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?

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

**A** 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>Hydroelectric</th>
<th>Other</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. 1 Norway</td>
<td>19.4</td>
<td>59.7</td>
<td>18.0</td>
<td>6.2</td>
<td>1.3</td>
<td>0.3</td>
<td>98.2</td>
</tr>
<tr>
<td>No. 2 Australia</td>
<td>19.4</td>
<td>59.7</td>
<td>18.0</td>
<td>6.2</td>
<td>1.3</td>
<td>0.3</td>
<td>98.2</td>
</tr>
<tr>
<td>No. 3 Canada</td>
<td>19.4</td>
<td>59.7</td>
<td>18.0</td>
<td>6.2</td>
<td>1.3</td>
<td>0.3</td>
<td>98.2</td>
</tr>
<tr>
<td>No. 4 USA</td>
<td>19.4</td>
<td>59.7</td>
<td>18.0</td>
<td>6.2</td>
<td>1.3</td>
<td>0.3</td>
<td>98.2</td>
</tr>
<tr>
<td>No. 5 Japan</td>
<td>19.4</td>
<td>59.7</td>
<td>18.0</td>
<td>6.2</td>
<td>1.3</td>
<td>0.3</td>
<td>98.2</td>
</tr>
<tr>
<td>No. 6 UK</td>
<td>19.4</td>
<td>59.7</td>
<td>18.0</td>
<td>6.2</td>
<td>1.3</td>
<td>0.3</td>
<td>98.2</td>
</tr>
<tr>
<td>No. 7 France</td>
<td>19.4</td>
<td>59.7</td>
<td>18.0</td>
<td>6.2</td>
<td>1.3</td>
<td>0.3</td>
<td>98.2</td>
</tr>
<tr>
<td>No. 8 Germany</td>
<td>19.4</td>
<td>59.7</td>
<td>18.0</td>
<td>6.2</td>
<td>1.3</td>
<td>0.3</td>
<td>98.2</td>
</tr>
<tr>
<td>No. 9 Spain</td>
<td>19.4</td>
<td>59.7</td>
<td>18.0</td>
<td>6.2</td>
<td>1.3</td>
<td>0.3</td>
<td>98.2</td>
</tr>
<tr>
<td>No. 10 South Korea</td>
<td>19.4</td>
<td>59.7</td>
<td>18.0</td>
<td>6.2</td>
<td>1.3</td>
<td>0.3</td>
<td>98.2</td>
</tr>
</tbody>
</table>

Japan energy self-sufficiency ratio: **20.3%**

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 energy required for life and economic activity, the ratio that can be secured within a 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 ratio in the table is those of the 25 OECD member countries in 2017.*

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**Q** What resources does Japan depend on?

**A** Japan is largely 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**: 94.0% Nuclear power + 5.2% Hydroelectric
- **FY 2017**: 87.4% LNG + 11.6% Coal + 2.6% Nuclear power

Source: Comprehensive energy statistics.

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

**A** 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)

- **Oil**: 90.3% Middle East
- **LNG**: 82.85 million tons (84.7% Middle East)

Source: Trade statistics.

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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?

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 (Yen/kWh)</th>
<th>Industries (Yen/kWh)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2010</td>
<td>13.7</td>
<td>17.5</td>
</tr>
<tr>
<td>2011</td>
<td>14.5</td>
<td>15.7</td>
</tr>
<tr>
<td>2012</td>
<td>15.9</td>
<td>17.7</td>
</tr>
<tr>
<td>2013</td>
<td>16.6</td>
<td>17.6</td>
</tr>
<tr>
<td>2014</td>
<td>16.4</td>
<td>16.6</td>
</tr>
<tr>
<td>2015</td>
<td>16.5</td>
<td>16.8</td>
</tr>
<tr>
<td>2016</td>
<td>16.4</td>
<td>16.6</td>
</tr>
<tr>
<td>2017</td>
<td>16.5</td>
<td>16.6</td>
</tr>
</tbody>
</table>

Source: Created on monthly reports of generated and received electric power, and financial materials of each electric power company.

