Japanese Energy Market
- Optimum Use of Distributed Energy Resources for Demand-side Response -

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Power generation and supply

- 80% Thermal power, 8% Hydro, 8% RE and 3% Nuc.

(TWh)
1,200

- Renewables (excl. hydro)
- Oil
- LNG
- Hydro
- Coal
- Nuclear

Source: Energy White Paper 2019 in Japan

Based on "Outline of electric power development (METI)" and "Outline of power supply plan (METI)"

Based on "Comprehensive energy statistics (METI)"

2
Power Grid

- 10 TSOs/DSOs manage grid stabilization.
- Two frequency areas exist

*The figures below indicate the maximum electricity demand in 2016.

**Frequency:** 60Hz

**Frequency:** 50Hz

- Hokkaido: 5GW
- Tohoku: 14GW
- Kansai: 25GW
- Hokuriku: 5GW
- Chubu: 24GW
- Chugoku: 10GW
- Kyushu: 15GW
- Shikoku: 5GW
- Okinawa: 2GW

**Installed Capacity:**
- 5.6GW
- 12.6GW

**Total Capability:**
- 5.7GW → 10.28GW by 2027

**Converter:**
- 1.2GW → 2.1GW by 2020
- 2.1GW → 3.0GW by 2027

**Frequency Converter:**
- 0.6GW
- 0.6GW → 0.9GW by 2019

10 TSOs/DSOs manage grid stabilization.
Mission/ Background

日本のエネルギー移行の責任

エネルギーの不確定性

- Energy security
- Environment (Sustainability)
- Economic affordability (Cost)

Measures:

- Energy Efficiency
- Renewable energy
- Nuclear energy
- CCS + Fossil fuels
- Hydrogen
More Renewable requires 3 key actions

1. Lower Cost, 2. Strengthen Grid, 3. Flexibility system

![Chart showing renewable generation ratio from 2011 to 2017 (FY)].
Energy system reform

**Past**

Non-interactive supply system based on bulk electricity resources (BER) and large-scale transmission

**Electricity**
One-way supply by thermal power generation, varied with demand

**Heat**
Not consumed enough

**Players**
Vertically integrated companies

**Current and Future**

Interactive supply system based on both BERs and DERs

**Electricity**
Interactive supply by DERs, using IoT technology

**Heat**
Flex. and sharing energy consumption

**Players**
Liberalization encouraging various companies to enter the market

![Diagram of energy system reform]
Steady growth of DER’s market in Japan

- Existence of post FIT solar PV in 2019 happened. **2GW solar PV** in household graduated from FIT in **2019**. Residential PV in Post-FIT will reach **7GW in 2023**.

- **Lithium-Ion battery storage in behind the meter** marked market record of annual additions, **800MWh in 2019**. Cumulative battery storage-BTM reached **3GWh at the end of 2020**.

### Household Solar PV (Post FIT)

### LiB market (Behind the Meter BS)
Combination of EV and V2X enhances their values.

1. **Emergency power sources**
2. **Smart charging**
3. **Solar prosumer**
4. **Reducing demand**
5. **Grid stabilization**

Key element is EV Aggregation business.

1. Emergency power sources for blackout

2. Smart charging with price signal (Dynamic Prc.)

3. Solar PV Prosumers

4. Reducing peak demand

5. Flexibility resources for grid stabilization

80 EVs/PHEVs in Kansai

8 EVs/PHEVs in V2G site

6 EVs/PHEVs in V2H site

Repurposing Batteries.
Recent transaction prices in Kyushu area

- Renewables are installing rapidly in Kyushu, traded by lowest prices. Need to use lower electricity.
1.8 GW Demand-side Response (DR) was awarded in TSO’s auction of reserve power.

- Major resources: Large-scale loads of factories in industry sector. Requirement: 3 hours duration, 3 hour response, 12 times/year.

- DR (Load curtailment) provided huge contributions in severe peak period in January 2021. Energy Market welcomes more active participants of DR. Challenges are how to encourage large-scale loads in industry sector to DR businesses.

- 4GW DR won auction in Capacity Market, which will deliver in 2024.

