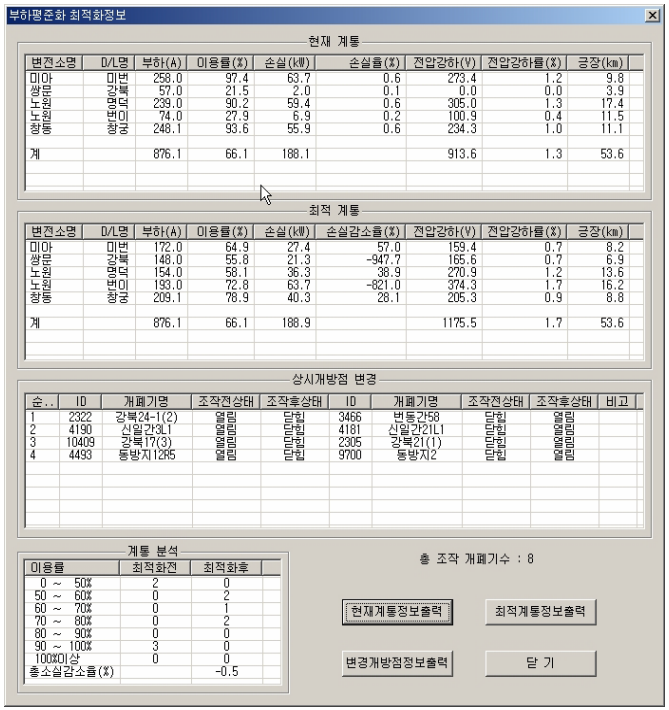




<Result of relay protection between OCR and recloser in non-grounded feeder>

Load balancing

- Feeder reconfiguration of distribution network
  - For load balancing and loss minimization
  - Using the exchange method of normal open point



Loss minimization

- **Feeder reconfiguration**
  - Using the exchange method of normal open point
  - Make the switching schedule

손실최소화 현재계통

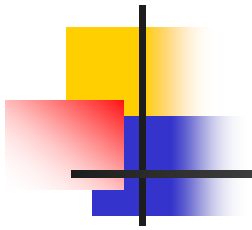
변전소명	선로명	부하(A)	이용률(%)	손실(kW)	전압강하(V)	전압강하률(%)	긍장(km)
미아	미번	258.00	97.40	63.70	273.40	1.20	9.80
쌍문	강북	57.00	21.50	2.00	0.00	0.00	3.90
노원	명덕	239.00	90.20	59.40	305.00	1.30	17.40
노원	번이	74.00	27.90	6.90	100.90	0.40	11.50
창동	창궁	248.10	93.60	55.30	234.30	1.00	11.10
계		876.10	330.60	187.90		3.90	53.70

손실최소화 최적계통

변전소명	선로명	부하(A)	이용률(%)	손실(kW)	전압강하(V)	전압강하률(%)	긍장(km)
미아	미번	111.00	41.90	11.50	105.40	0.50	6.20
쌍문	강북	250.00	94.30	47.70	220.70	1.00	10.60
노원	명덕	171.00	64.50	29.20	193.80	0.90	14.50
노원	번이	135.00	50.90	24.30	191.70	0.80	13.50
창동	창궁	209.10	78.90	40.30	205.30	0.90	8.80
계		876.10	330.50	153.00		4.10	53.60

손실최소화 개폐기 조작 내용

순번	개폐기 ID	개폐기 명	변경전	변경후	개폐기 ID	개폐기 명	변경전	변경후	비고
1	2,322	강북24-1(2)	열림	닫힘	3,466	번동간58	닫힘	열림	
2	10,389	번동19(4)	열림	닫힘	3,470	번동간65	닫힘	열림	
3	4,190	신일간3L1	열림	닫힘	4,181	신일간21L1	닫힘	열림	
4	10,371	강북14(2)	열림	닫힘	3,619	장수간51	닫힘	열림	



