Opportunities and Challenges for Smart Grid in Japan

March 8, 2016

Shuichi Ashidate

Vice President of TEPCO Research Institute
Tokyo Electric Power Co., Inc.
Capacity of Renewables in Japan

Before FIT
(~2012.6)

After FIT
(2012.7~2015.3)
 Structural Challenge of Future Utility

- Decrease in Sales and Load Factor
- Energy Efficiency
- Decrease in Population
- Structural Change in Industry
- Distributed Generation
- Environment Policy
- Increase in Aged Infrastructure
- Further Energy Saving
- Customer Reaction
- Further Increase in Distributed Energy
- Raise of Retail Price

Environment Policy

Structural Challenge of Future Utility
“Smart Grid” for a futuristic energy infrastructure

Transmission System
- Wind
- Mega Solar
- DC Connecting
- Central dispatch center
- Integration of Large-scale RE
- 50Hz Area
- Wide-area operation
- 60Hz Area
- Integration of Large-scale RE
- Next-generation monitoring/control technology
- DC Connecting
- Nuclear
- Hydro
- Thermal
- Wide-area network
- Increase of wide-area interconnection capacity
- DC Connecting
- International contribution
- Upgrading transmission and distribution network
- Overseas

Distribution System
- Speedy Deployment of smart meters
- EV Smart Meter
- EV Charger
- Battery
- Renewable
- Smart Community, BCP enhancement
- Control Center
- Coordination
- Speedy Deployment of smart meters

ICT
- Integration of Large-scale RE
- Speedy Deployment of smart meters
- Coordination
- International contribution
- Upgrading transmission and distribution network
- Overseas
- Smart Community, BCP enhancement
Future Smart Grid 3.0 in 2020

- Realization of secure, safe, and comfortable Smart Society by realizing the Smart Grid through the digital integration

Whole optimization and high value-added creation

- High reliable inter-connectibility of systems and Standardization of data structure
- Utilizing Big Data
- Cyber security

- Cooperation and optimization with centralized power plants, distributed power plants, and electricity apparatus of customers
- Participation of various players such as system operators, retails, consumers, resource aggregators
Integrated Solutions are Needed

Market and Regulation
- Wholesale Market
- Capacity Mechanism
- Transmission and Distribution Code, Tariff
- Pricing
- DR

Cyber Space
- IoT (Integration of IT and OT)
- Smart Grid
- Behavior Analysis
- Diagnosis, Asset Management, Optimization

Hardware and Devices
- Decommission
- Renewable Energy
- Robotics
- Material Technology
- Superconductivity
- HVDC
- Energy Storage
- Smart House
- EV

Generation
T&D
Customer

(Climate Change Policy)

Transmission and Distribution Code, Tariff

Copyright ©2015 Tokyo Electric Power Co., Inc. All Rights Reserved
Verification of Coordinated Control of RE and Demand side devices
Demonstration Project on the Island

Verification of the Power Network System, which maximize output of Renewable Energy

- Control/Suppress
- Prediction
- Compensation

- Output
- Fluctuation
- Ramp

- Supply Capacity
- Adjusting Capacity for Frequency Control

Generator & Battery

Control Center

Distribution Network

Communication Network

Energy Storage
Demonstration Project on the Island

Diesel Generator 7,700kW
- 2,500kW, 2,000kW
- 1,200kW, 1,000kW*2

Energy Storage 500kW*2

PV315kW

Heat Pump

PV9kW + Energy Storage 12kWh

WT300kW*2 + Energy Storage 500kWh

PV9kW + Energy Storage 12kWh
Demonstration Project on the Island

Development of Integrated EMS for Niijima island

Existing System

- Demand Prediction
  - Prediction of outputs and fluctuations of RE
  - Meteorological Information

Development of Integrated EMS

- Integrated control of energy storage (battery, time shift)
- Control of outputs of Renewables

