# Energy trends in Japan

The Institute of Energy Economics, Japan

***Energy Dialogue***

Lund University, East Asian Student Association
IEEJ

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**1. Overview of energy trends and perspective in Japan**

**2. Renewable Energy Policy**

**3. Climate Change Policy**

**4. New Energy Policy - Hydrogen -**

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**1. Overview of energy trends and perspective in Japan**

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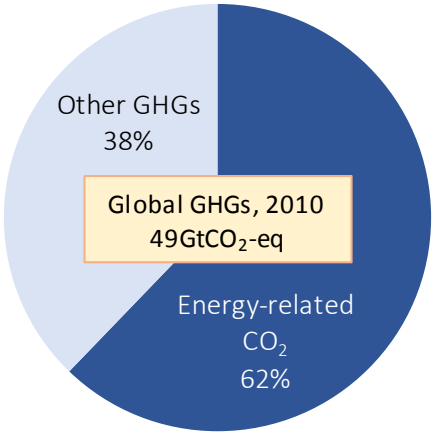
# Energy is an important agenda for realizing a sustainable society

## Paris Agreement[1]

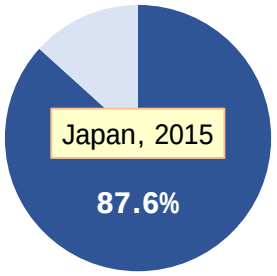
Article 2

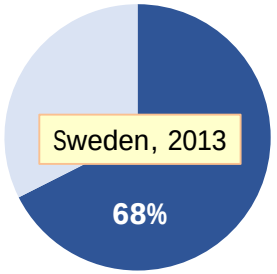
*"This agreement … aims to strengthen the global response to the threat of climate change …, including by (a)* ***Holding the increase in the global average temperature to well below 2ºC above pre-industrial levels*** *…"*

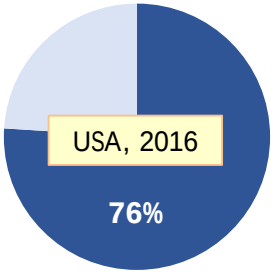

## Energy-related $CO_2$ emissions[2]




- "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



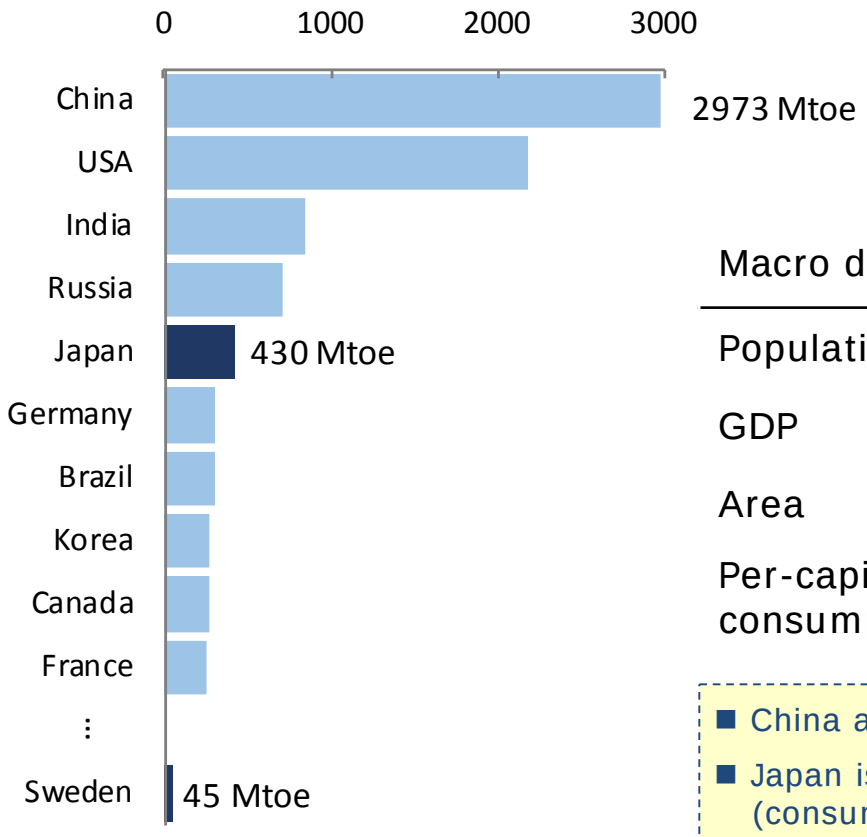

1 Source: UNFCCC.

2 GHG=Green House Gas (such as $CO_2$, $CH_4$, $N_2O$, 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[1]

Unit: Million tons of oil equivalent (Mtoe)




| Macro data (2015) | Japan | Sweden |
|---|---|---|
| Population | 127.1 Million | 9.7 Million |
| GDP | 4 395 Bil. USD | 498 Bil. USD |
| Area | 378 000 km$^2$ | 450 000 km$^2$ |
| Per-capita energy consumption | 3.4 toe/capita | 4.6 toe/capita |

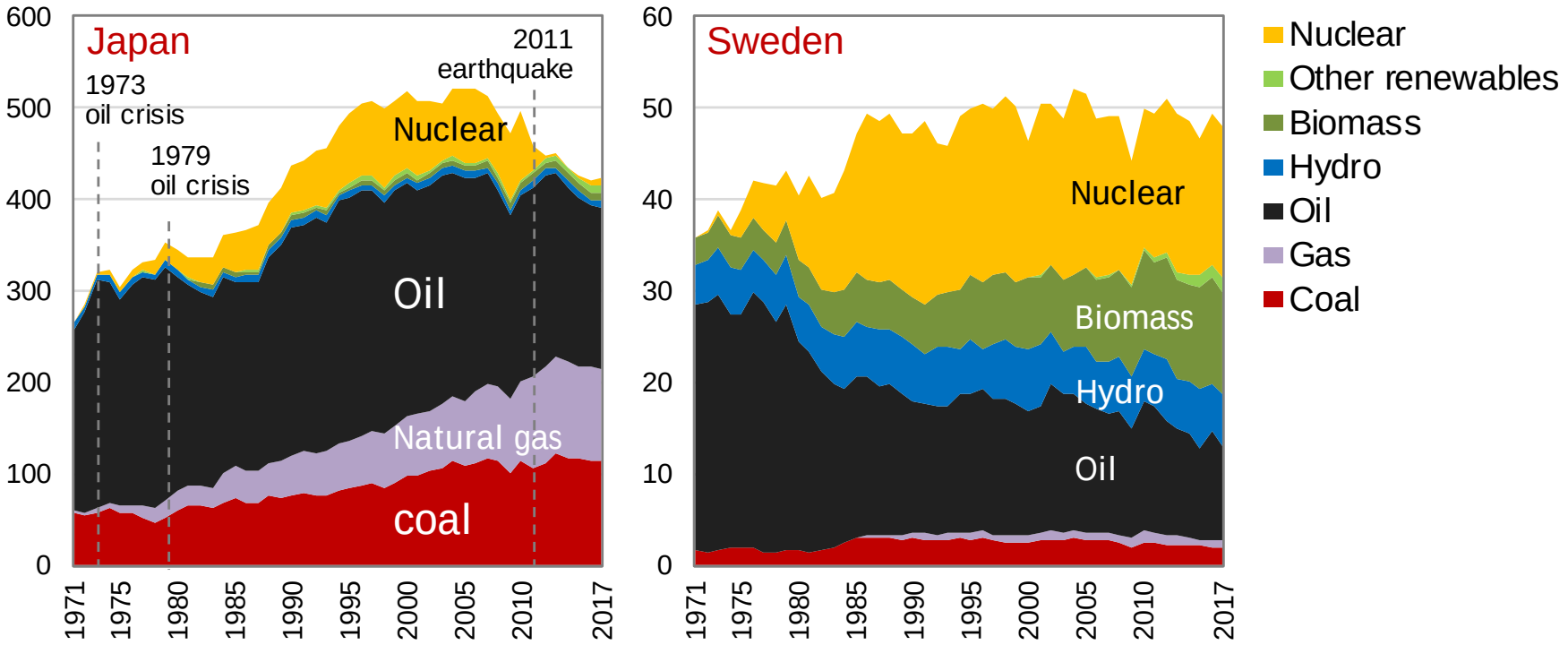
- China and the US are by far the largest energy consumers
- Japan is the fifth largest, accounting for 3% in the world (consuming almost 10 times larger than Sweden)

