Energy trends in Japan

The Institute of Energy Economics, Japan

Energy Dialogue

Lund University, East Asian Student Association
IEEJ
1. Overview of energy trends and perspective in Japan

2. Renewable Energy Policy

3. Climate Change Policy

4. New Energy Policy - Hydrogen -
1. Overview of energy trends and perspective in Japan

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Energy is an important agenda for realizing a sustainable society

Paris Agreement\(^1\)

Article 2
"This agreement ... aims to strengthen the global response to the threat of climate change ..., including by (a) **Holding the increase in the global average temperature to well below 2\(^o\)C above pre-industrial levels ...**"

Energy-related CO\(_2\) emissions\(^2\)

- "Energy-related CO\(_2\)" is CO\(_2\) from fuel combustion
- Energy-related CO\(_2\) accounts for 60%+ globally. "Other GHGs" include forestry and land-use changes
- Decarbonizing energy sector is crucial for mitigating climate change

Nations Unies
Conférence sur les Changements Climatiques 2015

Global GHGs, 2010
49GtCO\(_2\)-eq

Other GHGs
38%

Energy-related CO\(_2\)
62%

Japan, 2015
87.6%

Sweden, 2013
68%

USA, 2016
76%

1 Source: UNFCCC.
2 GHG=Green House Gas (such as CO\(_2\), CH\(_4\), N\(_2\)O, HFC, PFC, SF\(_6\)). The figures are estimated combining the IPCC’s fifth assessment report (Figure 1.3) and the IEA CO2 Emissions from Fuel Combustion
Japan is one of the largest energy consumers

**Major energy consumers, 2015**

Unit: Million tons of oil equivalent (Mtoe)

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>China</td>
<td>2973</td>
<td>Population 127.1 Million</td>
</tr>
<tr>
<td>USA</td>
<td>430</td>
<td>GDP 4 395 Bil. USD</td>
</tr>
<tr>
<td>India</td>
<td>297</td>
<td>Area 378 000 km²</td>
</tr>
<tr>
<td>Canada</td>
<td>204</td>
<td>Per-capita energy consumption 3.4 toe/capita</td>
</tr>
<tr>
<td>Brazil</td>
<td>204</td>
<td>Japan 127.1 Million</td>
</tr>
<tr>
<td>France</td>
<td>104</td>
<td>Sweden 4.6 toe/capita</td>
</tr>
<tr>
<td>Germany</td>
<td>61</td>
<td>Japan 4 395 Bil. USD</td>
</tr>
<tr>
<td>Russia</td>
<td>61</td>
<td>Sweden 458 Bil. USD</td>
</tr>
<tr>
<td>Sweden</td>
<td>45</td>
<td>Japan 378 000 km²</td>
</tr>
</tbody>
</table>

- China and the US are by far the largest energy consumers
- Japan is the fifth largest, accounting for 3% in the world (consuming almost 10 times larger than Sweden)

1 Primary energy consumption, including coal, oil, natural gas, nuclear and renewables consumption. Data from the IEA Energy Balance Table.
2 Data in 2017.
Fossil fuels dominate in Japan’s energy mix, while non-fossils in Sweden

Primary energy supply in Japan and Sweden\(^1\)

Unit: Million tons of oil equivalent (Mtoe)

- Japan has diversified its energy mix since the 1970s (after the two oil crises). Nuclear shrunk after the earthquake in 2011.
- Nuclear and renewables together contribute to 74% of Sweden’s energy mix in 2017.

\(^1\) Data from the IEA Energy Balance Table.
After the nuclear accident, the government introduced FiT (Feed-in Tariff) in 2012, which boosted solar PV

Renewable energy capacity in Japan

Unit: Giga-Watt (GW)

FiT started from July 2012
Yet, renewables face challenges in Japan

- **Solar PV**: intermittency (frequency control, voltage stabilization, ...), ...
- **Onshore wind**: intermittency, geographical imbalance, ...
- **Offshore wind**: intermittency, costs, ...
- **Geothermal**: resource location (national park, hot spring area, ...)
- **Biomass**: costs (production and transportation), ...