Source: Energy Pool Japan
Aggregation Communication Structure
- protocol and cyber security -

① Transmission System Operator (Demand Response Application Server)

② Retailer

OpenADR

Proprietary standard

GW

Output control (one way)

Output control (two way)

GW

Output control

GW

GW

BEMS

ECHONET Lite

controller

controller

controller

controller

controller
Third Party Aggregators enhancing DERs values

- **Current business model** in Japan
  - Major resources: **Large-scale loads** in industry sectors
  - Major business area: **Demand response in severe peak time**

- **New business models** in Japan
  - New resources: **Small-scale DERs** (EVs, Battery Storages, Fuel Cells in Households), **Solar PV, Wind, Grid-scale Battery Storages**. DERs need to be **cost down** and **market entrance**.
  - New business area: **Balancing Market, Capacity Market, JEPX (FIP Scheme for REs)**, and **Local Residents in Micro-Grid**
VPP national demonstration project (2016-20)

- About **100 participants** joined.
- **Major Resources:** **BTM Battery, CHP, EV, HP.** Total Capacity: **60MW**
- **Outcomes:** **Demand response for Replacement Reserves for FIT,** **Demand shift by dynamic pricing,** **EV aggregation (V2H or V2G)**

Aggregation Coordinators

Resource Aggregators
VPP flattening demand load

- VPP can reduce use during peak generation (kWh) (which is costly) and reduce the need for investment in peak operating capacity (kW) by reshaping the demand load flat.

### Flattening duration curves

**Reduction of peak generating time (kWh value)**

**Reduce investment in peak capacity (kW value)**

Source: METI
VPP helping PV to generate power in low-demand period

- Solar PV output produced 73% of demand in Kyushu.
- VPP can help solar PV to generate electricity by shifting demand to necessary times, similarly pumped hydro storage.
VPP provides new reserve power sources

- Aggregators provide reserve power by controlling multiple distributed energy resources.
- VPP shifts electric power to necessary time for grid stabilization.

Source: KEPCO
### Market Reform Schedule

- Energy market reform has been progressed. **Replacement Reserves for FIT** in Balancing market has opened **in April 2021.**

- **FIP scheme**, **new business license of Aggregators or Distributed Network Operators** and **new imbalance price** based on JEPX price will be in force **in April 2022.**

- **FIP scheme** requires aggregators to support VREs to enter JEPX.

<table>
<thead>
<tr>
<th></th>
<th>2020FY</th>
<th>2021FY</th>
<th>2022FY</th>
<th>2023FY</th>
<th>2024FY</th>
<th>2025FY~</th>
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<tbody>
<tr>
<td><strong>Capacity Market (C.M.)</strong></td>
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<tr>
<td>Main auction in C.M. for 2024</td>
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<td>R.R.-FIT in B.M.</td>
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<td>F.R. in B.M.</td>
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<tr>
<td>F.R. in B.M.</td>
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<tr>
<td>F.F.R. and F.C.R. in B.M.</td>
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| **Balancing Market (B.M.)** |        |        |        |        |        |         |
| TSO’s auctions for reserve power |        |        |        |        |        |         |
| Additional auction in C.M. for 2024 |        |        |        |        |        |         |
| Delivering in C.M. |        |        |        |        |        |         |
| In force |        |        |        |        |        |         |

| **FIP scheme** | In force |
| **License of Aggregators, DNOs** | In force |
### (Ref.) Product specification in balancing market

- Market specification decides who can enter the balancing markets.