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)



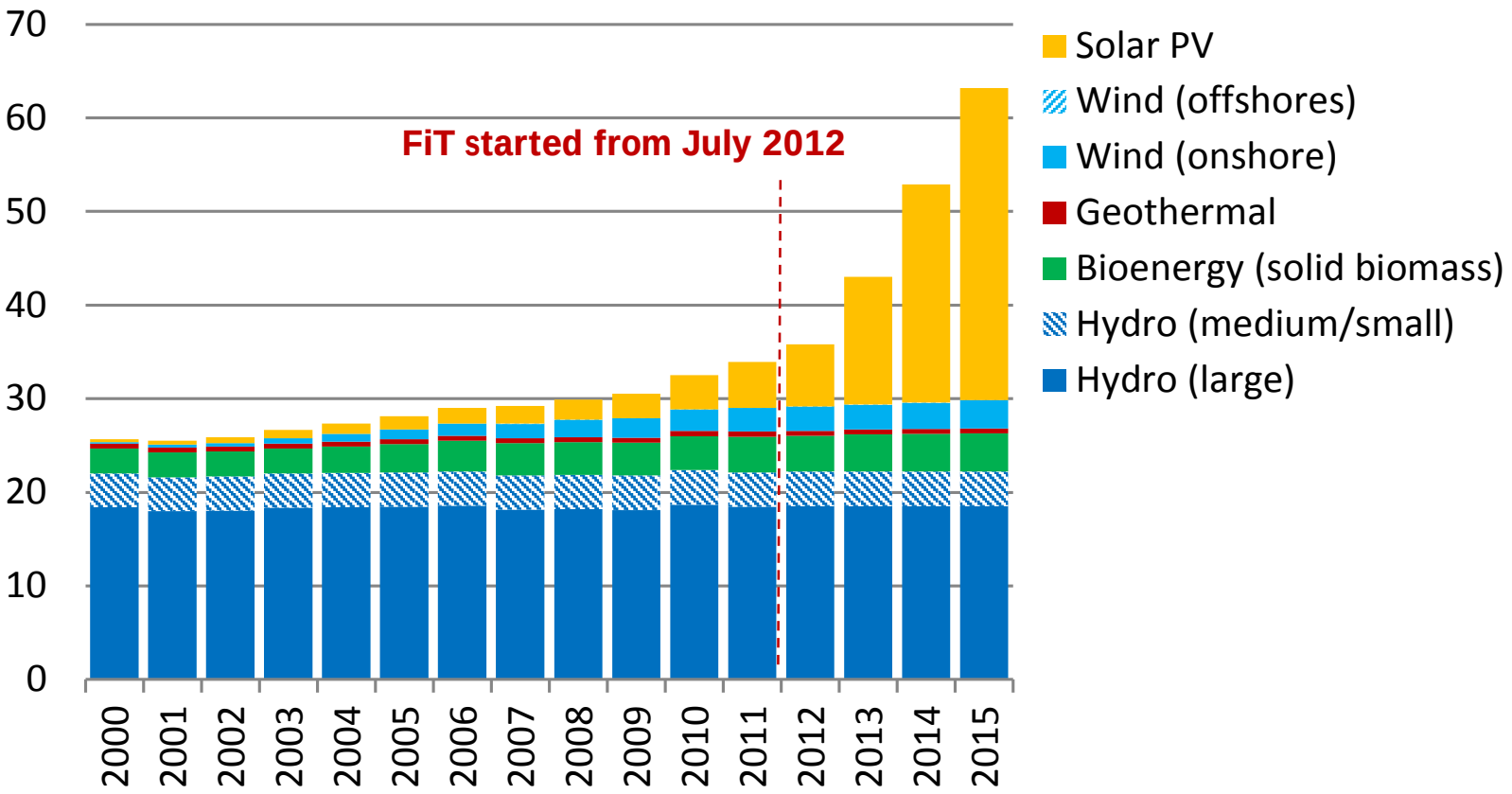

- Japan has diversified its energy mix since the 1970s (after the two oil crises). Nuclear shrank after the earthquake in 2011
- Nuclear and renewables together contribute to 74% of Sweden's energy mix in 2017

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

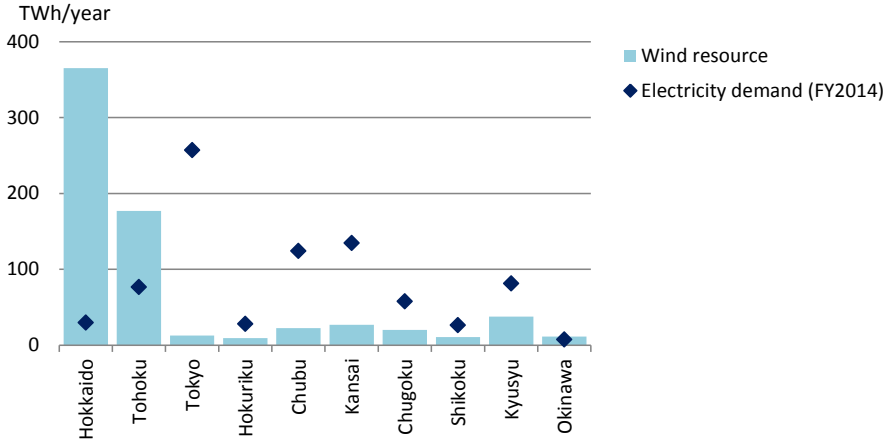
Unit: Giga-Watt (GW)