On-Going Project of DAS

Advanced DAS

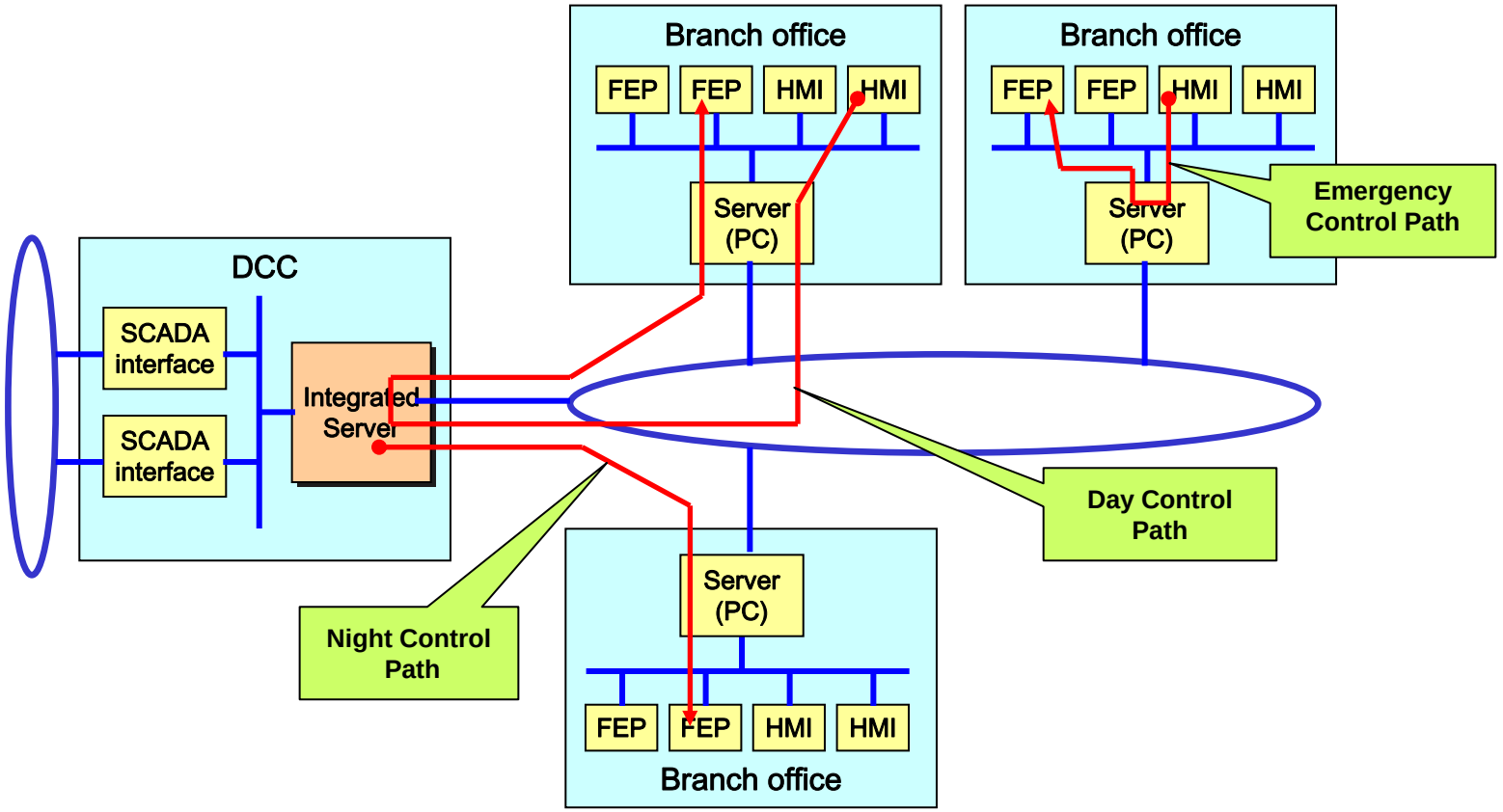
- On-going Project
  - Wide area DAS operation
  - PQ real-time Monitoring
  - Multi functioned RTU with PQ & wave real-time monitoring
  - Design and development of Micro-Grid
- Future Project
  - Smart Distribution Project
  - Advanced Distribution Automation

