The difference of the wholesale electricity market and operational methods in Japan, the United States and Europe

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Japanese Electricity Market Reform Step

<table>
<thead>
<tr>
<th>First Stage</th>
<th>Second Stage</th>
<th>Third Stage</th>
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<tbody>
<tr>
<td>2015</td>
<td>2016</td>
<td>2020</td>
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</table>

- **National Independent Transmission Organization (OCCTO)**
- **Full retail market opening**
- **Regulation tariffs**
- **Non-Regulated tariffs (excluding last resort service)**
- **Non-Regulated tariffs**
- **Legal unbundling of Transmission Sector and Distribution Sector**
- **National reliability assessment, Nation-wide transmission planning process, Nation-wide coordination in emergency situation**
- **Capacity Obligations and Capacity Market**
- **Under discussion**
- **TEPCO Legal unbundling**
- **Capacity Mechanism**
- **Electricity and Gas Market Surveillance Commission**
- **New Regulator**
- **French Model -> German Model**
Different Market Model

European Model

Transmission system operator

Market operator

Balancing Group

Customer

Balancing Group

Ancillary Trade

D/S Schedule Trade

US RTO Model

Transmission system operator and Market operator

Generation Unit

Ancillary Trade

Grid constrained Economic dispatch

LSE

Unit Commitment

Customer

※Japan Future -> European Model?
## Frequency control reserve

<table>
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<tr>
<th>Region</th>
<th>Primary Frequency Control Reserves</th>
<th>Secondary Frequency Control Reserves</th>
<th>Tertiary Frequency Control Reserves</th>
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<tbody>
<tr>
<td>PJM</td>
<td>Frequency Response (30s(no recommendation)) (±0.36Hz)(Obligation)</td>
<td>Operating Reserve(Biggest unit)</td>
<td>Reserve beyond 30 minutes</td>
</tr>
<tr>
<td></td>
<td>Regulation(5m)(0.7% of Peak demand)(Marginal Pricing)</td>
<td>Spinning Reserve(10m)</td>
<td>Quick Start Reserve(10m)</td>
</tr>
<tr>
<td>CAISO</td>
<td>Frequency Response 30s(no recommendation)) (±0.36Hz) (Obligation)</td>
<td>Operating Reserve</td>
<td>Contingency Reserve</td>
</tr>
<tr>
<td></td>
<td>Regulation(10m)</td>
<td>Spinning Reserve(10m)</td>
<td>Non-Spinning Reserve(10m)</td>
</tr>
<tr>
<td>Germany</td>
<td>Primary Reserve (5s) (±0.2Hz) (663MW)</td>
<td>Secondary Reserve(5m) (over 2,000MW)</td>
<td>Minutes Reserve(15m) (3% of Peak demand)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Hours Reserve and Emergency Reserve</td>
</tr>
<tr>
<td>France</td>
<td>Primary Reserve(30s) (±0.5Hz) (700MW) (Obligation)</td>
<td>Secondary Reserve (5m) (500-1,000MW)</td>
<td>Operating Reserve(5m)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Fast Reserve(2m)</td>
</tr>
<tr>
<td>Great Britain</td>
<td>Operating Reserve</td>
<td>N.A.</td>
<td>Fast Start(5m)</td>
</tr>
<tr>
<td></td>
<td>Response Primary/Secondary High Frequency (10s, 30s) (±0.2Hz, ±0.5Hz) (Obligation)</td>
<td></td>
<td>Short-term operating reserve(5m-120m)</td>
</tr>
<tr>
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<td>BM Start-Up (Warming and Hot Standby)</td>
</tr>
<tr>
<td>Spain</td>
<td>Primary Reserve(±0.8Hz)(30s-15m) (1.5% of Peak demand)</td>
<td>Secondary Reserve(100s-15m) (Av. 500MW)</td>
<td>Tertiary Reserve(15m-2h)</td>
</tr>
<tr>
<td>Sweden</td>
<td>FCR-N(±0.1Hz, 3m) and FCR-D(-0.3Hz, -0.5Hz, 30s) (559MW)</td>
<td>N.A.</td>
<td>Manual Frequency Restoration Reserves(FRR-M)(15m)and Automatic Frequency Restoration Reserves(FRR-A)(2m) (Biggest unit(weekly))(1,220MW)</td>
</tr>
<tr>
<td>Japan</td>
<td>Spinning Reserve(10s) (no band, but target: ±0.2Hz)(3% of Peak demand)</td>
<td>Operating Reserve (10m)(5% of Peak demand)</td>
<td>Cold Reserve (no recommendation)</td>
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<td>EDC(Economic Load Dispatch Control)</td>
</tr>
</tbody>
</table>

**Note:** FCR-N: Frequency Containment Reserves for normal operating band, FCR-D: Frequency Containment Reserves for disturbances Sources)NERC, “NERC IVGTF Task 2.4 Report- Operating Practices, Procedures, and Tools”, 2011/3 and others
Complexity of the regulation of electric power industry

- IEA examines how the design of electricity markets enables the transition to a low-carbon electricity system, at least cost, while maintaining electricity security.
- The transition to a low-carbon power system requires the incorporation of carbon and support policies into a consistent electricity market framework.

<table>
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<tr>
<th>Objective</th>
<th>Policy</th>
<th>Type of regulation</th>
<th>競争的市場</th>
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</table>
| Low-carbon investment | Carbon Pricing | ○ Carbon regulation | • Carbon price (trading scheme)  
• Long-term contracts |
| Additional policy: Support schemes | ○ Low-carbon long-term support | • Auctions set support level  
• Integration in markets |
| Operational efficiency / Reliability and adequacy | Short-term energy markets | ○ Market rule  
○ Scarcity Pricing  
○ Reliability standards | • Energy prices with a high geographical resolution  
• Energy prices with a high temporal resolution  
• Dynamic pricing offers |
| Additional policy: Capacity market | ○ Capacity requirements  
○ Demand response product definition | • Capacity prices  
• Demand response participation |
| Network efficiency | Regulation | ○ Regional planning  
○ Network cost allocation | • Congestion revenues  
• Transmission auctions |
| Consumption | Retail pricing | ○ Network tariff structure  
○ Taxation and levies | • Retail competitive prices  
• Distributed resources |

Source: IEA, “Re-powering Markets: Market design and regulation during the transition to low-carbon power systems”, 2016
With promotion policy of renewable energy power generations, concerns about the sustainability of the electricity business by vicious circle due to the decrease in grid power demand has occurred. Is called the Death Spiral, discussion in the United States and Australia has occurred.

Unfavorable or favorable?

Incentive to produce distributed solar due to higher retail price

Retail electricity price increased to cover transmission costs

Reduced demand for grid power due to distributed consumption

Transmission costs fall on reduced customer base

Difficult to fixed cost recovery of thermal power generation

Increasing the preference for regulatory assets for income keeping

Phase 1: Government subsidies to encourage production and drive cost reduction

Phase 2: Grid parity as LOCE of solar and retail electricity prices inflect and diverge

Phase 3: Commercial storage solution allow consumers to rely on localised grid systems or go completely off-grid

Source: Carbon Tracker, ”Caught in the EU Utility Death Spiral”, 2015/6
Future of Electric Power System

- Increasing small scale distributed resources interconnected distribution network
- How to utilize
- Need to change roles of distribution system operators

Differences of the wholesale electricity market and operational methods

How to cooperate

- Transmission system control
- Balancing
- Energy storage
- Wholesale market

Transmission system operator

- Gen
- RE
- L

Distribution system operator

- RE
- L

Distribution system operator

- RE
- L

Distribution system operator