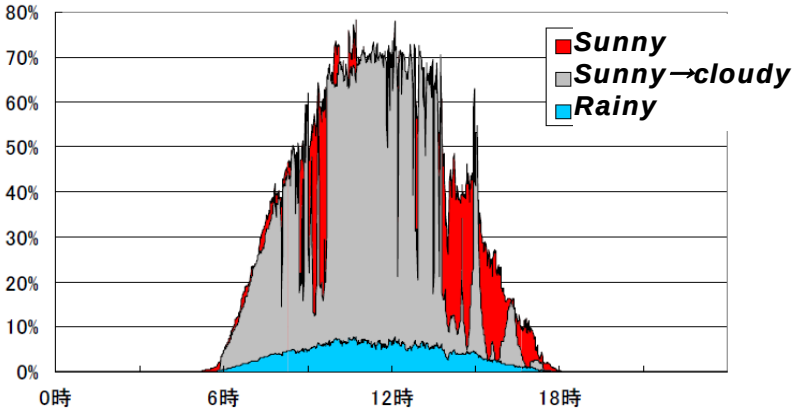
# Yet, renewables face challenges in Japan

- **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), …

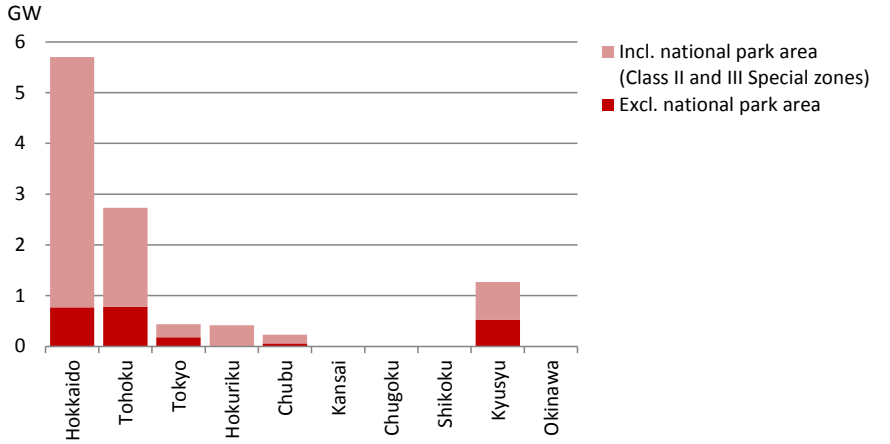
***Wind resources: mainly in Hokkaido and Tohoku***




***Example of solar PV intermittency***




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




Source for wind and geothermal potential data: MOE, Study on Basic Zoning Information Concerning Renewable Energies (FY 2015), http://www.env.go.jp/earth/report/h28-03/index.html [Accessed 12th September, 2016]

# Japan's "3E+S" targets for the fiscal year 2030

## "3E+S" policy targets[1]

**Safety** (foremost condition)

| | | |
|---|---|---|
| **Energy security** (Energy self-sufficiency rate: 6.5% in FY2013) | → | Improved self-sufficiency (about 25% by FY2030) |
| **Economic efficiency** (Electricity costs: surged due to fossil fuel costs, FiT and grid integration of renewables) | → | Electricity costs lower than the level in FY2013 |
| **Environment** (GHG emissions: FY2013 was the worst level) | → | GHG emissions reductions comparable to EU and USA (-26% from FY2013) |

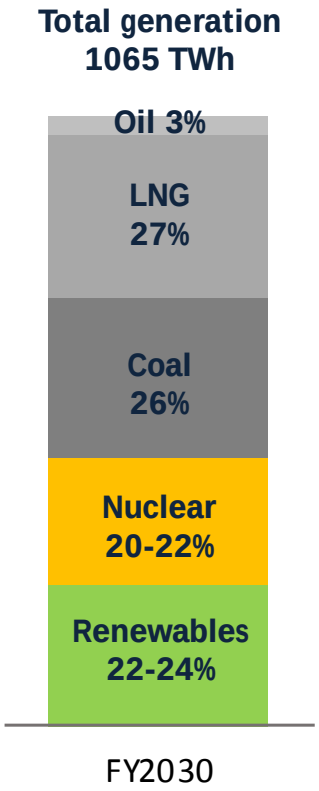
- Japan prioritizes "Energy Security", while improving "Economic efficiency" and pursuing "Environment". Nuclear Safety is foremost condition

1 Source: METI (2015), Long-Term Supply and Demand Outlook, http://www.meti.go.jp/english/press/2015/0716_01.html.

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

## Outlook for power generation[1]

Fiscal year 2030




## Energy-related $CO_2$ emissions[1]

| Unit: Mt-$CO_2$ | FY2013 | FY2030 |
|---|---|---|
| Total emissions | 1,235 | 927<br>(-24% from 2005)<br>(-25% from 2013) |
| Power generation | 548 | 360<br>(-22% from 2005)<br>(-34% from 2013) |

- The share of nuclear decreases compared to the level before the earthquake (about 30%)
- Energy-related $CO_2$ 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)

