TEPCO’s decarbonization challenges

Masaaki HANAOKA
Executive General Manager, London Office
Tokyo Electric Power Company Holdings, Inc
26 September 2016
Key Figures of TEPCO

◆ Service Area: 39,576 km²
◆ Population: 45 million
◆ Electricity Sales: 247 billion kWh
◆ Revenue: $50 billion
◆ Generation Capacity: 66GW
◆ Number of customers: 29 million
◆ Number of employees: 33,853

$1=¥120 As of FY 2015 or End of FY 2015

TEPCO covers:
- 10% of Japan’s land area
- 35% of Japan’s population
- 31% of Japan’s electricity sales

<table>
<thead>
<tr>
<th>Japan</th>
</tr>
</thead>
<tbody>
<tr>
<td>Land area</td>
</tr>
<tr>
<td>Population</td>
</tr>
</tbody>
</table>

“ELECTRICITY REVIEW JAPAN” (The Federation of Electric Power Companies of Japan)
Fukushima Daiichi Five years Later
Fuel Removal from Unit 4 Spent Fuel Pool
Completed on Dec. 22, 2014

- Nov. 2011: Rubble removal
- Apr. 2012: Cover construction
- Nov. 2013: Fuel removal
- Dec. 2014: Completion

Fuel Handling Machine

to remove fuel from spent fuel pool
Roadmap for Recovery and Decommissioning

- Global collaboration needed to work on unprecedented R&D efforts.

**December 2011**
- **Phase-1**: Begin removal of fuel from spent fuel pools
  - **Nov. 18, 2013**

**Within 2 years**
- **Phase-2**: Begin removal of fuel debris

**Within 10 years**
- **Phase-3**: Complete decommissioning

---

Removal of Rubble from Reactor Buildings
Radiation Dosage Levels around Fukushima Daiichi

Aerial Radiation Dose (μSv/h) at 1 m above ground

**as of April 2011**

**as of November 2015**

4 years

1 μSv/h = 8.76 mSv/y
2.3 μSv/h = 20 mSv/y

©Tokyo Electric Power Company Holdings, Inc. All Rights Reserved.
Energy Mix in Japan
The goals of energy policy are to be achieved regarding safety, energy security, economic efficiency and environment which are the basic perspectives in the Strategic Energy Plan.

**Electric Power Demand**

- Economic growth 1.7%/year
- Thorough energy efficiency 196.1 billion kWh

<table>
<thead>
<tr>
<th>Year</th>
<th>Power Demand</th>
<th>Power Source Mix</th>
</tr>
</thead>
<tbody>
<tr>
<td>FY2013</td>
<td>966.6 billion kWh</td>
<td>Economic growth 1.7%/year</td>
</tr>
<tr>
<td>FY2030</td>
<td>980.8 billion kWh</td>
<td>Thorough energy efficiency 196.1 billion kWh</td>
</tr>
</tbody>
</table>

**Power Source Mix**

- (Total Power generation) 1,0650 billion kWh
- Efficiency (17%)
- (Renewable) Geothermal 0~1.1%
- Biomass 3.7~4.6%
- Wind 1.7%
- Solar 7.0%
- Hydro 8.8~9.2%

- Renewable 22~24%
- Nuclear 22~20%
- LNG 27%
- Coal 26%
- Oil 3%

**TEPCO**

- Before Fukushima 10 years average
- FY 2014

- Renewable 11%
- Nuclear 27%
- LNG 47%
- Coal 31%
- Oil 10%
Power Market Reform in Japan
Power market reform in Japan

- Japan’s power market liberalization started in 2000.
- From April 2016, it is fully opened.

Gas market will be fully opened in April 2017.
‘Market penetration’ under full liberalization

Accumulated switching application number in Japan

<table>
<thead>
<tr>
<th>EPCo</th>
<th>No. of application (k)</th>
<th>Rate (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hokkaido</td>
<td>45.9</td>
<td>1.15</td>
</tr>
<tr>
<td>Tohoku</td>
<td>17.6</td>
<td>0.23</td>
</tr>
<tr>
<td>Tokyo</td>
<td>647.3</td>
<td>2.22</td>
</tr>
<tr>
<td>Chubu</td>
<td>64.0</td>
<td>0.60</td>
</tr>
<tr>
<td>Hokuriku</td>
<td>2.3</td>
<td>0.11</td>
</tr>
<tr>
<td>Kansai</td>
<td>216.3</td>
<td>1.59</td>
</tr>
<tr>
<td>Chugoku</td>
<td>2.5</td>
<td>0.05</td>
</tr>
<tr>
<td>Shikoku</td>
<td>4.2</td>
<td>0.15</td>
</tr>
<tr>
<td>Kyushu</td>
<td>35.4</td>
<td>0.41</td>
</tr>
<tr>
<td>Okinawa</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Japan</td>
<td>1036</td>
<td>1.22</td>
</tr>
</tbody>
</table>

