Rebuilding Japan’s Electricity System

Electricity Policy to Realize Society 5.0

Keidanren
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Defining the Issues:
The Crises Facing Japan’s Electricity System (1)

The electricity system in Japan faces four crises brought about by factors including changes in circumstances following the Great East Japan Earthquake.

**Issue 1:** Reliance on fossil fuels remains high, attracting criticism from the international community.

**Issue 2:** Renewable energy, which is expected to be effective in addressing global warming, cannot be expanded due to transmission constraints and other limiting factors.

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**Issue 1**
Ending heavy reliance on fossil fuels

- **2010:** 65%
- **2016:** 84%

Contrary to global expectations, the proportion of fossil fuels in the energy mix has risen.

(Source: Energy White Paper 2018)

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**Issue 2**
Expanding introduction of renewable energy

- Uneven distribution of areas suited to renewable energy
- Methods of transmission required

Development of electricity networks is inadequate.
Defining the Issues:
The Crisis Facing Japan’s Electricity System (2)

**Issue 3:** Although nuclear power safety measures have been reinforced, resumption of operations has been slow.

**Issue 4:** Electricity charges have not fallen to a level comparable with other countries.

- There is a risk of being unable to ensure stable supply of electricity in economically efficient and environmentally responsible ways.

### Number of nuclear power plants in operation

- **2010:** 54
- **2018:** 9
- **2030 (target):** Around 30

### Resumption of operations

Resumption of operations still delayed even 8 years after the earthquake.

### Reducing electricity charges

**Industrial electricity charge in Japan:** 15.8 yen/kWh

**Electricity charges in Japan are relatively high**

Note: Base price/tax breakdown not available for US (Source: Energy White Paper 2018)
Direction of the Electricity System

- The broad principle for energy policy is balancing energy security, economic efficiency, and environment on the premise of ensured safety (S+3E).
- In addition, electricity systems around the world are moving towards decarbonization, decentralization, and digitalization (3D), a direction shared by Society 5.0.
- There is a need to encourage investment in electricity and forge ahead with development, enhancement, and deployment of technology.

Basis of energy policy: S+3E

- Safety: Ensure levels of safety demanded by society (prerequisite)
- Energy security: Stable supply of high-quality electricity
- Economic efficiency: Levels of electricity charges comparable with other countries
- Environment: End heavy reliance on fossil fuels

Direction of electricity systems around the world: 3D

- Decarbonization
- Decentralization
- Digitalization

Achieve S+3E

Refine S+3E, move towards 3D
Current Situation in Japan: Sluggish Electricity Investment

- Japan currently faces sluggish investment in electricity. There are concerns that failure to address this will hamper S+3E and impede resolution of a wide range of important issues.
- Breaking this impasse will require the creation of a virtuous cycle of electricity investment.

### 1. Overview

**Uncertain future for electricity industry**
- Liberalization of power generation and retailing
- Delayed re-start of nuclear power generation
- Large-scale introduction of solar power under the feed-in tariffs scheme
- Concern over falling electricity demand

**Sluggish electricity investment**

3D initiatives will be difficult under current circumstances. In addition, S+3E will be hampered.

**Impact on a wide range of key policy issues and, by extension, daily lives and business activities.**

- No expansion in nuclear power and renewable energy
  - Impedes climate change countermeasures

- Inferior quality of electricity supply and rise in electricity charges
  - Harms industrial competitiveness

- Increase in aging infrastructure and excessive delay in decentralization
  - Hinders reinforcement of resilience

- Failure to stimulate the energy value chain and excessive delay in decentralization
  - Hampers regional revitalization

etc.
To secure electricity investment, it is necessary to present a vision and enhance predictability. In drawing up its 6th Strategic Energy Plan, the government needs to present electricity system scenarios beyond 2030. At the same time, it should examine the social impact of achieving these scenarios.

