Passive and Active Distribution Networks

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Metropolitan Electricity Authority (MEA)
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"อุตสาหกรรมไฟฟ้าในทศวรรษหน้า"

"ESI in the Future"
Outline

- Classic electricity paradigm
- DG electricity paradigm
- Evolution of distribution system
- Active distribution network
- Microgrid (μGrid)
Classic electricity paradigm

Yesterday
Central power station

Transmission Network

House
Distribution Network

Factory
Commercial building

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Passive distribution network

Transmission

Generation

Supply

Traditional one way supply system

Demand

Distribution

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Distributed generation electricity paradigm

Tomorrow

distributed/on-site generation with fully integrated network management.

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Central vs. DG

Central vs. DISTRIBUTED GENERATION

Central Generation

Distributed Generation

- Solar
- Fuel Cell
- Central Plant
- Building
- Wind
- Micro-Turbine Generator

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Driving force

- Governmental policy
- Global warming and climate change
- Energy efficient utilization
- Electricity and heat loads
- Reliability and power quality
- Emerging technologies
Government policy

Cleaner & renewable sources of electricity generation

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By 2025, Obama would like 25% of U.S. electricity to be generated from clean, renewable sources including wind, solar and geothermal with a Renewable Portfolio Standard (RPS).

Obama calls for $150 billion to be invested over 10 years in clean energy and infrastructure to support it.
ตารางที่ 2: เป้าหมายการส่งเสริมการผลิตไฟฟ้าจากพลังงานหมุนเวียนระหว่างปี 2551 – 2554

<table>
<thead>
<tr>
<th>แหล่งกำเนิด</th>
<th>กำลังผลิตในปี 2549 (MW)</th>
<th>เป้าหมายในปี 2554 (MW)</th>
</tr>
</thead>
<tbody>
<tr>
<td>แสงอาทิตย์</td>
<td>30</td>
<td>45</td>
</tr>
<tr>
<td>ลม</td>
<td>1</td>
<td>115</td>
</tr>
<tr>
<td>พลังน้ำชายแดนเล็กและเล็กมาก</td>
<td>44</td>
<td>156</td>
</tr>
<tr>
<td>ชื้นวัด</td>
<td>1,977</td>
<td>2,800</td>
</tr>
<tr>
<td>ขยะ</td>
<td>4</td>
<td>100</td>
</tr>
<tr>
<td>ก้าชาติภาพ</td>
<td>5</td>
<td>60</td>
</tr>
<tr>
<td>กระจก</td>
<td>2,061</td>
<td>3,276</td>
</tr>
<tr>
<td>การผลิตไฟฟ้าสูงสุดของระบบ</td>
<td>21,064</td>
<td>27,996</td>
</tr>
</tbody>
</table>

ที่มา/ แผนพัฒนาพลังงานทดแทนและอนุรักษ์พลังงานของประเทศไทย ปี 2551 – 2554, กันยายน 2550, กระทรวงพลังงาน

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Global warming & climate change

How new renewable energy creates 
CO₂ emissions reductions

Clean

More Electricity from
Renewable Energy
= LESS electricity from fossil fuels
= CO₂ emission reductions

Dirty

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Energy efficient utilization

Separate Heat and Power

Power Plant & Grid

Useful Electricity

Power Plant fuel (121 units)

Boiler fuel (59 units)

180 units

BOILER

Useful Heat

9 units (Losses)

Combined Heat and Power

CHP System

Useful Heat

Useful Electricity

CHP system fuel (100 units)

100 units

15 units (Losses)

79 (Gen. Losses)

7 (Grid Losses)

35 units

50 units

50 units

35 units

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Electricity and heat loads


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Reliability

North America power blackout

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### Table 1: Summary of Power Quality Variation Categories

