GLOBAL POLICY CHALLENGES TOWARD ENERGY TRANSITIONS

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2. Hydrogen Strategy

3. German-Japanese Energy Transition Council
Japan’s Energy Supply Structure

Japan’s Primary Energy Source

* “Renewables etc.” consists of solar power (1.5%), wind power (0.2%), geothermal heat (0.1%), and biomass (1.9%), effective recovery use of wasted energy (2.2%).

Source: Prepared based on “Comprehensive Energy Statistics 2016” issued by the Agency for Natural Resources and Energy.
Energy demand and primary energy supply

**Energy demand**

2013 (Actual result)

- Electric power 25%
- Heat, gasoline, town gas, etc. 75%

Final energy consumption: 361 million kl

Economic growth: 1.7%/year

2030 (After energy conservation measures)

- Electric power 28%
- Heat, gasoline, town gas, etc. 72%

Final energy consumption: 326 million kl

**Primary energy supply**

2030

- Coal 25%
- Natural gas 18%
- Petroleum 30%
- Nuclear power 10 to 11%
- Renewable energy 13 to 14%
- LPG 3%

Primary energy supply: 489 million kl

Self-sufficiency rate: 24.3%

50.3 million kL Energy Saving 13% lower than BAU

* Values are approximate.
1,065 billion kWh Energy conservation + renewable energy account for 40%.

196.1 billion kWh Energy Saving 17% lower than BAU

Power demand and power source composition

Economic growth 1.7%/year

Electric power 966.6 billion kWh

Power demand

1,278 billion kWh (Total generated energy)

Energy conservation 17%

Renewable energy 19 to 20%

Nuclear power 17 to 18%

LNG 22%

Coal 22%

Petroleum 2%

2030

1,065 billion kWh (Total generated energy)

Renewable energy 22 to 24%

Nuclear power 20 to 22%

LNG 27%

Coal 26%

Petroleum 3%

2030

* Values are approximate.
Major Stream of Energy Shifts

**First shift**
From domestic coal to petroleum (1960s)

Energy self-sufficiency rates
1960: 58%
1970: 15%

**Second shift**
Two oil crises (1970s)

Electricity rates (1970=100)
1970: 100
1980: 203

**Third shift**
Liberalization of markets and global warming (1990s-)

Kyoto Protocol (1997)

**Fourth shift**
Great East Japan Earthquake and Fukushima Accidents (2011-)

**Fifth shift**
Paris Agreement 2050 Reduction targets (2030-)

We are here
Strategic Energy Plan 2014 setting goals to be achieved by 2030; progress made therein (as of FY2016)

[i] Scenario for cutting CO2 emissions
→ From 10%(2013) to 17%(2016) (44% in 2030 as the zero-emission power source rate)
  (approx. renewable energy: 15%; nuclear energy: 2%)

[ii] Scenario for improving energy self-sufficiency rates
→ From 6%(2013) to 8%(2016) (24% in 2030)

[iii] Scenario for curbing costs
→ Electricity rate hike by 30% after the occurrence of Great East Japan Earthquake
  (recently by 10% after this)
  (oil price ↓, purchase cost of renewable energy ↑, coal-fired as an alternative for nuclear ↑)

Identifying issues standing in the way of realization
2030 = Working with a focus on realization

Paris Agreement
- Developed countries share very ambitious, high-level goals for decreasing greenhouse gas emissions by 2050.

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<tbody>
<tr>
<td>2030</td>
<td>Down by 26%</td>
<td>Down by 26-28%</td>
<td>Down by 30%</td>
<td>Down by 40%</td>
<td>Down by 40%</td>
</tr>
<tr>
<td>2050</td>
<td>Down by 80%</td>
<td>Down by 80%</td>
<td>Down by 80%</td>
<td>Down by 80-95%</td>
<td>Down by 75%</td>
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* As for Japan, no base year for the 2050 target is determined yet.
* As for the U.S., 2025 target = decrease emissions by 26-28% from 2005 level.

