Current Trends in the Power Sector in Japan: Their Implications for Deep Decarbonisation

Socio-economic Research Center
Central Research Institute of Electric Power Industry

Kenji Asano, Ph.D
Senior Research Scientist

September 6th, 2017
Japan-China Policy Research Workshop in 2017
Outline

Electricity sector in Japan
- Vertically integrated utilities
- Liberalisation of electricity market

Energy services after the restructure
- Japan’s Generation Mix Target
- Stable Supply of electricity
- Suppressing electricity rates
Electricity sector in Japan

VERTICALLY INTEGRATED UTILITIES
Basic design of electricity market
Vertically integrated utilities

Before April, 1995

Generation

Network (Transmission & Distribution)

Retail

Vertically Integrated Utilities

(Obligation to supply)

All customers

© CRIEPI 2017
Ten General Electric Utilities (GEUs)
- Investor-owned & Vertically integrated
- Have their own supply areas
Power supply system in Japan

As of April, 2005

Japan Electric Power Exchange (JEPX)

- Wholesale Electric Power Companies
- Other Utilities
- PPS

Vertically Integrated Utilities

- Information firewall
- Account separation
- Prohibition of discrimination

Electric Power System Council of Japan (ESCJ)
* ESCJ has been closed in 2015 April

Wholesale

Retail

Obligation to supply

Other customers

Ultra high & high voltage customers

Non-eligible  Eligible
Electricity sector in Japan

RESTRUCTURING OF THE ELECTRICITY MARKET
Energy Market Reform

**Produce**
- It is expected that cooperation and competition at the upstream market will lead to suppressed fuel supply costs and distinctive local initiatives such as promotion of local green power.
  - Large-Scale Power Plants
  - LNG Terminals
  - Power generation that utilizes renewable energy and local resources

**Transport**
- All businesses will have equal access to transmission/distribution networks and gas pipelines.
  - Electricity
  - Gas

**Retail**
- All consumers get to be able to buy electricity and gas from any company, regardless of location.
  - Electricity Companies
  - Gas Companies
  - Mobile Phone Companies
  - Internet Service Providers
  - Housing Companies
  - Mail Order Services
  - Consumer Electronics Retailers
  - Green Electricity Companies

It is expected that new rate plans, as well as package plans with electricity/gas supply and multiple services will be offered.

[Source] METI
Electricity Market Reform Goals

1. Secure the Stable Supply of electricity
   - Establish reliable electricity system without relying on planned outages, by promoting
     i. cross-regional transmission of electricity
     ii. effective use of the variety of generation resources including renewables and in-house power generations
     iii. reasonable power-saving measures such as demand response

2. Suppress Electricity Rates to the maximum extent possible
   - Promote market competition to encourage creativity and management efforts among energy-producing and selling companies.

3. Expand Electricity Choices for Consumers and Business Opportunities
   - Develop innovation and business opportunities for companies, by introducing full retail choices for all electricity consumers – including both households and corporations.

[Source] METI
Roadmap for the Restructuring

1st Step: Establishment of OCCTO*
- Apr 2015

2nd Step: Establishment of EGC**
- Sep.
- Apr 2016

3rd Step: Abolishment of Regulated Retail Tariff
- Apr 2020

1st Reform

2nd Reform
- Full liberalization of Retail Market

3rd Reform
- Transition Period of Regulated Retail Tariff
- Legal Unbundling

* The Organization of Cross-regional Coordination of Transmission Operators
** Electricity and Gas Market Surveillance Commission

[Source] METI, Electricity and Gas Market Surveillance Commission
Roadmap for the Restructuring

April, 2013

[Step 1] 2015
- Establishing the OCCTO (Organization for Cross-regional Coordination of Transmission Operators) and dissolving current ESCJ.
  - Role (1): To make supply-demand and grid plans.
  - Role (2): To coordinate wider-area S/D balancing in normal situations.
  - Role (3): To balance S/D under tight situations.

[Step 2] 2016
- Fully opening the retail market (including households)
  - Household and other small customers have retail choice.
  - Current GEUs should offer transitional regulated tariffs for those customers.

[Step 3] Approx. 2020
- Legally Unbundling T&D Sectors
  - To achieve level playing field b/w current GEUs and competitors.