1. Overview

Data-based discussion

Multiple scenarios

Possible vision

- Specific scenarios encompassing electricity sources, networks, demand, public burden, etc.
- Strive for best mix combining a range of options
The importance of improving 3E through energy-saving efforts is obvious. To stimulate electricity investment, it is also important to expand the amount of economic activity and make the electricity business more attractive. By utilizing the strength of electricity and responding to diverse demand-side needs, electricity is expected to be used in forms optimal for society.
Ensuring Stable Supply

- Electricity system reforms are creating a structure that ensures stable supply of electricity by dividing roles into generation, transmission & distribution, and retail, including new entrants.

- In order to ensure stable supply, the government should examine additional measures beyond establishment of wholesale markets.

3. Generation Sector

Ensure stable supply through division of roles

- Provide supply capacity and adjustment capabilities
  - Will generators maintain electricity sources with declining utilization rates?
    - Additional mechanisms should be examined to ensure adjustment capabilities and supply capacity

- Coordinate balance between supply and demand
  - Will diverse players fulfil appropriate roles?
    - A grid code* should be developed, together with compliance mechanisms

- Procure supply capacity corresponding to subscriber volume
  - *A grid code specifies technical requirements for connection to a transmission and distribution network to ensure stable supply (remote control capability, output adjustment capability, etc.)
Diverse Value of Power Generation

- Generation facilities provide value in terms of more than just electricity volumes (kWh).
- Mechanisms for assessing such value are required in order to encourage smooth investment in electricity generation.

3. Generation Sector

Cost and nature of generation facilities

<table>
<thead>
<tr>
<th>Fuel costs, etc. ≈</th>
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<tbody>
<tr>
<td>Plant costs, etc. ≈</td>
</tr>
</tbody>
</table>

Variable costs

- Renewables (non-hydro)
- Hydro
- Nuclear
- Coal
- LNG
- Oil

Fixed costs

- Cost and nature of generation facilities

Image of costs per kWh

<table>
<thead>
<tr>
<th>Electricity volumes (kWh)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Capacity (kW)</td>
</tr>
<tr>
<td>Adjustment capability (ΔkW)</td>
</tr>
<tr>
<td>Non-fossil-fuel value</td>
</tr>
</tbody>
</table>

Appropriate investment will not be made on this basis alone

We need to build systems capable of assessing diverse forms of value

Capable of speedy output adjustment

No CO₂ emissions at time of generation

Appropriate investment will not be made on this basis alone

We need to build systems capable of assessing diverse forms of value
The government envisions subdividing the value of power generation and transacting each form of value on a separate new market.

Various concerns exist over the design and operation of such new markets, and careful consideration is required.

It will also be important to verify that each market and the system as a whole function soundly.

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**Electricity volumes (kWh)**
- Electricity generated

**Capacity (kW)**
- Capability to generate electricity

**Adjustment capability (ΔkW)**
- Capability for short-term adjustments in supply and demand

**Environmental value**
- Value of power derived from non-fossil-fuel sources

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Internal transactions by electricity power company

- Unnoticed

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Electricity system reform ➤ Introduction of market mechanisms

- Wholesale electricity market, etc.
- Capacity market
- Supply-demand adjustment market
- Non-fossil-fuel energy value trading market

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While conducting simulations, regulators should verify that the system functions soundly as a whole.

Flexible reform or abolition of sub-systems

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These markets need to be designed and operated while focusing on their contribution to both stimulating competition and addressing questions of common good.
An appropriate business environment needs to be created with a view to turning renewables into a major energy source.

The feed-in tariff (FIT) scheme imposes a growing public burden, and urgently requires sweeping revision.

One option is to use a feed-in premium (FIP) scheme for portions of electricity generation that continue to require public subsidies.

1. FIT is a system of purchasing renewable energy at fixed prices.
2. FIP is a system of adding a certain level of premium to regular revenue from selling electricity at market prices.

[Diagram showing FIT purchasing costs: 3.7-4.0 trillion yen (premise for the 2030 energy mix)]

Sweeping revision of the FIT scheme is essential to curb the public burden.

