Realizing the Asia Super Grid - Japan’s situation and challenges

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The Japanese electricity system

- One of the largest power markets in the world: 1,000 TWh/annum; 280 GW installed capacity.
- Technically a open wholesale and partially liberated (>50kW) market.
- However, dominated by 10 vertically integrated EPCOs – 96.4% of the power transacted.
- Bilateral, Day-ahead and forward markets since 2005 but small liquidity: JEPX – <2% of wholesale market
- High wholesale prices, but “average” retail prices (few add-ons and taxes)
- 2015: creation of new institutions:
  - OCCTO – coordinating the TSOs
  - Energy Market Surveillance Commission
  - April 2016: full retail liberalization

Source: Hiroshi Okamoto, TEPCO, 2013

Exhibit 5: Electricity Prices for Households – 2012 (USD/MWh, including taxes)

After “March-11” policy: nuclear phased out – replaced short term by LNG; on long term by renewable energy

- LNG import has sharply increased since 3/11 Earthquake.
- The cost of power generation has increased $ 36 billion.
- Negative impact to Japanese economy.
- Trade balance fell into the red, $180 billion budget deficits (2015).
Renewables integration - challenges

Example from Germany:
- Problem with system balancing when renewable sources not available
- Need to have substantial “backup” in forms of conventional thermal energy (coal, gas)
- Negative prices: not allowed to cut off renewable when total generation exceeds total demand.
- “Missing money”: the back-up generators will not receive sufficient revenue from the market to cover their capital/fixed expenses.
- Wholesale market prices decreased due to “free” renewable energy
- Renewable incentive program has led to 40% increase in retail prices for residential consumers since 2005 - however this leads to energy efficiency and self-generation.

Solutions:
- Flexible generation
- Increased interconnection
- Demand Side Response (DSR)
- Electricity storage
Importance of strong inter-regional/national grids

Dorte Foquet on the importance of a strong European grid framework:

- Grid operation – reliability and redundancy.
- Sharing generation resources – reducing costs by avoiding regional peaking generators
- Enhancing consumers choices – downward pressure on energy tariffs
- Enablement of large scale renewable penetration – export of RES from supply to demand

- Europe’s 2020 target: 10% of all generation across interconnectors (15% by 2030?)
Grid issues in Japan

✓ «linear» grid structure
✓ Weak connections – bottlenecks
✓ Limited sharing of resources (energy, reserves, ancilliary services) between regional system operators (utilities)
✓ No interconnections to e.g. Korea or Russia
Utilization of existing interconnectors..

Source: OCCTO report, 2015
Allocation of transmission rights

Entities that wishes to trade energy across regions must have rights to transport the energy across interconnectors. In energy markets across the world, this is typically arranged by two schemes:

Explicit allocation:
- The grid owner, system operator or other entity allocates transmission capacity to individual market participants through auctions and/or longer-term agreements.
  - Many different schemes for firm vs financial rights, take-or-pay, re-allocation etc.

Implicit allocation:
- Transmission capacity is “given” to the Market Operator, and by methods of “market splitting”, the transmission capacity is socialized and shared among all market participants.
Explicit (contracted) allocation of transmission rights

Generation 10MW
Marginal cost 15 JPY/kwh

Profit for generator:
5 JPY/kwh

Need 10MW transfer right
Hokkaido-Tohoku

Need 10MW transfer right
Tohoku-Tokyo

Complexity of application
Availability of transmission?
Cost of transmission rights?
Fairness and priority of rights?

Customer (demand) 10MW
Contract price 20 JPY/kwh

Cost for consumer:
20 JPY/kwh
Implicit (socialized) allocation of transmission rights

Power market is handling transmission for ALL market participants

Generation 10MW
Marginal cost 15 JPY/kwh
Selling to the market for 25 JPY/kwh

Bilateral “contract for difference”
5 JPY/kwh

Market clearing price = 25 JPY/kwh

Customer (demand) 10MW
Buying from the market at 25 JPY/kwh

Profit for generator:
5 JPY/kwh

Cost for consumer:
20 JPY/kwh
Renewable energy and energy storage in Japan

Intermittence and seasonality is one of the major problems with renewable energy.

- High capacity interregional grid can “smear out” local variations in e.g. solar and wind generation across larger regions.
- Local energy storage can balance out some short and long term variations.
- The current RES target in Japan is about 10-12% = 100 – 120 GW (excluding hydro)
  - Some utilities are already putting limitation on RES deployment due to balancing and grid operation issues.
Japan will continue its role as one of the world leaders in energy storage deployment, but with more focus on the end-user side rather than the distribution side as before.

- In terms of applications, generation, transmission and distribution-level applications will make up the majority of capacity before 2018.
- From 2018 onwards the end-user segments will start to grow in size at a significant rate as payback periods for end-user systems start to become more economically attractive.
- In terms of power-intensive systems vs. energy-intensive systems, the former takes 20% of the total in 2020, and the latter 80%.

Note: E is short for Energy and P is short for Power.

