An update on electricity industry restructuring and renewable energy integration in Japan

WEER presentation (Oct 15, 2017)

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Acknowledgement and notes

• Thanks to Dr. Yoshiki Iinuma at Japan Electric Power Information Center (JEPIC) for sharing with me many JEPIC reports

• Other references include various committee documents from the Ministry of Economy, Trade, and Industry (METI), Agency for Natural Resources and Energy (ANRE)
Agenda

- Recent development in Japan's electricity industry restructuring
- Restructuring challenges
- Policy challenges in pursuing both restructuring and large-scale renewable energy integration at the same time
- A case study on efforts to enhance competition in the wholesale electricity market (if time permits)
Total electricity generation in Japan (2010 and 2015)

IEA (2016) *Electricity Information*  
(U.S. total: 4,078TWh; HI total: 10.2TWh in 2015)
Source: (METI 2014)
Fossil fuel use and the 2011 Earthquake

- Share of fossil generation increased from 63% to 82% in 2010-2015, largely due to the 2011 Fukushima accident
Implications to CO2 emissions

Figure 2-3  Trends in CO₂ emissions in each sector
(Figures in brackets indicate relative increase or decrease to the FY1990 values)

NIES (2017) National Greenhouse Gas Inventory
For references: electricity production by source in Hawaii and the U.S.

Japan’s electricity industry: historical evolution

• After World War II: Nine regional monopolies were established; each providing integrated services from generation, transmission, and distribution (Okinawa Electric added in 1972)
10 electric utilities and their coverage (1972-)

- Except for Okinawa, interconnection exists among the nine regions
- Frequency difference between western and eastern Japan (with limited converter capacity in between)
- But interconnections are weak, capacity-constrained (especially Hokkaido-Honshu)
Electric industry restructuring: Japan’s case

1. Overview of the Japanese Electric Industry

- 10 General Power Utilities (GPUs), vertically-integrated generation, transmission and distribution segments, with their franchised areas under public service obligation.
- Japanese network system does not form mesh network, and interconnection capabilities between GPUs are sometimes said to be weak.
- Japanese network is isolated with no international connection.
- Scarce indigenous resources brings about heavy independence on imported energy resources.

http://slideplayer.com/slide/6899546/
Market split (i.e., interconnection constraints bind in some areas)

Figure 26 Monthly market-splitting by interconnector in Japan

Source: (EGMSC 2017c, p. 33)
Reforms

• Electricity industry restructuring efforts in many countries in the 1990s
• 1995: Liberalization of wholesale supply: independent power producers’ entries to generation allowed
• 2000: Retail supply for large (extra high voltage) customers deregulated
• 2016: Retail supply for all customers deregulated
Reforms

• Wholesale electricity exchange 2008-
• Expansion of cross-regional grid operation (Organization for Cross-regional Coordination of Transmission Operators, OCCTO, 2015-)
  – Oversees grid enhancements; network expansion and upgrade
• 2016: Retail supply for all customers deregulated
• 2020: Legal unbundling of transmission and distribution; abolish retail rate regulation
After 2020

• Transmission and distribution lines will be unbundled by 2020
• The network operator will be prohibited from engaging in generation and retail businesses from 2020
• Consolidation of the network operators might occur
• May lead to a nation-wide network organization similar to an ISO
Order of restructuring: is Japan’s case unique?

• In EU and U.S.: Wholesale/generation deregulation; then transmission unbundled
• In Japan: Wholesale/generation deregulation; then retail deregulated without transmission unbundling
  – One reason why incumbents may outbid new entrants via cross-subsidization (bw retail and higher up)
Why electricity restructuring has been slow

- Typical industry in “iron triangle” (tied with politics and bureaucracy)
- 9 incumbent “General Power Utilities” account for 20% of corporate bonds issued annually in Japan
Net electricity consumption (2000=1)
Ownership of generating sources

Overcapacity and hence limited rooms for new entrants to invest in and own generators

Source: (EGMSC 2017b, 2017a)
Retail deregulation

• Complete deregulation in 2016
• “Switching” to new retail companies increasing, but their share is still small
Number of Switching Cases for Low Voltage Customers by Region