**Example of solar PV intermittency**

**Wind resources: mainly in Hokkaido and Tohoku**

**Geothermal potential: mainly in national park area**


The government pursues relatively well-balanced energy mix to achieve the “3E+S” policy

Outlook for power generation

Fiscal year 2030

<table>
<thead>
<tr>
<th>Energy Source</th>
<th>Share FY2030</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oil</td>
<td>3%</td>
</tr>
<tr>
<td>LNG</td>
<td>27%</td>
</tr>
<tr>
<td>Coal</td>
<td>26%</td>
</tr>
<tr>
<td>Nuclear</td>
<td>20-22%</td>
</tr>
<tr>
<td>Renewables</td>
<td>22-24%</td>
</tr>
<tr>
<td>Total generation</td>
<td>1065 TWh</td>
</tr>
</tbody>
</table>

Energy-related CO₂ emissions

Unit: Mt-CO₂

<table>
<thead>
<tr>
<th></th>
<th>FY2013</th>
<th>FY2030</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total emissions</td>
<td>1,235</td>
<td>927 (24% from 2005)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(-25% from 2013)</td>
</tr>
<tr>
<td>Power generation</td>
<td>548</td>
<td>360 (22% from 2005)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(-34% from 2013)</td>
</tr>
</tbody>
</table>

- The share of nuclear decreases compared to the level before the earthquake (about 30%)
- Energy-related CO₂ in FY2030 is expected to decrease by 25% from FY2013
- This government’s outlook is used as the basis for Japan’s NDC (Nationally Determined Contribution)

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Renewables have achieved 26% of the average annual growth rate mainly due to the increase of Solar PV

- The main driver shifted from RPS and residential surplus electricity purchasing to **FIT in 2012**
  - 26% annual increase of renewables
  - Solar PV rapidly increased (5.6GW (2012) → 39GW (2016))

**Trend in renewables generation by technology**

Source: METI
Examples of the renewable projects in Japan

**Wind Project**
- Location: Shimane
- Operation: June 2016
- Wind: 48MW
- Electricity Supply: 23,000 houses

**Solar PV Project**
- Location: Chiba (444,000 m²)
- Operation: July 2014
- PV: 40.4MW
- CO2 reduction: 15,700 t/year
The government sets the target to introduce renewables 22-24% of the power supply by FY2030

- **FY2010:**
  - Renewables: 10%
  - Nuclear: 25%
  - Thermal power: 65%

- **FY2016:**
  - Renewables: 14.5%
  - Nuclear: 1.7%
  - Thermal power: 83.8%

- **FY2030:**
  - Renewables: 22 - 24%
  - Thermal power: 56%
  - LNG: 27%
  - Petroleum: 3%
  - Coal: 26%

Source: METI
Toward 2030, the introduction of Solar PV shows the distinctive proportion

<table>
<thead>
<tr>
<th>Source: METI</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th></th>
<th>Before FIT (June 2012)</th>
<th>After FIT [A] (as of Sep 2017)</th>
<th>Target [B] (FY2030)</th>
<th>Progress [A]/[B]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Geothermal</td>
<td>0.5GW</td>
<td>0.5GW</td>
<td>1.4 - 1.6GW</td>
<td>33%</td>
</tr>
<tr>
<td>Biomass</td>
<td>2.3GW</td>
<td>3.5GW</td>
<td>6.0 - 7.3GW</td>
<td>53%</td>
</tr>
<tr>
<td>Wind</td>
<td>2.6GW</td>
<td>3.4GW</td>
<td>10GW</td>
<td>34%</td>
</tr>
<tr>
<td>Solar PV</td>
<td>5.6GW</td>
<td>42.4GW</td>
<td>64GW</td>
<td>66%</td>
</tr>
<tr>
<td>Hydro</td>
<td>48.1GW</td>
<td>48.4GW</td>
<td>48.5 - 49.3GW</td>
<td>99%</td>
</tr>
</tbody>
</table>
There are some challenges to overcome: Challenge I: Budget constraint and cost reduction

✓ **Higher cost/tariff** compared with global trends
e.g. Non-residential solar PV 18 JPY/kWh (190 USD/MWh)

