JAPAN'S ENERGY 2018
10 questions for understanding the current energy situation

1. How much energy can Japan supply independently?
2. How are electric power rates changing?
3. How much greenhouse gases are being emitted?
4. Is the reconstruction of Fukushima in progress?
5. What is the government's energy policy?
6. Are programs being implemented for improving energy efficiency?
7. Is the introduction of renewable energy in progress?
8. Is nuclear power generation necessary?
9. Will hydrogen energy and power storage technologies come into general use?
10. 2018 Energy Topics

Ministry of Economy, Trade and Industry
Agency for Natural Resources and Energy
1. How much energy can Japan supply independently?

**How much energy can Japan supply independently from domestic resources?**

Japan has always been a country that lacks resources such as oil and natural gas. The energy self-sufficiency ratio of Japan in 2017 was 9.6%, which is a low level when compared with other OECD countries.

Comparison of Primary Energy Self-Sufficiency Ratios of Major Countries (2017)

<table>
<thead>
<tr>
<th>Country</th>
<th>Coal</th>
<th>Crude Oil</th>
<th>Natural gas</th>
<th>Nuclear Power</th>
<th>Hydro Power</th>
<th>Geothermal, Wind, Solar, etc.</th>
<th>Total self-sufficiency ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. 1 Norway</td>
<td>11.6</td>
<td>6.7</td>
<td>6.6</td>
<td>20%</td>
<td>20%</td>
<td>3%</td>
<td>28%</td>
</tr>
<tr>
<td>No. 2 Australia</td>
<td>6.7</td>
<td>6.6</td>
<td>20%</td>
<td>20%</td>
<td>20%</td>
<td>3%</td>
<td>28%</td>
</tr>
<tr>
<td>No. 3 Canada</td>
<td>6.4</td>
<td>7.4</td>
<td>20%</td>
<td>20%</td>
<td>20%</td>
<td>3%</td>
<td>28%</td>
</tr>
<tr>
<td>No. 5 USA</td>
<td>6.4</td>
<td>7.4</td>
<td>20%</td>
<td>20%</td>
<td>20%</td>
<td>3%</td>
<td>28%</td>
</tr>
<tr>
<td>No. 7 UK</td>
<td>6.6</td>
<td>7.4</td>
<td>20%</td>
<td>20%</td>
<td>20%</td>
<td>3%</td>
<td>28%</td>
</tr>
<tr>
<td>No. 8 Italy</td>
<td>6.6</td>
<td>7.4</td>
<td>20%</td>
<td>20%</td>
<td>20%</td>
<td>3%</td>
<td>28%</td>
</tr>
<tr>
<td>No. 9 China</td>
<td>6.6</td>
<td>7.4</td>
<td>20%</td>
<td>20%</td>
<td>20%</td>
<td>3%</td>
<td>28%</td>
</tr>
<tr>
<td>No. 10 India</td>
<td>6.6</td>
<td>7.4</td>
<td>20%</td>
<td>20%</td>
<td>20%</td>
<td>3%</td>
<td>28%</td>
</tr>
</tbody>
</table>

**Japan energy self-sufficiency ratio**

<table>
<thead>
<tr>
<th>Year</th>
<th>Overall</th>
<th>꜒</th>
<th>2011</th>
<th>2012</th>
<th>2013</th>
<th>2014</th>
<th>2015</th>
<th>2016</th>
<th>2017</th>
</tr>
</thead>
<tbody>
<tr>
<td>2018</td>
<td>20.3</td>
<td>11.6</td>
<td>6.7</td>
<td>6.6</td>
<td>6.4</td>
<td>7.4</td>
<td>8.2</td>
<td>9.6</td>
<td></td>
</tr>
</tbody>
</table>

A low energy self-sufficiency ratio results in dependence on other countries for resources. This makes a country susceptible to the effects of international situations, raising concerns over the stability of the energy supply.

**Energy self-sufficiency ratio** in primary energies required for life and economic activity, the ratio that can be secured within one's own country.

Source: 2017 estimates in IEA "World Energy Balances 2018". For Japan only, the FY 2017 figures from "Comprehensive energy statistics of Japan".

The ratios in the table are those of the 25 OECD member countries in 2017.

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**What resources does Japan depend on?**

Japan is highly dependent on fossil fuels such as oil, coal and natural gas (LNG) imported from overseas. Before the Great East Japan Earthquake, Japan was dependent on supply for 81.2% of its fossil fuels demands (primary energy supply basis). This dependence rose to 87.4% in FY 2017 as a result of power generation using thermal power plants resulting from the shutdown of nuclear power plants.