Factors causing changes in electricity rates: Renewable energy cost

- **Trends in Surcharge after Introducing the FIT**
  - **FIT costs (April 2012)**
    - 2.8 billion yen
  - **FIT costs (March 2019)**
    - 2.4 billion yen

- **Averaged surcharge price in 2018**
  - 0.75 yen/kWh (Average rate)

- **Change in average annual growth in 2018**
  - 9%

- **Average annual growth**
  - 10.602 billion kWh

- **Dependence on power from fossil fuels**
  - 100% in 2010, 80.9% in 2017

Source: Created by Agency for Natural Resources and Energy "Comprehensive energy statistics"

**Factors causing changes in electricity rates: Fuel prices**

- **The situation in the past where the crude oil price fell and the current situation**
  - International crude oil price WTI (USD/barrel)
  - US shale oil boom
  - Arab Spring

- **Decade since 2010**: Since the start of the "Arab Spring", crude oil prices have hovered around 100 USD due to geopolitical risks in the Middle East and North Africa regions. Subsequently, the price has fallen due to sluggish demand, overwhelmingly caused by steady production of US shale oil, and other factors.

- **According to the new policy scenario and other forecasts for the International Energy Agency (IEA)**
  - Price of crude oil is expected to be 96 USD/barrel in 2030 and 112 USD/barrel in 2040. This will make an impact on electricity rates and energy costs.

- **Japanese imported LNG price (USD/MMBTU)**
  - IEA Outlook (base policy scenario)
  - 2030: 96 USD/barrel
  - 2040: 112 USD/barrel

- **Surcharge price in 2019**
  - 2.95 yen/kWh

- **Average of FIT costs from 2012 to 2019**
  - 2.3 trillion yen

- **FIT costs**
  - Around 2.7 trillion yen

- **Average of FIT costs from 2012 to 2019**
  - 1.8 trillion yen

- **Surcharge price in 2019**
  - 767 yen

**Average model**: Monthly power usage 260 kWh model that is posted on the websites of the Tokyo EP and Kansai EP.

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 costs have reached 3.6 trillion yen (approximately 33 billion USD) and cost of the surcharge based on the standard model (260kWh/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.

Source: Created on the basis of NYXN announced figures and IEA World Energy Outlook 2018.

**Japan Energy 2018**

https://www.enecho.meti.go.jp/
3. How much greenhouse gases are being emitted?

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

### How much greenhouse gases are emitted in Japan?

**Q** 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 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.

**A**

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

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

#### 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>Year</th>
<th>16,000</th>
<th>14,000</th>
<th>12,000</th>
<th>10,000</th>
<th>8,000</th>
<th>6,000</th>
</tr>
</thead>
<tbody>
<tr>
<td>(MTCE)</td>
<td>USA (4,833)</td>
<td>28 EU countries (3,192)</td>
<td>India (2,076)</td>
<td>Russia (1,438)</td>
<td>USA (1,129)</td>
<td>Others (28.3%)</td>
</tr>
</tbody>
</table>

#### CO₂ emissions forecast

<table>
<thead>
<tr>
<th>Year</th>
<th>50,000</th>
<th>41,250</th>
<th>32,500</th>
<th>23,750</th>
<th>17,647</th>
</tr>
</thead>
<tbody>
<tr>
<td>(MTCE)</td>
<td>Scenario of maintaining current policies</td>
<td>New policy scenario</td>
<td>Sustainable development scenario</td>
<td>New policy scenario</td>
<td>Sustainable development scenario</td>
</tr>
</tbody>
</table>

### Global warming countermeasures: Paris Agreement, COP negotiations

- **November 2015: Adoption of the Paris Agreement (COP21)**
  - The target is set to keep a global temperature rise well below 2°C above pre-industrial levels and pursue efforts to limit the temperature increase even further to 1.5°C.

- **November 2016: Paris Agreement takes effect.**

- **December 2018: Decision of Paris Agreement Implementation rules (COP24 Katowice, Poland)**
  - The rules necessary to fully implement the Paris Agreement beginning from 2020 were adopted.