Source: Bloomberg New Energy Finance
What about the 25,500 MW installed pumped storage in Japan?
The role of the Power Exchange (JEPX) – growth potentials

• Market Liquidity
  • Today limited liquidity (< 2%):
    • Most energy is transacted within the utilities
    • Interregional trading is mainly by bilateral contract
    • IPPs have bilateral contracts with utilities

• Means to increase liquidity:
  ✓ Transact interregional transmission capacity in the PX (implicit auction):
    • Total 52GW capacity @ 20% utilization = 100 TWh/annum

  ✓ Transacting the pumped storage capacity in JEPX:
    • 25 GW capacity @ 10% trading = 25TWh/annum

  ✓ System losses are bought by the system operators from the PX:
    • 5% of total 1,000 TWh = 50 TWh/annum
## Comparison Japan – EU energy markets

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<th>Europa</th>
<th>Japan</th>
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<td><strong>Unbundling of utilities</strong></td>
<td>Full unbundling. Separate System Operators from genco/disco.</td>
<td>Legal unbundling 2018-2020</td>
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<td><strong>Market model</strong></td>
<td>“Nordpool model”</td>
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<td><strong>Interregional transmission access</strong></td>
<td>Implicit auction &amp; traded transmission rights</td>
<td>Not concluded: currently controlled by power utilities.</td>
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<td><strong>Integration of renewable energy sources</strong></td>
<td>Substantial amount (up to 20-40%), issues with balancing and storage.</td>
<td>Small, but increasing amount (1-2%), reported issues with grid stability</td>
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<td><strong>Energy storage</strong></td>
<td>Limited, exchange between countries. Norway &amp; Switzerland hydro storage.</td>
<td>Pumped storage very substantial (25,000 MW), can be utilized for RE balancing?</td>
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<td><strong>Power exchanges</strong></td>
<td>Multiple – 5 large. Good coordination. High liquidity (+50% of market). Good reference prices. Essential part of the power market.</td>
<td>JEPX. Low liquidity for the moment. Will play important role in future market.</td>
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Backup slides
JAPAN’S ELECTRICITY MARKET STRUCTURE

GENERATION
- Other suppliers include:
  - Independent power producers
  - ‘Specified electric utilities’ (eg, JR East)
  - Designated power producers and purchasers (eg, Summit Energy)

SYSTEM OPERATION
- DUE TO CHANGE FROM APRIL 2016
- 10 vertically integrated utilities are in charge of system operation in their designated region
- System operation is governed under the rules of Electric Power System Council of Japan

TRANSMISSION
- The 10 vertically integrated regional utilities own and operate the majority of the transmission and distribution (T&D) grid in designated service area

DISTRIBUTION
- Wholesale utilities (J-Power and Japan Atomic) own transmission link to their assets
- Specified electric utilities own T&D assets within their designated areas

SALES/RETAIL
- DUE TO CHANGE FROM APRIL 2016
- Retail for consumers below 50kW (residential and SMEs) is regulated and limited to the local vertically integrated monopoly. Aggregation of contracts to exceed the 50kW limit is allowed

CONSUMPTION
- Designated power producers and purchasers may engage in retail above 50kW.
- Specified electricity utilities may engage in retail in their designated areas

Regulator: Agency for Natural Resources and Energy (under Ministry of Economy, Trade and Industry). Electricity Power System Council of Japan

MAJORITY STATE-OWNED  MAJORITY PRIVATE  MIXED OWNERSHIP  POWER SELLER  POWER BUYER

Last updated: Oct 2014 Excludes small-scale and captive plants
Electricity market reforms – from monopolies to markets
**Electricity market reform road map**

**Objectives:**
- Promote investment in new generation (conventional and renewable)
- Fair grid access ⇒ promote competition
- Smarter use of energy ⇒ smart-grid, retail competition, markets

**Means:**
1. Establish a market regulator and an nationwide system operator (2015)
2. Full liberalization of retail market (2016-17):
   - ✓ replace fixed tariffs with market prices
   - ✓ facilitate wholesale electricity markets
3. Unbundling of the power companies (2018-20)
   - ✓ Separation of generation, transmission and distribution

Introducing the “Nordic electricity market model”
Congestion management by “market splitting”

• Implicit auction mechanism:
  • Step 0: The whole system is one market, but with predefined bid areas
  • Step 1: Calculate system price neglecting congestion - “Unconstrained MCP”
  • Step 2: Check transmission limits
  • Step 3: In case of congestion; split market into price areas and recalculate prices in each new area with the congested intertie capacity.
  • Increase price in deficit area -> more generation/less demand
  • Decrease price in surplus area -> less generation/more demand
  • Iterate until all congestion solved.
• This leads to area price differentials (zonal prices) and an income to the Market Operator
  • Income = Transmission flow * Δ price
Transmission management in deregulated markets

Right to interregional energy transmission is crucial for energy trading

Allocation of transmission is done differently in different markets:
✓ Explicit rights given directly to one or more market participants
✓ Auction of transmission rights
✓ The market operator holds all or parts of the transmission rights

Optimal utilization of transmission is important for efficient market and to lower system operation costs

Choice of transmission utilization regulation is important for deployment of renewable energy, liquidity of energy markets and cost of the market.
Not so lucrative position - hedge

Market clearing price Hokkaido
21 JPY/kwh

Market clearing price Tokyo
16 JPY/kwh

Generation 10MW
Marginal cost 10 JPY/kwh
Selling to the market for 21 JPY/kwh

Profit: 15 JPY
21 JPY from JEPX +
4 JPY in CdF –
10 JPY generation cost

Bilateral “contract for difference”
4 JPY/kwh

Customer (demand) 10MW
Buying from the market at 16 JPY/kwh

“Loss”: 4 JPY
Cost of CdF.