<table>
<thead>
<tr>
<th>Area</th>
<th>Number (ten thousand)</th>
<th>Share of total contracts for low-voltage customers (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hokkaido</td>
<td>9.1</td>
<td>3.3</td>
</tr>
<tr>
<td>Tohoku</td>
<td>5.4</td>
<td>1.0</td>
</tr>
<tr>
<td>Tokyo</td>
<td>106.2</td>
<td>4.6</td>
</tr>
<tr>
<td>Chubu</td>
<td>13.5</td>
<td>1.8</td>
</tr>
<tr>
<td>Hokuriku</td>
<td>0.6</td>
<td>0.5</td>
</tr>
<tr>
<td>Kansai</td>
<td>37.1</td>
<td>3.7</td>
</tr>
<tr>
<td>Chugoku</td>
<td>0.4</td>
<td>0.1</td>
</tr>
<tr>
<td>Shikoku</td>
<td>1.1</td>
<td>0.6</td>
</tr>
<tr>
<td>Kyushu</td>
<td>7.7</td>
<td>1.2</td>
</tr>
<tr>
<td>Okinawa</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Total</td>
<td>181.1</td>
<td>2.9</td>
</tr>
</tbody>
</table>

Note: number of total contracts for low voltage customers including households ~62.5 million.

Source: (ANRE 2017d)
Figure 14  Comparison of Average Electricity Prices of Incumbent and New Participant by Customer Class; unit: € cent

Source: (EGMSC 2017b)
Retail is still concentrated

• Perhaps too early to tell if retail deregulation is working

• A few reasons why “switching” from incumbents to new retail companies has been slow (Work by Takanori Ida etc.):
  – Discounts that new companies provide are not large enough to entice switching;
  – In some cases, switching to TOU makes most customers worse off (Ito, Ida, Tanaka (2017) “Information Frictions, Inertia, and Selection on Elasticity: A Field Experiment on Electricity Tariff Choice”)
Challenges in pursuing restructuring and renewables integration

• Energy market liberalization planned in the 1990’s and 2000’s in Europe—implications of RE transitions were not an issue

• Today Japan is pushing liberalization and RE integration at the same time
Average electricity prices in USD/MWh (using PPPs)

IEA (2017) ENERGY PRICES AND TAXES Third Quarter 2017
Incentives for renewable energy integration

• Renewable Portfolio Standard (introduced in 2003 but the target was low)
  – (Official national target: 20% by 2030)

• RPS abolished and replaced with a feed-in tariff (FIT) system in 2012

• Researchers and practitioners argue FIT has been instrumental for the RE industry growth in Japan
Average capacity factors

<table>
<thead>
<tr>
<th>Region</th>
<th>Hydro</th>
<th>Solar</th>
<th>Wind</th>
</tr>
</thead>
<tbody>
<tr>
<td>United States</td>
<td>11.9</td>
<td>15%</td>
<td>23.6</td>
</tr>
<tr>
<td>Canada</td>
<td>15%</td>
<td>8%</td>
<td>27%</td>
</tr>
<tr>
<td>Mexico and Chile</td>
<td>10%</td>
<td>10%</td>
<td>24%</td>
</tr>
<tr>
<td>Brazil</td>
<td>6%</td>
<td>11%</td>
<td>26%</td>
</tr>
<tr>
<td>Other Central and South America</td>
<td>11%</td>
<td>5%</td>
<td>26%</td>
</tr>
<tr>
<td>OECD Europe</td>
<td>3%</td>
<td>11%</td>
<td>22%</td>
</tr>
<tr>
<td>Other non-OECD Europe and Eurasia</td>
<td>3%</td>
<td>5%</td>
<td>7%</td>
</tr>
<tr>
<td>Russia</td>
<td>5%</td>
<td>3%</td>
<td>9%</td>
</tr>
<tr>
<td>China</td>
<td>8%</td>
<td>15%</td>
<td>21%</td>
</tr>
<tr>
<td>India</td>
<td>12%</td>
<td>21%</td>
<td>18%</td>
</tr>
<tr>
<td>Japan</td>
<td>12%</td>
<td>12%</td>
<td>20%</td>
</tr>
<tr>
<td>South Korea</td>
<td>12%</td>
<td>8%</td>
<td>26%</td>
</tr>
<tr>
<td>Other non-OECD Asia</td>
<td>12%</td>
<td>8%</td>
<td>26%</td>
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<tr>
<td>Middle East</td>
<td>15%</td>
<td>27%</td>
<td>27%</td>
</tr>
<tr>
<td>Africa</td>
<td>49%</td>
<td>20%</td>
<td>28%</td>
</tr>
<tr>
<td>Australia and New Zealand</td>
<td>32%</td>
<td>9%</td>
<td>30%</td>
</tr>
</tbody>
</table>
Wind resource in Japan
Wind resource in Hawaii
RE generation capacity

in 10,000kW

Solar growth (with small wind growth)