All countries including developed and developing countries must submit targets for reducing greenhouse gas emissions.

All countries are to take action including reporting their emissions and submitting reduction targets under the same rules.

### Japan 2030 target: 26% reduction from FY 2013 level

Japanese reduction targets are in comparison to the 2013 level. USA targets are in comparison to the 2005 level. EU targets are in comparison to the 1990 level. When the targets are all converted to 2013 values for comparison, you can see that the target for Japan is high.

### Source

- Comprehensive energy statistics, environmental action plans (EAP), and calculation results of the amount of greenhouse gas emissions in Japan (Ministry of the Environment).
- FY 2017 greenhouse gas emissions
- Comparison of pledges from major countries (targets for reduction of greenhouse gas emissions) (Ministry of Economy, Trade and Industry created)

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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: No change 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?

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?

A

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

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 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.

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 is the first project to construct 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 water 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 (Tosимa Town)
Universities, research institutes, and companies within and outside Japan have gathered in Fukushima and are conducting research related to decommissioning nuclear reactors and other subjects.

Naraha Center for Remote Control Technology Development (Naraha Town)
Conducting investigations of reactor containment 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 kW demonstration project - 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 Shintori Town, Soma City, Namie Town, Naraha Town and Katsurao Village

Handling of the water stored in the tanks
At present, the water in the tanks has been treated by multiple treatment facilities which reduced the concentration of radioactive substances to around 1/1,000,000 of the original value. Because this water contains tritium, which cannot be removed by purification facilities, and other nuclides. The handling of the water is the problem. Consultations are being conducted, including societal perspectives such as the reputational damage.

For a simple exploration of the basics and the latest information related to the contaminated water management, please visit our website.

Related Article
ALPS-Treated Water Stored at the TEPCO Fukushima Daiichi Nuclear Power Station
JET - Japan Economic Foundation
Reference: https://www.jet.or.jp/journals/pdf/222th_Special_Article_01.pdf

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.
- Unlike the period immediately after the earthquake, no products received the standard limit (100 bq/kg) in recent years.
- There have been zero incidents of rice exceeding the standard since 2015 crop, and zero incidents of meat exceeding the standard since April 2017 (except for cases outside specified areas due to the necessity of food security).

Status of monitoring inspections for agricultural, forestry and fishery products
- Number of samples: 2,230
- Number of samples monitoring: 2,230
- Percentage of samples meeting the standard: 100%

*Fruits excludes chestnuts from certain areas
Argentina, Turkey, and Brazil have lifted their import restrictions, while import restrictions have been relaxed in China and the USA.

Source: Created by Reconstruction Agency based on Progress of Fukushima Recovery (Ver. 2.2) and the newly released in Fukushima homepage.

Toward Reconstruction of Fukushima

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 reoccupation 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.
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)

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)

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
Japan achieved economic growth through past policy choices to reduce dependence on coal and oil. The country is making steady progress towards achieving the target energy mix in 2030, and a carbon-free energy supply has become visible as a possible direction for 2050.

Innovations aimed at achieving zero carbon
Innovations are the key to the decarbonization challenge that we are looking at for 2050. For this purpose, it is important to pursue all options including renewable energy, nuclear power, hydrogen, storage batteries, and CCUS.

Q  What will the future composition of power sources look like?

A  The figure below shows the ideal energy supply and demand structure for the future (FY 2030) that will be realized by policies aimed at achieving 3E+S based on the basic energy policies.

Primary energy supply

Composition of Power Sources

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

Energy Security

Economic Efficiency

Environment

* 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 figure) and other information.