※ As of May 31
TEPCO moved to a holding company structure in April 2016.
Electricity demand in Japan

- Electricity demand declined after Fukushima nuclear accident.
Renewable Energy in Japan
Growing Purchase of Electricity from Solar

July 2012, Introduction of FIT
Outline of FIT System in Japan (July 2012-)

- Power utilities purchase power generated from renewable energy at fixed price for a certain period of time
- Purchasing cost is surcharged to consumers depending on consumption volume

Renewable energy power producers
- Solar
- Wind
- Small hydro
- Geothermal
- Biomass
- Private home facility

Sells power generated from renewable energy

Utilities, etc
- Purchases power at fixed price for a period set by government
- Compensates purchase cost
- Reports purchase volume

Surcharge Adjustment Organization
(collects and distributes surcharge)
- Sets purchase price / period
- Decides surcharge per kWh
- Reports purchase volume
- Collects surcharge with electricity bill
- Pays collected surcharge

National government
- Special Committee for Determination of Tariffs and Durations
(Members appointed by Diet)
- Certify

Power consumers
- Supplies electricity
- Collects surcharge with electricity bill
## Purchase Conditions for FY 2012-2015

<table>
<thead>
<tr>
<th>Energy</th>
<th>Purchase category</th>
<th>Price (JPY/kWh)</th>
<th>Period (yrs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Solar</td>
<td>Under 10 kW (surplus purchase)</td>
<td>42</td>
<td>38</td>
</tr>
<tr>
<td></td>
<td>10 kW or more</td>
<td>40</td>
<td>36</td>
</tr>
<tr>
<td>Wind</td>
<td>Under 20 kW</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>20 kW or more</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Offshore</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hydro</td>
<td>Newly built</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Under 200 kW</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>From 200 kW up to 1MW</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>From 1MW up to 30MW</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Existing headrace used</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Under 200 kW</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>From 200 kW up to 1MW</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>From 1MW up to 30MW</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bio-mass</td>
<td>Wood biomass (recycled wood)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Waste (non-wood) biomass</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Wood biomass (imported chips, PKS, etc)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Wood biomass (unused wood) 2MW or more</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Wood biomass (unused wood) Under 2MW</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Methane fermented gasified biomass</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Geothermal</td>
<td>Under 15MW</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>15MW or more</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

(※1) When generators are not required to install output control equipment
(※2) When generators are required to install output control equipment
Results of FIT Introduction (Jul 2012-Nov 2015)

Since FIT system introduction in July 2012, renewable facilities with total output of approximately 94 GW have been granted FIT certifications.

Solar power is particularly high in certified output.

Certified output for each energy source (as of end of Nov 2015)

<table>
<thead>
<tr>
<th>(MW)</th>
<th>Solar</th>
<th>Wind</th>
<th>Small/med hydro</th>
<th>Geothermal</th>
<th>Biomass</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Certified Output (New)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Under 10kW</td>
<td>4,330</td>
<td></td>
<td></td>
<td></td>
<td>2,790</td>
<td>85,580</td>
</tr>
<tr>
<td>10kW or more</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>75,310(88%)</td>
<td>2,330</td>
<td>740</td>
<td>70</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Installed Output (New)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Under 10kW</td>
<td>3,670</td>
<td></td>
<td>380</td>
<td>130</td>
<td>430</td>
<td>25,370</td>
</tr>
<tr>
<td>10kW or more</td>
<td>20,740</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Installed Output (Existing)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Under 10kW</td>
<td>4,700</td>
<td></td>
<td>2,530</td>
<td>210</td>
<td>1,130</td>
<td>8,830</td>
</tr>
<tr>
<td>10kW or more</td>
<td>260</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Caused problems such as shortage of transmission capacity, increase in surcharges, and so on.