1 Source: METI (2015), Long-Term Supply and Demand Outlook, http://www.meti.go.jp/english/press/2015/0716_01.html.

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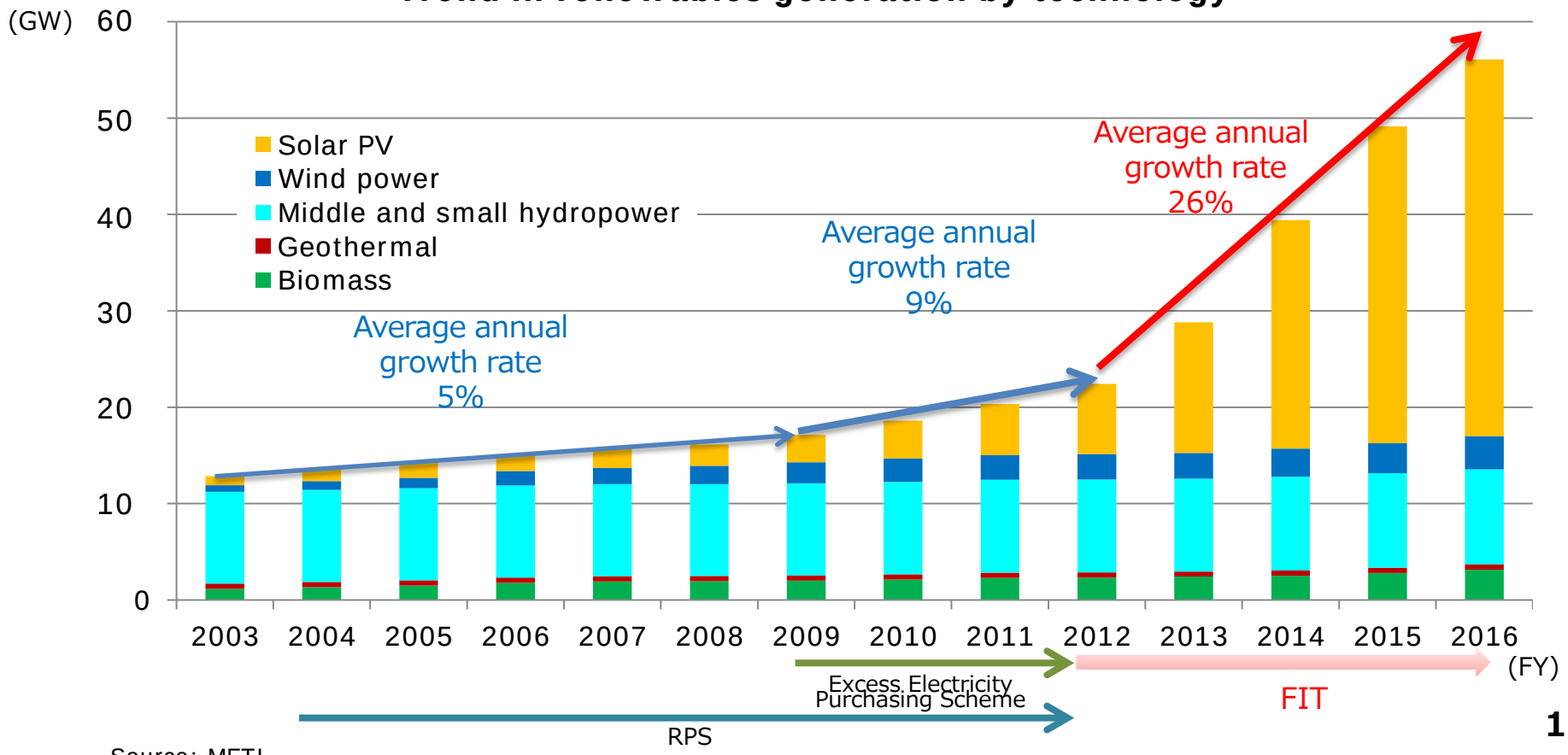
# Renewables have achieved 26% of the average annual growth rate mainly due to the increase of Solar PV

- 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

Source: SB Energy

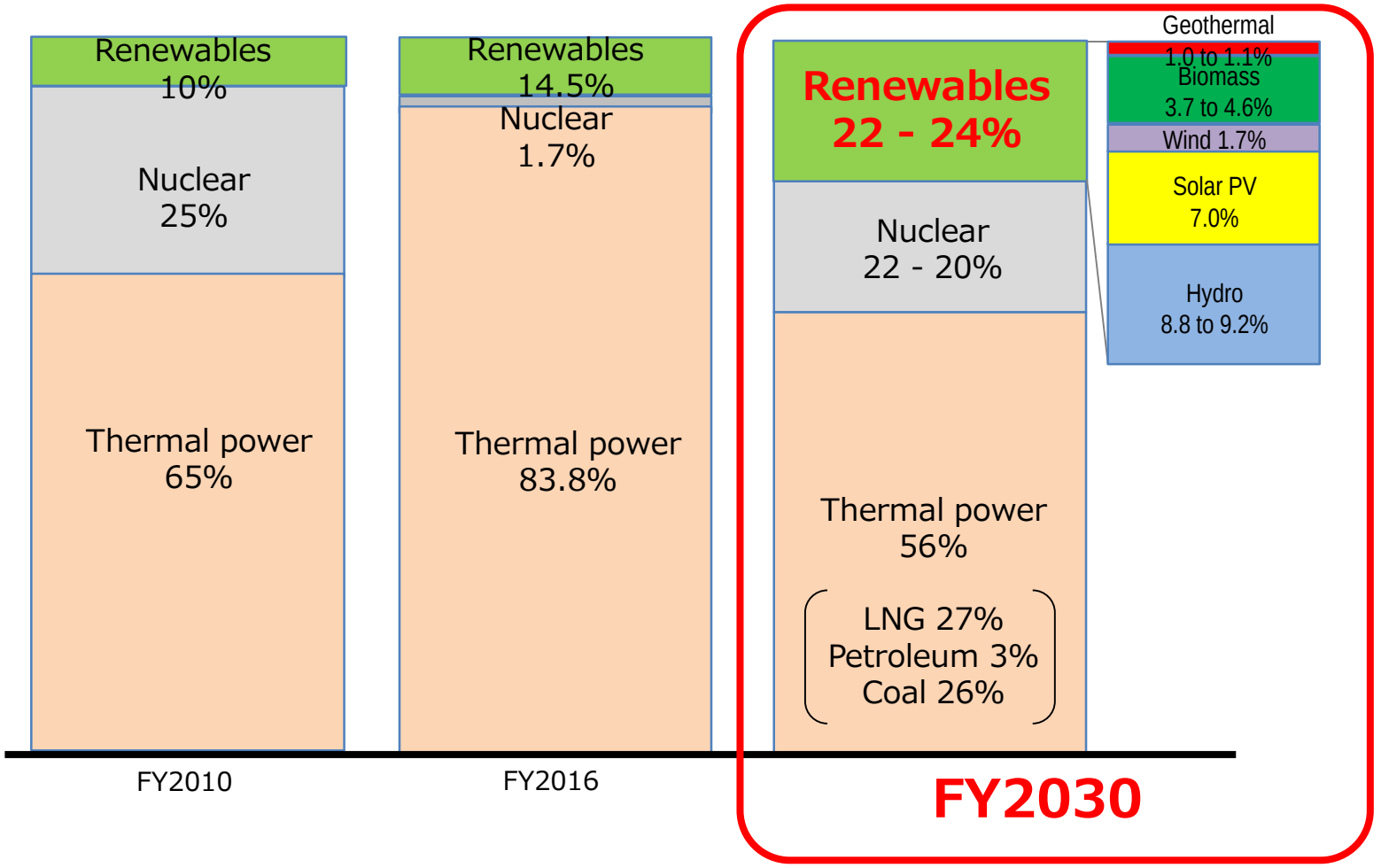
- ✓ Location: Shimane
- ✓ Operation：June 2016
- ✓ Wind: 48MW
- ✓ Electricity Supply: 23,000 houses

## Solar PV Project

Source: RENOVA

- ✓ Location: Chiba (444,000㎡)
- ✓ 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