#### Major requirements in balancing market, as of now

<table>
<thead>
<tr>
<th></th>
<th>Frequency Containment Reserves (FCR)</th>
<th>Synchronized Frequency Containment Reserves (S-FCR)</th>
<th>Frequency Restoration Reserves (FRR)</th>
<th>Replacement Reserves (RR)</th>
<th>Replacement Reserves for FIT (RR-FIT)</th>
<th>Ref. Auction: Severe peak reserve</th>
<th>Ref. Capacity Mechanism</th>
</tr>
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<tbody>
<tr>
<td><strong>Open of Markets</strong></td>
<td>2024</td>
<td>2024</td>
<td>2024</td>
<td>2022</td>
<td>2021</td>
<td>2017-2023</td>
<td>2024</td>
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<tr>
<td><strong>Response time</strong></td>
<td><strong>Within 10 Sec.</strong></td>
<td>Within 5 Min.</td>
<td>Within 5 Min.</td>
<td><strong>15 Min.</strong></td>
<td><strong>45 Min.</strong></td>
<td>3 hours</td>
<td>3 hours</td>
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<tr>
<td><strong>Duration time</strong></td>
<td><strong>5 Min. or more</strong></td>
<td>30 Min. or more</td>
<td>30 Min. or more</td>
<td><strong>3 hours</strong></td>
<td><strong>3 hours</strong></td>
<td>3 hours</td>
<td>3 hours</td>
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<tr>
<td><strong>Minimum Capacity</strong></td>
<td><strong>5MW (1 MW Off-line)</strong></td>
<td><strong>5MW</strong></td>
<td><strong>5MW</strong></td>
<td><strong>1MW</strong></td>
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The table above summarizes the major requirements in the balancing market. It includes columns for opening of markets, response time, duration time, and minimum capacity. Each requirement is specified with specific values, indicating the year, duration, and capacity details. The table highlights that the market specification is crucial for准入 the balancing markets.
(Rf.) Transaction schedule

**Capacity Market**
- **Auction**
- **Additional auction**

**Wholesale Market**
- **Day-ahead market**
- **Intraday market**

**Balancing Market**
- **Flexibility**
  - **RR-FIT**
    - Response: within 45min
    - Duration: 3hrs
  - **RR**
    - Response: within 15min
    - Duration: 3hrs
  - **FRR**
    - Response: within 5min
    - Duration: 30min
  - **S-FRR**
    - Response: within 5min
    - Duration: 30min
  - **FCR**
    - Response: within 10sec
    - Duration: 5min

- **kWh bid**
- **ΔkW bid**

Price Changeable till GC

- Bid is closed at 2pm previous day, and price must be agreed by 3pm.
- Bid is closed at 2pm on Wednesday previous week, and price must be agreed by 3pm.

- **Ancillary services Price**
- **Imbalance Price**
Natural disasters require more resilient energy system

Typhoon No.15 hit Tokyo area in Sep. 2019

Collapsed transmission tower

Destroyed utility poles and fallen trees

Damaged floating solar power plant
DERs making energy system more resilient

- DERs (CHP, FCV/PHEV, Battery Storage), provided **electricity to the locals in Chiba Prefecture**, when power outage happened.

Power outage in Mutsuzawa Wellness Smart Town (Distributed Energy System)

FCV/PHV supplies electricity to homes
Local micro-grid system

- Local micro-grid system can contribute to **reducing cost to run private power distribution lines** and improving power sector resilience to natural disasters.
- **2 local micro-grid projects** has been developed in **Odawara** and **Miyako in Okinawa**. **25 feasibility studies** was conducted as of now.

**Local micro-grid system**

- **Disconnected from power grid when power outage occurs**, and the micro-grid system continue to supply power.

**Local micro-grid projects**

1. **Local micro-grid project in Miyako**
   - Membership: NEXTEM, Okinawa EPCO, Miyako-city
   - Location: Miyako island, Okinawa
   - Resources: Residential PV, Industry-scale BS

2. **Local micro-grid project in Odawara**
   - Membership: Kyocera, TEPCO, Odawara-city
   - Location: Odawara-city, Kanagawa
   - Resources: Solar PV, EVs, Large-scale loads
Conclusions

- DER market development;
  - Residential PV in Post-FIT accounts for 2GW in 2019, and will reach 7GW in 2023.
  - Lithium-Ion battery storage in BTM reached 3GWh at the end of 2020.
- Demand-side Response (DR);
  - Reducing loads by DR for severe peak time accounts for 1.8 GW in 2021.
  - 4GW DR won the auction in Capacity Market, which will deliver in 2024.
  - Reshaping load curves based on JEPX prices make use of electricity from renewables. Smart charging system of EV has possibilities to improve energy system.
  - DR has started to enter RR-FIT in April 2021.
- Micgro-grid systems can use renewables as much as possible, reduce cost to construct and run private power distribution lines, and improve power sector resilience to natural disasters.