Source: Created by the Agency for Natural Resources and Energy
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**

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>Year</th>
<th>Industry</th>
<th>Services</th>
<th>Household</th>
</tr>
</thead>
<tbody>
<tr>
<td>FY 2013 (actual)</td>
<td>140 million kJ</td>
<td>65 million kJ</td>
<td>52 million kJ</td>
</tr>
<tr>
<td>FY 2020 (after energy efficiency programs)</td>
<td>170 million kJ</td>
<td>62 million kJ</td>
<td>54 million kJ</td>
</tr>
</tbody>
</table>

**Improvement of Energy Consumption Efficiency**

- **FY 1970-1980** Average consumption: 110 kJ
- **FY 2000-2010** Average consumption: 100 kJ

**Progress of improving energy efficiency**

**Main measures to improve energy efficiency**

<table>
<thead>
<tr>
<th>Sector</th>
<th>FY 2016</th>
<th>FY 2030</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Industry</strong></td>
<td>Top Runner Motors (Wide spread use in pumps, fans, etc.)</td>
<td>Approx. 1.48 million units (90.000 kJ)</td>
</tr>
<tr>
<td></td>
<td>Adoption rate</td>
<td>41%</td>
</tr>
<tr>
<td><strong>Services</strong></td>
<td>Buildings</td>
<td>Large unit: 97% Medium unit: 94% Small unit: 96%</td>
</tr>
<tr>
<td></td>
<td>High efficiency hot water systems</td>
<td>Approx. 101.01 million (202,000 kJ)</td>
</tr>
<tr>
<td></td>
<td>Units in use</td>
<td></td>
</tr>
</tbody>
</table>

**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 e-commerce market (which has grown 1.8 times for the past 5 years).

**Changes in home deliveries**

- **FY 1990** 4.5 billion
- **FY 2010** 3.22 billion
- **FY 2017** 4.25 billion

### The Act on the Rational Use of Energy

Lacking 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.

### Introduction of Renewable Energy

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

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?

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>Source of Energy</th>
<th>Nuclear power 11.8%</th>
<th>Nuclear power 21.3%</th>
<th>Nuclear power 12.6%</th>
<th>Nuclear power 19.8%</th>
<th>Nuclear power 14.7%</th>
<th>Nuclear power 3.2%</th>
<th>Nuclear power 3.1%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Natural gas</td>
<td>15.4</td>
<td>23.5</td>
<td>47.5</td>
<td>31.0</td>
<td>39.5</td>
<td>68.6</td>
<td>66.6</td>
</tr>
<tr>
<td>O/LJHA</td>
<td>6.1</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>Coal</td>
<td>38.9</td>
<td>17.2</td>
<td>7.0</td>
<td>9.0</td>
<td>32.7</td>
<td>38.9</td>
<td>32.7</td>
</tr>
<tr>
<td>Hydroelectric</td>
<td>3.1</td>
<td>6.0</td>
<td>13.3</td>
<td>18.8</td>
<td>7.0</td>
<td>3.1</td>
<td>3.1</td>
</tr>
<tr>
<td>Renewable energy</td>
<td>Hydroelectric</td>
<td>12.9</td>
<td>12.9</td>
<td>18.8</td>
<td>12.9</td>
<td>12.9</td>
<td>12.9</td>
</tr>
<tr>
<td>Total</td>
<td>100%</td>
<td>100%</td>
<td>100%</td>
<td>100%</td>
<td>100%</td>
<td>100%</td>
<td>100%</td>
</tr>
</tbody>
</table>