Source: METI

# Toward 2030, the introduction of Solar PV shows the distinctive proportion

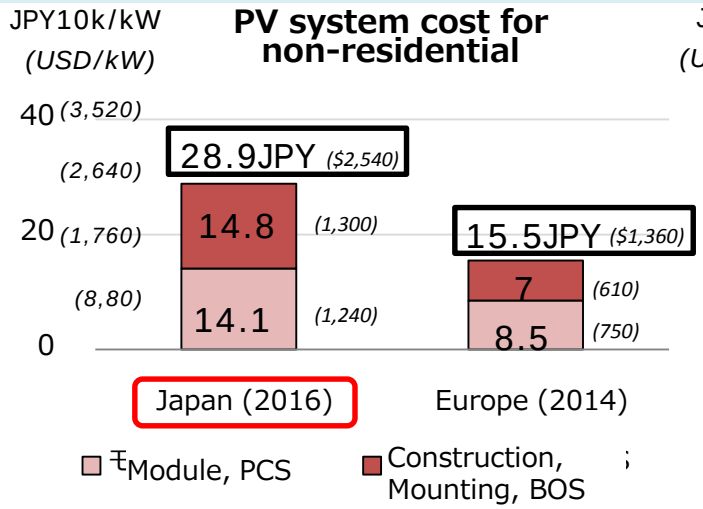
| | Before FIT (June 2012) | After FIT [A] (as of Sep 2017) | Target [B] (FY2030) | Progress [A]/[B] |
|---|---|---|---|---|
| Geothermal | 0.5GW | 0.5GW | 1.4 - 1.6GW | 33% |
| Biomass | 2.3GW | 3.5GW | 6.0 - 7.3GW | 53% |
| Wind | 2.6GW | 3.4GW | 10GW | 34% |
| Solar PV | 5.6GW | 42.4GW | 64GW | 66%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

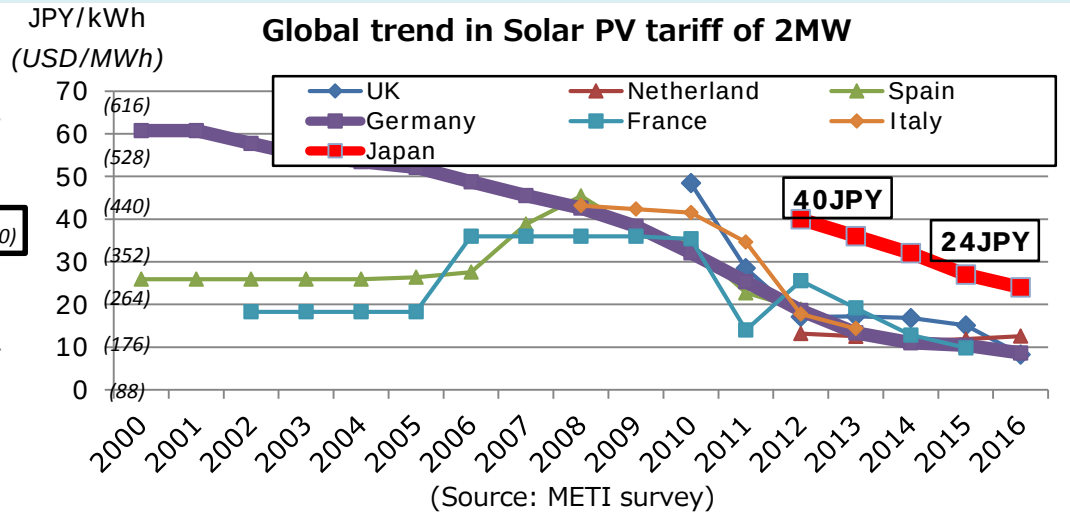
Source: METI

# 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)




- *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

# Challenge II: Balance between solar & other renewables

✓ **Solar PV accounts for 95%** in newly installed capacity under FIT

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

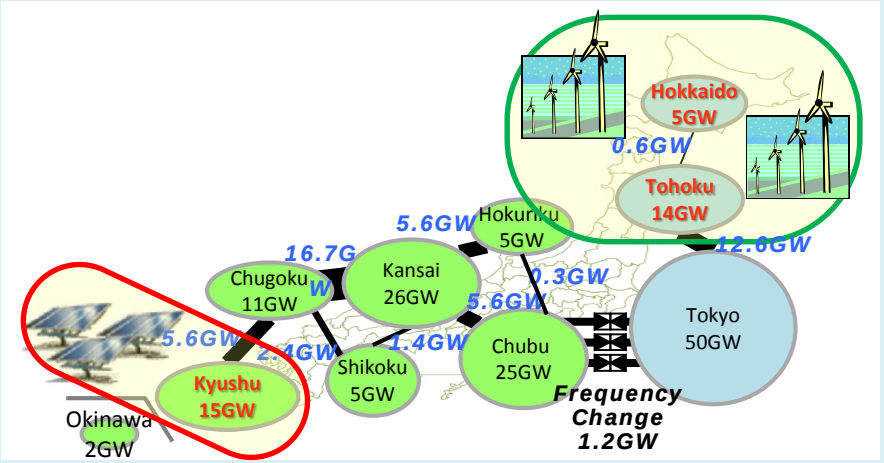
- *Set **three-year tariff** for wind, geothermal, biomass and hydro*
- *Further **foreseeability on coordination of regional stakeholders** and **adaptation of regulation** (e.g. offshore wind)*

