Challenges for Japan's Energy Transition

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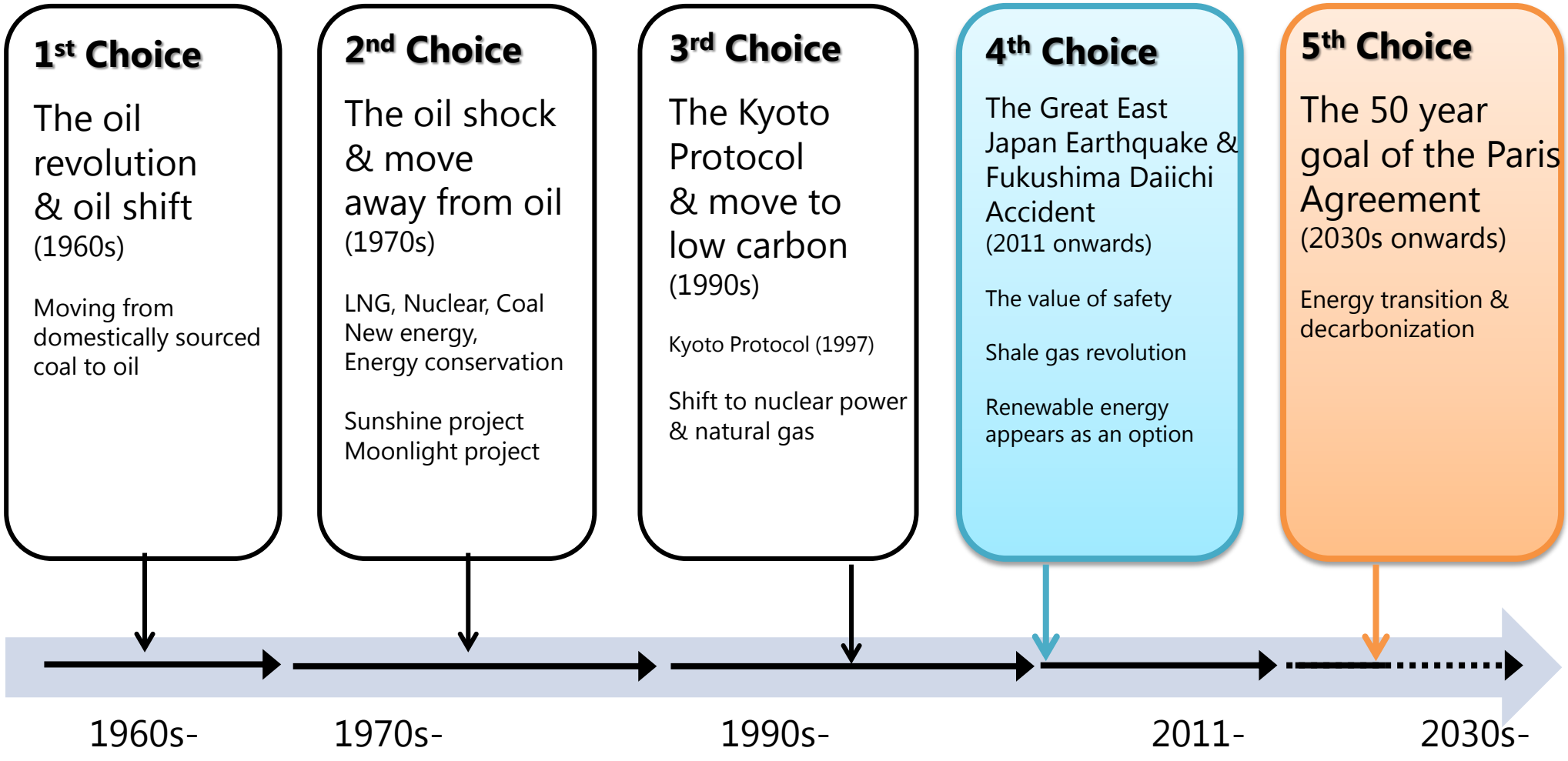