Multi function RTU

Category	Major function
• PQ monitoring	• Sag, Swell, Interruption monitoring • Over voltage, under voltage, over current, low frequency monitoring • Unbalance & phaser monitoring • Harmonics analysis to 32nd • Save and transmit the PQ wave
• Fault detection • Protection function	• New algorithm of fault indicator and restraint of inrush current • Sectionalizer function • Detection the direction of fault current flowing • Fault detection in non grounding feeder • Save and transmit the current wave and voltage wave in fault
• Communication	• DNP3.0 • Modbus, Bluetooth • RS-232, Rs-485, Ethernet
• Temperature data	• Give the temperature and humidity data of inside and outside control box
• Firmware upgrade	• Remote firmware upgrade by file transfer function

Wide area DAS operation

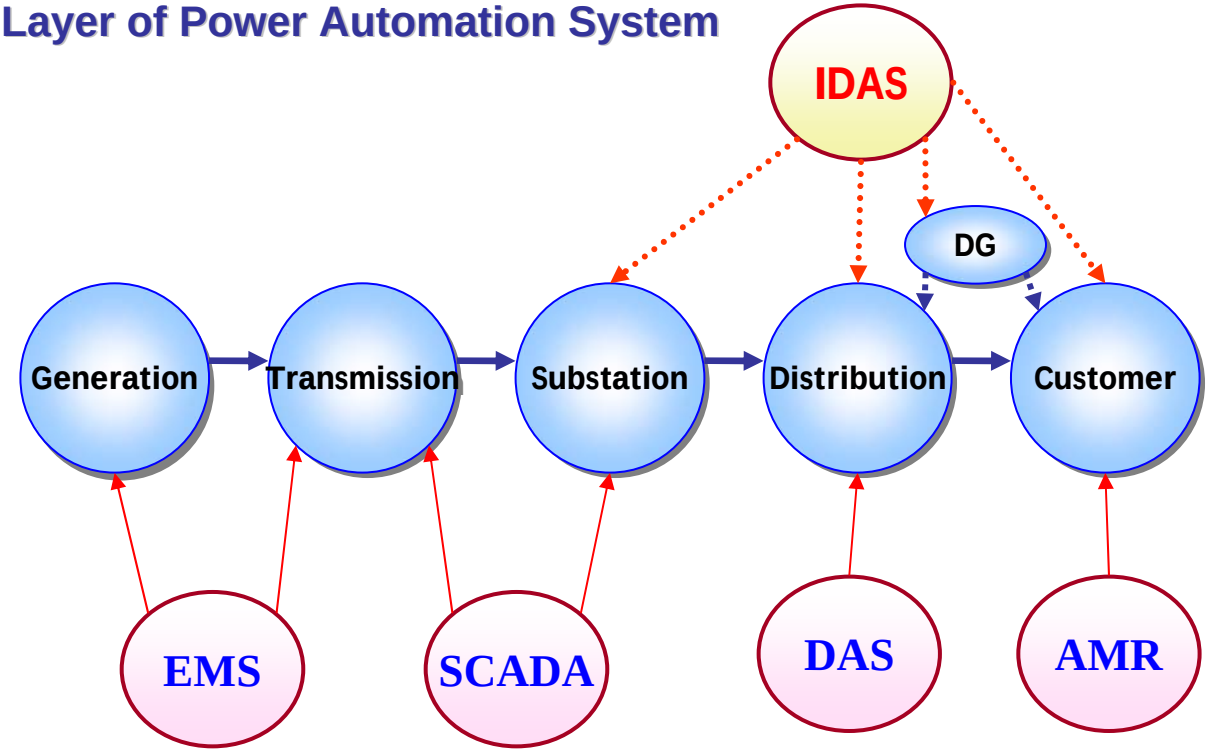
- Concept
  - Select to centered operation or distributed operation
  - Economical configuration by operation with one server and several PCs
  - Possible to back-up operation when emergency status



