Smart Grid Implementations - Case of Japan -

Yoshito SAKURAI
(Hitachi, Ltd.)

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• Introduction
• Japan’s Electricity Market Deregulation
• Real Use Case of Smart Grid
• Conclusion
Blackout time/year in Japan

Due to natural disasters

<table>
<thead>
<tr>
<th>Year</th>
<th>Blackout Time (minutes)</th>
<th>Numbers / House</th>
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<tbody>
<tr>
<td>1966</td>
<td></td>
<td></td>
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<tr>
<td>1975</td>
<td></td>
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<tr>
<td>1985</td>
<td></td>
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<td>1995</td>
<td></td>
<td></td>
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<tr>
<td>2007</td>
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Blackout time/year in the World

<table>
<thead>
<tr>
<th>Country</th>
<th>Time (min.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Japan</td>
<td>16</td>
</tr>
<tr>
<td>US (New York)</td>
<td>12</td>
</tr>
<tr>
<td>US (California)</td>
<td>162</td>
</tr>
<tr>
<td>Germany</td>
<td>37</td>
</tr>
<tr>
<td>France</td>
<td>57</td>
</tr>
<tr>
<td>UK</td>
<td>100</td>
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</tbody>
</table>
Situation in Japan

- The electric supply system in Japan has been already very “Smart” as far as electric transmissions and distributions.
- The smart grid in Japan is not a technology issue but a policy/regulation issue.
- It will be realized by the Market Deregulation that will introduce here after.
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Kashiwa-no-ha Smart City

Kashiwa-no-ha Smart City locates 25km north-east from Tokyo metropolitan area (It takes about 30 minutes by train) that is equipped AEMS (Area Energy Management System) etc. It is a real city people live in. There are residential areas, hospitals, universities, etc.
Area Energy Management System

Kashiwa-no-ha Smart City optimizes energy usage for the entire city. AEMS plays a pivotal role in this setup, drawing on an independently operated power grid and enabling area expansion as well as enhancing functions. This system is designed to contribute to smart grid progress that underpins lifestyles and innovations.
AEMS Operation Center

Energy management system that is central to Kashiwa-no-ha Smart City.

The Kashiwa-no-ha Smart Center oversees energy operations, management, and control for the entire town. The center uses wheeling throughout the area to cut peak power consumption by 26%, helping to conserve energy and cut CO₂ emissions.
Japan's first smart grid to use distributed power sources to share electricity in the community

Overall setup (Normal times)
Emergency electricity sharing

Kashiwa-no-ha Smart Center
- Visualization of energy usage promotes energy conservation activities that make eco-living easy.
- Electricity sharing equipment controls peak cuts and shifts.
- Lifelines get priority access to electricity during disasters.

Electricity Sharing Facilities
- Electricity sharing equipment
- Extra-high-voltage substation facilities
- Storage batteries
- Solar power plants

Emergency electricity sharing
Electricity flow and control information
Information flow
Power Generation Facilities

Solar power generation facilities

Wind power generation facilities
Instead of individually owning electric vehicles, electric scooters, and bicycles, residents share them to help cut overall carbon dioxide emissions and travel more conveniently. During emergencies, residents can share power from electric vehicles.
HEMS displays energy consumption so residents can become more aware of their contributions to power conservation, thereby fostering environmentally friendly lifestyles. Dedicated tablets, PCs, smartphones, and other devices show CO2 emissions from residences. This setup uses artificial intelligence for such purposes as advising on energy usage and ranking the effectiveness of energy-saving approaches. HEMS enhances disaster management through its demand response function, which solicits residents help in using less power during emergencies. Residents can control lighting and air conditioning settings while away from home.
Conclusion

The smart grid in Japan will be realized by the policy:

1. Securing a stable supply of electricity
2. Suppressing electricity rates to the maximum extent possible
3. Expanding choices for consumers and business opportunities

Real smart grids are introducing in rather Smart Cities than nation wide such as Kashiwa-no-ha city.
Thank you for your attention