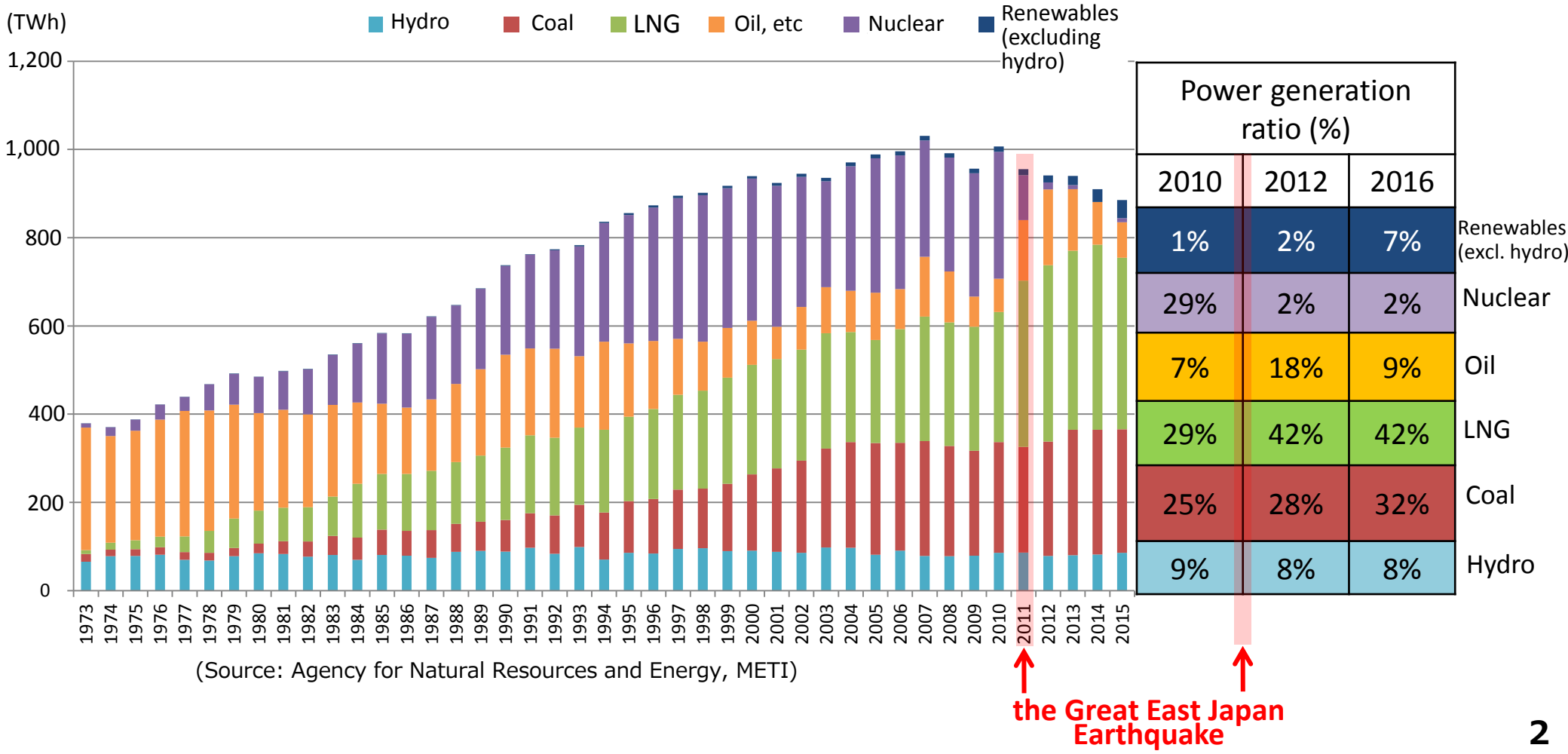
The history of energy choice & the 5th energy choice