Support should be examined based on the characteristics of each energy source:

- **Solar and wind power**: Move to subsidy-free market pricing of electricity as swiftly as possible
- **Hydro and geothermal power**: Examine support for development and other measures to further expand introduction in the post-FIT era
- **Biomass power**: Examine subsidies as part of agriculture and forestry policy and waste disposal policy

(Trillion yen)

- 2012: 0.6 trillion yen
- 2019: 3 trillion yen
- 2030: 3.6 trillion yen
### Continuing Use of Nuclear Power

- Ensuring world-class safety levels is a prerequisite for utilization of nuclear power.
- Nuclear power is an essential source of energy for Japan and the world as a whole to secure stable future energy supply and pursue decarbonization.
- As well as swiftly and steadily working to restart existing nuclear plants, the government should include replacement and new facilities in its policies. A stable business environment and technology development are also crucial.

<table>
<thead>
<tr>
<th>Creation of a stable business environment</th>
<th>Use of existing power plants</th>
<th>Future use of nuclear power</th>
</tr>
</thead>
<tbody>
<tr>
<td>Foster public trust</td>
<td>Restart operations swiftly and steadily</td>
<td>Include replacement and new facilities in policies</td>
</tr>
<tr>
<td>Improve the environment for back-end operations</td>
<td>Streamline regulations and speed up inspections</td>
<td>Develop technologies for new types of reactor, etc.</td>
</tr>
<tr>
<td>Review damage compensation systems</td>
<td>Conduct technical investigation of operational lifespan (treatment of plant downtime, extension of lifespan to more than 60 years)</td>
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</tbody>
</table>

Ensure both swift, certain aid for victims and predictability for business.
Energy Storage Technology Development and Deployment

- Energy storage technologies are rapidly growing in importance with the expansion of variable renewable energy (VRE) sources.
- The government should promote development of technologies for storage batteries, hydrogen, etc., present a road map for reducing costs, and propose approaches for practical implementation throughout society.
- Energy storage technologies are deeply intertwined with industrial policy, especially for the transport sector. Measures should be put in place from a broad range of perspectives.

Stable supply of electricity is achieved by matching supply and demand

Issues with VRE sources

- Surplus generation capacity at times of low demand
- Frequent changes in output due to weather conditions, etc.

Resolve with energy storage technologies

Deeply intertwined with industrial policy beyond the electricity industry, e.g. transport industry

Measures should be put in place from a broad range of perspectives
Need for Next-Generation Electricity Networks

- Next-generation electricity networks will enable higher levels of S+3E and pursuit of 3D.
- Existing networks need to be progressively upgraded in the aim of moving ahead to the next generation.

Transmission networks

Adapt to expansion of large-scale renewable energy generation

Uneven distribution of areas suited to renewable energy

Means of transmission required

Distribution networks

Expand use of decentralized resources

Optimize transmission routes and expand capacity where necessary

Utilize digital technologies for demand forecasting, monitoring, and control driven by AI, IoT, etc.
Upgrading Networks with a Balance between Social Benefit and Public Burden

- The cost required is the biggest issue in building next-generation electricity networks.
- Maximum use should first be made of existing facilities (e.g. Japanese version “Connect & Manage” scheme).
- Building networks will require data-based cost-benefit analysis.
- More compact and networked social infrastructure will also be vital.

Overseas cost-benefit analysis (Example from ENTSO-E in Europe)

<table>
<thead>
<tr>
<th>Costs</th>
<th>Benefits</th>
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<tbody>
<tr>
<td>Project costs</td>
<td>■ Contribution to stable supply</td>
</tr>
<tr>
<td></td>
<td>● Better balance between supply and demand</td>
</tr>
<tr>
<td></td>
<td>● Better network stability</td>
</tr>
<tr>
<td></td>
<td>■ Social and economic welfare</td>
</tr>
<tr>
<td></td>
<td>● Control of CO₂ emissions</td>
</tr>
<tr>
<td></td>
<td>● Reduction of fuel costs</td>
</tr>
<tr>
<td></td>
<td>● Lower transmission losses</td>
</tr>
</tbody>
</table>

- More compact
- More networked
From the perspective of building next-generation networks and expanding renewables while controlling public burden, government policy calls for reduction of total unit costs (renewable energy generation costs + network costs) below current levels.