<table>
<thead>
<tr>
<th>Example Waveform or RMS Variation</th>
<th>Power Quality Variation and Category</th>
<th>Method of Characterizing</th>
<th>Typical Causes</th>
<th>Example Power Conditioning Solutions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Impulsive Transients</td>
<td>Transient Disturbance</td>
<td>Peak magnitude, Rise time, Duration</td>
<td>Lightning, Switching, Breakers, Maintenance, Breakers, Switching</td>
<td>Surge Arresters, Filters, Isolation Transformers</td>
</tr>
<tr>
<td>Oscillatory Transients</td>
<td>Transient Disturbance</td>
<td>Waveforms, Peak Magnitudes, Frequency Components</td>
<td>Line Voltage Swelling, Generator Switching, Load Switching</td>
<td>Surge Arresters, Filters, Isolation Transformers</td>
</tr>
<tr>
<td>Sag/Small RMS Disturbance</td>
<td></td>
<td>Voltage, Time, Magnitude, Duration</td>
<td>Remote System Faults</td>
<td>Remotemonitoring Transformers, Energy Storage Technologies, UPS</td>
</tr>
<tr>
<td>Interruption RM S2 Disturbance</td>
<td></td>
<td>Duration</td>
<td>System Protection, Breakers, Fuses, Maintenance</td>
<td>Energy Storage Technologies, UPS, Backup Generators</td>
</tr>
<tr>
<td>Undershoots</td>
<td>Overvoltages</td>
<td>RMS Versus Time, Statistics</td>
<td>Major Starting, Load Variation, Over Load, Over Voltage</td>
<td>Voltage Regulators, Protective Devices, Transformers</td>
</tr>
<tr>
<td>Harmonics Disturbance</td>
<td></td>
<td>Harmonic Spectrum, Total Harmonic Distortion, Statistics</td>
<td>Nonlinear Loads, System Resonance</td>
<td>Active or Passive Filters, Transformers with cancellation or anti harmonic components</td>
</tr>
<tr>
<td>Voltage Flicker</td>
<td></td>
<td>Variation, Magnitude, Frequency of CE, Modulation, Frequency</td>
<td>Harmonic Loads, Motor Starting, Anti Flicker</td>
<td>Static Var systems</td>
</tr>
</tbody>
</table>

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### Cost of poor power quality

<table>
<thead>
<tr>
<th>Industry</th>
<th>Typical financial loss per event</th>
</tr>
</thead>
<tbody>
<tr>
<td>Semiconductor production</td>
<td>€3 800 000</td>
</tr>
<tr>
<td>Financial trading</td>
<td>€6 000 000 per hour</td>
</tr>
<tr>
<td>Computer centre</td>
<td>€750 000</td>
</tr>
<tr>
<td>Telecommunications</td>
<td>€30 000 per minute</td>
</tr>
<tr>
<td>Steel works</td>
<td>€350 000</td>
</tr>
<tr>
<td>Glass industry</td>
<td>€250 000</td>
</tr>
</tbody>
</table>
Present and future architecture of electric power system

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Evolution of distribution system

- The more DG devices penetrate the distribution networks, the more these systems are expected to evolve towards transmission-like architectures.
Unlike transmission grids, the distribution networks have generally not been designed to operate in the presence of power injections.

Indeed, the distribution networks have been developed with radial structures (especially at low and medium voltage level) or with meshed structures and radial operation (mostly at medium and high voltage level).
• With an increasing DG penetration the situation is changing and resulting in possible bi-directional power flows (uni-directional power flows without DG)
Active distribution network

Traditional one way supply system

Bidirectional supply system

Supply

Demand

Generation

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The evolution shall be accompanied by

- *an appropriate upgrade of the protection schemes*

- *introduction, at different stages, of new soft (ICT) and hard (power electronics-based devices) technologies for a more flexible system control*
An example of the evolution of distribution architecture, from the traditional one towards the active distribution scheme

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Basic scheme of distribution grid evolution process

- Traditional distribution grid architectures
- New distribution grid architectures

- Additional investment effort
- DG connection to existing grid (fit and forget)
- System reinforcement/adaption/update
- Network reinforcement/upgrade
- New control strategies

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PEA-SCADA/EMS/DMS

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Microgrids

- Microgrids comprise low voltage distribution systems with distributed energy sources, storage devices and controllable loads, operated connected to the main power network or islanded, in a controlled, coordinated way.
Microgrid architecture

MC – Micro Source Controller
LC – Load Controller
MGCC – MicroGrid Center Controller
Microgrid: Hachinohe project

• This project will produce electricity from 100% renewable energy resources such as photovoltaic solar panels (PV) and wind turbines (WT), gas engines utilizing methane gas from a sewage treatment facility, and a storage battery.

• The maximum total capacity of energy generated by the gas engine, PV and wind turbines will total 710 kW.

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Microgrid: Hachinohe project (cont.)

Regional Power Grid with Renewable Energy Resources: A Demonstrative Project in Hachinohe

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Thank you

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