Change in generation mix

- **Nuclear has been rapidly replaced by fossil fuels** since the Great East Japan Earthquake and the nuclear accident in March 2011

Trend in domestic power generation by technology



Power generation ratio (%)			
	2010	2012	2016
Renewables (excl. hydro)	1%	2%	7%
Nuclear	29%	2%	2%
Oil	7%	18%	9%
LNG	29%	42%	42%
Coal	25%	28%	32%
Hydro	9%	8%	8%

(Source: Agency for Natural Resources and Energy, METI)

Strategic Energy Plan and Energy mix plan

FY2002 Basic Act on Energy Policy

- The 1st Strategic Energy Plan, 2003
- The 2nd Strategic Energy Plan, 2007
- The 3rd Strategic Energy Plan, 2010

FY2014 The 4th Strategic Energy Plan

○Nuclear power: To reduce as much as possible and restart with safety priority.

○Renewable energy: >20%

FY2015 Long-term Energy Supply and Demand Outlook (Energy mix plan)

○Nuclear power: 20-22% (Before the earthquake: 30%)

○Renewable energy: 22-24%

FY2018 The 5th Strategic Energy Plan

○Towards 2030 ⇒ To achieve energy mix target

○Towards 2050 ⇒ Challenges towards energy transitions and decarbonisation

Japan's Strategic Energy Plan

- Based on the Strategic Energy Plan, Japan tackles the policy targets related to **Safety, Energy security, Economic efficiency, and Environment** simultaneously.（3E＋S）
- The Plan also refers **reducing dependence on nuclear power generation as much as possible** by promoting energy efficiency and conservation, introduction of renewable energy, and introduction of efficient thermal power plants.

<Policy target for 3E+S>

Safety

Safety is the top priority.

Energy security

Self-sufficiency: About 25%, higher than before the earthquake (about 20%)

Economic efficiency

Electricity cost: To lower from the current level
(9.7 trillion yen in FY2013 to 9.5 trillion yen in FY2030)

Environment

Greenhouse gas emission reduction target:
(reduction of 26.0% in FY 2030 compared to FY 2013)

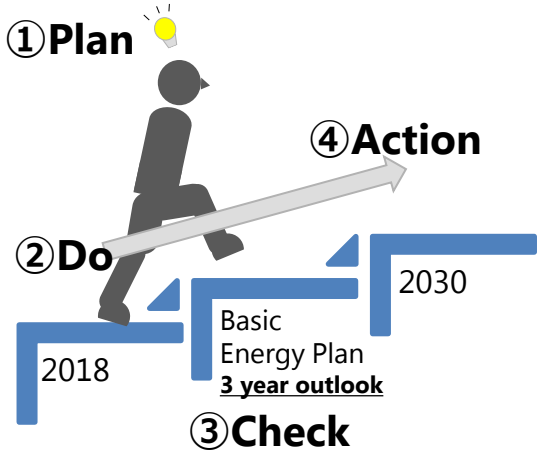
Renewables introduction toward 2030 target

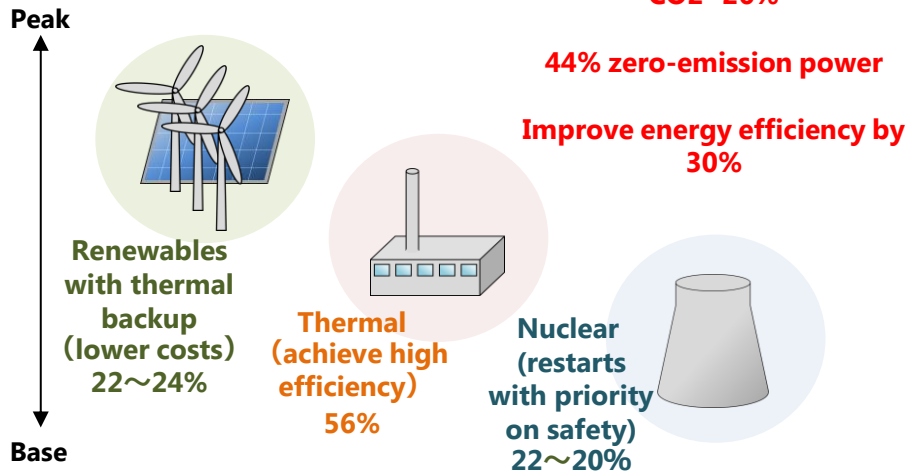
	Before FIT (June 2012)	After FIT [A] (as of Sep 2017)	Target [B] (FY2030)	Progress [A]/[B]
Geothermal	0.5GW	0.5GW	1.4 - 1.6GW	33%
Biomass	2.3GW	3.5GW	6.0 - 7.3GW	53%
Wind	2.6GW	3.4GW	10GW	34%
Solar PV	5.6GW	42.4GW	64GW	66%
Hydro	48.1GW	48.4GW	48.5 - 49.3GW	99%