**Basic Government Policy on Electricity Network Cost Reform**

1. Rigorous reduction of existing network costs, etc.
2. Securing of next-generation investment (to expand network capacity, enhance adjustment capability, etc.)
3. Mechanisms for generators to also minimize network costs

- Shift to next-generation networks to achieve large-scale introduction of renewables
- Minimize total cost of introducing renewable energy (generation + network costs)

**Cost of introducing renewable energy: A (present) > B + C (future)**

- Present
  - Cost of generating renewable energy (A)
  - Sharp reduction Self-supporting
  - Next-generation investment (Expand network capacity, enhance adjustment capability, etc.)
  - Existing network costs, etc.

- Future
  - Cost of generating renewable energy (B)
  - Increase (C)
  - Shift to next-generation network
  - Reduction mechanisms
  - Network costs
  - Generation costs

Overall reduction:
- Reduce
- Maximize control
- Reduce

Note: It will also be necessary to reduce the amount of network investment required through a Japanese version “Connect & Manage” scheme, etc.

(Source: Interim Report of Subcommittee on Mass Introduction of Renewable Energy and Next-Generation Electricity Networks)
Under current circumstances, medium- to long-term investment incentives hold little attraction for transmission and distribution businesses. Effective mechanisms to incentivize investment should be built into wheeling charge systems on the assumption of rigorously reducing existing network costs and maximizing the effectiveness of investment.

- Grid power demand not predicted to expand
- Rigid auditing and ex-post-facto assessment
- Situation not conducive to investment decisions

Example of wheeling charge system that has introduced investment incentives (UK RIIO model)

- Total transmission and distribution business revenue
- Basic revenue
- Performance incentive
- Investment in innovation
- Adjustment for uncertainty

Ensuring predictability
Adjustment according to changes in customer numbers, etc.

Innovation
Funds for investment in new technology development

Stability and environmental responsibility
Remunerated according to achievement of targets

Economic efficiency
Regulatory authority adjusts amount based on overall costs, etc.

No incentives to invest built into charging systems

Current wheeling charges

Other (taxes, etc.)
Depreciation expenses
Repair costs
Personnel costs
In the current situation, fixed costs of transmission and distribution infrastructure are largely recovered through volume-based user charges. Taking into account factors such as the shift towards decentralization, the proportion of wheeling charges recovered through base charges should be increased.

Assuming appropriate consideration is given to governance, etc., it is not impossible to envision applying funding other than wheeling charges (e.g., FIT levies) to network construction. In doing so, it would be essential to compare potential outcomes with the scenario of funding next-generation networks solely through wheeling charges.

Risk that decline in grid power demand could impede recovery of investment in networks

- Recover fixed costs, which account for 53% of total costs, through volume-based charges
- Proportion of costs recovered through base charges needs to increase

Scenario where FIT levies are applied to development of next-generation networks that support a shift to renewables as a major electricity source

- FIT scheme reforms and sound governance are prerequisites
- Re-examine the way to share levy burden
- Strictly adhere to upper limits which is the premise for the energy mix
- Clarify gradual abatement of levies
- Avoid unassessed sources of funding (through examination of charges, etc.)

