Japan’s Energy Transition toward Carbon Neutrality by 2050

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2050 Carbon Neutrality Goal and Revised 2030 Energy Mix Target

- October 2020, PM Suga declared net-zero GHG by 2050 goal.
- December 2020, updated in June 2021, Green Growth Strategy covering 14 sectors, e.g. offshore wind, fuel ammonia, hydrogen, nuclear, mobility/battery
- April 2021, PM Suga announced 46% GHG reduction target in 2030
- May 2021, CN 2050 is enacted (Law on Measures to Cope with Global Warming) by consensus
- October 2021, Kishida government has decided Basic Energy Plan and 2030 Energy mix
- May 2022, Kishida government has announced provisional Clean Energy Strategy
Path to 2050 CN through 2030

- **2019**
  - Consumer: 110 mill ton
  - Industry: 280 mill ton
  - Transport: 200 mill ton
  - Non-electricity: 1.03 bill ton

- **2030**
  - Values are the amounts of CO2 derived from energy (46% reduction compared to 2013, total GHG emission)
  - Continue challenge up to 50% reduction

- **2050**
  - Emission reduction + Removals = net zero (▲100%)

- **Mainstreaming renewable energy.**
- **Re-establishment of the nuclear energy policy.**
- **Reduce the ratio of thermal power generation based on the premise of stable supply.**
- **Hydrogen/ammonia power generation.**

- **Electrification by decarbonized power.**
- **Pursue options: hydrogen, ammonia, CCUS/CR.**
- **Use carbon removal technologies for leftover.**

- **Efforts for the utilization of renewable energy as the major power.**
- **Use of nuclear power.**
- **Pursue options: hydrogen, ammonia, CCUS/CR.**

- **Hydrogen**
- **Decarbonized electricity sources**
- **Synthesis fuel methanation**
- **Biomass**
- **Plantation, DACCs, etc**

Source: METI
Revised Energy Mix in 2030

Energy Demand

- 363M kL
  - Electricity 25%
  - Heat & Fuels 75%

- 326M kL
  - Electricity About 28%
  - Heat & Fuels About 72%

- 280M kL
  - Electricity About 30%
  - Heat & Fuels About 70%

Primary Energy Supply

- 430M kL
  - Hydrogen & Ammonia 1%
  - Self-sufficiency About 30%

- 489M kL
  - Renewables 20%
  - Nuclear 10%
  - Natural gas 18%
  - Coal 20%
  - Oil 30%

Source: METI

- The self-sufficiency rate is about a little over 30% on a comprehensive energy statistics basis and about a little under 30% on an IEA basis.
- Note that the integrated energy statistics have been revised since the formulation of the Long-Term Energy Supply and Demand Outlook in 2015, and the actual figures for FY2013 as the starting point for the FY2030 estimates are different, so simple comparisons cannot be made.

Economic Growth: 1.4% / Year
Population: -0.6%
Passenger Volume: -2%

280M kL
Revised Energy Mix in 2030 (2): Power Mix in 2030

An ambitious deeper conservation by 230 TWh (-20%)

Electricity Demand

- FY2013: 989.6 TWh
- FY2030 (As of FY2015): 870 TWh
- FY2030: 980.8 TWh

Power Mix

- FY2019: 1,024 TWh
- FY2030: 930-940 TWh
- FY2030 (As of FY2015): 1,065 TWh

- Renewables: 18%
- Nuclear: 6%
- LNG: 37%
- Coal: 32%
- Oil: 7%

- Non-fossil fuel: 24%
- Non-fossil fuel: 59%
- Non-fossil fuel: 44%
- Fossil fuel: 76%
- Fossil fuel: 20%
- Fossil fuel: 22%

Source: METI
### 14 sectors in the Green Growth Strategy (Dec. 2020, June 2021)

