KEPCO

Distribution Automation System
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)

**Generation**
- Korea’s Total Capacity: 68,268MW (100%)
- KEPCO & Subsidiaries: 60,100MW (88%)
- IPPs & Others: 8,168MW (12%)

**Transmission**
- Line Length: 29,979 C-km
- Supports: 39,937 Units
- 669 Substations

**Distribution**
- Line Length: 401,485 C-km
- Support: 7,894,577 Units
- No. of Customers: 18,039 (Thousand Households)
Major Changes over last 4 decades

<table>
<thead>
<tr>
<th></th>
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</thead>
<tbody>
<tr>
<td>Installed capacity (MW)</td>
<td>367</td>
<td>9,835</td>
<td>49,632</td>
<td>68,268</td>
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<tr>
<td>Peak demand (MW)</td>
<td>305</td>
<td>6,144</td>
<td>43,125</td>
<td>62,285</td>
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<tr>
<td>Consumption per capita (kWh)</td>
<td>46</td>
<td>927</td>
<td>5,965</td>
<td>7,524</td>
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<td>Electrification rate (%)</td>
<td>12</td>
<td>99.3</td>
<td>99.9</td>
<td>99.9</td>
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<td>T/D loss (%)</td>
<td>29.4</td>
<td>6.7</td>
<td>4.7</td>
<td>3.99</td>
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</table>
Korea’s Power System

Power system (1965)

Power system (2007)

154kV System : 
345kV System : 
765kV System : 

154kV System : yellow
345kV System : red
765kV System : black
In Autumn....
### Present DAS Status

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

- 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]**

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

---

- **A Feeder**
  - S/S:
    - CB
    - GS
    - GS
    - R
    - REC
    - GS
    - GS
    - GS
    - GS

- **B Feeder**:
  - GS

- **C Feeder**:
  - GS (normal open)

- **D Feeder**
Feeder Segmentation Effect

- Recovery Rate vs. No of Sections

![Graph showing recovery rate vs. number of sections for KEPCO (past-minimum) and KEPCO (now-optimum).]
**Analysis the number of links**

- **Feeder capacity (normal/emergency)**

<table>
<thead>
<tr>
<th></th>
<th>KOREA</th>
<th>JAPAN</th>
<th>IRAN</th>
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</thead>
<tbody>
<tr>
<td>Normal Capacity (Cn)</td>
<td>10MVA (250A)</td>
<td>6MVA</td>
<td>7MVA (200A)</td>
</tr>
<tr>
<td>Emergency Capacity</td>
<td>14MVA (350A)</td>
<td>8MVA</td>
<td>10MVA (320A)</td>
</tr>
<tr>
<td>No of sections</td>
<td>2.5 → 3</td>
<td>3</td>
<td>3</td>
</tr>
</tbody>
</table>

- **No of Links(n) = Cn/(Ce−Cn)**
  - $n \geq \frac{6}{8-6} = 3$
  - No of links should be minimum three
Feeder Linkage Effect

- Reliability vs. Number of linked back-up feeder

![Graph showing the relationship between reliability and the number of linked back-up feeders.](image)

- S/S CB
- A Feeder
- (Normal close)
- (C Feeder)
- (Normal open)
- (B Feeder)
- (D Feeder)
Effective Use of Facilities

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

Feeder 1

Feeder 2

Feeder 3

Feeder 4

450 + 150 = 600/600A

450 + 150 = 600/600A

450 + 150 = 600/600A

Loading level 75%

<Manual Operation Only>
Effective Use of Facilities

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

Enhance Loading Level

510/600A

Feeder 1
Feeder 2
Feeder 3

510 - 85 + 170 = 595/600A

510 + 85 = 595/600A

Loading level 85%
Current & Voltage Sensors

- 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
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
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
**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

*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
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
- **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**
  - 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

- **Protection function**

- **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
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
New equipment with sensors

With Sensors
- PD
- ECT
- EVT
- Gas Density
- Temperature
- Coil oper current
- Security
- Water
- Fire

New Equipment
- CB / Switchgear
- Capacitor bank
- MV/LV Transformer
- Voltage regulator
- Lightning monitor
- Compact substation

CCU
- Feeder RTU
- Control
- Monitoring
- Com.Modem

- PQ monitoring
- Life cycle expectation
- Battery monitoring
- Leakage current detect

Distribution Control Center
CDMA
Optic
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

<table>
<thead>
<tr>
<th>Monitoring Items</th>
<th>IEEE std 1159</th>
<th>Data Storage</th>
<th>SR TU</th>
<th>DR TU</th>
<th>GR TU</th>
<th>T TU</th>
<th>FR TU</th>
<th>Customer</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Magnitude</td>
<td>Duration (cycle)</td>
<td>Event</td>
<td>Wave</td>
<td>Counter</td>
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<tr>
<td>Sag</td>
<td>Instantaneous</td>
<td>0.1~0.9 pu</td>
<td>0.5~30</td>
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<td>O</td>
<td>O</td>
<td>O</td>
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<tr>
<td></td>
<td>Momentary</td>
<td>0.1~0.9 pu</td>
<td>30~180</td>
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<td>O</td>
<td>O</td>
<td>O</td>
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<tr>
<td></td>
<td>Temporary</td>
<td>0.1~0.9 pu</td>
<td>180~3600</td>
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<td>Swell</td>
<td>Instantaneous</td>
<td>1.1~1.8 pu</td>
<td>0.5~30</td>
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<td>O</td>
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<tr>
<td></td>
<td>Momentary</td>
<td>1.1~1.8 pu</td>
<td>30~180</td>
<td>O</td>
<td>O</td>
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<td>O</td>
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<tr>
<td></td>
<td>Temporary</td>
<td>1.1~1.8 pu</td>
<td>180~3600</td>
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<td>O</td>
<td>O</td>
<td>O</td>
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<tr>
<td>Interruption</td>
<td>Instantaneous</td>
<td>&lt;0.1 pu</td>
<td>0.5~180</td>
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<tr>
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<td>Momentary</td>
<td>&lt;0.1 pu</td>
<td>180~3600</td>
<td>O</td>
<td>X</td>
<td>O</td>
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<td>0.0 pu</td>
<td>&gt; 3600</td>
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<td>X</td>
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<td>Under Voltage</td>
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<td>&gt; 3600</td>
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<td>X</td>
<td>O</td>
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<td>Over Voltage</td>
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<td>Multiple Order</td>
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<td>O</td>
<td>O</td>
<td>O</td>
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<tr>
<td></td>
<td>Current</td>
<td>0~100 %</td>
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<td>PQM Waveform</td>
<td>On-demand Waveform</td>
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<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
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<tr>
<td>On-demand Waveform</td>
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<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
</tr>
</tbody>
</table>
Real-time PQ monitoring

- Intranet (VPN) for other system interface
- Integrated Server
- Historical Server
- Integrated DAS HMI
- WEB Server
- DAS FEP
- Center Office Terminal
- SCADA FEP
- Gateway FEP
- Remote Terminal
- Redundant Optical Ring for Field RTUs
- DRTU for Distribution Substation
- SRTU for Primary Substation
- FRTU
- GWY for TTUs or WHMs
- TTUs for Transformers
- RF
- PLC
- CRTU for High Voltage Customer
- WHMs for Low Voltage Customers
- GRTU for DGR
- FRTU for Line Switch

Redundant RTUs for Distribution and Primary Substations.
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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