Trends in Composition of Primary Energy Supply of Japan

- **FY 1973**
  - Oil: 75.5%
  - Coal: 16.9%
  - Nuclear power: 4.4%
  - Renewable energy: 2.0%

- **FY 2010**
  - Oil: 40.3%
  - Coal: 22.7%
  - Nuclear power: 11.2%
  - LNG: 18.2%
  - Renewable energy: 4.4%

- **FY 2017**
  - Oil: 39.0%
  - Coal: 25.1%
  - LNG: 23.4%
  - Renewable energy: 7.6%

Source: Comprehensive energy statistics.

* The total amount expressed in % may not be the 100% due to rounding.
* Renewable energy here includes unused energy such as biomass and excludes hydroelectric power.

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**What countries does Japan import resources from?**

Japan depends on the Middle East for around 86% of its crude oil imports. For natural gas and coal as well, Japan relies almost entirely on overseas imports from regions such as Australia, Russia, Asia-Oceania and the Middle East.

Sources of Japanese fossil fuel imports (2018)

- **2018 total Japanese LNG (natural gas) imports**
  - Indonesia: 6.2%
  - Qatar: 12.0%
  - Malaysia: 13.6%
  - Singapore: 26.3%

- **2018 total Japanese crude oil imports**
  - Middle East: 82.85 million tons
  - OPEC: 64% (Iraq: 17%, Saudi Arabia: 11.5%, Iran: 8.1%, UAE: 5.4%, Others: 3.9%)
  - Other: 17.15 million tons

In order to secure a stable supply of resources, Japan is endeavoring to strengthen relations with oil-producing countries in the Middle East that are its main sources of crude oil. It is also diversifying its supply sources, working for further acquisition of resource rights and interests, and pursuing more active LNG transactions.

Source: Trade statistics
2. How are electric power rates changing?

Changes in electricity rates

Electricity rates were increased multiple times after the Great East Japan Earthquake. The rates then began trending downward since FY 2014 due to factors such as the subsequent decline in crude oil prices. However, they have recently begun to rise again.

Changes in average electricity rates

<table>
<thead>
<tr>
<th>Year</th>
<th>Homes Around 16% increase</th>
<th>Industries Around 21% increase</th>
</tr>
</thead>
<tbody>
<tr>
<td>2010</td>
<td>12.5</td>
<td>17.2</td>
</tr>
<tr>
<td>2011</td>
<td>14.5</td>
<td>17.7</td>
</tr>
<tr>
<td>2012</td>
<td>15.7</td>
<td>17.7</td>
</tr>
<tr>
<td>2013</td>
<td>16.6</td>
<td>17.7</td>
</tr>
<tr>
<td>2014</td>
<td>17.5</td>
<td>18.6</td>
</tr>
<tr>
<td>2015</td>
<td>18.3</td>
<td>19.2</td>
</tr>
<tr>
<td>2016</td>
<td>19.1</td>
<td>19.9</td>
</tr>
<tr>
<td>2017 (FY)</td>
<td>20.7</td>
<td>20.8</td>
</tr>
</tbody>
</table>

Changes in the industry composition of power sources (supply)

<table>
<thead>
<tr>
<th>Year</th>
<th>March 2011 Great East Japan Earthquake</th>
<th>Average annual growth</th>
</tr>
</thead>
<tbody>
<tr>
<td>2011</td>
<td>8.8% (251%)</td>
<td>9%</td>
</tr>
<tr>
<td>2012</td>
<td>8.8% (251%)</td>
<td>9%</td>
</tr>
<tr>
<td>2013</td>
<td>3.5% (99%)</td>
<td>9%</td>
</tr>
<tr>
<td>2014</td>
<td>3.5% (99%)</td>
<td>9%</td>
</tr>
<tr>
<td>2015</td>
<td>3.5% (99%)</td>
<td>9%</td>
</tr>
<tr>
<td>2016</td>
<td>3.5% (99%)</td>
<td>9%</td>
</tr>
<tr>
<td>2017 (FY)</td>
<td>3.5% (99%)</td>
<td>9%</td>
</tr>
</tbody>
</table>

Changes in the industry composition of power sources (demand)

<table>
<thead>
<tr>
<th>Year</th>
<th>March 2011 Great East Japan Earthquake</th>
<th>Average annual growth</th>
</tr>
</thead>
<tbody>
<tr>
<td>2011</td>
<td>8.8% (251%)</td>
<td>9%</td>
</tr>
<tr>
<td>2012</td>
<td>8.8% (251%)</td>
<td>9%</td>
</tr>
<tr>
<td>2013</td>
<td>3.5% (99%)</td>
<td>9%</td>
</tr>
<tr>
<td>2014</td>
<td>3.5% (99%)</td>
<td>9%</td>
</tr>
<tr>
<td>2015</td>
<td>3.5% (99%)</td>
<td>9%</td>
</tr>
<tr>
<td>2016</td>
<td>3.5% (99%)</td>
<td>9%</td>
</tr>
<tr>
<td>2017 (FY)</td>
<td>3.5% (99%)</td>
<td>9%</td>
</tr>
</tbody>
</table>

Thanks to the introduction of the Feed-in Tariff scheme (FIT) in 2012, the installed capacity of renewable energy systems is growing rapidly. However, the purchase price has reached 36 billion yen (approximately 33 billion USD) and the cost of the surcharge based on the standard model (260 kWh/month) has risen to 767 yen/month. In order to maximize the introduction of renewable energy while also reducing the burden on the people, it will be necessary to expand cost-efficient introduction. For this purpose, we will proceed with setting long-term price targets for the FIT system, utilize a "top runners approach" to reducing solar and wind power prices to meet those targets, use a competitive bidding system, and develop technologies for reducing cost.