<table>
<thead>
<tr>
<th>JPY10k/kW (USD/kW)</th>
<th>PV system cost for non-residential</th>
</tr>
</thead>
<tbody>
<tr>
<td>40 (3,520)</td>
<td></td>
</tr>
<tr>
<td>28.9 JPY ($2,540)</td>
<td></td>
</tr>
<tr>
<td>20 (1,760)</td>
<td></td>
</tr>
<tr>
<td>14.8 (1,300)</td>
<td></td>
</tr>
<tr>
<td>14.1 (8,80)</td>
<td></td>
</tr>
<tr>
<td>8.5 (1,240)</td>
<td></td>
</tr>
<tr>
<td>0</td>
<td></td>
</tr>
</tbody>
</table>


- **Module, PCS**
- **Construction, Mounting, BOS**

**Global trend in Solar PV tariff of 2MW**

<table>
<thead>
<tr>
<th>Year</th>
<th>UK</th>
<th>Netherland</th>
<th>Spain</th>
<th>Germany</th>
<th>France</th>
<th>Italy</th>
<th>Japan</th>
</tr>
</thead>
<tbody>
<tr>
<td>2000</td>
<td>616</td>
<td>616</td>
<td>616</td>
<td>616</td>
<td>616</td>
<td>616</td>
<td>616</td>
</tr>
<tr>
<td>2001</td>
<td>528</td>
<td>528</td>
<td>528</td>
<td>528</td>
<td>528</td>
<td>528</td>
<td>528</td>
</tr>
<tr>
<td>2002</td>
<td>440</td>
<td>440</td>
<td>440</td>
<td>440</td>
<td>440</td>
<td>440</td>
<td>440</td>
</tr>
<tr>
<td>2003</td>
<td>352</td>
<td>352</td>
<td>352</td>
<td>352</td>
<td>352</td>
<td>352</td>
<td>352</td>
</tr>
<tr>
<td>2004</td>
<td>264</td>
<td>264</td>
<td>264</td>
<td>264</td>
<td>264</td>
<td>264</td>
<td>264</td>
</tr>
<tr>
<td>2005</td>
<td>176</td>
<td>176</td>
<td>176</td>
<td>176</td>
<td>176</td>
<td>176</td>
<td>176</td>
</tr>
<tr>
<td>2006</td>
<td>88</td>
<td>88</td>
<td>88</td>
<td>88</td>
<td>88</td>
<td>88</td>
<td>88</td>
</tr>
<tr>
<td>2007</td>
<td>78</td>
<td>78</td>
<td>78</td>
<td>78</td>
<td>78</td>
<td>78</td>
<td>78</td>
</tr>
<tr>
<td>2008</td>
<td>72</td>
<td>72</td>
<td>72</td>
<td>72</td>
<td>72</td>
<td>72</td>
<td>72</td>
</tr>
<tr>
<td>2009</td>
<td>61</td>
<td>61</td>
<td>61</td>
<td>61</td>
<td>61</td>
<td>61</td>
<td>61</td>
</tr>
<tr>
<td>2010</td>
<td>50</td>
<td>50</td>
<td>50</td>
<td>50</td>
<td>50</td>
<td>50</td>
<td>50</td>
</tr>
<tr>
<td>2011</td>
<td>40</td>
<td>40</td>
<td>40</td>
<td>40</td>
<td>40</td>
<td>40</td>
<td>40</td>
</tr>
<tr>
<td>2012</td>
<td>30</td>
<td>30</td>
<td>30</td>
<td>30</td>
<td>30</td>
<td>30</td>
<td>30</td>
</tr>
<tr>
<td>2013</td>
<td>20</td>
<td>20</td>
<td>20</td>
<td>20</td>
<td>20</td>
<td>20</td>
<td>20</td>
</tr>
<tr>
<td>2014</td>
<td>10</td>
<td>10</td>
<td>10</td>
<td>10</td>
<td>10</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>2015</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>2016</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

(Source: METI survey)

- **Introduce auction** (e.g. solar PV (>2MW) since 2017 / biomass (>10MW) since 2018)
- **Set forward-looking price target** (e.g. midterm price target)