Need to conduct careful comparison with scenario where next-generation networks are funded solely through wheeling charges

<table>
<thead>
<tr>
<th>Total costs</th>
<th>Wheeling charges</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fixed costs</td>
<td>80%</td>
</tr>
<tr>
<td>Base charges</td>
<td>27%</td>
</tr>
<tr>
<td>Variable costs, etc.</td>
<td>20%</td>
</tr>
<tr>
<td>Volume-based charges</td>
<td>73%</td>
</tr>
</tbody>
</table>

Recover fixed costs, which account for 53% of total costs, through volume-based charges

(Prepared based on the interim report of the Working Group to Examine the Cost Burden of Maintaining and Operating the Transmission and Distribution Network)
In addition to means of recovering investment, financing measures also need to be examined. Certain provisions should be put in place to ensure uninterrupted financing of electricity infrastructure, especially adjustable electricity sources and transmission and distribution networks, which offer a high degree of public benefit.

- For example, measures such as two-step loans* utilizing the Fiscal and Investment Loan Program (FILP) should be considered.

Creation of an environment that attracts domestic and international capital, including ESG investment, will also be vital.

*Two-step loans: Financing by a designated financial institution that has received long-term funds at low interest from the Japan Finance Corporation, which is able to take advantage of FILP.
No form of infrastructure can continue in use forever.

In the current situation, electricity investment required for the future is being postponed, and constraining the present burden is bound to result in a future bill.

The government needs to design appropriate systems and continually verify and revise them. The business community will actively participate in discussions to this end.

The proposals presented in this document set out the direction that should be taken for the government to pursue higher levels of S+3E and accelerate 3D as part of this process.

There is potential to revolutionize business models for the electricity sector and related industries in the future. Japan needs to develop an image of future electricity systems under multiple scenarios, envision the corresponding change of society, and examine measures required to achieve its goals.

We hope that the entire country will work together to ensure strong and sound development of Japan’s economy and society as a whole and bring Society 5.0 to fruition.
(For Reference) Key Courses of Action to Resolve Issues Set Out in This Proposal

Develop a specific vision for the electricity system

- In compiling the 6th Strategic Energy Plan, present multiple scenarios setting out specifics of electricity sources, networks, demand, public burden, etc. to develop a vision for the electricity system in beyond 2030. At the same time, conduct quantitative discussion in advisory councils and other public forums.

- Develop specific system plans and related policies based on a framework for periodic review of long-term scenarios.

- During the period until scenarios are drawn up, examine ways of creating an environment to develop crucial infrastructure for the future.

Ensure electricity demand

- Engage in public- and private-sector efforts to constantly improve energy intensity through energy-saving initiatives.

- To secure base demand by leveraging the attractions of electricity, respond to diverse demand-side needs (internationally competitive levels of electricity charges, value provided by high-quality, affordable renewable energy, etc.).

Secure investment in electricity generation

- Clarify allocation of responsibilities and authority in wholesale markets.

- Design and operate systems considering concerns over wholesale markets.

- Build mechanisms to control electricity volumes required for adjustment capability and appropriately allocate the burden of necessary costs.

- Formulate a future-proof grid code and establish mechanisms for ensuring compliance with it.

- Verify that the entire system functions soundly once wholesale markets have started operation, and review as required.

- Create a suitable business environment for renewable energy.
  - Solar and wind power: Achieve market sale of electricity independent of government subsidies as swiftly as possible.
  - Hydro and geothermal power: Examine measures to further expand introduction in the post-FIT era.

- Create a business environment conducive to nuclear energy (back-end operations, compensation systems, safety inspections and regulation, etc.) and promote technology development.

- Promote development of energy storage technologies such as storage batteries and hydrogen while maintaining an industrial policy perspective.

Secure investment in transmission and distribution

- Examine mechanisms to ensure system stability in an era of widespread introduction of variable renewable energy sources.

- Examine rules for data usage and handling of personal and business information.

- Build cost-effective next-generation networks based on cost-benefit analysis.

- Examine electricity supply according to need, without being bound by uniform national supply models.

- Reform wheeling charge systems (build in mechanisms to incentivize investment and raise proportion of costs recovered through base charges).

Secure finance

- Examine measures to deal with the impact of electricity system reforms on financing (e.g. prepare a two-step loan framework utilizing FILP as a means of raising funds for adjustable sources of electricity and transmission and distribution networks, including a safety-net role).