Feed-in Tariff Scheme (FIT): This is a system in which the electricity generated by renewable energy is purchased by electric power companies at a fixed rate for a certain period of time. The purchase costs are collected by means of a surcharge that is paid by electricity users.

Average model: Monthly power usage 260 kWh model that is posted on the websites of the Tokyo EP and Kansai EP.
3. How much greenhouse gases are being emitted?

**An increase in the amount of CO₂ emissions**

**Q** How much greenhouse gases are emitted in Japan?

Since the Great East Japan Earthquake, the amount of greenhouse gas emissions in Japan has been increasing, reaching a historical peak of 1.4 billion tons in FY 2013. The level started to decline after FY 2013, and in FY 2017 emissions of greenhouse gases have dropped to below the level of FY 2010 before the Great East Japan Earthquake. We must continue making efforts with the standards that are comparable to other countries’ reduction targets.

**Changes in Japan’s greenhouse gas emissions**

<table>
<thead>
<tr>
<th></th>
<th>FY 2010</th>
<th>FY 2013</th>
<th>FY 2015</th>
<th>FY 2017</th>
</tr>
</thead>
<tbody>
<tr>
<td>CO₂ emissions (million tCO₂)</td>
<td>1,305</td>
<td>1,410</td>
<td>1,324</td>
<td>1,292</td>
</tr>
</tbody>
</table>

Greenhouse gas emissions other than CO₂ from energy sources ($BQBO$)

|           | 168     | 175     | 177     | 181     |

Other than electric power ($BQBO$)

|           | 455     | 573     | 519     | 492     |

Amount due to electric power ($BQBO$)


**Changes in greenhouse gas emissions from global energy sources (1990 - 2016)**

Global greenhouse gas emissions from energy sources in 2016 were 32.1 billion tons of CO₂. Although emissions in North America and the EU are declining, they are growing in China, India, and Africa. Japan is the only country with declining emissions in the growing Asia region.

**Forecast for fossil fuel (coal, oil, gas) demand**

<table>
<thead>
<tr>
<th>(MTOE)</th>
<th>16,000</th>
<th>14,000</th>
<th>12,000</th>
<th>10,000</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Scenario of maintaining current policies</td>
<td>New policy scenario</td>
<td>Sustainable development scenario</td>
<td></td>
</tr>
<tr>
<td>China</td>
<td>26.6%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>India</td>
<td></td>
<td>4.7%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Japan</td>
<td></td>
<td></td>
<td>9.0%</td>
<td></td>
</tr>
<tr>
<td>USA</td>
<td>12.0%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Others</td>
<td>28.3%</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**CO₂ emissions forecast**

<table>
<thead>
<tr>
<th>(MI)</th>
<th>50,000</th>
<th>41,250</th>
<th>32,500</th>
<th>23,750</th>
<th>15,000</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Scenario of maintaining current policies</td>
<td>New policy scenario</td>
<td>Sustainable development scenario</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2000</td>
<td>8,186</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2020</td>
<td>13,139</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2030</td>
<td>15,143</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2040</td>
<td>17,647</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Source: IEA World Energy Outlook 2018
Note: 2000 and 2016 figures are actual. 2017 figure is an estimate.

As the consumption of fossil fuels has a large impact on the planet, it is important to change energy sources and shift away from carbon.

Notes: Scenario of maintaining current policies - If no changes are made to current policies.
New policy scenario - If the currently announced policy targets are achieved.
Sustainable development scenario - If the shift to clean energy is accelerated, ensuring universal access, preventing climate change, and achieving a clean atmosphere.
4. Is the reconstruction of Fukushima in progress?

Q How is the progress of decommissioning & the management of the contaminated water at Fukushima Daiichi Nuclear Power Station?

A Although it is an unprecedented challenge, continuous measures are being implemented safely and steadily based on the “Mid-and-Long-Term Roadmap.”

### Decommissioning of Fukushima Daiichi Nuclear Power Station

#### How is the progress of decommissioning & the management of the contaminated water at Fukushima Daiichi Nuclear Power Station?

#### Decommissioning

Stable conditions are being kept at all reactors, and rubble removal, decontamination, and other measures are carried out aimed at removing the fuel from the spent fuel pool. Internal investigation of the containment vessel is conducted toward retrieval of the fuel debris (fuel that melted and resolidified). Based on the investigation results, the method of retrieval will be determined and retrieval will start in 2021.