IDAS development

IDAS→

Layer of Power Automation System

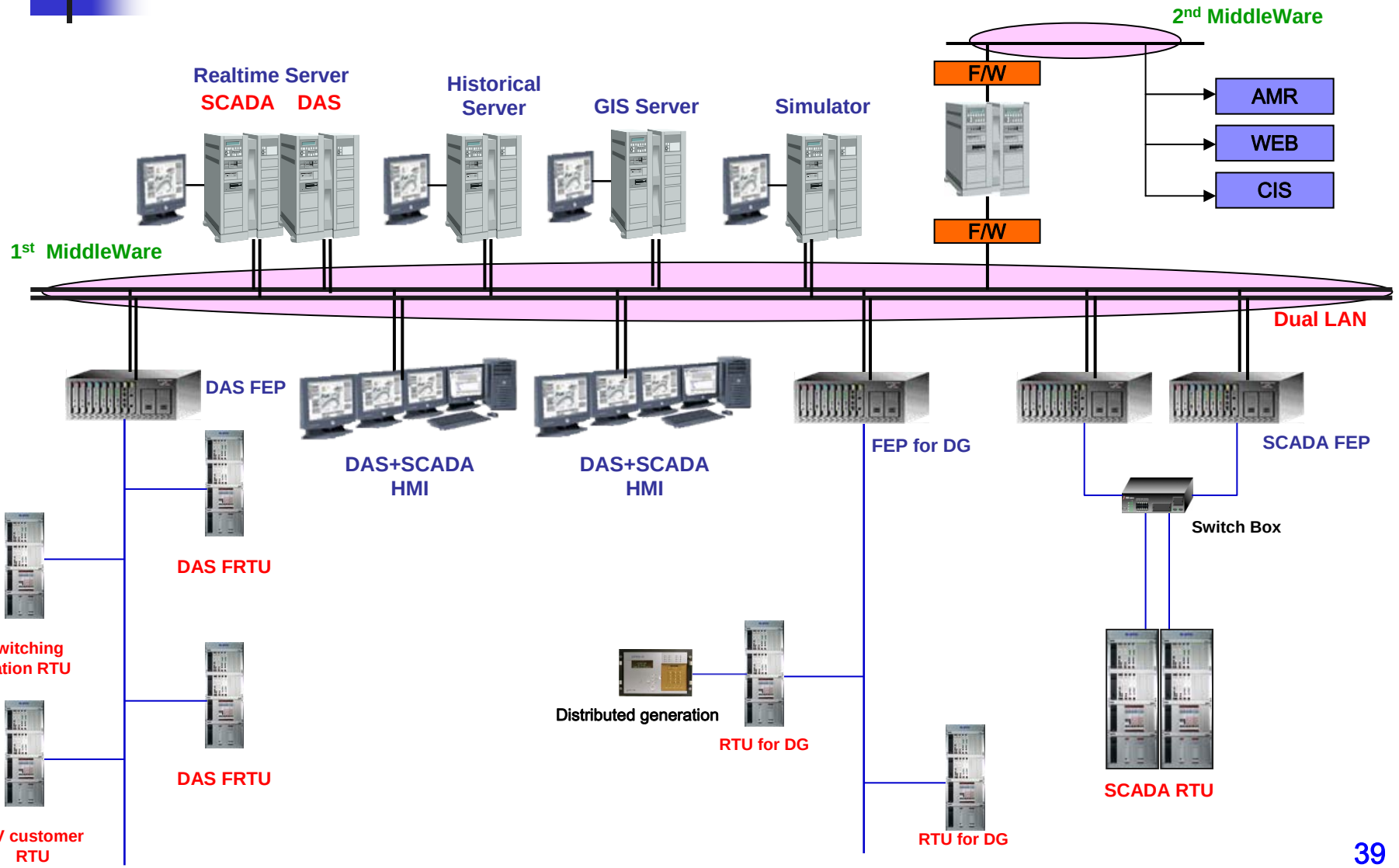


- Remote operation of facilities from S/S to customer
- Management of high voltage and low voltage networks on GIS
- SCADA+DAS+GIS+AMR Integration
- Distributed generation interface
- Application power line communication
- Online data acquisition of distribution facilities with deterioration detection sensor
- Network optimal operation program for loss minimization, load balancing, voltage and VAR control, power quality monitoring, power outage management