Ambitious Multi-Path Scenario

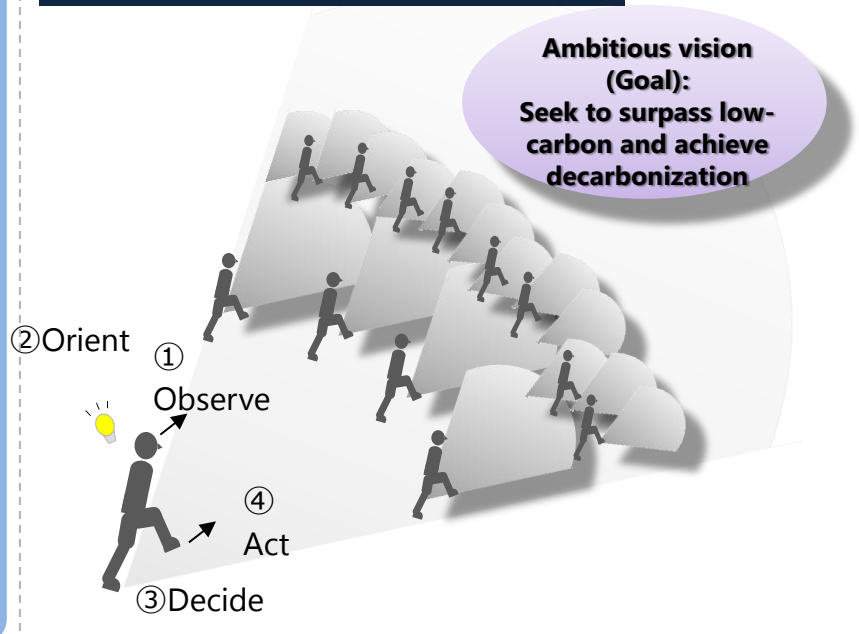
Mainstreaming of renewable energy based on Fukushima accident
Priority on energy technology

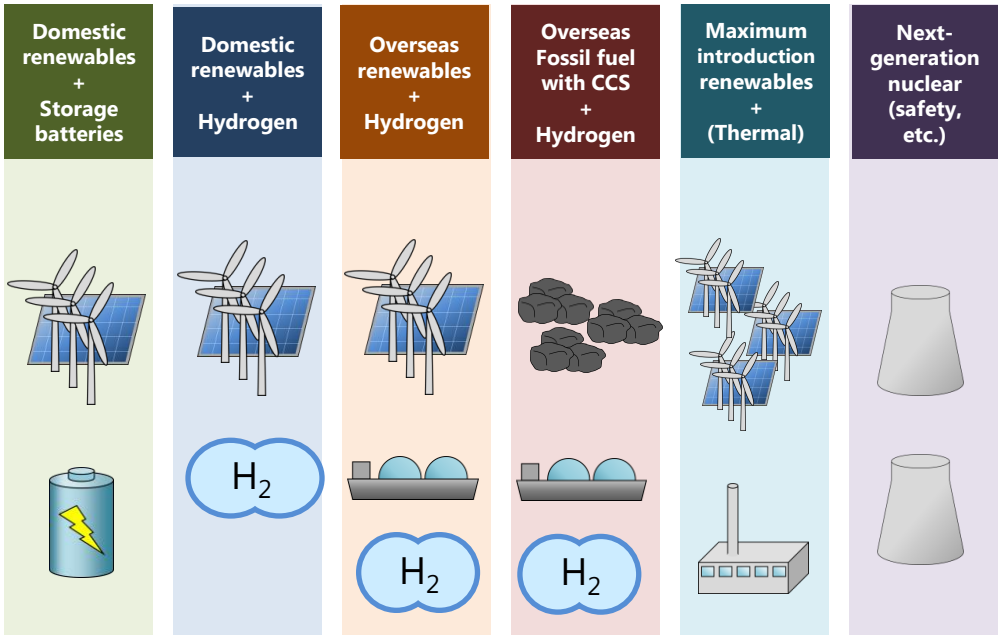
2030 Single target





2050 towards multiple goals





Towards 2050:
Challenges towards energy transitions and decarbonisation

	2030 Advanced utilization of existing technology	2050 Creation of future technology
Renewable Energy	●Cost reduction ●Overcome system	Future energy technology ● Space Solar power ● Supercritical Geothermal (Magma Power Generation) ● Coating PV + Next Generation Storage / Supply and Demand Automatic Control System
Fossil fuels	●High-efficiency power generation	CO2-free by using hydrogen ● Manufacturing: Super efficient hydrogen production ● Transportation: liquefaction / transportation of hydrogen ● Utilization: 100% hydrogen power generation, Next Generation Fuel Cell (FCV, etc) Fixing / Utilization of Carbon Dioxide ● CO2 utilization ● Innovative CO2 separation and recovery technology
Heat & Transportation	Industry ●Investment in high efficiency equipment Transportation ●Improve fuel consumption of automobile	Innovation of Manufacturing process ● Hydrogen reduction steelmaking ● Artificial photosynthesis Automotive electric : Automation ● EV, PHV, FCV ● Automatic
Distributed energy	●ZEB/ZEH ●Cogeneration system ●VPP	Distributed and digitized technology <Next Generation Storage Battery> ● Post lithium ● Innovation for stationary type battery <Automatic energy supply and demand control system> ● AI-driven system ● Block-chain technology