- Abolishing the transitional regulated tariff
  - To abolish the tariff when the market is found to be sufficiently “competitive.”

© CRIEPI 2017
1st step: Establishment of OCCTO

- OCCTO promotes network expansion required for cross-regional operation of supply capacity and reinforces the nationwide supply-demand balancing function in both normal and emergency conditions.

- OCCTO establishes the long term cross-regional network development policy.

- OCCTO installed the switching support system, to support smooth transfer of customers to switch their retail company from one to another.
2nd step: Full Retail Competition

- Regional monopoly for all customers before 1995

※ As transitional measures to protect demanders, regulations on charges remain applicable at least until 2020 (demanders can select regulated charges).

[Source] METI : Electricity and Gas Market Surveillance Commission
2nd step: Full Retail Competition

Current categories

- **GEU (10 EPCOs)**
  - Supply for customers, including those in regulated sector with obligation to supply, regional monopoly and rate regulation
  - Secure stable frequency and voltage

- **PPS (Power Producer and Supplier)**
  - Supply for customers in liberalised sector (more than 50kW)

- **Wholesale Electricity Utilities, etc**
  - Supply for GEU

New categories (after 2016)

- Obtain 3 licenses (not necessary to change corporate organization)

- **Generation**
  - Supply for customers, including those in regulated sector with obligation to supply, regional monopoly and rate regulation
  - Secure stable frequency and voltage

- **Transmission & Distribution**
  - Operate and maintain transmission/distribution lines
  - Regional monopoly and rate regulation

- **Retail**
  - Supply for customers
  - Obligation to secure the capacity of power supply
  - Regulation based on the level playing field of competition

- **Generation**
  - Supply for GEU

- **Retail**
  - Supply for customers in liberalised sector (more than 50kW)

Source: METI

- 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

- Holding company
  - Generation company
  - Transmission/Distribution company
    - (System operation)
  - Transmission/Distribution company
    - (Transmission/distribution facilities)
  - Retail company

Competitive

Competitive

Regulated
- Regional monopoly
- Network tariff
- Responsibility for maintaining frequency & providing LR service
- Code of conduct

>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

[Source] METI
Energy services after the restructure

JAPAN’S GENERATION MIX TARGET AND ITS CHALLENGES
**S+3E**
METI’s Long-term Energy Supply and Demand Outlook

**Self Sufficiency**
- Currently at 6%
- Self-sufficiency rate of 25%
  - (20% before the earthquake)

**Electric power costs**
- Increase in electricity prices
  - (Industrial=30%, Residential=20%)
- FIT purchase cost up to 1.3 trillion in 2013
- Reduce electric power cost to 2013 level or less

**GHG emissions**
- 2013 CO₂ Emissions Worst on Record
  - ※from fuel combustion only
- Set the GHG mitigation target matching that of Europe and the USA

**Energy security**
- 【Target】

**Economy**
- 【Target】

**Environment**
- 【Target】

[source] the Long-term Energy Supply and Demand Outlook Subcommittee, Advisory Committee for Natural Resources and Energy

© CRIEPI 2017
Japan’s Generation Mix Target

Electricity Demand

- Economic growth 1.7%/yr
- 966.6 TWh (FY2013, Historical data)
- 980.8 TWh (FY2030)

Energy-saving measures (196.1 TWh, ▲17%)

Electricity generation by energy source

- (Gross generation) 1278 TWh
- Energy-saving measures: 17%
- Share of baseload: 56%

- Renewables: 19-20%
- Nuclear: 18-17%
- LNG: 22%
- Liquefied Natural Gas (LNG): 27%
- Coal: 22%
- Oil: 2%

- Renewables: 22-24%
- Nuclear: 22-20%
- LNG: 27%
- Coal: 26%
- Oil: 3%

- Geothermal: 1.1%
- Biomass: 3.7-4.6%
- Wind: 1.7%
- Photovoltaic (PV): 7.0%
- Hydro: 8.8-9.2%

FY2030

(source) the Long-term Energy Supply and Demand Outlook Subcommittee, Advisory Committee for Natural Resources and Energy
Challenge #1: Restart of Suspended Nuclear Power Units

- Review and inspection take a long time.
  - Typically 1-2 years for a unit
  - 4 restarted in operation and 5 out of 25 approved since the 1st application (July 2013)

[Source] METI
Challenge #2: Renewable Energy

◆ As of 2015, the renewable energy ratio in the generated electric power amount of Japan is 14.6% (6% if hydroelectric power is excluded)

◆ Thanks to the introduction FIT in 2012, the installed capacity of renewable energy is growing rapidly. Meanwhile, the purchase costs reached 2.7 trillion yen (aprx.$24.5 billion), and the levy burden(surcharge) to average households amounts up to 792 yen/month (aprx. $7.2).