Source: METI
✓ Solar PV accounts for 95% in newly installed capacity under FIT

<table>
<thead>
<tr>
<th>Sources</th>
<th>Started operation after FIT (MW)</th>
<th>Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>Geothermal</td>
<td>15</td>
<td>0.04%</td>
</tr>
<tr>
<td>Biomass</td>
<td>1164</td>
<td>3.0%</td>
</tr>
<tr>
<td>Wind</td>
<td>829</td>
<td>2.1%</td>
</tr>
<tr>
<td>Solar PV (non-residential)</td>
<td>31,732</td>
<td>81.2%</td>
</tr>
<tr>
<td>Solar PV (residential)</td>
<td>5,044</td>
<td>12.9%</td>
</tr>
<tr>
<td>Mid to small sized hydro (less than 30MW)</td>
<td>284</td>
<td>0.7%</td>
</tr>
<tr>
<td>Total</td>
<td>39,068</td>
<td>100%</td>
</tr>
</tbody>
</table>

- Set **three-year tariff** for wind, geothermal, biomass and hydro
- Further **foresseeability on coordination of regional stakeholders** and **adaptation of regulation** (e.g. offshore wind)

Source: METI
Challenge III: Grid constraint

✓ Interconnection & local grid constraint
e.g. suitable for variable renewables (VRE) but limited regional demand and interconnection capacity

✓ Curtailment by overcapacity
in the regions suitable for VRE

• Establish **organization for cross-regional coordination of transmission (OCCTO)**

• Further discussion on the **implicit auction for interconnections, Connect & Manage** scheme

• Promote **self-consuming renewables & demand with storages**
  (e.g. roof-top solar PV + battery + EV)

Source: METI
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Current Situation in CO2 Emissions

- Japan’s CO2 emissions went down due to financial crisis
- Economic recovery from the crisis resulted in higher emission level, accelerated by shutdown of nuclear plants after Fukushima disaster

Japan’s CO2 emissions by sector

After Fukushima disaster, nuclear plants were shut down and replaced by natural gas and oil, resulting in higher emission level from power sector.

Japan’s power generation mix

<table>
<thead>
<tr>
<th>Year</th>
<th>Nuclear</th>
<th>Oil</th>
<th>Natural gas</th>
<th>Coal</th>
<th>Hydro</th>
<th>Renewables</th>
<th>Other</th>
</tr>
</thead>
<tbody>
<tr>
<td>2010</td>
<td>26%</td>
<td>7%</td>
<td>3%</td>
<td>27%</td>
<td>8%</td>
<td>7%</td>
<td>7%</td>
</tr>
<tr>
<td>2011</td>
<td>14%</td>
<td>10%</td>
<td>27%</td>
<td>35%</td>
<td>3%</td>
<td>8%</td>
<td>3%</td>
</tr>
<tr>
<td>2017</td>
<td>7%</td>
<td>3%</td>
<td>34%</td>
<td>37%</td>
<td>7%</td>
<td>8%</td>
<td>8%</td>
</tr>
</tbody>
</table>
Japanese Energy Challenges after disaster

Energy Security

Self-Sufficiency: Currently, 9% only

Economic Efficiency

Electricity Price
Substantial increase of electricity price from 2011
※FY 2018 Industry = 39%, FY2010 11.9 cent/kWh → FY2018 16.6 cent/kWh
Residential = 26%, FY2010 17.8 cent/kWh → FY2018 22.5 cent/kWh

Renewable levy at 1.9 billion $ in 2019
(3 billion $ once all permitted renewables become operational)

Environment

GHG Emissions Reduction
Increasing CO₂ emissions level from fuel combustion after Fukushima
Japan’s 2030 target

- 26% GHG reduction from 2013 level by 2030
- Building blocks for the target
  - Power generation mix with more renewable and restarted nuclear
  - Massive energy conservation
  - Energy saving amount ▲ 50.3 million kl