Source: METI website
## Results of FIT Introduction – Grid Connection Problems

<table>
<thead>
<tr>
<th>Illustration</th>
<th>(1) Demand-supply restriction</th>
<th>(2) Network capacity restriction</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td><img src="image" alt="Diagram" /></td>
<td><img src="image" alt="Diagram" /></td>
</tr>
<tr>
<td>Problem and measures</td>
<td>Hokkaido, Tohoku, Shikoku, Kyushu, Okinawa Power Companies announced that they would postpone their replies on the network access applications from renewable developers. (Sep 2014)</td>
<td>Surplus of renewable energy output at transmission lines, transformers.</td>
</tr>
<tr>
<td></td>
<td>➢ Mandatory installation of output control equipment.</td>
<td>➢ Setting the rule of transmission system information publication.</td>
</tr>
<tr>
<td></td>
<td>➢ Transition to time-based output restriction rule (from 30 d/y to 360 h/y (PV), 720 h/y (wind)).</td>
<td>➢ Launched bidding scheme for renewable developers to share the burden of upgrading the network facilities.</td>
</tr>
<tr>
<td></td>
<td>➢ Utilization of “designated power company scheme”.</td>
<td></td>
</tr>
</tbody>
</table>
Recent adoption on FIT revision (Date of effect: April 2017)

[Purpose of the revision]

To achieve the target of 22-24% (※) renewables in FY2030 energy mix

- Balanced renewable installation
- Cost-efficient to limit national burden
- Efficient Cross-regional electricity trading & coordination

Combine maximum renewable energy installation and limited national burden

[Revision points]

1. **The establishment of a new certification scheme.**
   - Taking into consideration non-operative projects
2. **Installation of scheme for proper operation.**
3. **Installation of cost-efficient scheme.**
   - Bidding scheme (target TBD)
   - Showing future purchase prices (target TBD)
4. **Promotion of renewable projects with long lead-times.**
5. **Promotion of renewable projects utilizing the electricity market reforms.**
   - Change of purchase obligation party (from retailer to network operator)

Source: METI document
TEPCO’s challenges

- Reduction of fuel costs and consumption
- Adopting adjustable-speed pumped storage hydro
- Distribution Upgrade & Smart Meter
- Digital Utility
Reduction of fuel costs and consumption

- Chiba Thermal Group 3 and Kashima Thermal Group 7 started operation in series; they were installed immediately after 3.11 and were improved to be combined cycled and highly efficient.

- TEPCO will purchase up to 1.20 million tons of LNG per year over 17 years from BPS, starting in April 2017. The supply features the inclusion of lean LNG, of which TEPCO intends to increase its share, and also the inclusion of gas link (Henry Hub link) for price indexation.

### Thermal Efficiency (Lower heating value basis)

- **1,100℃ Class**
  - Futtsu Group 1, 2
  - CC
  - 47%

- **1,300℃ Class**
  - Yokohama Group 7, 8
  - Chiba Group 1, 2
  - Shinagawa Group 1
  - Futtsu Group 3
  - Kashima Group 7 (57%)
    - 54%
    - 55%

- **1,500℃ Class**
  - MACC
  - Kawasaki Group 1
  - Futtsu Group 4
  - Kawasaki Group 2 Unit 1
  - Chiba Group 3 (58%)
    - 59%

- **1,600℃ Class**
  - MACC II
  - Kawasaki Group 2 Unit 2, 3

### Volume of low spec LNG

- Max 10 Gt/year
- Current Procurement 2Gt/year

- Participation in the value chain of some low spec LNG projects
- Forming optimal portfolio of price index
- Introduction of bargaining linked to natural gas prices
- Equipment/Operation
  - Additional Tank (Futtsu)
  - Improved terminal/power plant
  - Expansion of reception of low spec LNG (Higashi-ohgijima)

### Equipment/Operation

- Chiba Group 3 (1002 MW → 1500 MW)
  - Unit 1: 4/24, Unit 2: 6/16, Unit 3: 7/31 commercial operation
- Kashima Group 7 (80.4万kW → 126.0万kW)
  - Unit 1: 5/1, Unit 2: 6/18, Unit 3: 6/2 commercial operation
Adopting adjustable-speed pumped storage hydro

- Adopt a high-volume grid to absorb surplus power from unstable electrical sources (e.g., solar, wind) on light-load days
- Provide LFC service even while in pumping operation
Distribution Upgrade & Smart Meter

- TEPCO will roll out 27 million smart meters by 2020.

Smart Meter:

- Metering and memorizing every 30 min.
- Measuring currents and power
- Communicative Function, Remote disconnect / reconnect, Demand-limit change, Emergency demand limit, Event memorization, etc.
- Automated meter reading
- Energy management for HEMS
- Possible in various rate plans
Brand slogan of TEPCO Group

The Energy for Every Challenge

As expressed in the word “Challenge,” TEPCO aims to be the chosen partner in this industry while remaining highly competitive and fulfilling its responsibility. TEPCO will continue to provide a stable supply of electricity and moreover, contribute to improving the lives of our customers. In every business field, we pledge to pursue a higher goal.

The word “Energy” here refers not only to our business domain, but to our passion and power to serve people.