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




*Italic: interconnection capacity*

- *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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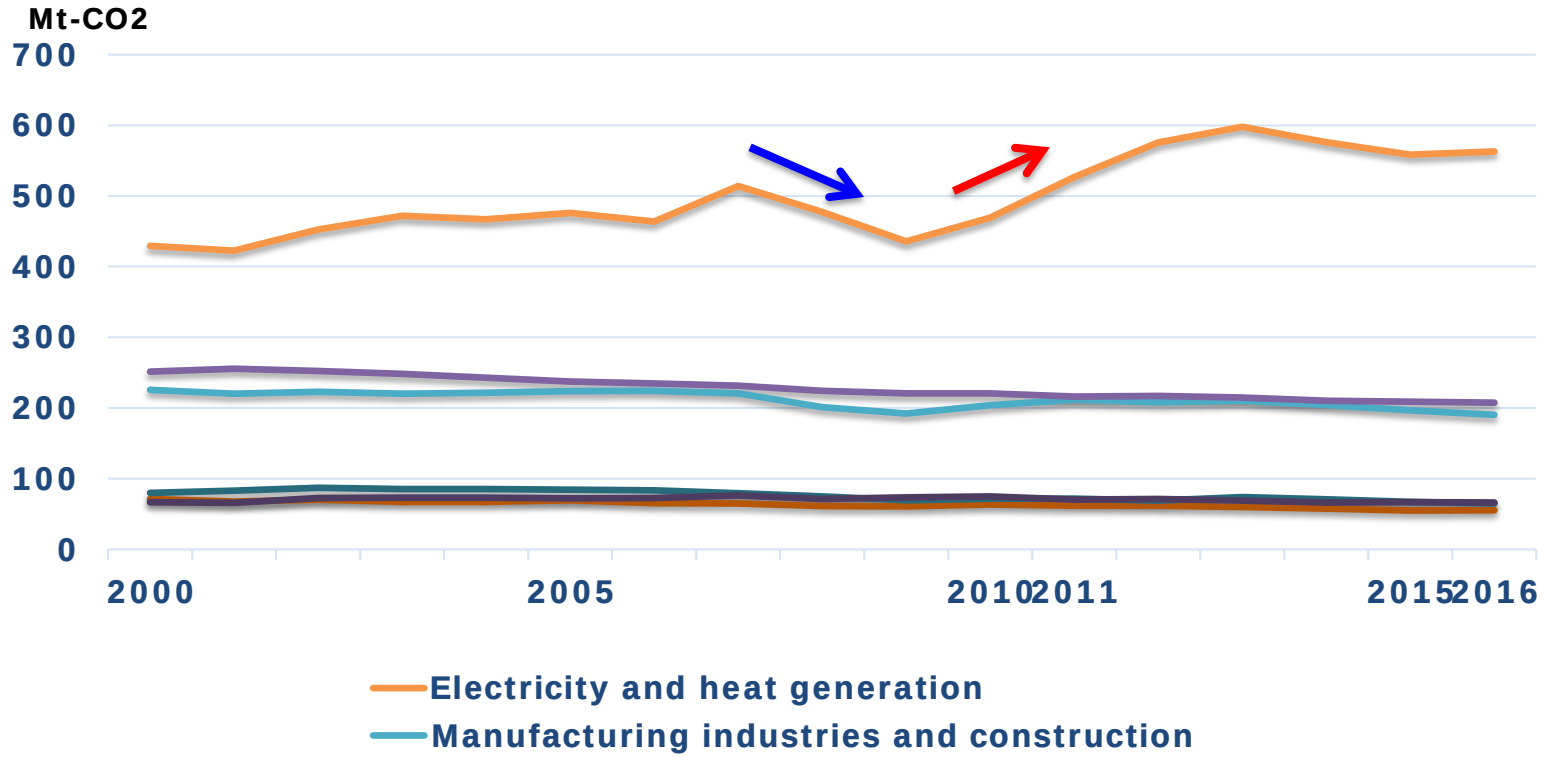
# Current Situation in CO2 Emissions

- 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

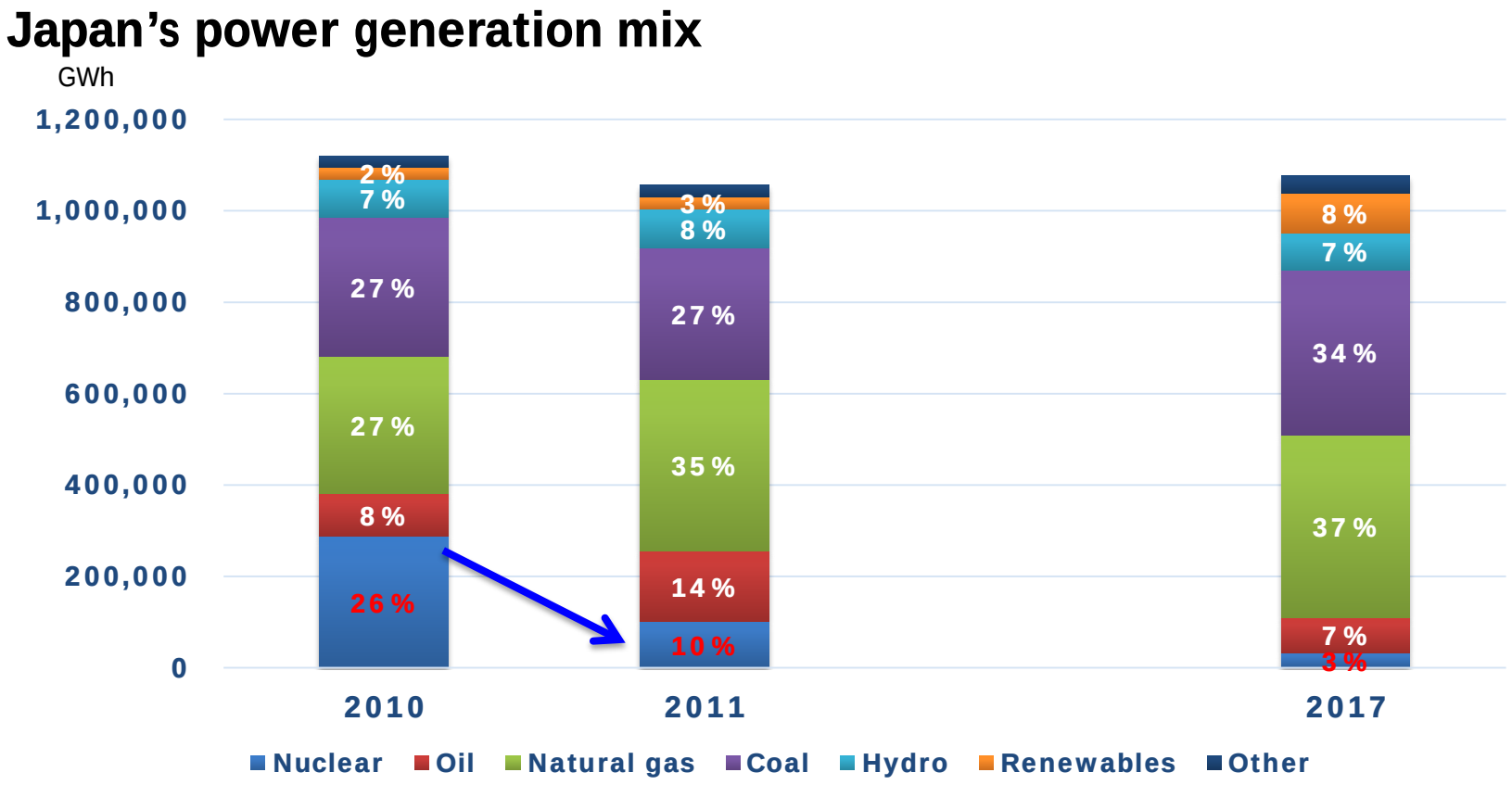
**Japan's CO2 emissions by sector**




(Source) IEA (2018) "CO2 Emissions from Fuel Combustions for OECD Countries"