Japan’s energy related CO2 emissions in 2030 and 2005

<table>
<thead>
<tr>
<th>Sector</th>
<th>2005 emissions (Mt)</th>
<th>2030 emissions (Mt)</th>
<th>Reduction Ratio (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Industrial</td>
<td>429</td>
<td>401</td>
<td>-7%</td>
</tr>
<tr>
<td>Commercial</td>
<td>279</td>
<td>168</td>
<td>-40%</td>
</tr>
<tr>
<td>Residential</td>
<td>201</td>
<td>122</td>
<td>-39%</td>
</tr>
<tr>
<td>Transport</td>
<td>225</td>
<td>163</td>
<td>-28%</td>
</tr>
<tr>
<td>Energy Transfer</td>
<td>101</td>
<td>73</td>
<td>-28%</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>1235</strong></td>
<td><strong>927</strong></td>
<td><strong>-25%</strong></td>
</tr>
</tbody>
</table>

Assumption of the Target

(Source) METI “Long-Term Energy Supply/Demand Outlook, Related Documents” (July 16, 2015)
### Progress of the Energy saving

**Total <Energy saving amount ▲ 50.3 million kl>, ▲ 6 million kl (progress rate: 11.8%) as of FY2015**

<table>
<thead>
<tr>
<th>Industry ▲ ▲10.4 million kl</th>
<th>Commercial ▲ ▲12.3 million kl</th>
</tr>
</thead>
<tbody>
<tr>
<td>▲1.19 Million kl (11.5%) in 2015</td>
<td>▲1.26 million kl (10.3%) in 2015</td>
</tr>
<tr>
<td>• LED [330 thousand kl/1080 thousand kl (30.6%)]</td>
<td>• LED [490 thousand kl/2288 thousand kl (21.4%)]</td>
</tr>
<tr>
<td>• Industrial Heat Pump [31 thousand kl/87.9万 (3.5%)]</td>
<td>• Energy Efficiency standard for appliance [250 thousand kl/2784 thousand kl (6.1%)]</td>
</tr>
<tr>
<td>• Industrial Motor [40 thousand kl/1660 thousand kl (2.4%)]</td>
<td>• BEMS [430 thousand kl/2353 thousand kl (19.6%)]</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Residential ▲ ▲11.6 million kl</th>
<th>Transport ▲ ▲16.1 million kl</th>
</tr>
</thead>
<tbody>
<tr>
<td>▲1.11 million kl (9.5%) in 2015</td>
<td>▲2.41 million kl (15.0%) in 2015</td>
</tr>
<tr>
<td>• LED [600 thousand kl/2011 thousand kl (29.8%)]</td>
<td>• Next generation vehicles [0.591/9.389 million kl (6.3%)]</td>
</tr>
<tr>
<td>• Energy Efficiency standard for appliance [108 thousand kl/1335 thousand kl (8.1%)]</td>
<td>• Other measures [1.815 vs 6.682 million kl (27.2%)]</td>
</tr>
<tr>
<td>• HEMS [1.0kl/1783 thousand kl (0.6%)]</td>
<td></td>
</tr>
</tbody>
</table>

Source: METI (2017) ※Compiling data related to EE measures under Energy Mix
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What is hydrogen

Production

- Coal
- Gas
- LPG (C\textsubscript{n}H\textsubscript{m})

Water electrolysis

\[
\begin{align*}
\text{O}_2 & \xrightarrow{\text{electricity}} \text{H}_2 \\
\text{H}_2\text{O} & \xrightarrow{\text{water}} \text{H}_2 \\
\end{align*}
\]

Clean fuel

Combustion

Chemical reaction


Current industrial use of hydrogen

- Refinery
- Ammonia
- Methanol
- Other

Source: http://www.essentialchemicalindustry.org/chemicals/hydrogen.html
Why hydrogen: deep decarbonization

- Using excess renewable electricity (electricity that cannot be absorbed by the grid) to produce hydrogen.
- Hydrogen can be utilized in various sectors.
PtG projects in Europe

Wind $\rightarrow$ H$_2$ $\rightarrow$ Gas P/L

Remote Island

Wind $\rightarrow$ Synthetic CH$_4$ $\rightarrow$ GasP/L $\rightarrow$ CNG vehicle