Yoshito Sakurai
Hitachi, Ltd.
Japan
yoshito.sakurai.hn@hitachi.com
Japan’s Electricity Market Deregulation

June, 2015

Electricity and Gas Market Reform Office
Agency for Natural Resources and Energy (ANRE)
Japan’s Electricity Market Outline

- 10 Vertically Integrated Electricity Power Companies (EPCOs)
- TWO frequencies, 50Hz and 60Hz

**Frequency in West: 60Hz**

- DC – Direct Current,
- FC – Frequency Conversion

**Frequency in East: 50Hz**

- Hokkaido [2012] 5.52 GW
- Tohoku [2012] 13.72 GW
- Kansai [2012] 26.82 GW
- Hokuriku [2012] 5.26 GW
- Chugoku [2012] 10.85 GW
- Kyushu [2012] 15.21 GW
- Shikoku [2012] 5.26 GW
- Chubu [2012] 24.78 GW
- Tokyo [2012] 50.78 GW

- DC Tie line 0.6GW
- FC 1.2GW
- BTB 0.3GW

- Frequency in West: 60Hz
- Frequency in East: 50Hz

- 10 Vertically Integrated Electricity Power Companies (EPCOs)
- TWO frequencies, 50Hz and 60Hz

- DC – Direct Current,
- FC – Frequency Conversion
Japan’s Electricity Market Outline (cont.)

- Market volume (Total): 982.4TWh / 289 GW
- Market volume (10 big EPCOs): 848.5TWh / 209GW / ¥18.2 trillion (= $151.7bn, €134.8bn) (2013)
- Retail competition for over 50kW customers (62% of the market in 2013)
  - Share of non-EPCOs: 4.2% (2013)
  - 1.3% of the total retail market sales is transacted at JEPX (2013)

*JEPX: Japan Electric Power Exchange*

**Liberalized Sector**

- Market Volume: ¥10.1 trillion (= $84.2bn, €74.8bn)

**Regulated Sector**

- Market Volume: ¥8.1 trillion (= $67.5bn, €60.0bn)
- Number of contracts
  - Residential Customers: 77.3m
  - Small shops and offices: 7.3m

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Changes in Electricity price

- Increased 19.4%
- Increased 28.4%

[Source]: Created based on the “Electricity Demand Report” (Federation of Electric Power Companies in Japan) and the materials concerning the power companies' final settlement reports, etc.
No competition in the electricity market before 1995: 10 vertically integrated EPCOs dominated and controlled the market.

**History of Electricity Market Reforms in Japan**

METI embarked on a series of reforms...

<table>
<thead>
<tr>
<th>No.</th>
<th>Year enforced</th>
<th>Overview</th>
</tr>
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</table>
| 1   | 1995          | • Opened the IPP (Independent Power Producer) market  
              • Allowed specified-scaled and vertically integrated power generators |
| 2   | 2000          | • Introduced partial retail competition  
              (over 2,000kW in 2000 [26%], over 500kW in 2004 [40%])  
              • Introduced regulation of third party access to grid lines |
| 3   | 2005          | • Expanded retail competition (over 50kW [62%])  
              • Established the wholesale power exchange (JEPX) and its supporting body for transmission in wider areas  
              • Improved regulation of third party access to grid lines, and introduced accounting separation of transmission/distribution sector |
| 4   | 2008          | • Modified the rule of wheeling rates |
Problem revealed by 3.11

- Negative aspects of regional monopoly system with 10 big and vertically integrated EPCOs were revealed in the Great Earthquake on March 11, 2011:
  1. Lack of system to transmit electricity beyond regions
  2. Little competition and strong price control
  3. Limit in handling the change in energy mix including the increase in renewables

Frequency in West: 60Hz

Frequency in East: 50Hz

* DC – direct current, FC – frequency conversion
Agency for Natural Resources and Energy organized the Expert Committee on Electricity System Reform in February 2012. Based on the discussions over 12 meetings, the Committee compiled a final report on February 8, 2013.