[Source] METI
Challenge #2: Renewable Energy

Changes to Feed-in tariff law (April 2017)

In order to maximize introduction of renewable energy while minimizing national burden, it is required to increase the introduction of renewable energy cost efficiently.

July 2012: Start of the Feed-In-Tariff system
(Introduced capacity volume increased by 2.5-fold in four years after the start of the system)

Emerging problems

- **Capacity introduction tilted heavily toward solar power**
  - Approved volume for solar power accounts for approx. 90%
  - Non-implemented solar power projects (310,000 projects)

- **An increasing burden on the people**
  - Acquisition cost at approx. 2.3 trillion yen in FY2016
  - Estimated at 3.7 trillion to 4.0 trillion yen in FY2030 under the energy mix plan

- **Electricity system reform**
  - A system that strikes the balance with retail sale liberalization and broad-area sharing

Revised FIT Act: enacted in May 2016 and put into force in April 2017

1. **Establishment of a new approval system**
   - Elimination of non-implemented projects and a system to prevent the occurrence of new non-implemented projects
   - A system to ensure appropriate project implementation

2. **Cost-efficient introduction**
   - Auction system for large-scale solar power generation
   - Setting of mid- and long-term acquisition price targets

3. **Introduction of power sources with a long lead time**
   - Indicate multi-year acquisition prices in advance in order to promote expansion of introduction of geothermal, wind, hydroelectric and other power sources.

4. **Review of the fee reduction system**
   - Revise the reduction rate based on the confirmation of efforts to maintain or enhance international competitiveness and promote energy conservation

5. **Shift to purchase by power transmission business operators**
   - Change business operators obligated to purchase FIT electricity from retail business operators to power transmission and distribution business operators
   - Expand introduction through broad-area sharing of electricity

Introduce renewable energy to the maximum extent and curb the burden on the people at the same time

Energy mix: toward achieving 22 to 24% (FY2030)

[Source] METI
Challenge #3:
Mechanism to support the framework of voluntary efforts by the electric utility industry

(i) **[Framework of voluntary efforts by the electric utility industry]**

Set a target consistent with a new energy mix to be achieved (0.37kg-CO2/kWh in FY2030)

| (ii) **[Supporting mechanism]**
<table>
<thead>
<tr>
<th>(at power generation stage)</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Set <strong>efficiency standards</strong> for each facility newly constructed (Coal: Level equivalent to USC coal-fired power stations; LNG: Level equivalent to combined cycle power stations)</td>
</tr>
<tr>
<td>- Set efficiency standards for each operator, including existing ones (Power generation efficiency consistent with a new energy mix to be achieved (44.3%))</td>
</tr>
</tbody>
</table>

| (iii) **[Supporting mechanism]**
<table>
<thead>
<tr>
<th>(at retailing stage)</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Targeted ratio of non-fossil power sources in FY2030: <strong>44%</strong> (Equivalent to 0.37kg-CO2/kWh in line with the Act on the Rational Use of Energy)</td>
</tr>
<tr>
<td>- In addition to the ratio of non-fossil power sources, CO₂ emissions must be reported.</td>
</tr>
</tbody>
</table>

Based on performance, the Minister of Economy, Trade and Industry issues guidance, advice, recommendations or orders.  
[Ensure effectiveness and transparency]

**[Supporting mechanism] (market design)**

Design an energy market consistent with deregulation: Creation of a low-carbon power-source market
Thank you for your attention

K-asano@criepi.denken.or.jp
Outline of METI’s Long-term Energy Supply and Demand Outlook

Based on the Strategic Energy Plan, the Long-term Energy Supply and Demand Outlook presents the ideal structure of energy supply and demand that can be realized if appropriate measures are taken based on the fundamental direction of energy policies by envisioning policy objectives to be achieved on safety, energy security, economic efficiency, and environment, which are the basic ideas of the policies (S+3E).