#### Contaminated Water Management

Amount of contaminated water generated at Fukushima Daiichi Nuclear Power Station has reduced to one third by multi-layered countermeasures (frozen-soil wall, etc.), compared to it before measures were taken. Contaminated water from the Fukushima Daiichi Nuclear Power Station is processed by multiple treatment facilities to remove as much of the radioactive substances as possible before the water is stored in the tanks. The quality of water of the surrounding sea areas has also greatly improved.

### Toward Reconstruction of Fukushima

Q How is the progress of the reconstruction of Fukushima?

A By spring 2017, all “restricted residence areas” and “areas in preparation for lifting of the evacuation order” had been lifted except for Okuma Town and Futaba Town. Efforts to construct bases for reconstruction are also being made in designated “difficult-to-return” areas. In addition, we are working for regional revitalization of Fukushima in a number of ways, such as by accelerating decontamination and the construction of infrastructure and daily living services, by creating new technologies and industries, and by promoting industrial clusters.

#### Fukushima Innovation Coast Framework:

We are working for constructing a new industrial infrastructure to revitalize industries in the Hama-dori (coastal) area and other areas.

#### Fukushima Robot Test Field (Minamisoma City, Namie Town)

This constructed a robot test field for development and demonstration of robots, and an international facility for collaboration by industry, academia, and government (partially opened in July 2018).

#### Fukushima Hydrogen Energy Research Field (Namie Town)

Conducting demonstration projects for large-scale production of hydrogen from renewable energy using the world’s largest 10,000 kW class electrolyzer.

#### Okuma Analysis and Research Center (Okuma Town)

Conducting analysis of low- and medium-dose radioactive rubble and fuel debris.

#### Collaborative Laboratories for Advanced Decommissioning Science (Tomioka Town)

Universities, research institutes, and companies within and outside Japan have gathered in Fukushima and are conducting research related to decontamination, nuclear reactors and other subjects.

#### Narihira Center for Remote Control Technology Development (Narihira Town)

Conducting investigations of reactor contain-ment vessels, development and demonstration tests of repair robots, and training for workers using virtual reality systems.

### The Fukushima Plan for a New Energy Society

We are creating a model for a “future energy society” and promoting the “Fukushima Model” to the world.

#### Expanding the introduction of renewable energy

- Reinforcement of transmission lines for new wind farms in the Abukuma and Futaba areas

#### Development of a model for realizing a “Hydrogen Society”

- Demonstration project for large-scale hydrogen production using renewable energy (10,000 kWe demonstration - the largest in the world)

- Demonstration project for next-generation hydrogen transport and storage technologies (To be utilized during the 2020 Tokyo Olympics and Paralympics)

#### Creation of Smart Communities

- Support for construction of Smart Communities in some Fukushima regions including Shinhō Town, Soma City, Namie Town, Nara Town and Katsurao Village

#### Food Safety in Fukushima Prefecture

- Agricultural, forestry, and fishery products are subject to thorough monitoring inspections before shipping, and the results of these and other inspections are made public.

- Under the period immediately after the earthquake, all products received the standard limit 100 Bq/kg in each year.

- There have been less incidents of rice exceeding the standard since 2015 crop, and zero incidents of seafood exceeding the standard since 2017.

- Various activities are taken to prevent it from reaching the market.

#### Status of monitoring inspections for agricultural, forestry and fishery products

- Number of inspections: 3,814 (incurred in 2017)
- Number of results exceeding standard: 0 (incurred in 2017)
- Percentage exceeding standard: 0.00%
5. What is the government’s energy policy?

**Basic Policies**

**Q** What are the basic energy policies?

**A** Keeping in mind that safety always comes first, programs are being carried out in order to simultaneously achieve improvement of energy security, economic efficiency, and environment suitability. (3E+S)

It is essential to create a multi-layer energy supply structure where each power source delivers its maximum strength and complements the weaknesses of the others.

- **Safety**
  - Safety always comes first.
- **Self-sufficiency**
- **Electric power cost**
- **Greenhouse gas emissions**

**Energy Security**

Exceed the level from before the Great East Japan Earthquake (approx. 20%).

- Approx. 25% (currently 9.6%)

**Economic Efficiency**

Reduce costs from their current level.

- (FY 2013 9.7 trillion yen → FY 2030 9.5 trillion yen)
  - When formulating the energy mix

**Environment**

Achieve targets for reduction in greenhouse gases that are comparable to Western countries.

- (26% reduction from FY 2013 levels by FY 2030)

**Q** What does "decarbonization" mean?

**A** The policy is to reduce carbon emissions.

It will change the energy supply structure of Japan that is highly dependent on fossil fuels, and also help reduce greenhouse gas emissions.