# Current Situation in Power Generation Mix

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



# 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 $CO_2$ emissions level from fuel combustion after Fukushima**

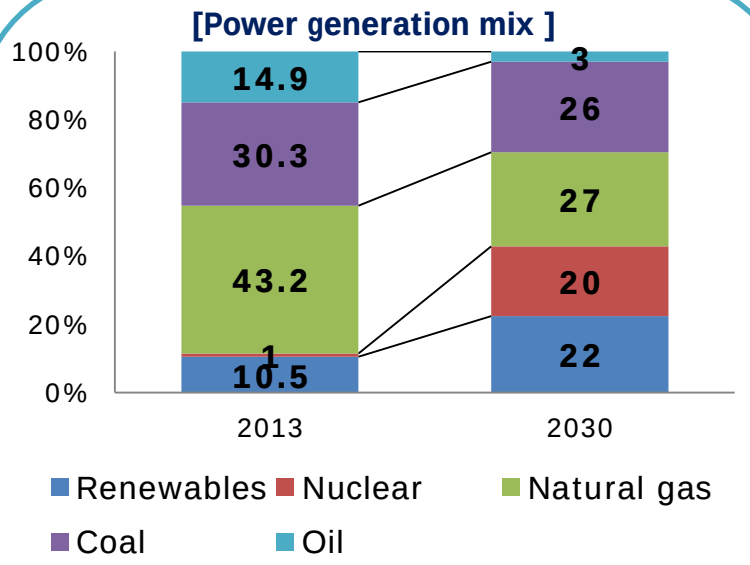
# Japan's 2030 target

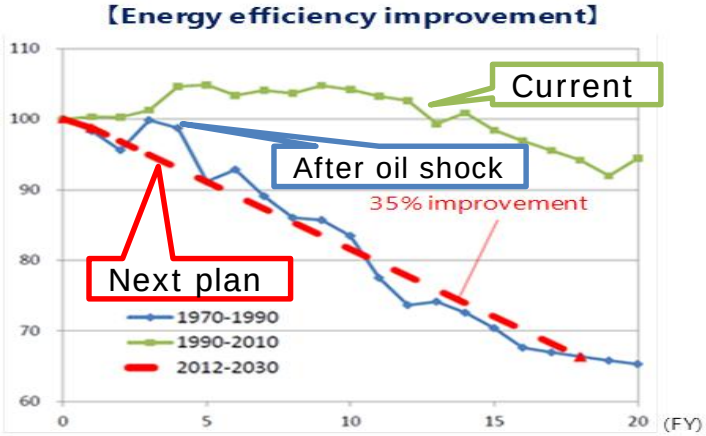
- 26% GHG reduction from 2013 level by 2030
- Building blocks for the target
  - Power generation mix with more renewable and restarted nuclear
  - Massive energy conservation
    - Energy saving amount ▲ 50.3 million kl

**Japan's energy related CO2 emissions in 2030 and 2005**

| Sector | 2005 emissions (Mt) | 2030 emissions (Mt) | Reduction Ration (%) |
|---|---|---|---|
| Industrial | 429 | 401 | -7% |
| Commercial | 279 | 168 | -40% |
| Residential | 201 | 122 | -39% |
| Transport | 225 | 163 | -28% |
| Energy Transfer | 101 | 73 | -28% |
| Total | 1235 | 927 | -25% |

## Assumption of the Target




Energy efficiency=final energy consumption/real GDP

(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**

## Industry <▲10.4 million kl>

**▲1.19 Million kl（11.5%）in 2015**

- LED
  [330 thousand kl/1080 thousand kl 30.6%)]
- Industrial Heat Pump
  [31thousand kl/87.9万kl (3.5%)]
- Industrial Motor
  [40 thousand kl/1660 thousand kl (2.4%)]

## Commercial <▲12.3 million kl>

**▲1.26 million kl（10.3%）in 2015**

- LED
  [490 thousand kl/2288 thousand kl (21.4%)]
- Energy Efficiency standard for appliance
  [250 thousand kl/2784 thousand kl (6.1%)]
- BEMS
  [430 thousand kl/2353 thousand kl (19.6%)]

## Residential <▲11.6 million kl>

**▲1.11 million kl（9.5%）in 2015**

- LED
  [600 thousand kl/2011 thousand kl (29.8%)]
- Energy Efficiency standard for appliance
  [108 thousand kl/1335 thousand kl (8.1%)]
- HEMS
  [1.0kl/1783 thousand kl (0.6%)]

## Transport <▲16.1 million kl>

**▲2.41 million kl（15.0%）in 2015**

- Next generation vehicles
  [0.591/9.389 million kl(6.3%)]
- Other measures
  [1.815 vs 6.682 million kl (27.2%)]

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

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# What is hydrogen

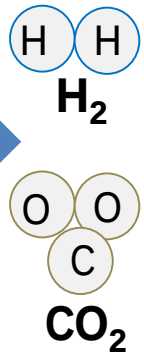
## Production

### Fossil fuel

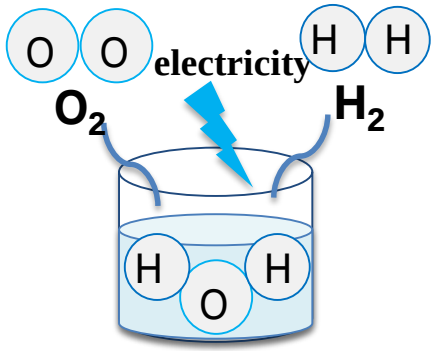
- Coal
- Gas
- LPG ($C_nH_m$)