- 90% of all FIT approved units (though about 310,000 cases have not been active)
- FIT rates favorable for solar
- Implementation costs lower with solar (e.g., environmental impact assessments waiver)
- Though FIT costs passed through to retail, some industrial customers were exempt from FIT surcharges (to be revised)
FIT rates in Japan

PV(<10kWh): about 30 cents/kWh in 2017
RE generation capacity

Annual growth rate

Surcharge/kWh
FIT payment
Surcharge
HH incidence
Yen/month

FIT rates for solar PV (as of 2014 in USD)

Renewable Energy Tariffs Worldwide, www.wind-works.org
Solar PV installation in Japan

System cost
530,000yen/kW
530yen/W in 2014

Cumulative system size
In 10 MW
Total 4,914MW
Residential 4,078 MW
In 2014
• In 2014 Kyushu Electric Power decided to cut access to its grid for renewable energy suppliers because of concerns about network limitations (Reuters September 25, 2014).
Kyushu load profile, May 4, 2016 (with solar system size 6,010 MW)

- Solar, peak at 4680MW
- Nuclear
- Fossil fuel thermal
- Pumped hydro charge
Access rules and curtailment

• Rules of output restrictions
• Thermal units (Oil, NG) curtailed first; then
• Wide-area frequency adjustment;
• Biomass power source;
• Wind and solar PV;
• Then “long-term fixed power sources” (i.e., nuclear, geothermal, hydro)

Rick allocation with FIT generation

1. Planned output delivery must equal planned purchase in principle

2. Suppose a FIT generator has a 100 kW delivery contract

3. If actual output is 110kW (10kW excess), imbalance cost rate * 10kW paid to the generator

4. If actual output is 90kW (10kW short), the generator could procure 10kW at discount (wholesale/mc) from General Power Utilities

5. 3. and 4. are reviewed as the FIT regime changes
Auction is now favored instead of FIT -- Japan is likely to follow suit

Germany Confirms End To Renewable Energy Feed-in Tariffs

July 12th, 2016 by Joshua S Hill

Germany's parliament has approved a plan that will end renewable energy feed-in tariffs in favor of competitive auctions and clear volumes for wind energy development.

It was revealed in early June that Germany’s Chancellor Angela Merkel had hammered out a new agreement with state leaders to restrict onshore wind expansion to 2.8 GW per year, putting a clear cap on the volume of wind energy development. It is expected that the limit for onshore wind will increase after 2020 to 2.9 GW per year, while the offshore cap (applicable from 2021 to 2030) will vary from year to year to ensure that Germany reaches its 15 GW wind energy target by 2030.

The new reforms, which also include repowering older turbines, is expected to come into effect in January 2017.

https://cleantechnica.com/2016/07/12/germany-confirms-end-renewable-energy-feed-tariffs/
• End of FIT, and transition to auction, are expected by the industry
• “Post FIT” profit opportunities for new electricity service companies
Multiple other markets considered at METI

- “Baseload market” to be established in 2019
- Capacity market (to be established in 2020)
- “Non-fossil value market” (to be established in 2019)—all non-fossil sources, i.e., RE and nuclear, may be used for fulfilling the 2030 target (44% “low carbon energy”)
Capacity mechanisms

• Nord Pool and Germany are those that adopted energy-only wholesale market (without capacity markets). (Instead of capacity market, count on strategic reserve)
• PJM is an example with a capacity market
• Expected to address “missing money” problem (penetration of low-MC intermittent renewables leading to downward pressure on cost recovery of legacy units)
• “Without wide and deep wholesale market, the capacity market might not work as designed” (izes gGmbH 2017)

• A question of interest: How might the capacity market work with or without complete unbundling of vertically integrated utilities? With or without a well-functioning wholesale market?
“Baseload source market”

- Only middle/peak sources have been traded at JEPX, which have higher costs than the baseload sources
- Baseload source market is meant to make those low-cost baseload sources available to new retailers
- (Some argue this is a way to compensate legacy nuclear investments)
Future of nuclear power?

- Retail power companies are required to keep the ratio of electricity generated by renewable sources or nuclear power at 44% or more of their total supply in 2030.