Optimal Economical Operation of DG

New DG control Panel

- DG (Diesel Generator)
- Large Battery (Grid Side)
- Battery (Customer Side)
- Large Heat Storage
- EV
- PV
- WT
- Small PV (Customer Side)

Forecasting of outputs and fluctuations of RE

1. Development of Integrated EMS
2. Forecasting of outputs and fluctuations of RE
3. Development of Integrated EMS
4. DG (Diesel Generator)
5. Control monitor
6. G

Copyright ©2015 Tokyo Electric Power Co., Inc. All Rights Reserved
Schematic view of output curtailment system

- Prediction of electric power demand
- Power generation plan
- Prediction of the output of PV power plants
- Calculation of the possible capacity for PV power plants etc...

Utility (Central Dispatch Center)

PV Power Plant

Telecommunication and control unit

Server

Communication Network

Scope of Demonstration

Determination of curtailment amount for PV power plants

PCS (Solar inverter)

PV Panel
Battery SCADA

Control room
Battery Containers

Lithium ion Batteries

Battery SCADA
Deployment of Smart Meters

<table>
<thead>
<tr>
<th>Classification</th>
<th>Number of customers</th>
<th>Ratio of Energy Use</th>
<th>Progress of Installation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Over 20kV Supply</td>
<td>3,000</td>
<td>40%</td>
<td>Finished</td>
</tr>
<tr>
<td>6kV Supply and over 500kW</td>
<td>12,000</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6kV Supply and below 500kW</td>
<td>230,000</td>
<td>20%</td>
<td>will finish by 2016.</td>
</tr>
<tr>
<td>Under 6kV Supply</td>
<td>27 million</td>
<td>40%</td>
<td>have started to install from 2014 and will finish by 2020.</td>
</tr>
</tbody>
</table>

Advanced services using meter data

B-route to communicate between smart meter and HEMS

Devices for visualizing Energy Consumption
Research on Introducing Dynamic Pricing for Residential Customers

- Measurement and Verification of Demand Response (DR) in the Yokohama Smart City Project (YSCP)

< DR for Residential Customers

Average peak cur efforts of 14.9% by DR trial (2014)

CPP (Critical Peak Pricing)  PTR (Peak Time Rebate)

Customers are Provided a Rebate for Reductions in Consumption.
Electric Vehicles and Quick Chargers

EV (under quick charging)  CHAdeMO Connector  Quick Charger
Wind Power Generation on the ocean

Wind Turbine which endures a typhoon
(Very large typhoon No.26 in 2013)

Wind observation tower
Wind Turbine
(be started generation in Jan 2013)

The height from sea level to top of blade is 126.0m

100m
Concluding Remarks

- We, major core Japanese entities, have been demonstrating various national projects in order to establish smart grid technologies to solve the issues caused by massive integration of the renewable energy while referring both the efforts of massive introduction of renewable energy and the examination of the electric power system reform in Europe and U.S..
- We would like to contribute to establish smart islands or smart cities overseas, along with the grid technologies which is the core technology in TEPCO.
Situation of PV and Wind Power Installation in Japan

<table>
<thead>
<tr>
<th>Region</th>
<th>Renewable Energy / Min. Peak Demand [%]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hokkaido</td>
<td>72%</td>
</tr>
<tr>
<td>Tohoku</td>
<td>88%</td>
</tr>
<tr>
<td>Kansai</td>
<td>18%</td>
</tr>
<tr>
<td>Hokuriku</td>
<td>19%</td>
</tr>
<tr>
<td>Chugoku</td>
<td>47%</td>
</tr>
<tr>
<td>Kyushu</td>
<td>112%</td>
</tr>
<tr>
<td>Shikoku</td>
<td>45%</td>
</tr>
<tr>
<td>Chubu</td>
<td>27%</td>
</tr>
<tr>
<td>Tokyo</td>
<td>31%</td>
</tr>
</tbody>
</table>

Peak Demand
Capacity (appl.-base)

Renewables / min. peak demand [%]