<table>
<thead>
<tr>
<th>Energy</th>
<th>Transport/Manufacturing</th>
<th>Home/Office</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Offshore wind power</strong>&lt;br&gt;Wind turbines, parts, floating wind turbines</td>
<td><strong>Mobility and battery</strong>&lt;br&gt;EV (electric vehicle), FCV (fuel cell vehicle), next generation batteries</td>
<td><strong>Housing and building,</strong>&lt;br&gt;Next generation PV&lt;br&gt;(perovskite solar cell)</td>
</tr>
<tr>
<td><strong>Ammonia fuel</strong>&lt;br&gt;Combustion burner (as fuel in transition period to hydrogen-powered society)</td>
<td><strong>Semiconductor and ICT</strong>&lt;br&gt;Data centers, energy-saving semiconductors (demand-side efficiency)</td>
<td><strong>Lifestyle-related industry</strong>&lt;br&gt;Local decarbonization business</td>
</tr>
<tr>
<td><strong>Hydrogen</strong>&lt;br&gt;Turbines for power generation, hydrogen reduction steel-making, carrier ships, water electrolyzers</td>
<td><strong>Maritime</strong>&lt;br&gt;Fuel-cell ships, electric propulsion ships, gas-fueled ships</td>
<td><strong>Resource circulation</strong>&lt;br&gt;Biomaterials, recycled materials, waste power generation</td>
</tr>
<tr>
<td><strong>Nuclear power</strong>&lt;br&gt;SMR (Small Modular Reactor), nuclear power for hydrogen production</td>
<td><strong>Logistics, people flow and infrastructure</strong>&lt;br&gt;Smart transportation, drones for logistics, fuel-cell construction machinery</td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>Foods, agriculture, forestry and fisheries</strong>&lt;br&gt;Smart-agriculture, wooden skyscrapers, blue carbon</td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>Aviation</strong>&lt;br&gt;Hybrid electric, Hydrogen-powered, Aircraft</td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>Carbon Recycling</strong>&lt;br&gt;Concrete, biofuel, plastic materials</td>
<td></td>
</tr>
</tbody>
</table>

Source: METI
Clean Energy Strategy (provisional) (May 2022)

- Society, economic and industrial structure has to be converted.
- Necessary decarbonization investment: 17 trillion yen (130 billion US$) /2030 (3% of GDP)
  - power gen. / fuel conversion (renewables, hydrogen/ammonia, batteries, etc.): 5 trillion yen
  - manufacturing process (steel, chemical, etc.): 2 trillion yen
  - end-use (buildings, autos, etc.): 4 trillion yen
  - infrastructure (grids, charging stations, etc.): 4 trillion yen
  - R&D: 2 trillion yen
- 150 trillion yen (1.2 trillion US$) /next 10 years
- Fiscal stimuli, regulatory/market design, finance, GX League development, global strategy

Source: METI
Challenge: Renewables

- 330-350TWh in 2030 by the current and the additional stronger policies
- Toward 2050 is unknown horizon. A variety of challenges face, kW and kWh.

Source: IEEJ
Challenge: Nuclear (1) Existing Plants

Extension of lifetime or construction of new reactors is required

20-22% target requires 30-35GW

New target may requires 27 NPP in operation

Re-started capacity as of August 2019 9.1GW

Source: IEEJ
Challenge: Nuclear (2) Innovation

- Through **NEXIP** and other programs, METI supports various types of nuclear reactor technologies including **international cooperation projects**.
- The Japan Atomic Energy Agency (JAEA) possess **important test facilities**.

**Small Modular LWR**
- Smaller size, modular type
- Passive safety
  - ✔ Affordable capital cost
  - ✔ Smaller EPZ

**Fast Reactor**
- Sodium-cooled reactor
- Fast neutrons
  - ✔ Effective use of resources
  - ✔ HLW management

**High Temperature Gas-cooled Reactor**
- Helium gas-cooled reactor (chemically stable)
- Coated particle fuel
- Very high temperature
  - ✔ Heat/hydrogen use
  - ✔ Smaller EPZ

**International Cooperation**

- **France**
  - Fast reactor R&D cooperation based on simulations and experiment

- **U.K.**
  - High-temperature Gas-cooled Reactor

- **U.S.**
  - Versatile Test Reactor (VTR) cooperation

**JAEA’s Facilities**

- **Joyo**:
  - Experimental Fast Reactor
- **HTTR**:
  - Experimental HTGR

Source: METI
Challenge: Hydrogen & Ammonia

- **Basic Hydrogen Strategy (2017)**
  - First comprehensive national strategy
  - H₂ as a future energy option toward 2050
  - Goals: making H₂ affordable
    - Cost: $10/kg ⇒ $3/kg by 2030 & less than $2/kg by 2050
    - Scale up: up to 3 Mts by 2030 & around 20 Mts by 2050

  3 conditions for realizing affordable hydrogen

  [Supply]  
  ① Inexpensive feedstock (unused resources, renewables)
  ② Large scale H₂ supply chains

  [Demand]  
  ... ③ Mass usage (Mobility ⇒ Power Generation ⇒ Industry)

- **Key Technologies**
  - Production
    - Electrolysis System
    - Gasification + CCS
  - Transportation
    - Energy Carrier (LH₂, MCH, NH₃, etc.)
  - Use
    - Fuel Cells (Mobility, Generation)
    - H₂-fired Generation

Source: METI
Challenge: Technology & Innovation

It is important to accelerate innovation and prepare for the next generation of further actions.