The Members of the Expert Committee of Electricity System Reform

<Chairman>
Motoshige Ito
Professor at Graduate school of Economics, The University of Tokyo

<Deputy Chairman>
Junji Annen
Professor at Law School Academy, Chuo University

<Members>
Toshinori Ito
Representative Director and analyst at Ito Research and Advisory Co., Ltd.

Hiroko Ohta
Professor, National Graduate Institute for Policy Studies

Junichi Ogasawara
Chief Research fellow and Manager at The Institute of Energy Economics, Japan, Electric Power Group

Takao Kashiwagi
Specially appointed professor at Tokyo Institute of Technology

Hiroshi Takahashi
Chief researcher at Fujitsu Research Institute of Economics Co., Ltd.

Kikuko Tatsumi
Regular adviser, Public Corporation, Nippon Association of Consumer Specialists

Tatsuo Hatta
Special visiting professor, Gakushuin University

Toshihiro Matsumura
Professor at The Institute of Social Science, The University of Tokyo

Akihiko Yokoyama
Professor at Graduate School of Frontier Sciences, The University of Tokyo
April 2, 2013, Cabinet decided the “Policy on Electricity System Reform” to realize three objectives in Japan’s market with a three-step approach.

3 Objectives

1. Securing a stable supply of electricity
2. Suppressing electricity rates to the maximum extent possible
3. Expanding choices for consumers and business opportunities

At around 2015: Transition to new regulatory organizations
1st step: Establish the OCCTO

- Established the Organization for Cross-regional Coordination of Transmission Operators (OCCTO) in Apr. 2015

Main functions of OCCTO
1. Aggregate and analyze the EPCO’s supply-demand plans and grid plans, and order to change EPCO’s plans such as tie lines construction
2. Order EPCOs to reinforce generations and power interchanges under a tight supply-demand situation

Frequency in West: 60Hz
Frequency in East: 50Hz

* DC – direct current, FC – frequency conversion, TDSO – Transmission and Distribution System Operator
2\textsuperscript{nd} step: Full Retail Competition

- Expand retail competition to the residential sector in 2016, opening a new market
- Maintain regulated tariffs to 10 big EPCOs until the same time as or after the unbundling

\textbf{Liberalized Sector}

(50kW~)

- Market Volume: ¥10.1 trillion ($84.2bn, €74.8bn)
- Share of total power supply: 62%

\textbf{Regulated Sector}

(\sim 50kW)

- Market Volume: ¥8.1 trillion ($67.5bn, €60.0bn)
- Number of contracts:
  - Residential Customers: 77.3m
  - Small shops and offices: 7.3m
- Share of total power supply: 38%
Revision of Business License Categories

- Business License categories under the Electricity Business Act, such as “General Electricity Utilities (GEU)” and “Wholesale Electricity Utilities”, will be revised in line with the full retail choice.
3rd step: Unbundle the T/D sector

- Unbundle the transmission/distribution sectors of big EPCOs by legal unbundling style in 2020

**Holding company style**
- Generation company
  - Competitive
- Transmission/Distribution company
  - (System operation)
  - Regulated
  - Regional monopoly
  - Network tariff
  - Responsibility for maintaining frequency & providing LR service
  - Code of conduct
- Retail company
  - Competitive

**Affiliated company style**
- Generation company
  - Competitive
- Transmission/Distribution company
  - (System operation)
  - Regulated
  - Regional monopoly
  - Network tariff
  - Responsibility for maintaining frequency & providing LR service
  - Code of conduct
- Retail company
  - Competitive

<Note>
- Big EPCOs will be required to unbundle transmission and distribution companies from generation ones or retail ones, in “legal unbundling.”
- Both the holding company style and the affiliated company style, in which a generation and retail company has a transmission and distribution company as a subsidiary company, are allowed.
Future Design of Japan’s Electricity Market

Generation companies

Transmission/Distribution companies

Retailers

Consumers

JEPX

Hydroelectric plant
Thermal plant
Nuclear power plant
Wind farm, etc.

220-500kV

220-500kV

Super high voltage substation

Primary substation

Substation for distribution

66kV

66-154kV

6.6kV

100/200V

154-220kV

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