- Basic Hydrogen Strategy -

Mission/ Background

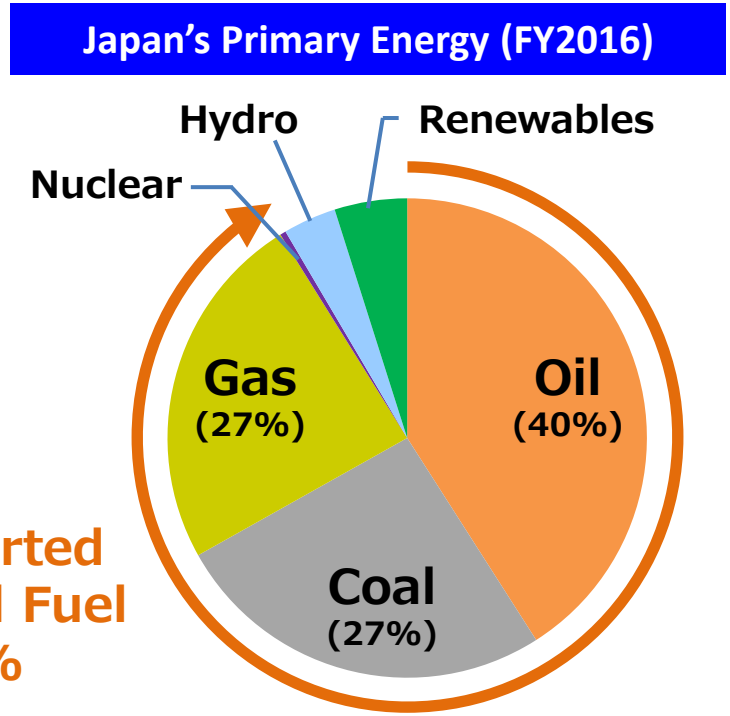
- **Japan's Responsibility for Energy Transition**

  ⇔ **Energy trilemma**

  - ✓ **E**nergy security
  - ✓ **E**nvironment (Sustainability)
  - ✓ **E**conomic affordability (Cost)

  } **3"E"** + **S**afety

- **Measures;**
  - ✓ Energy saving
  - ✓ Renewable energy
  - ✓ Nuclear energy
  - ✓ CCS + Fossil fuels
  - ✓ **Hydrogen**

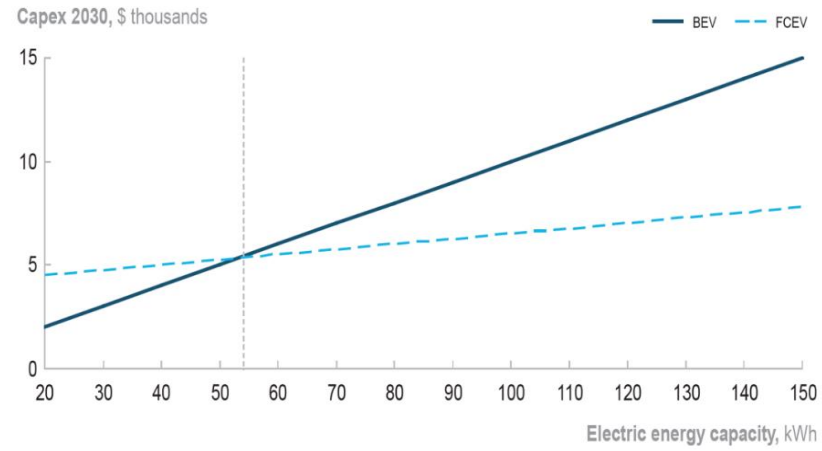


Why Hydrogen?