**Flow of energy choice**

<table>
<thead>
<tr>
<th>Policy</th>
<th>Energy Source</th>
<th>Other Considerations</th>
</tr>
</thead>
<tbody>
<tr>
<td>1st choice</td>
<td>Change from domestic coal to oil (1980s)</td>
<td>- Dramatic decline in energy demand following oil crises</td>
</tr>
<tr>
<td>2nd choice</td>
<td>2 oil crises (1970s)</td>
<td>- Rising oil prices</td>
</tr>
<tr>
<td>3rd choice</td>
<td>Liberalization and global warming (1990s)</td>
<td>- Kyoto Protocol (1997)</td>
</tr>
<tr>
<td>4th choice</td>
<td>Great East Japan Earthquake and 11.3 accident (2011)</td>
<td>- Ensuring safety of nuclear power plants</td>
</tr>
<tr>
<td>5th choice</td>
<td>50 year targets of the Paris Agreement (from 2030)</td>
<td>- Contribution to global efforts to reduce carbon emissions</td>
</tr>
</tbody>
</table>

**Innovations aimed at achieving zero carbon**

- Transport: Decarbonization oriented future
  - Main elements: Vehicles, systems, fuel, electricity, hydrogen, biofuels, CCUS, hydrogen production, smart use of energy
  - Decarbonization oriented future: Electrification, autonomous driving, materials

**Column: Progress towards achieving the 2030 energy mix**

Although steady progress is being made towards achieving the 2030 energy mix, we are still only halfway there.

- **Energy Security**
  - Energy self-sufficiency
- **Economic Efficiency**
  - Electric power cost
- **Environment**
  - CO2 emissions from energy sources

*Electricity costs are unstable as a result of changing fuel prices and an increase in FIT purchase costs.*

Source: Created by the Agency for Natural Resources and Energy based on comprehensive energy statistics (FY 2017 figures) and other information.
6. Are programs being implemented for improving energy efficiency?

**Energy efficiency**

**Q** Why is improving energy efficiency necessary?

It is necessary in view of effective use of limited resources. In addition, measures to improve energy efficiency can reduce CO₂ emissions, and can lead to a solution to the problem of global warming. Continuing efforts for improving energy efficiency measures is essential.

**A**

**Q** To what extent have measures to improve energy efficiency in Japan progressed?

Japan is a nation with excellent energy efficiency and advanced measures for energy efficiency improvements. However from 1990 to 2010, improvements of energy efficiency stalled. Further measures to improve energy efficiency will need to be implemented in the future.

**Final energy demand in the energy mix**

<table>
<thead>
<tr>
<th>Economic growth 1%/year</th>
<th>Household</th>
<th>361 million kJ</th>
<th>376 million kJ</th>
<th>Total</th>
<th>827 million kJ</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transport</td>
<td>38 million kJ</td>
<td>42 million kJ</td>
<td>70 million kJ</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Services</td>
<td>65 million kJ</td>
<td>65 million kJ</td>
<td>65 million kJ</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Improvement of Energy Consumption Efficiency**

2. Energy efficiency = Final energy consumption / Real GDP

**Further improvement of energy efficiency in the transport sector (cargo transportation)**

As trucks are more difficult to electrify than passenger vehicles, improving the efficiency of logistics in cargo transportation is essential. Actions are needed to be taken against concerns of growing energy consumption resulting from the increase in small shipments and repeated deliveries in the rapidly expanding ecommerce market (which has grown 1.8 times for the past 5 years).

**Changes in home deliveries**

<table>
<thead>
<tr>
<th></th>
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</thead>
<tbody>
<tr>
<td>(1990)</td>
<td>4.25 billion</td>
<td>3.22 billion</td>
<td>2.89 billion</td>
<td>2.58 billion</td>
<td>2.34 billion</td>
<td>2.08 billion</td>
</tr>
<tr>
<td>12% increase (approx. 530 million parcels) in 5 years</td>
<td></td>
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</tr>
</tbody>
</table>

**The Act on the Rational Use of Energy**

Lacking in fossil fuels, Japan has worked on improving energy efficiency and has achieved top class results on a worldwide scale. The Act on the Rational Use of Energy was revised in June 2018, and improving energy efficiency methods that are adapted to the changing times will be used to achieve further improvements in energy efficiency.

7. Is the introduction of renewable energy in progress?

**Introduction of Renewable Energy**

**Q** Why does renewable energy need to be introduced?

**A** Renewable energy is an important source of energy for Japan as it generates energy without emitting CO₂ and contributes to energy self-sufficiency.

**Q** Is the introduction of renewable energy in progress in Japan?

**A** As of 2017, the percentage of electrical power generated by renewable energy in Japan is 16.0% (8.1% if hydroelectric power is excluded). This is low compared to other major countries, and further expansion is needed.