Source: (METI 2015)
Germany’s case

• Due to the large overcapacities, the closedown of coal capacities for emission reduction is also beneficial for the economics of the generation system as a whole.
• Currently, the overcapacities suppress wholesale prices and contribution margins.
• Removal of capacities improves the economics for the remaining capacities as a whole.
• The nuclear phase-out is also beneficial from a purely energy market point of view as an improvement of the economic situation for the remaining generation system is only expected upon the completion of the phase-out (enervis 2015, cited in izes gGmbH 2017).
Enhancing competition in wholesale electricity markets

- Issues

![Market share of each nation's largest electricity company (average, 2011-13)](image)

- Chart showing market share of each nation's largest electricity company, with population-weighted regional average: 44%
- France: 13%
- United Kingdom: 13%
- Germany: 16%
- Italy: 12%
- Spain: 9%
- Poland: 8%
- Rest of Europe: 29%
Internal transfers, bilateral trading, and wholesale market trading

Source: (EGMSC 2017b, p. 36)
Why market power is likely an issue in wholesale electricity markets

• Market power by generators upon deregulation in California, US
• Conventional wisdom says that a firm’s market share must be large enough (>20%) for it to exercise market power
• In CA generation markets, a firm had at most 8% or so—why market power?
  – Demand is highly inelastic; so was every generator’s MC curve...
Figure 1
Supply and Demand in the Electricity Market

Borenstein, S. 2002 “The Trouble With Electricity Markets: Understanding California’s Restructuring Disaster” *Journal of Economic Perspectives* 16(1) 191-211
Evidence on market power in wholesale electricity markets

- On strategic bidding in ERCOT (Hortescu and Puller 2008 RAND)
- Duopoly pricing in the British market (Wolfram 1999 AER)
- California in the restructuring period (Jowkow and Kahn 2002 *Energy Journal*)
Wholesale trading

• Japan Electric Power Exchange (JPEX)
• Exchange: Unlike the “pool model”
  – transactions are decentralized
  – Participation is not mandatory
1. ②卸電力市場の活性化状況

1）電源の所有構造

・我が国の電源は、旧一般電気事業者と旧卸電気事業者（電源開発等）が出力ベースで85%を所有している。

METI (2017)「電力市場における競争状況の評価(2017/04/05)」
入札の方法
一日前市場（スポット市場）は、取引システムを通じて行います。
入札は、下記のフォームに1日（48時間帯）を1入札単位として入力します。

取引所が用意するWebシステムの場合

出典：日本卸電力取引所（JEPX）取引ガイド
JEPX spot: day ahead market

- Blind single price auction format
- Each submits a bid profile (e.g., X kW for $Y) for each 30-min time slot
- (So there are 48 markets per day)
1. ②卸電力市場の活性化状況

3) 卸電力取引所へのアクセス（取引所の活用状況）

- JEPXにおける取引量（約定量）が日本の電力需要に占めるシェアは、年9月時点では2.8%（2016年7月～9月では平均2.9%）となっており、JEPX取引量（約定量）のシェアは前年同時期対比で増加している。

JEPX取引量（約定量）のシェアの推移
(2012年4月～2016年9月)

JEPX取引量のシェア：2.8%（2016年9月時点）

（参考）
諸外国における国内電力消費量に占める電力スポット取引量の割合（2013年）

<table>
<thead>
<tr>
<th>国名</th>
<th>割合</th>
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<tbody>
<tr>
<td>イギリス</td>
<td>50.7%</td>
</tr>
<tr>
<td>ドイツ</td>
<td>50.1%</td>
</tr>
<tr>
<td>Nord Pool</td>
<td>86.2%</td>
</tr>
</tbody>
</table>

JEPX取引量（約定量）のシェアの前年同時期対比

<table>
<thead>
<tr>
<th></th>
<th>2015年</th>
<th>2016年</th>
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<tbody>
<tr>
<td>10月</td>
<td>1.2倍</td>
<td></td>
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<tr>
<td>11月</td>
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<td></td>
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<tr>
<td>12月</td>
<td>1.1倍</td>
<td></td>
</tr>
<tr>
<td>1月</td>
<td>1.6倍</td>
<td></td>
</tr>
<tr>
<td>2月</td>
<td>1.5倍</td>
<td></td>
</tr>
<tr>
<td>3月</td>
<td>1.5倍</td>
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<tr>
<td>4月</td>
<td>1.4倍</td>
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<tr>
<td>5月</td>
<td>1.1倍</td>
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<tr>
<td>6月</td>
<td>1.3倍</td>
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<tr>
<td>7月</td>
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<tr>
<td>8月</td>
<td>1.5倍</td>
<td></td>
</tr>
<tr>
<td>9月</td>
<td>1.4倍</td>
<td></td>
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</table>