- **Contribution to 3"E"**
  - ✓ Contribute **de-carbonization** (**E**nvironment)
  - ✓ Mitigate **dependence on specific countries** (**E**nergy security)
  - ✓ Enable to utilize **low cost feedstock** (**E**conomic affordability)
  - **+ Japan's edge in technology** since 1970s

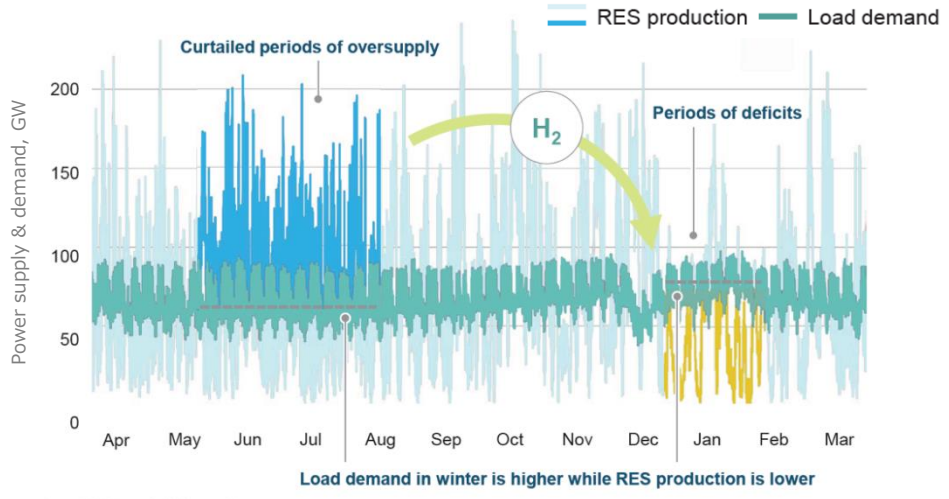
- **Roles of H_2 in Electrified Mobility/ Generation Mix**

Powertrain Costs Analysis for FCEVs & BEVs



Source: "Hydrogen Scaling Up", Hydrogen Council (2017)

Power Supply & Demand Simulation for Germany in 2050



Source: "How Hydrogen Empowers the Energy Transition", Hydrogen Council (2017)

Strategy

- **"Basic Hydrogen Strategy" (Prime Minister Abe's Initiative)**
  - ✓ **World's first national strategy**
  - ✓ **2050 Vision: position H_2 as a new energy option** (following Renewables)
  - ✓ **Target: make H_2 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 H_2 supply chains**

【Demand】 ・・・ ③ **Mass usage** (Mobility ⇒ Power Generation ⇒ Industry)

- **Key Technologies to be Developed**

Production	Transportation	Use
• Electrolysis System • Gasification + CCS	• Energy Carrier (LH_2, MCH, NH_3, etc.)	• Fuel Cells (Mobility, Generation) • H_2-fired Generation

Direction of Activities to Realize a “Hydrogen Society”

Production

Domestic fossil fuels
- City gas
- LP gas
- Reforming
- Byproduct hydrogen

Future

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

Renewable energy
- Solar power
- Wind power
- Water electrolysis

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

- Demonstration of large-scale power-to-gas @Fukushima/aiming for use in the 2020 Tokyo Olympic and Paralympic Games

Transportation and supply (supply chain)

- City gas pipeline/LPG supply network
- Liquefied hydrogen lorry
- Hydrogen pipeline

- Installation of 100 stations nationwide
- Promotion of regulatory reform for cost reduction

Hydrogen station

- Demonstration of the world’s first international hydrogen supply chain in 2020

Large-scale hydrogen ocean Transportation network

Use

- 2,500 vehicles installed
- 40,000 vehicles by 2020

Fuel cell vehicles (FCV, FC bus, etc.)

- Entered service in Tokyo in March 2017
- 100 buses by 2020

Transportation

- Over 230,000 units installed

Fuel cell cogeneration (e.g. Ene-Farm)

Reforming

- For Business and Industry use, some models have already been launched in 2017

Future

Hydrogen power generation (CO_2-free thermal power plants)