Establish industrial structures and policies under which Japan can engage in technological innovation and investment as well as in contributions to related efforts overseas, as indispensable initiatives

2050 = pursuing all possibilities

Advisory Committee for Natural Resources and Energy

Round Table for Studying Energy Situations
Recommendations by the Round Table for Studying Energy Situations
- Initiatives for Energy Transitions -

○ Possibility → **Ambitious scenario**: Energy transitions and taking on decarbonization through the transitions

○ Uncertainty → **Multiple track scenario**: Seeking possibility in all choices
  ※ Currently, no such energy source that is economic and fully decarbonized exists.

○ Unclarity → **Scientific review mechanism**: Flexible determination of priority issues in light of the latest situations
  ※ All consequences derived from geopolitical situations, geoeconomic situations and inter-technology competitions are unclear.

○ Energy transitions in complicated and uncertain environments
  → **Sophistication** of energy policy requirements; “3E+S”※
  ※ Safety, Energy security, Economic efficiency, Environment

○ Accidents at the Fukushima Daiichi Nuclear Power Station
  → Efforts for **renewable energy** aiming to place economically-independent decarbonized major power sources, meanwhile decrease the dependency on nuclear energy

○ Full-scale efforts for successful energy transitions
  [i] Domestic policy/diplomacy; [ii] enhancement of competitiveness of industries and reconstruction of infrastructures; [iii] finance

2. Hydrogen Strategy

3. German-Japanese Energy Transition Council
“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
• Gasification + CCS

Transportation
• Energy Carrier (LH₂, MCH, NH₃, etc.)

Use
• Fuel Cells (Mobility, Generation)
• H₂-fired Generation
Direction of Activities to Realize a “Hydrogen Society”

**Production**
- Domestic fossil fuels
  - City gas
  - LP gas
  - Byproduct hydrogen
  - Future

- Overseas unused energy
  - Brown coal
  - Byproduct hydrogen
  - Overseas renewable energy
    - Gasification
    - CCS

- Renewable energy
  - Solar power
  - Wind power
  - Water electrolysis

*Use hydrogen as a means of energy storage (absorb fluctuations in intermittent RES)*

**Transportation and supply (supply chain)**
- City gas pipeline/LPG supply network
- Liquefied hydrogen lorry
- Hydrogen pipeline

**Use**
- **Fuel cell vehicles (FCV, FC bus, etc.)**
  - Over 230,000 units installed
  - • Entered service in Tokyo in March 2017
  - • 100 buses by 2020

- **Fuel cell cogeneration (e.g. Ene-Farm)**
  - For Business and Industry use, some models have already been launched in 2017

- **Hydrogen power generation (CO₂-free thermal power plants)**
  - • Combined heat and power supply using hydrogen cogeneration in Kobe in early 2018

- **Large-scale hydrogen ocean Transportation network**
  - • Demonstration of large-scale power-to-gas @Fukushima/aiming for use in the 2020 Tokyo Olympic and Paralympic Games

**Use in the industrial sector (Power-to-X)**
- • 2,400 vehicles installed
- • 40,000 vehicles by 2020

- **Other**
  - Reforming
  - Byproduct hydrogen
  - Gasification
  - Water electrolysis
### Scenario for Basic Hydrogen Strategy

#### Supply

**Fossil fuel-based hydrogen** (by-product hydrogen, natural gas reformation)
- Supply chain development and demonstration, scale-up
- Developing international hydrogen supply chains
- Developing domestic Power-to-Gas for renewable hydrogen supply

**CO2-free hydrogen** (Brown coal combined with CCS, utilizing renewable energy)

#### 2030

- 300k (commercial supply chain capacity)
- 5~10m + α (depending heavily on consumption for power generation)

#### Use

**Hydrogen Stations**
- (Present) 200
- (2020) 4k
- (R&D stage) ~10
- (hydrogen station price)

**Cost ($/kg)**
- 2 (1/5 or less)
- 3 (1/3 or less)
- 17/kWh (commercial stage)
- 12/kWh (Reference)

**Supply chain development and demonstration, scale-up**

#### Mobility

**Ene-Farm**
- 230k

**Utilization of fuel cells**
- 2030
- 5.3m

**FCV/Hydrogen stations**
- Halving hydrogen station costs
- Demanding hydrogen power generation, establishing an environmental value assessment system