Hydrogen > Methane

4H$_2$ + CO$_2$ $\rightarrow$ CH$_4$ + 2H$_2$O

Synthetic Methanol

Source: http://www.powertogas.info/power-to-gas/pilotprojekte-im-ueberblick/windgas-falkenhagen/
Source: Audi e-gas project
Source: The MYRTE project: implementing hydrogen energy storage through the ‘GreEnergy Box’
Source: https://www.spire2030.eu/mefco2
PtG demonstration project in Japan: Fukushima
Hydrogen energy research field (FH2R)

- The new 10,000 kW class hydrogen production facility with world largest electrolysis will start supplying hydrogen in 2020


- NEDO
- Toshiba ESS
- Tohoku Electric Power Company
- Iwatani Corporation
**Hydrogen strategy**

- **“Basic Hydrogen Strategy” (Prime Minister Abe’s Initiative)**
  - World’s first national strategy
  - 2050 Vision: position H₂ as a new energy option (following Renewables)
  - Target: make H₂ affordable ($3/kg by 2030 ⇒ $2/kg 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 to be Developed**

- **Production**
  - Electrolysis System
  - Brown coal gasification + CCS

- **Transportation**
  - Energy Carrier (LH₂, MCH, NH₃, etc.)

- **Use**
  - Fuel Cells (Mobility, Stationary)
  - H₂-fired Generation

Source: Ministry of Economy, Trade and Industry (METI)
Japan’s hydrogen strategy: Basic Hydrogen Strategy

**Supply**

- **Fossil fuel-based hydrogen** (by-product hydrogen, natural gas reformation)
  - Supply chain development and demonstration, scale-up
  - (Present) 200 ktons/year
  - (2030) 4 ktons/year
  - (R&D stage) ~10 ktons/year

**Cost ($/kg)**

- (Present) ~10
- (2030) 2 (1/5 or less)
- (Reference) 10 $/kg

**Power generation**

- (Present) ¥20/kWh
- (2030) ¥17/kWh (Commercial stage)
- (Reference) ¥12/kWh
- (Comparison) ¥17/kWh (Commercial stage)

**Use**

- **Mobility**
  - FCV (fuels) (Present) 25 k units
  - (2030) 40 k units
  - 1.2 k units
  - 10 k units

- **Utilization of fuel cells**
  - Ene-Farms (fuels) (Present) 230 k units
  - (2030) some 900 k units

- **Roadmap targets**
  - FCV/hydrogen stations becoming independent
  - 2 (1/5 or less)
  - 5 ~ 10 million t + α (depending heavily on consumption for power generation)
  - ¥17/kWh (Commercial stage)

**Target future picture**

- **CO2-free hydrogen** (Brown coal combined with CCS, utilizing renewable energy)
  - ¥12/kWh
  - Replacing gas power generation
  - Replacing gas stations
  - Replacing conventional gasoline mobility
  - Introducing large FCVs
  - Replacing traditional residential energy systems

**Source:** Basic Hydrogen Strategy (2017)
Japan’s hydrogen strategy: various CO$_2$-free hydrogen sources

**Large scale transport of H$_2$** (either from fossil fuel + CCS or renewables)
- CO$_2$ free hydrogen can also be produced from fossil fuel + CCS (blue hydrogen).
- Pilot projects are under way aiming to commercialize long-distance hydrogen shipment.

- **Power to Gas (PtG)**
  - Led by Europe, recently followed by Japan.

Diagram:
- Hydro in Russia
- Hydro in Canada
- Power to Gas in Europe
- Oil/gas, flaring gas in the Middle East + CCS
- PV in the Middle East
- Brown coal in Australia + CCS
- PV in Australia
Japan’s hydrogen strategy: private sector

**HySTRA: commercialization of hydrogen supply chain**

Source: [http://www.hystra.or.jp/en/](http://www.hystra.or.jp/en/)

**AHEAD: commercialization of hydrogen supply chain**

Source: [https://www.ahead.or.jp/en/organization.html](https://www.ahead.or.jp/en/organization.html)

**JHyM: Japan H₂ Mobility, hydrogen refueling station**

Source: [https://www.jhym.co.jp/en/partners/](https://www.jhym.co.jp/en/partners/)
Thank you very much!