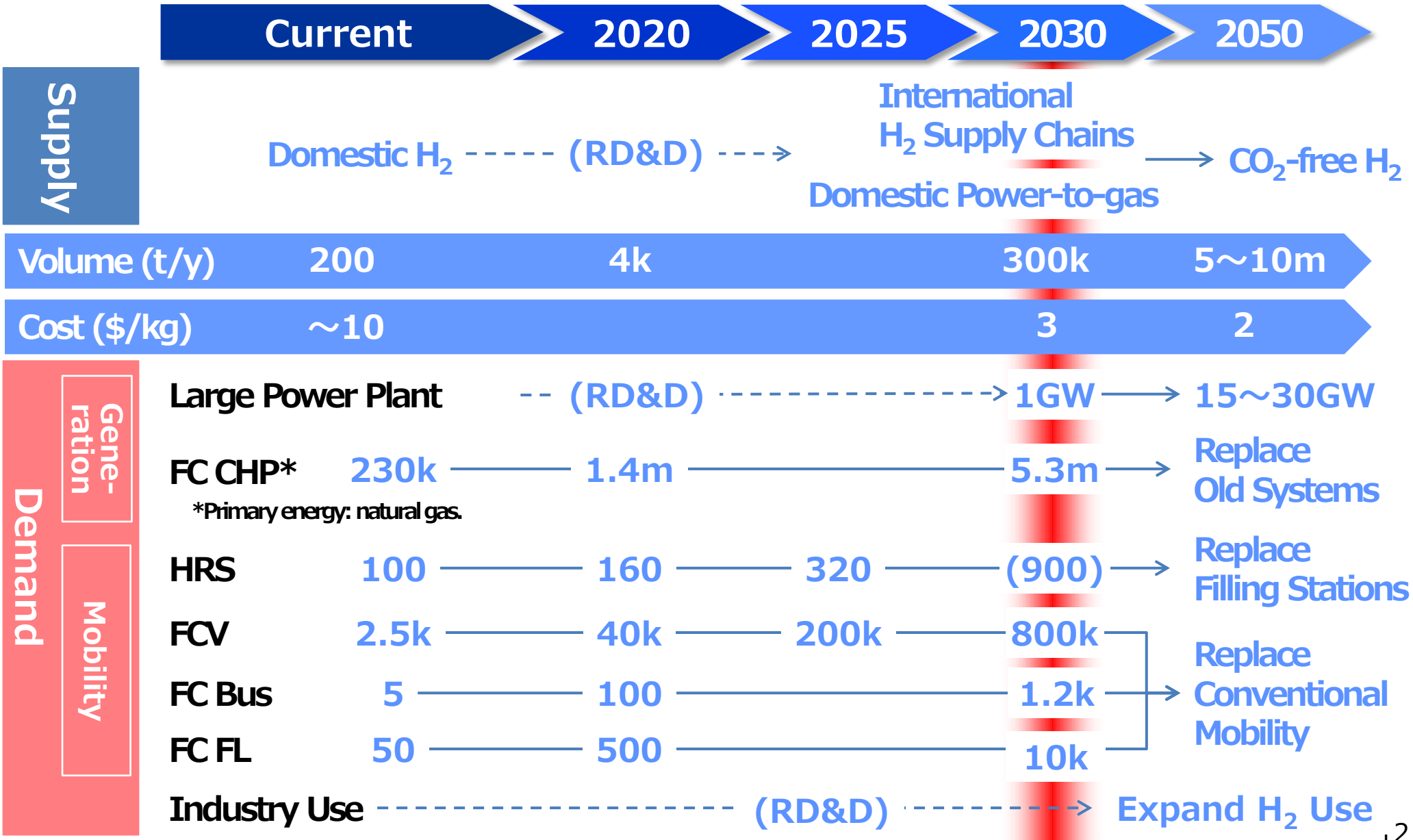
- Combined heat and power supply using hydrogen cogeneration in Kobe in early 2018

Power generation

Use in the industrial sector (Power-to-X)

Other

Scenario


Current
2020
2025
2030
2050
Supply
Domestic H_2 ----- (RD&D) ---→
International H_2 Supply Chains
Domestic Power-to-gas
→ CO_2-free H_2
Volume (t/y)
200
4k
300k
5～10m
Cost ($/kg)
～10
3
2
Demand
Gene-ration
Mobility
Large Power Plant
-- (RD&D) ----------→
1GW → 15～30GW
FC CHP*
230k — 1.4m — 5.3m →
Replace Old Systems
*Primary energy: natural gas.
HRS
100 — 160 — 320 — (900) →
Replace Filling Stations
FCV
2.5k — 40k — 200k — 800k
FC Bus
5 — 100 — 1.2k
FC FL
50 — 500 — 10k
Replace Conventional Mobility
Industry Use
---------- (RD&D) ---------→
Expand H_2 Use

Ongoing Projects (Supply-side)