### Questions and Answers

#### 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)

Source: Investigation by the Agency for Natural Resources and Energy
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, and 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>Owners</th>
<th>Reactors in operation</th>
<th>Reactors approved for installation license amendment</th>
<th>Reactors under assessment for new regulatory requirements</th>
<th>Reactors that have not been applied for assessment</th>
<th>Reactors to be decommissioned</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hokkaido</td>
<td>(TEPCO) Tomari Nuclear Power Plant</td>
<td>TEPCO</td>
<td>9</td>
<td>9</td>
<td>12</td>
<td>9</td>
<td>24</td>
</tr>
<tr>
<td>Niigata</td>
<td>(TEPCO) Tsuruga Nuclear Power Plant</td>
<td>TEPCO</td>
<td>8</td>
<td>8</td>
<td>8</td>
<td>8</td>
<td>8</td>
</tr>
<tr>
<td>Fukushima</td>
<td>(KEPCO) Higashidori Nuclear Power Plant</td>
<td>KEPCO</td>
<td>7</td>
<td>7</td>
<td>7</td>
<td>7</td>
<td>7</td>
</tr>
<tr>
<td>Miyagi</td>
<td>(TEPCO) Onagawa Nuclear Power Plant</td>
<td>KEPCO</td>
<td>6</td>
<td>6</td>
<td>6</td>
<td>6</td>
<td>6</td>
</tr>
<tr>
<td>Shikoku</td>
<td>(TEPCO) Fukushima #1 Nuclear Power Plant</td>
<td>KEPCO</td>
<td>5</td>
<td>5</td>
<td>5</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>Ibaraki</td>
<td>(JAPC) Tokai/Tokai No.2 Power Plant</td>
<td>JAPC</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>Chiba</td>
<td>(Shikoku EPC) Hamaoka Nuclear Power Plant</td>
<td>Chiba</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>Saga</td>
<td>(TEPCO) Genkai Nuclear Power Plant</td>
<td>KEPCO</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Kagoshima</td>
<td>(Shikoku EPC) Sendai Nuclear Power Plant</td>
<td>Shikoku</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
</tbody>
</table>

(As of Aug. 5, 2016)

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 its new regulatory requirements. Measures to prevent accidents are being reinforced and prepared for emergencies enhanced as well.

New regulatory requirements (July 2013)

- Anti-terrorism measures (newly introduced)
- Measures against intentional aircraft collisions
- Measures against the proliferation of radiological 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 internal overflows (newly introduced)
- Preparedness for fires
- Preparedness for natural phenomena
- Preparedness for fires
- Preparedness for natural phenomena
- Preparedness for fires
- Reliability of power sources
- Performance of other instruments
- 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).

Scientific characteristics map

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. Reference: https://www.eenecho.meti.go.jp/category/electricity_and_gas/nuclear/ri_hagakutekelokusumap/

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.

Reference: https://www.eenecho.meti.go.jp/about/special/shihenkou/shiapoutennergy.html

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)

<table>
<thead>
<tr>
<th>Country</th>
<th>Power generation capacity</th>
</tr>
</thead>
<tbody>
<tr>
<td>USA</td>
<td>388.8</td>
</tr>
<tr>
<td>France</td>
<td>232.8</td>
</tr>
<tr>
<td>China</td>
<td>90.1</td>
</tr>
<tr>
<td>Russia</td>
<td>141.3</td>
</tr>
<tr>
<td>South Korea</td>
<td>95.1</td>
</tr>
<tr>
<td>Canada</td>
<td>80.4</td>
</tr>
<tr>
<td>Germany</td>
<td>72.2</td>
</tr>
<tr>
<td>UK</td>
<td>63.9</td>
</tr>
<tr>
<td>Sweden</td>
<td>56.6</td>
</tr>
<tr>
<td>Spain</td>
<td>36.1</td>
</tr>
<tr>
<td>Belgium</td>
<td>6.0</td>
</tr>
<tr>
<td>India</td>
<td>34.9</td>
</tr>
<tr>
<td>Japan</td>
<td>29.3</td>
</tr>
<tr>
<td>Czech Republic</td>
<td>26.8</td>
</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th>Country</th>
<th>Power generation capacity</th>
</tr>
</thead>
<tbody>
<tr>
<td>China</td>
<td>21.3</td>
</tr>
<tr>
<td>South Korea</td>
<td>5.7</td>
</tr>
<tr>
<td>UAE</td>
<td>5.6</td>
</tr>
<tr>
<td>Russia</td>
<td>4.7</td>
</tr>
<tr>
<td>India</td>
<td>4.3</td>
</tr>
<tr>
<td>USA</td>
<td>2.5</td>
</tr>
<tr>
<td>Belarus</td>
<td>2.4</td>
</tr>
<tr>
<td>Pakistan</td>
<td>2.2</td>
</tr>
<tr>
<td>Ukraine</td>
<td>2.2</td>
</tr>
<tr>
<td>Finland</td>
<td>1.7</td>
</tr>
<tr>
<td>France</td>
<td>1.7</td>
</tr>
<tr>
<td>Bangladesh</td>
<td>1.2</td>
</tr>
<tr>
<td>Slovakia</td>
<td>0.9</td>
</tr>
</tbody>
</table>

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

IAEA Tracking Clean Energy Progress
9. Will hydrogen energy and power storage technologies come into general use?