経済産業省 電力市場における競争状況の評価(2017/04/05)
Thin wholesale market

• In 2014, with formerly vertically integrated incumbents:
  – 77.3% of supply came from incumbents’ own generating power plants
  – Bilateral trade with other players accounted for 21.3%
  – Trading at JEPX was only 1.0%

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Share</td>
<td>86.2%</td>
<td>50.1%</td>
<td>1.6%</td>
<td>50.7%</td>
</tr>
</tbody>
</table>

Note: The share for Japan was derived using data from JEPX and METI’s Electric Power Survey Statistics

Source: (EGMSC 2017c, p. 38)
Market design for enhancing competition

• Prevalence of bilateral trading and intra-firm trading (as opposed to market trading)
• What enhances market trading? A number of markets have introduced gross bidding for the purpose
  – Rationale
  – Predictions
  – Comparison with net bidding
同一会員の発電部門と小売部門が、それぞれ別会員のように売と買を入れる行動は、広域メルトオーダーの徹底と市場の厚み(ひいては価格形成の信頼性)に寄与。(適取GLの望ましい行為である「取引所の積極的活用」)に沿うものと思料

このような「グロス・ビデオ」を行う事業者を、取引所として、取引環境面からサポートすることを検討。

1. グロス・ビデオを行う会員に売買両アカウントを無償で提供。発電と小売が独立の計算で入札し易くする。
2. 手数料の定額制(導入済)を、売買両アカウントの合計量に適用。当該会員の手数料負担の増加を回避。

参考 英国大手事業者の発電と小売のポジション

出所: Offigern

価格指標の観点から
1. 前日市場は各種料金に参照される。指標価格形成の信頼性の観点からは、全国大の需給の「縮図」であるべき。そのための「厚み」が必要。ただし現在の取引量のシェアは新電力に偏り。第4回当会合資料。
2. 「一般電気事業者であった発電事業者(略)においては、余剰電源を卸電力取引所に対して積極的に投入」(適取GL)とされているが、「余剰の捉え方によっては、取引量拡大の制約となりかねない。
3. 実需において大きなシェアを持つ事業者には、ライセンス制も契機に、「余剰」の発想にとらわれることなく、より積極的な入札に取り組むことを期待。

経済産業省 第6回 制度設計専門会合 事務局提出資料より(2016.04.26)
Gross vs. net bidding

• Gains from gross bidding depend on the market structure
  – Are seller(s) and buyer(s) vertically integrated?
  – Horizontal market share of sellers/buyers?
  – A dominant seller and a dominant buyer with competitive fringe? Or strategic bidding by all participants (bilateral oligopoly)?
Models considered in the literature

- Monopolistic (or monopsonistic) firm(s) with competitive fringe on supply (demand) side with competitive buyers (sellers)
  - Hahn 1984 QJE; Salinger 1988 QJE

- Bilateral monopoly (market power on both sides)—bargaining, under some conditions, leads to joint profit maximization
Models considered (cont.)

• Bilateral monopoly with competitive fringe on both sides
  – Each seller/buyer with market power maximizes its profits taking competitive fringe’s response as given; Cournot equilibrium solution

• Bilateral oligopoly
  – Every firm has market power; bids supply/demand schedule
Preliminaries on bilateral monopoly

• A market with a single buyer and a single seller

• With complete information, bargaining leads to efficient trading: equivalent to joint profit maximization outcome

• (How the surplus is divided depends on the relative bargaining power)
• “the firms have strong incentives to reach mutually beneficial terms of trade to extract as much surplus as possible from their transaction” (Mills 2010)

Net bidding

• Vertically integrated dominant firm with competitive fringe of sellers and buyers
• Dominant firm’s internal trading
• If the buyer and the seller were integrated, there may be no concerns about private information or incomplete contracts (?)

• Then bilateral bargaining might lead to an efficient outcome

• But if the two are separate entities, then private info and incomplete contracts may become an issue. Impacts of gross bidding would be different depending on the market structure
Other relevant issues

• Entry and exit: does gross bidding lead to more entries?

• Private information on sellers’ costs and buyers’ benefits?
Energy Policy Reforms : Challenges and Opportunities

• How can electric utilities be best regulated given slowing (or negative) growth in sales/demand?
  – Population is shrinking
• “Post FIT” renewables integration and what supports it without large-scale subsidies
• Fundamental drivers for competition in wholesale markets