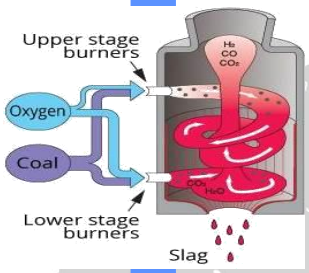
International H_2 Supply Chain

Japan-Australia Pilot Project

2020～ HySTRA

Brown Coal +CCS

Gasification



Liquefied H_2 Carrier*

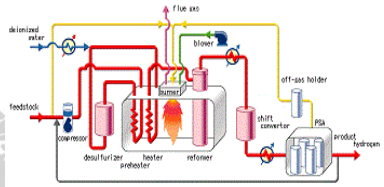
Loading Facility*

Japan-Brunai Pilot Project

2020～ AHEAD

Off-gas

Steam Methane Reforming



Hydro-genation* (TOL→MCH)

Chemical Tanker

Dehydro-genation* (MCH→TOL)

Power-to-gas

Fukushima Renewable H_2 Project

2020～ TOSHIBA Iwatani

Power-to-Gas Plant*

Electrolysis System (Alkaline)

H_2 Olympic Flame

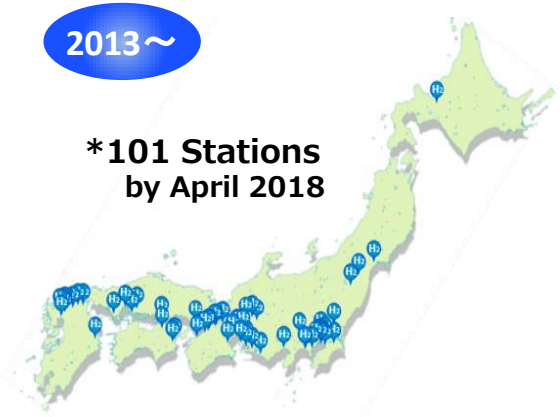
* Image

Ongoing Projects (Demand-side)

H_2 Mobility

H_2 Station Network

2013～



*101 Stations
by April 2018

H_2 Applications

2016～

FC Bus

× 100 in 2020

FC Truck Demo

Joint Venture for H_2 Infrastructure Development

2018～

H_2 Power Generation

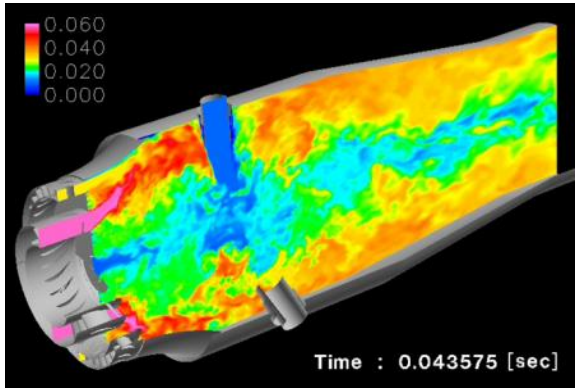
H_2 Co-generation Demonstration Project

Hydrogen Gas
Turbine (1.7MW)

2018～

R&D of H_2 Burner Systems

For Power
Generation
<500MW



Burning Simulation
(H_2 + CH_4)

Hydrogen Energy Ministerial Meeting

【Purpose】

- **Realize hydrogen as key technology and to be a new energy alternative for de-carbonization by connecting resources such as fossil fuel and Carbon Capture, Utilization and Storage(CCUS), or renewable energy**
- **Harmonize and cooperate for enhancing utilization of hydrogen at a global scale**
- **Verify and Discuss on**
  - ✓ **Innovative challenges and latest knowledge**
  - ✓ **Possibility of international cooperation**
  - ✓ **Future direction**

  for formulating global initiative on hydrogen

- Date: 23rd October 2018
- Venue: DAI-ICHI HOTEL TOKYO, Japan
- Host: Ministry of Economy, Trade and Industry, Japan
- Attendees : Ministers, Government officials, Private Sectors
- Invited Countries: Australia, Austria, Brazil, Brunei, Canada, China, Chile, Denmark, France, Germany, Iceland, India, Indonesia, Italy, Netherlands, New Zealand, Norway, Poland, Qatar, Russia, Saudi Arabia, Singapore, South Africa, South Korea, Spain, Sweden, United Arab Emirates, United Kingdom, United States of America, EC, IEA (29 countries, 1 region, and 1 organization)