**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

- **Unstable electrical power source**
- **Water electrolysis**
- **Stable electrical power source**
- **Power grid (power lines)**
- **Production of hydrogén**
- **Use**

Hydrogen station

- **Hydrogen power generation**
- **Fuel cell cogeneration**
- **Fuel cell vehicle**

Large-scale network for maritime hydrogen transport

- **Fukushima Hydrogen Energy Research Field**
- **2020 Demonstration project for large-scale hydrogen production using renewable energy - aiming for use during the Tokyo Olympics (Nami Town, Fukushima Prefecture)**

Hydrogen power generation demonstration test

- **2020 Japan-Australia and Japan-Brunei Hydrogen Energy Supply Chain Project Demonstration**
- **2018 The world’s first city district to achieve 100% hydrogen supply of heat and power entirely by hydrogen (NEED)**

Fukushima Hydrogen Energy Research Field

One of the projects aimed at the conversion to a hydrogen supply structure is the Fukushima Hydrogen Energy Research Field that is underway in Nami Town, Fukushima Prefecture. The goal is not only to utilize the hydrogen that is produced in Nami Town within Fukushima Prefecture, but also to utilize it in Tokyo during the Tokyo 2020 Olympic and Paralympic Games. Reference: https://www.enecho.meti.go.jp/about/special/photoKyoto/fukushimaasahoro.html

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**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.

<table>
<thead>
<tr>
<th>Resources</th>
<th>Distribution</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lithium (2017)</td>
<td>Zimbabwe 2.3% China 7.0% Others 1.6%</td>
</tr>
<tr>
<td>Cobalt (2017)</td>
<td>Democratic Republic of the Congo 62%</td>
</tr>
<tr>
<td>Nickel (2017)</td>
<td>Indonesia 19.0% Others 31.7%</td>
</tr>
</tbody>
</table>

Source: USGS (Mineral Commodity Summaries 2018)

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 scraped home electronics and mobile phones that contain mineral resources. Here we will introduce some mineral resources that play a variety of roles in places out of sight. Reference: https://www.enecho.meti.go.jp/about/special/tokaihu/zenenho/s-major.html#header
**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 Tomatuouatsuma Power Station, and multiple hydroelectric power generators that were taken offline by power transmission line accidents which affected 4 lines on 3 routes.

<table>
<thead>
<tr>
<th>Step</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Power is restored to the Eastern area.</td>
</tr>
<tr>
<td>2.</td>
<td>Frequency drops due to the increase in demand.</td>
</tr>
<tr>
<td>3.</td>
<td>The load dispatching center instructs the hydroelectric and thermal power stations that were stopped for balance to start up.</td>
</tr>
<tr>
<td>4.</td>
<td>Load-shutdown occurs.</td>
</tr>
<tr>
<td>5.</td>
<td>Power supply to the Eastern and Kitami areas stops. Hydroelectric power stops.</td>
</tr>
<tr>
<td>6.</td>
<td>The frequency drop stops at 46.13 Hz and begins recovering.</td>
</tr>
<tr>
<td>7.</td>
<td>Earthquake occurrence</td>
</tr>
</tbody>
</table>

*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 Iburi Earthquake.  
Reference: https://www.occto.or.jp/inTRA/hokkaido_kensho/hokkaidokensho_sashihoukoku.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.

Source: Based on Kyushu Electric Power Co., Inc.  
(http://www.kyuden.co.jp/power_usages/pdf/common/seigyo.pdf?d=20190517000000)

**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.