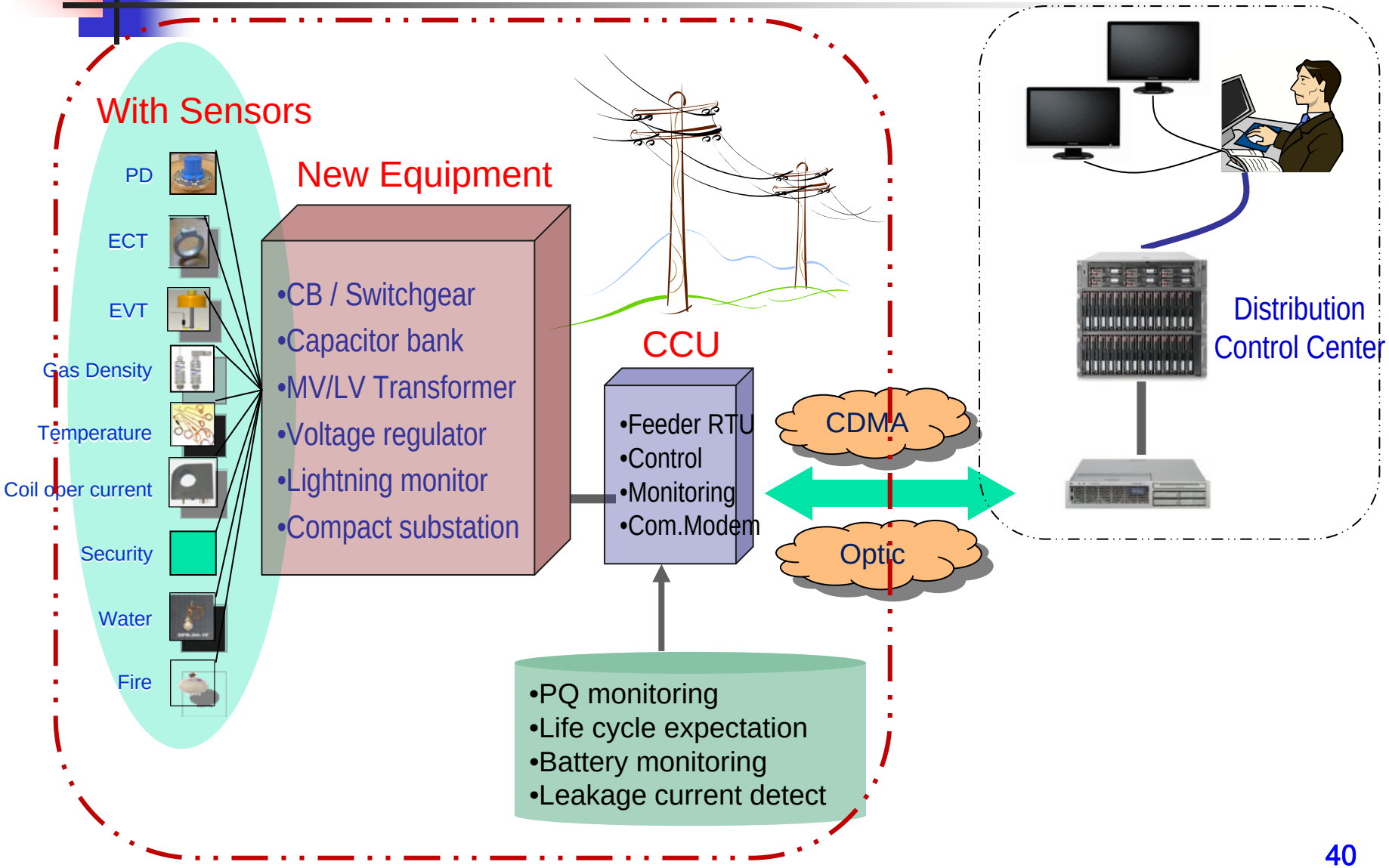
• IDAS : Intelligent Distribution Automation System