Basic Strategy of Development
1. Under the premise of “S+3E”
2. Lower nuclear dependence as much as possible through energy conservation, renewable energy and efficiency improvement of thermal power plants.
Japan’s Energy Mix Target

Energy demand

- 2013 (historical)
  - Electricity 25%
  - Heat Petroleum Natural Gas etc.. 75%

- FY2030 (after energy-savings)
  - Electricity 28%
  - Heat Petroleum Natural Gas etc.. 72%

Final energy demand: 326 million kL

Energy savings: 5.03 million kL (▲13%)

Economic growth: 1.7%/yr

Primary Energy

- FY2030
  - Oil 32%
  - Coal 25%
  - Natural Gas 18%
  - Nuclear 11~10%
  - Renewable 13~14%

Total primary energy: 489 million kL

Self-sufficiency rate: 24.3%

Economic growth: 1.7%/yr

Primary Energy

- FY2030
  - Oil 32%
  - Coal 25%
  - Natural Gas 18%
  - Nuclear 11~10%
  - Renewable 13~14%

Total primary energy: 489 million kL

Self-sufficiency rate: 24.3%

Source: the Long-term Energy Supply and Demand Outlook Subcommittee, Advisory Committee for Natural Resources and Energy
Japan’s Generation Mix Target

**Electricity Demand**

- FY2013 (Historical data): 966.6 TWh
- FY2030: 980.8 TWh
- Economic growth 1.7%/yr

**Energy-saving measures**

(196.1 TWh, ▲17%)

(Energy-saving measures: 17%)

(T&D losses etc.)

**Electricity generation by energy source**

- FY2030: 1065 TWh
- Renewable energy: 19-20%
- Nuclear: 18-17%
- LNG: 22%
- Coal: 22%
- Oil: 2%

- FY2030: 1278 TWh
- Renewable energy: 22-24%
- Nuclear: 22-20%
- LNG: 27%
- Coal: 26%
- Oil: 3%

- Economic growth: 1.7%/yr

- Share of baseload: 56%

[source] the Long-term Energy Supply and Demand Outlook Subcommittee, Advisory Committee for Natural Resources and Energy
History of Japan’s Energy Policy

1970s

[1] Responding to the oil crises (1970s-80s)

- Energy security

1973: First oil shock

1980s

[2] Promoting regulatory reform (since 1990s)

- Energy security + Economic efficiency

1979: Second oil shock

1990s

[3] Coping with global warming issues (since 1990s)

- Energy security + Economic efficiency + Environment

1997: Kyoto Protocol adopted

2000s


- Energy security + Economic efficiency + Environment

2005: Kyoto Protocol came into effect

2002: Basic Act on Energy Policy enacted


[source] METI
Japan’s Energy Supply Structure

- 1st Oil Shock
- 2nd Oil Shock
- Kyoto protocol adopted
- Tohoku Earthquake

[source] IEA
Japan’s Historical Trend of Power Generation Volume by source

(Note) Oil etc. includes LPG and other gases.
Figures may not add up to the totals due to rounding.
Total of 10 electric power companies and power purchased.
Figures within the graph represent the composition ratio.

[source] FEPC
Network access operation

OCCTO performs operations such as acceptance of preliminary consultation and system impact study from companies desiring interconnection of generation facilities to transmission network, check, validation, and reply of result of system impact study etc. under Article 28-40 (vii) of Electricity Business Act.

[Source] OCCTO
A market share of new entrant suppliers was about 9% in retail market for high voltage customers (>=50kW) in March 2015.