**Comparison of the Renewable Energy Ratio of Total Generated Electric Power**

<table>
<thead>
<tr>
<th>Percentage of total generated power</th>
<th>Nuclear power 3.5</th>
<th>Nuclear power 3.1</th>
<th>Natural gas 35.5</th>
<th>Natural gas 39.5</th>
<th>Coal 9.0</th>
<th>Coal 68.6</th>
<th>Oil other 8.7</th>
<th>Oil other 8.1</th>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Country</th>
<th>Renewable energy (excluding hydro and nuclear)</th>
<th>Renewable energy (including hydro and nuclear)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Germany</td>
<td>33.6% (2017)</td>
<td>33.6% (2017)</td>
</tr>
<tr>
<td>Spain</td>
<td>32.4% (2017)</td>
<td>32.4% (2017)</td>
</tr>
<tr>
<td>UK</td>
<td>29.7% (2017)</td>
<td>29.7% (2017)</td>
</tr>
<tr>
<td>France</td>
<td>29.7% (2017)</td>
<td>29.7% (2017)</td>
</tr>
<tr>
<td>Italy</td>
<td>16.5% (2017)</td>
<td>16.5% (2017)</td>
</tr>
<tr>
<td>USA</td>
<td>35.6% (2017)</td>
<td>35.6% (2017)</td>
</tr>
<tr>
<td>Canada</td>
<td>17.0% (2017)</td>
<td>17.0% (2017)</td>
</tr>
<tr>
<td>China</td>
<td>65.7% (2017)</td>
<td>65.7% (2017)</td>
</tr>
<tr>
<td>Japan</td>
<td>24.9% (2017)</td>
<td>24.9% (2017)</td>
</tr>
<tr>
<td>Japan</td>
<td>16.0% (2017)</td>
<td>16.0% (2017)</td>
</tr>
</tbody>
</table>

Source: Investigation by the Agency for Natural Resources and Energy

**Q** Is it possible to supply electricity only from renewable sources?

**A** The amount of electricity generated by renewable energy varies significantly depending on the weather or season, which makes power supply unstable. Flexible power sources such as thermal power need to be prepared as a backup. There are also a number of remaining issues, such as securing batteries and other means of energy storage, and determining how to transform power network that can integrate a large amount of electricity generated by renewable sources.

Image of supply/demand situation on the lowest demand day (such as a sunny day in May)

In order that consumers can use electricity in a stable manner, a balance between generation (supply) and consumption (demand) is needed on the same level. To this end, flexible power sources such as thermal power are used to adjust the fluctuation of renewable energy.

**Column: Energy network in Europe**

For example, Germany is connected by cross-border electricity interconnections to around 10 nearby countries including Poland, Czech Republic, Austria, Switzerland, France, The Netherlands, Denmark, and Sweden. When renewable electricity surplus occurs in one area, it is exported to other countries. When electricity is insufficient in one area, it is imported from other countries. Transmission network among countries are highly developed in Europe and it is possible to maintain a balance between supply and demand as a whole.

**European grid map (from ENTSO-E)**
8. Is nuclear power generation necessary?

Regarding Nuclear Power Plants

**Q** Is nuclear power generation necessary?

**A** For a country that lacks natural resources, nuclear power generation is essential in order to achieve the following 3 objectives: 1) securing a stable supply of power, 2) reducing electric power costs, 3) reducing CO2 emissions. In order for nuclear power plants to be restarted, conformance with new regulatory requirements that prioritize safety is required.

Operating status of nuclear power plants in Japan

<table>
<thead>
<tr>
<th>Prefecture</th>
<th>Plant Name</th>
<th>Operator</th>
<th>Reactors in operation</th>
<th>Reactors approved for dismantlement</th>
<th>Reactors under assessment for new regulatory requirements</th>
<th>Reactors that have not been assessed for dismantlement</th>
<th>Reactors to be decommissioned</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aomori</td>
<td>(Electric Power Development Co.)</td>
<td>Tōhoku Electric Power Development Co.</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Ōma</td>
<td>(Tōhoku Electric Power Development Co.)</td>
<td>Jōna Nuclear Power Plant</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Hokkaido</td>
<td>(TEPCO) Tōhoku Electric Power Development Co.</td>
<td>Higashidori Nuclear Power Plant</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>Mihama</td>
<td>(KEPCO) Tōhoku Electric Power Development Co.</td>
<td>Tōhoku Electric Power Development Co.</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Ōma</td>
<td>(Tōhoku Electric Power Development Co.)</td>
<td>Ōma Nuclear Power Plant</td>
<td>2</td>
<td>2</td>
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<td>2</td>
<td>0</td>
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<tr>
<td>Miyagi</td>
<td>(Tōhoku Electric Power Development Co.)</td>
<td>Onagawa Nuclear Power Plant</td>
<td>1</td>
<td>1</td>
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<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Fukushima</td>
<td>(TEPCO) Fukushina #1 Nuclear Power Plant</td>
<td>Fukushima #1 Nuclear Power Plant</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Fukushima</td>
<td>(TEPCO) Fukushina #2 Nuclear Power Plant</td>
<td>Fukushima #2 Nuclear Power Plant</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Ibaraki</td>
<td>JAPC Tokai/Tokai No.2 Power Station</td>
<td>JAPC Tokai/Tokai No.2 Power Station</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Shimonoseki</td>
<td>(Shimoseki EPC) Genkai Nuclear Power Plant</td>
<td>Shimoseki EPC Genkai Nuclear Power Plant</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Kasai</td>
<td>(Shimoseki EPC) Sendai Nuclear Power Plant</td>
<td>Shimoseki EPC Sendai Nuclear Power Plant</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>0</td>
</tr>
</tbody>
</table>