• DG : Distributed Generation

IDAS configuration



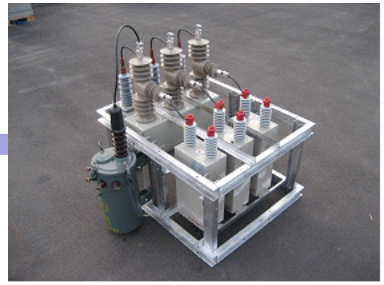
New equipment with sensors



Equipment with sensors

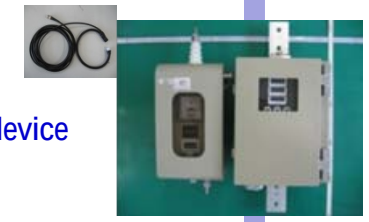
CB & Switch with sensors

Capacitor bank



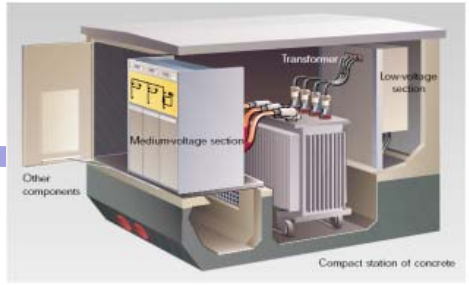
Polymer Recloser

Feeder RTU



Arrester monitoring device

Pad mounted Switchgear



Compact Substation

Pad mounted Transformer

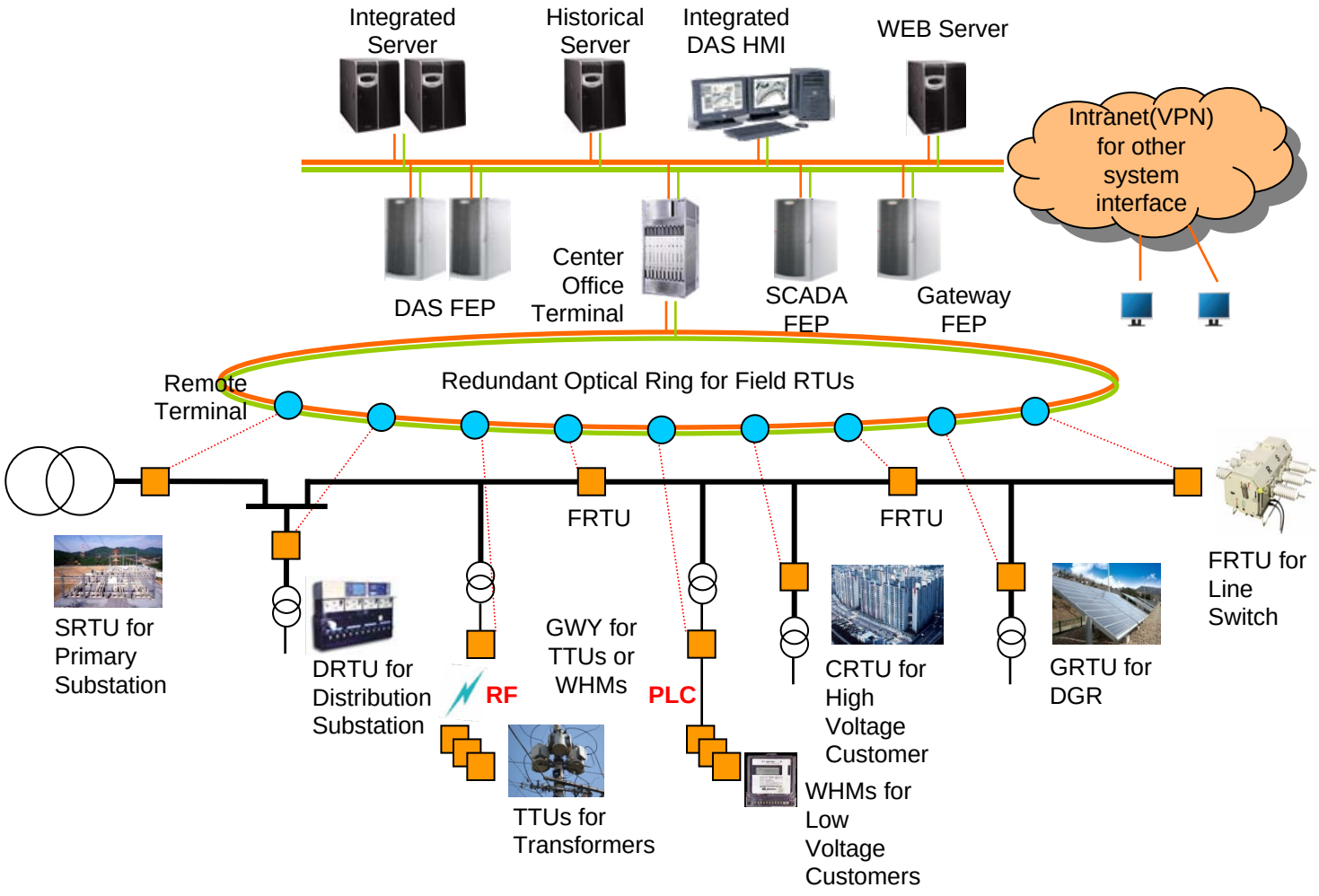
Power Quality Monitoring

- Monitoring Items
  - Sag (Instantaneous, Momentary, Temporary)
  - Swell (Instantaneous, Momentary, Temporary)
  - Interruption (Instantaneous, Temporary, Long-duration)
  - Total Harmonic Distortion-Voltage
  - Total Harmonic Distortion-Current
  - Current TDD
  - Current Unbalance Ratio
  - Over Voltage
  - Under Voltage