[source] Electricity and Gas Market Surveillance Commission
## History of Reforms in Japan

<table>
<thead>
<tr>
<th>No.</th>
<th>Year enforced</th>
<th>Overview</th>
</tr>
</thead>
</table>
| 1   | 1995          | • Open the IPP (Independent Power Producer) market  
• Allow specified-scaled and vertically integrated power generators |
| 2   | 2000          | • Introduce partial retail competition  
• Accounting separation of transmission/distribution sector |
| 3   | 2005          | • Expand retail competition  
• Establish the wholesale power exchange (JEPX) and its supporting body for transmission in wider areas |
| 4   | 2008          | • Modify the rule of wheeling rates... |

[Source] METI
## FIT price changes over time

<table>
<thead>
<tr>
<th>Energy Type</th>
<th>FY 2012</th>
<th>FY 2013</th>
<th>FY 2014</th>
<th>FY 2015</th>
<th>FY 2016</th>
<th>平成 29年度</th>
<th>平成 30年度</th>
<th>平成 31年度</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>PV (≥10kW)</strong></td>
<td>40 yen</td>
<td>36 yen</td>
<td>32 yen</td>
<td>29 yen</td>
<td>27 yen</td>
<td>24 yen</td>
<td>21 円</td>
<td>今年度では決定せず</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>今年度では決定せず</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>PV (&lt;10kW)</strong></td>
<td>42 yen</td>
<td>38 yen</td>
<td>37 yen</td>
<td>33 yen</td>
<td>35 yen</td>
<td>31 yen</td>
<td>28 円</td>
<td>26 円</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>26 円</td>
<td>今年度では決定せず</td>
<td></td>
</tr>
<tr>
<td><strong>Wind</strong></td>
<td></td>
<td></td>
<td></td>
<td>22 yen (≥20kW)</td>
<td></td>
<td>21 円</td>
<td>今年度では決定せず</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>55 yen (&lt;20kW)</td>
<td></td>
<td>今年度では決定せず</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Geothermal</strong></td>
<td></td>
<td></td>
<td></td>
<td>26 yen (≥15000kW)</td>
<td></td>
<td>今年度では決定せず</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>40 yen (&lt;15000kW)</td>
<td></td>
<td>今年度では決定せず</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Small/medium scale hydraulic power</strong></td>
<td></td>
<td></td>
<td></td>
<td>24 yen (≥1000kW, &lt;30000kW)</td>
<td></td>
<td>今年度では決定せず</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>29 yen (≥200kW, &lt;1000kW)</td>
<td></td>
<td>今年度では決定せず</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>34 yen (&lt;200kW)</td>
<td></td>
<td>今年度では決定せず</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Biomass</strong></td>
<td></td>
<td></td>
<td></td>
<td>39 yen (Biogas)</td>
<td></td>
<td>今年度では決定せず</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>32 yen (Timber from forest thinning)</td>
<td></td>
<td>今年度では決定せず</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>24 yen (Other woody materials)</td>
<td></td>
<td>今年度では決定せず</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>13 yen (Recycled wood)</td>
<td></td>
<td>今年度では決定せず</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>17 yen (Wastes excluding woody wastes)</td>
<td></td>
<td>今年度では決定せず</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

※1: 7/1～
※2: with output control equipment

© CRIEPI 2017
FIT: purchasing RE at a "fixed rate" over long term periods of around 20yrs

FIT prices: costs + profits based on costs for efficient supply and takes into consideration fair profits to be received by those trying to supply

Additional costs: Add on electricity fee as “surcharge” does not become excessive burden for electricity consumers (rate payers)

Avoided costs: around 10¥/kWh average variable cost of all power generated
1. the FIT price level of PV is appropriate?

The FIT price of PV is too high, as the price of PV is certain to fall significantly in the future, so there is no reason to greatly discount it.

- While the price of PV in Japan is definitely high at the moment, the price is falling as its import share increases (Nomura, 2013).
- As the price of PV modules sharply declines due to a global over supply, the cost of generating PV will follow a nearly identical trend under the same solar conditions.
2. the FIT price applied points

The FIT price can be applied only by submitting an application.

- Concern under the current system, the right to a purchase price is acquired first, then operations can begin 2-3 years later after the price of PV panels has sufficiently dropped, which can yield excessive profits for PV generators.
- In fact, over 90% of PV facilities are accredited only but have not commenced operations in FY2013 (cf. accredited 20GW, but only 2GW began operation).

Germany and other FIT countries:
- Planning
- Facilities accredited by METI
- Application for grid connect to utilities
- Financing and constructions of facilities
- Connect grid & operation

Japan:
- JP: FIT price applied point