Integration of Distributed Energy Resources
- Opportunities and Challenges in Japan -

August 20, 2015

Hiroshi Okamoto

Managing Executive Officer
President of TEPCO Research Institute
Secretary General of the New Growth Task Force
Tokyo Electric Power Co., Inc.
Renewable Generation Capacity in Japan

About 16GW
In TEPCO’s Area

Before FIT
(~2012.6)

After FIT
(2012.7~2014.3)
PV installations in TEPCO’s area

[number of spot] x1000

[MW]

capacity  number of spot

0 27 40 57 75 93 108 124 160 218 299 401 518 624

104 146 208 273 335 385 437 565 787 1118 1692 3315 5594

Copyright ©2015 Tokyo Electric Power Co., Inc. All Rights Reserved
Situation of PV and Wind Power Installation in Japan

Renewables / min. peak demand [%]

- HOKKAIDO: 72%
- TOHOKU: 88%
- KANSAI: 18%
- HOKURIKU: 19%
- CHUGOKU: 47%
- KYUSYU: 112%
- SHIKOKU: 45%
- CHUBU: 27%
- TOKYO: 31%

Legend:
- Peak Demand
- Capacity (appl.-base)
Structural Challenge of Future Utility

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

Generation

T&D

Customer

(Climate Change Policy)

Wholesale Market

Pricing

Capacity Mechanism

DR

Transmission and Distribution Code, Tariff

IoT (Integration of IT and OT)

Smart Grid

Behavior Analysis

Diagnosis, Asset Management, Optimization

Decommission

Superconductivity

Renewable Energy

HVDC

Robotics

Energy Storage

Material Technology

Smart House

Market and Regulation

Cyber Space

Hardware and Devices
Wind Power Generation on the ocean

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

Wind observation tower

Wind Turbine

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

100m

National Project
Photovoltaic Power Generation

Ukishima solar power plant
In grid demonstration of High Temperature Superconducting (HTS) cable

Test site (Asahi S/S)
Issues to be addressed for integration renewables to grids

Backup Generation and Energy Storage

Transmission Enhancement

Variable Speed Pumped Hydro Station
Verification of Coordinated Control of RE and Demand side devices
Battery SCADA

Control room

Battery Containers

Lithium ion Batteries

Battery SCADA
Electric Vehicles and Quick Chargers

EV (under quick charging)  CHAdeMO Connector  Quick Charger
Demonstration Project on the Island

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

Renewable Energy

Distribution Network

Communication Network

Control/Suppress

Prediction

Supply-Demand Control

Control Center

Generator & Battery

Compensation

• Output
• Fluctuation
• Ramp

• Supply Capacity
• Adjusting Capacity for Frequency Control

Energy Storage

National Project
Deployment of Smart Meters

We will complete 27 million smart meter deployment by FY 2020.
Moving up installation of Smart Meters

### Installation Schedule

<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>will finish by 2016.</td>
</tr>
<tr>
<td>6kV Supply and below 500kW</td>
<td>230,000</td>
<td>20%</td>
<td></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

Copyright ©2015 Tokyo Electric Power Co., Inc. All Rights Reserved
Measurement and Verification of Demand Response (DR) in the Yokohama Smart City Project (YSCP)

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.
“Smart Grid” for a futuristic energy infrastructure

- Increase of wide-area interconnection capacity
- Upgrading transmission and distribution network
- Speedy Deployment of smart meters
- International contribution
- Smart Community, BCP enhancement
- Demand Response
- Renewable
- Central dispatch center
- Transmission System
- Integration of Large-scale RE
- DC Connecting
- 60Hz Area
- Wide-area network
- 50Hz Area
- Wind
- Mega Solar
- EV
- Smart Meter
- EV Charger
- Battery
- Nuclear
- Hydro
- Thermal
- Wide-area operation
- Coordination
- ICT
- Overseas

Organization for Cross-regional Coordination of Transmission Operators (under construction)

Copyright ©2015 Tokyo Electric Power Co., Inc. All Rights Reserved