In order to realize the practical use of next-generation low-carbon technologies, it is important to accelerate technology development and promote demonstration facts on the scale of 90 billion dollars by 2030. To achieve this, more international cooperation is essential.

Source: IEA
## Challenge: Cost

### 2050 Electricity cost analysis by scenario

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Power generation</th>
<th>RE: %</th>
<th>Nuclear: %</th>
<th>H2/ Ammonia: %</th>
<th>CCUS power: %</th>
<th>Electricity cost JPY / kWh</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reference Case</td>
<td>1,350 TWh</td>
<td>54</td>
<td>10</td>
<td>13</td>
<td>23</td>
<td>24.9</td>
</tr>
<tr>
<td>RE: 100%</td>
<td>1,050 TWh</td>
<td>100</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>53.4</td>
</tr>
<tr>
<td>RE innovation</td>
<td>1,500 TWh</td>
<td>63</td>
<td>10</td>
<td>2</td>
<td>25</td>
<td>22.4</td>
</tr>
<tr>
<td>High nuclear</td>
<td>1,350 TWh</td>
<td>53</td>
<td>20</td>
<td>4</td>
<td>23</td>
<td>24.1                    (Max nuclear 19.5)</td>
</tr>
<tr>
<td>H2 innovation</td>
<td>1,350 TWh</td>
<td>47</td>
<td>10</td>
<td>23</td>
<td>20</td>
<td>23.5</td>
</tr>
<tr>
<td>High CCUS</td>
<td>1,350 TWh</td>
<td>44</td>
<td>10</td>
<td>10</td>
<td>35</td>
<td>22.7</td>
</tr>
<tr>
<td>Demand transformation</td>
<td>1,350 TWh</td>
<td>51</td>
<td>10</td>
<td>15</td>
<td>24</td>
<td>24.6</td>
</tr>
</tbody>
</table>

Source: IEEJ
Challenge: Carbon Pricing

- PM Kishida instructed ministries to conclude carbon pricing policy (Jan. 2022)
- MOE has proposed to raise carbon tax level (289 yen/CO2 t)
- METI has proposed GX League (voluntary commitments and carbon market)
- Clean Energy Strategy (provisional) has suggested to develop GX League to stronger framework, continuing discussion on carbon tax
Challenge: International Cooperation: AETI and Asia Zero-Emission Community

- Japan announced “Asia Energy Transition Initiative (AETI)” in the Special ASEAN Ministers meeting in June 2021 and the 1st Asia Green Growth Partnership Ministerial Meeting of ASEAN Ministers in October 2021
- PM Kishida announced “Asia Zero-Emission Community” based on AETI

1. Tech. development: roadmaps for transitions, hydrogen/ammonia, zero-emission thermal power, etc.
2. Co-investment, Co-finance: Asia Transition Finance rules, disclosure rule, building hydrogen/ammonia supply chains, Asia CCUS networks, etc.
3. Standardization: international standards, human resource development, emission data collaboration, etc.
4. Carbon credit market: assisting market mechanism, expansion of JCM partners,

Source: METI
JUCEP was established under the two partnerships of the “Japan-U.S. Competitiveness and Resilience (CoRe) Partnership” and the “Japan-U.S. Climate Partnership on Ambition, Decarbonization, and Clean Energy” announced at the Japan-U.S. summit meeting in April, 2021.

JUCEP is a framework to help Indo-Pacific countries utilize clean, affordable and secure energy technologies to accelerate decarbonization while promoting a stable energy supply and sustainable growth. It aims to contribute to the realization of the "Free and Open Indo-Pacific (FOIP)" through an open, competitive and transparent energy markets.

<Key Cooperation Areas>
1. **Renewable Energy**: Geothermal, wind, solar, hydropower, and critical minerals
2. **Power Grid Modernization**: Grid stability, energy management technology including battery storage, and transmission
3. **Nuclear Energy**: Advanced technologies such as small modular reactors and light water reactors.
4. **Decarbonization technologies**: CCUS/Carbon Recycling and other abatement technologies, as well as advanced fuels like ammonia, hydrogen, and others

Source: METI
Conclusion

- Japan's goals of Carbon Neutrality 2050 and 46% reduction 2030 are extremely tough mission.
- Toward 2030, existing technologies have to be deployed with utmost political, industrial and the public efforts.
- Toward 2050, Japan, as a technology leader, has to contribute to the world with new technology development.
- For global emission reduction on cost-effective basis and technology development, international cooperation is key.
- Article 6 of Paris Agreement (Market Mechanism) has to be utilized.