(As of Aug. 5, 2018)

Response to the new regulatory requirements for higher safety

The Nuclear Regulation Authority requires that before a nuclear power plant is restarted, it must conform to new regulatory requirements. Measures to prevent accidents are being reinforced and prepared for emergency procedures enhanced as well.

New regulatory requirements (July 2013)

- Anti-terrorism measures (newly introduced)
- Severe accident measures (newly introduced)
- Measures against terrorism and attacks on nuclear facilities
- Measures against intentional aircraft collisions
- Measures against the proliferation of radioactive materials
- Measures against container damage
- Measures against reactor core damage (in the case of multiple instruments malfunctioning)
- Preparedness for internal overflows newly introduced
- Preparedness for natural phenomena (eliciting,想不到, and event, etc., that have been newly introduced)
- Preparedness for fires
- Reliability of power sources
- Performance of other instruments
- Performance against earthquakes and tsunamis
- Performance against earthquakes and tsunamis

Conventional regulatory requirements

- Standards for prevention of severe accidents (design standards)
- Preparedness for natural phenomena
- Preparedness for fires
- Reliability of power sources
- Performance of other instruments
- Performance against earthquakes and tsunamis

Source: Documents of the Nuclear Regulation Authority

Treatment and disposal of spent fuel

Spent nuclear fuel that is produced by the operation of a nuclear power plant is recycled and reused as fuel. Raw glass material is melted into the remaining waste water to create a solidified glass mass known as “vitrified waste.” This mass is disposed by burying and isolating it deep underground (geological disposal).

To provide a better understanding of the mechanism of geological disposal and the geological environment of Japan, we published the “Scientific Characteristics Map” in July 2017 which shows the scientific characteristics of each region of Japan.

Current state of spent fuel: Towards completion of a nuclear fuel cycle

The spent fuel that is produced by power plants in Japan will be reprocessed at Rokkasho reprocessing plants to create MOX fuel which can be reused for power generation. The Rokkasho reprocessing plants are required to conform to the new regulatory requirements for nuclear power facilities, and are now under construction, with completion planned for the first half of FY 2021.

Column: Global trends in nuclear power

Based on the nuclear power generation results shown below, the leading countries are the United States, France, China, Russia, and Korea. The nuclear power generation capacity of plants under construction shows that China is constructing a large number of plants.

Power generation capacity of nuclear power plants worldwide (2017) (TWh)

- USA: 38.8
- France: 232.8
- China: 141.3
- Russia: 90.1
- South Korea: 95.1
- UK: 63.9
- Sweden: 63.1
- Spain: 55.6
- Belgium: 40.0
- India: 34.9
- Japan: 29.3
- Czech Republic: 26.8

Power generation capacity of nuclear power plants under construction (at the end of 2017) (GW)

- USA: 2.5
- UAE: 5.6
- Russia: 4.7
- India: 4.3
- China: 5.7
- South Korea: 2.2
- UA: 2.1
- France: 1.7
- Russia: 1.7
- Belarus: 1.6
- Pakistan: 1.2
- Bangladesh: 1.2
- Slovakia: 0.9

Source: IEA Energy, Electricity and Nuclear Power Estimates for the Period up to 2050 IEA Tracking Clean Energy Progress

Japan’s Energy 2018  https://www.eenecho.meti.go.jp/
### Hydrogen energy

**Q** Will the use of hydrogen energy become widespread in the future?

**A** In the future, hydrogen energy is expected to be used for a wide range of purposes and to play a central role of a future source of energy replacing oil and other energy sources.

A hydrogen-based society using clean energy - Power to Gas

Expanding the use of renewable energy with fluctuating output such as solar and wind power will require technologies for storage of excess power. For this purpose, power-to-gas technologies which store energy as hydrogen are receiving attention both in Japan and overseas.