PQ monitoring items

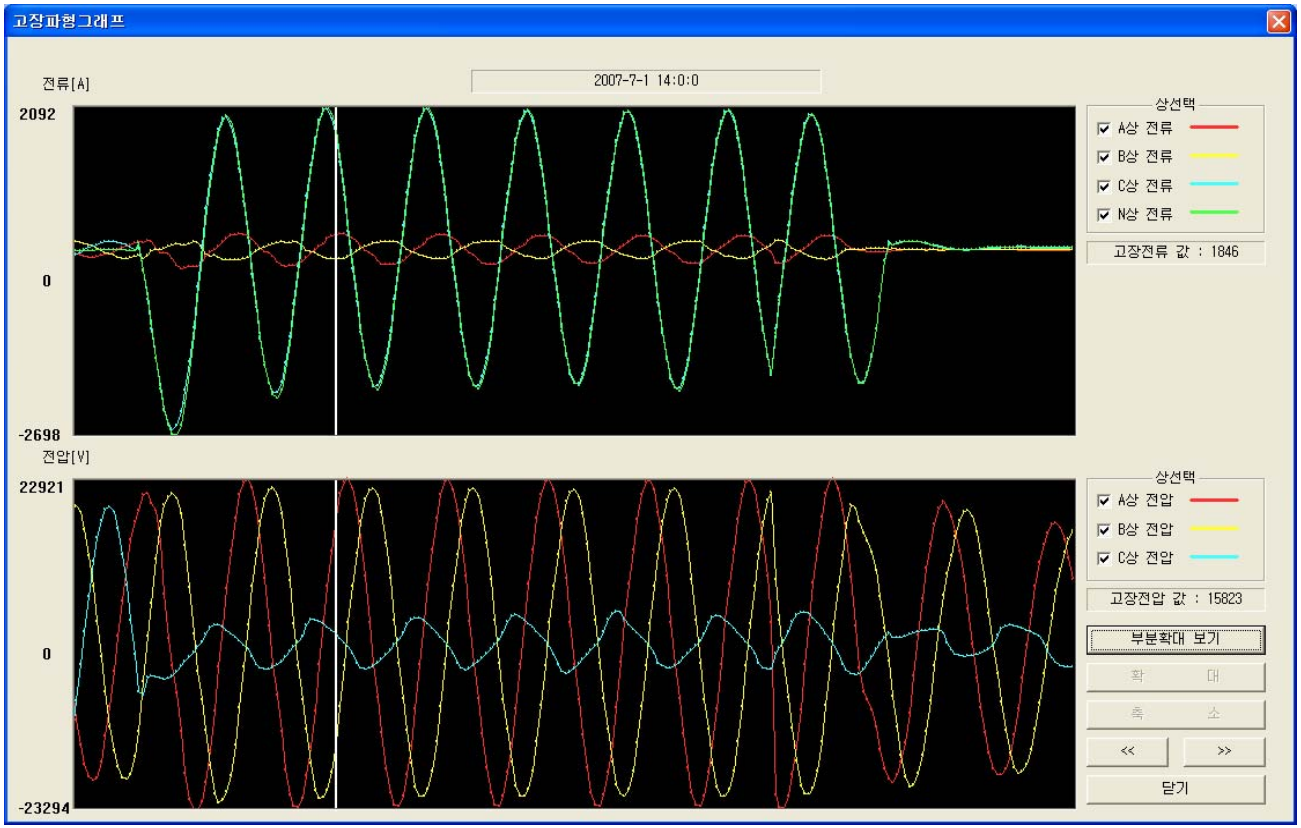
Monitoring Items		IEEE std 1159		Data Storage			SR TU	DR TU	GR TU	T TU	FR TU	Customer	
		Magnitude	Duration (cycle)	Event	Wave	Counter						CR TU	W HM
Sag	Instantaneous	0.1~0.9 pu	0.5~30	O	O	O	O	O	O	O	O	O	X
	Momentary	0.1~0.9 pu	30~180	O	O	O	O	O	O	O	O	O	X
	Temporary	0.1~0.9 pu	180~3600	O	O	O	O	O	O	O	O	O	X
Swell	Instantaneous	1.1~1.8 pu	0.5~30	O	O	O	O	O	O	O	O	O	X
	Momentary	1.1~1.8 pu	30~180	O	O	O	O	O	O	O	O	O	X
	Temporary	1.1~1.8 pu	180~3600	O	O	O	O	O	O	O	O	O	X
Interruption	Instantaneous	<0.1 pu	0.5~180	O	O	O	O	O	O	O	O	O	O
	Momentary	<0.1 pu	180~3600	O	X	O	O	O	O	O	O	O	O
	Temporary	0.0 pu	> 3600	O	X	O	O	O	O	O	O	O	O
Voltage	Under Voltage	0.8~0.9 pu	> 3600	X	X	O	O	O	O	O	O	O	O
	Over Voltage	1.1~1.2 pu	> 3600	X	X	O	O	O	O	O	O	O	O
Harmonics	THD(V)		Steady State		X	X	O	O	O	O	O	O	X
	THD(I)		Steady State		X	X	O	O	O	O	O	O	X
	TDD(I)		Steady State				O	O	O	O	O	O	X
	Multiple Order	32th order	Steady State				O	O	O	O	O	O	X
Unbalance	Voltage	0~100 %	Steady State	O	X	O	O	O	O	O	O	O	X
	Current	0~100 %	Steady State	O	X	O	O	O	O	O	O	O	X
Frequency		45~65Hz	Steady State	O	X	O	O	O	O	O	O	O	X
PQM Waveform				O	O	O	O	O	O	O	O	O	X
On-demand Waveform					O		O	O	O	O	O	O	X

Real-time PQ monitoring



Electronic meter with DA function

- It is installed in outgoing feeder at primary substation
- It can detect useful information such as CB trip, fault indicator, fault wave, PQ data, all analog data and remote setting function



Need a Technology

- Smart Grid & ADA
  - Distribution Fault Anticipator
  - DC Distribution System Technology
  - PQ Enhancement Technology
  - Fast Simulation and Modeling
  - Two Way Power Flow Analysis
  - CIM and IEC 61968 & 61970
  - IEC 61850 application for ADA
  - Solid State Switchgear & Intelligent Universal Transformer

Conclusion

- KEPCO prepares an integrated system with SCADA and DAS
  - SCADA function and DMS function
  - Apply DNP 3.0 and IEC 60870 protocol
- KEPCO prepares various advanced application program
  - FLISR, feeder reconfiguration, load flow, relay protection
  - Real-time PQ monitoring
  - Offer the technical calculation program using DAS data
- Launch some overseas project
  - Project in Indonesia, Vietnam and China
  - KEPCO can supply new DA technology with mutual cooperation

Thank You ☺

Wishing for Closer Cooperation

between India & Korea

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