**FCV**
- (Present) 2.5k
- (2020) 40k

**Forklifts**
- (Present) 2
- (2020) 100

**Power generation**
- Demonstrating hydrogen power generation, establishing an environmental value assessment system

**“Roadmap” targets**
- Replacing gas power generation
- Replacing conventional gasoline mobility
- Introducing large FCVs

**Number of gas stations**
- 100,000

**Number of passenger cars**
- 62 million

**Unit LNG power generation cost**
- ¥12/kWh

**Fossil power generation capacity**
- 132GW

**Natural gas imports**
- 85 million t/y
- Natural gas import price: $1.6/kg

**Number of households**
- 53 million

**Number of gas stations**
- 31,500

**Number of passenger cars**
- 62 million

**Reference**
- 5-10 million t
- Represents 15-30 GW in power generation capacity

**Reference comparison**
- 300kt in hydrogen consumption represents some 1GW in power generation capacity

**Strategic hydrogen station development, regulatory reform, technological development**

**Relevant government organizations cooperating in developing hydrogen supply networks**
EVs will contribute to a reduction in Japan’s dependency on fossil fuel

Dependency on fossil fuel (Transportation sector)

- Gasoline: 56.6%
- Diesel fuel: 29.3%
- Jet fuel: 4.8%
- Heavy oil: 4.5%
- Lubricating oil: 1.1%
- LPG Gas: 1.6%
- Electricity: 2.0%

CO2 total discharge: 1,265 million tons in 2014

EVs will contribute to cutting CO2 emissions

EVs could cut CO2 emissions by half compared to conventional vehicles, contributing to environmental benefits.

※ In the case of considering Japan’s future power generation portfolio.
The Japanese government is aiming at increasing the market share of Next Generation Vehicles among new car sales to between 50% and 70% by 2030.

## Next Generation Vehicle Target

<table>
<thead>
<tr>
<th>Type</th>
<th>2017 (Result)</th>
<th>2030 (Target)</th>
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<tbody>
<tr>
<td>Gasoline Vehicle</td>
<td>63.97%</td>
<td>30~50%</td>
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<tr>
<td><strong>Next Generation Vehicle</strong></td>
<td><strong>36.02%</strong></td>
<td><strong>50~70%</strong></td>
</tr>
<tr>
<td>Hybrid Vehicle</td>
<td>31.2%</td>
<td>30~40%</td>
</tr>
<tr>
<td>Electric Vehicle</td>
<td>0.41%</td>
<td>20~30%</td>
</tr>
<tr>
<td>Plug-in Hybrid Vehicle</td>
<td>0.82%</td>
<td></td>
</tr>
<tr>
<td>Fuel Cell Vehicle</td>
<td>0.02%</td>
<td>~3%</td>
</tr>
<tr>
<td>Clean Diesel Vehicle</td>
<td>3.52%</td>
<td>5~10%</td>
</tr>
</tbody>
</table>

【Source】Next Generation Automotive Strategy 2010  Automotive Industrial Strategy 2014

2. Hydrogen Strategy

3. German-Japanese Energy Transition Council
The Council consists of six energy experts on the German side and Japanese side with an additional three associated members on each side and is led by two co-chairs.

The aim is to find new, safer and more efficient ways to implement energy transitions.
<table>
<thead>
<tr>
<th>Four Key Recommendations</th>
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<tbody>
<tr>
<td>1. Importance of Exchange of Knowledge and Experience</td>
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<td>→ The transformation process can be accelerated and made more effective</td>
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<td>2. Simultaneous Achievement of Environmental and Economic objectives</td>
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<td>→ Long-term targets and strategies cooperation are useful.</td>
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<td>3. Efficiency First</td>
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<td>→ Great, underdeveloped potential should be explored.</td>
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<td>4. Importance of Liberalisation of Energy Sector</td>
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<td>→ diversified suppliers, innovative technologies, new business (eg. prosumer)</td>
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