Solar, wind, and other renewable energy

- Water electrolysis
- Fuel cell generation
- Fuel cell vehicle
- Hydrogen power generation

Power grid (power lines)

Production of hydrogen

Transport

Use

Fukushima Hydrogen Energy Research Field

2020 Demonstration project for large-scale hydrogen production using renewable energy - aiming for use during the Tokyo Olympics (Namie Town, Fukushima Prefecture)

Large-scale network for maritime hydrogen transport

2020 Japan-Australia and Japan-Brunei Hydrogen Energy Supply Chain Project Demonstration

Hydrogen power generation demonstration test

### Mineral resources

**Q** Have there been advances in research and development of domestic resources?

**A** An electric vehicle (EV) requires a large amount of mineral resources. Of particular importance are the minerals known as “rare earth metals”. The lithium-ion battery that accounts for 1/3 of the vehicle price contains rare earth metals such as lithium, cobalt, nickel, and graphite. Japan relies on imports for nearly 100% of its mineral resources demands.

Japan has the world’s 6th largest Territorial Sea / Exclusive Economic Zone (EEZ). This ocean area includes 4 marine mineral resource areas containing different metals. Suitable technologies are being developed according to the depth and distribution of each resource.

### Learn about the mineral resources that support industries around the world.

Rare earth metals and other mineral resources have become important resources that support industries all over the world. You may recall that they have frequently been hot topics, such as “rare earth metals” and “urban mines” - a term that describes scrapped home electronics and mobile phones that contain mineral resources. Here we will introduce some mineral resources that play a variety of roles in places outside of sight.

Reference: [https://www.enecho.meti.go.jp/english/special/kaiyou/06_kouza/kouza_04.html](https://www.enecho.meti.go.jp/english/special/kaiyou/06_kouza/kouza_04.html)
10. 2018 energy topics

Hokkaido earthquake and blackout - 18 minutes from earthquake to blackout

An earthquake with a maximum seismic intensity of 7 struck Hokkaido at 3:07 on the morning of September 6, 2018. As a result of this earthquake, at 3:25 the entire Hokkaido area suffered large-scale blackout, an incident that Japan has never experienced. The blackout resulted from a combination of factors, including stoppage of the No. 1, 2, and 4 generators at the Tomatouatsuma Power Station, and multiple hydroelectric power generators that were taken offline by power transmission line accidents which affected 4 lines on 3 routes.

![Graph showing blackout timeline](image)

- **1.** Tomatouatsuma Power Station generators No. 2 and 4 stop.
- **2.** Receiving of Kita-Hon emergency power starts.
- **3.** Load shut-off occurs.
- **4.** Wind power stops.
- **5.** As a result of the transmission line accidents, power supply to the Eastern and Kitami areas stops. Hydroelectric power stops.
- **6.** The frequency drop stops at 46.13 Hz and begins recovering.

**Earthquake occurrence**

*1: Includes estimates but regarded highly possible due to data available.
*2: It is not certain at the present time, however this sequence of events is possible or at least cannot be ruled out.

Source: Created by the Agency for Natural Resources and Energy from the final report of the Verification Committee for the 2018 Hokkaido Eastern Ibusi Earthquake. Reference: https://www.occto.or.jp/linkai/hokkaido_kensho/hokkaidokensho_sashihououkoku.html

Renewable energy output restriction in mainland Kyushu

In order to maintain a balance between supply and demand and prevent widespread blackouts, when power supply exceeds demand, several measures are taken based on the priority dispatch rule which is determined by laws and regulations. At first, thermal power is curtailed, and pumping operation of pumped storage generation and electric transmission to other areas through interconnections are maximized. If an electrical surplus still remains, renewable electricity such as solar and wind is curtailed. In Kyushu, where solar PV was rapidly introduced, renewable curtailment occurred in October 2018 for the first time in mainland Japan. Solar and wind power generation tends to fluctuate depending on natural conditions, but renewable curtailment serves as a safety valve adjusting electric output when surplus occurs, which enable more renewable energy to be integrated into the power grid with security.

![Graph showing renewable energy output restriction](image)

Source: Based on Kyushu Electric Power Co., Inc. (http://www.kyuden.co.jp/power_usages/pdf/common/seigyo.pdf?dt=2019051700000)

Accidents involving solar cell power generation equipment

As a result of the torrential rains that struck western Japan and typhoons in 2018, solar panels were blown away, immersed in water, or dislodged. Windmills were also knocked over, and other accidents occurred that brought concerns about the safety of renewable energy to the forefront. Together with measures aimed at reducing the cost of renewable energy, efforts will be made to ensure safety, to promote cooperation with local communities, and to work out measures for disposal of solar panel waste so that renewable energy can be used as a stable power supply source over the long-term.

Contact: Research and Public Relations Office, General Policy Division, Director- General’s Secretariat, Agency for Natural Resources and Energy, Ministry of Economy, Trade and Industry
1-3-1 Kasunigaseki, Chiyoda-ku, Tokyo 100-8931
TEL: +81-(0)3-3501-1511 (main) https://www.enecho.meti.go.jp/

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