Water

Oxygen

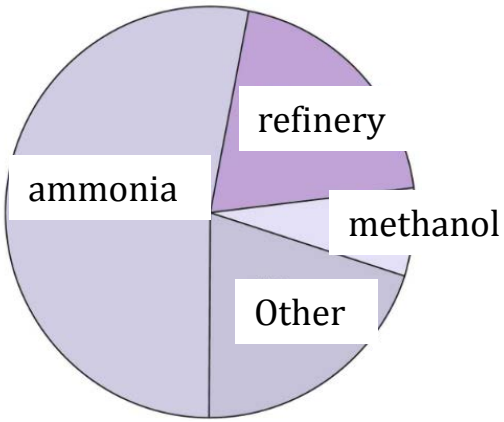



### Water electrolysis



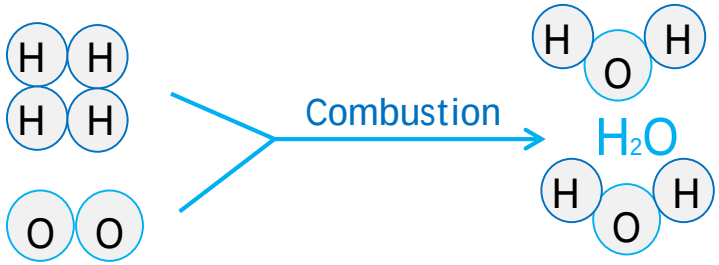

## Usage

### Current industrial use of hydrogen

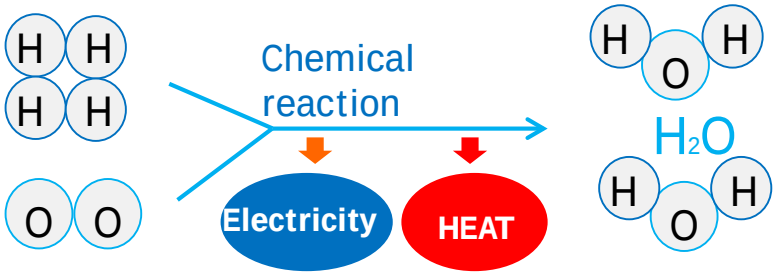



Source: http://www.essentialchemicalindustry.org/chemicals/hydrogen.html

### Clean fuel

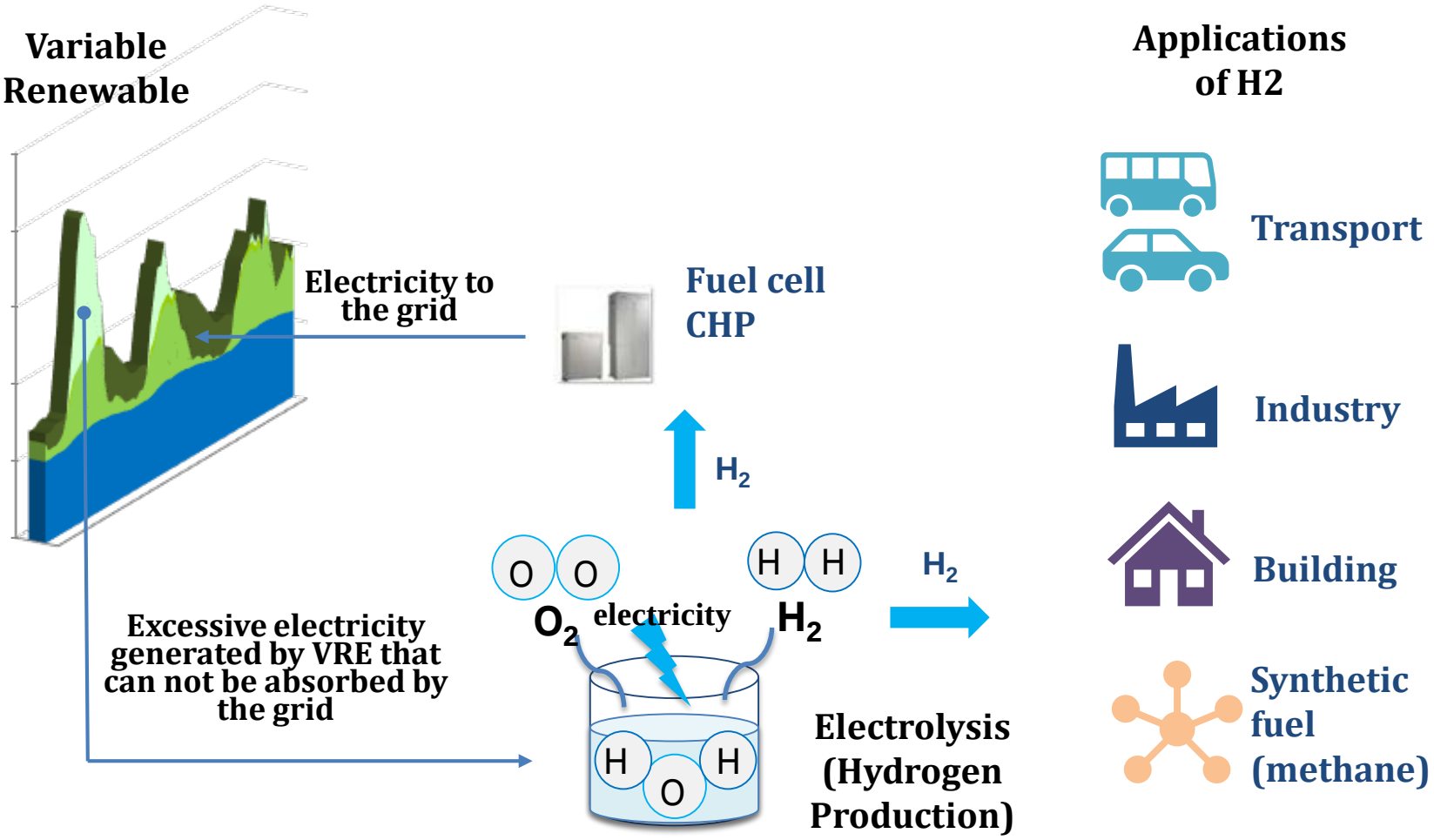



### Fuel cells




Source: Fuel Cell Association, http://www.fca-enefarm.org/about.html;

# Why hydrogen: deep decarbonization



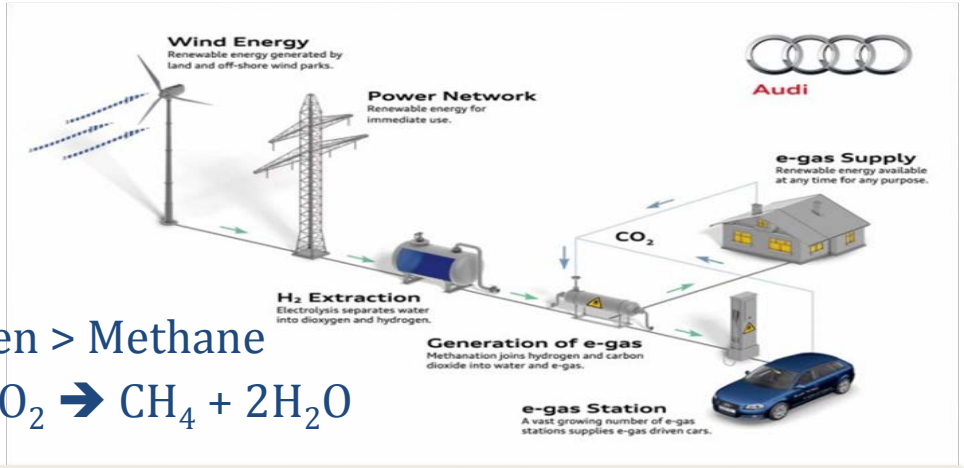

- Using excess renewable electricity (electricity that cannot be absorbed by the grid) to produce hydrogen.
- Hydrogen can be utilized in various sectors.

# PtG projects in Europe

## Wind➔$H_2$➔Gas P/L

## Remote Island

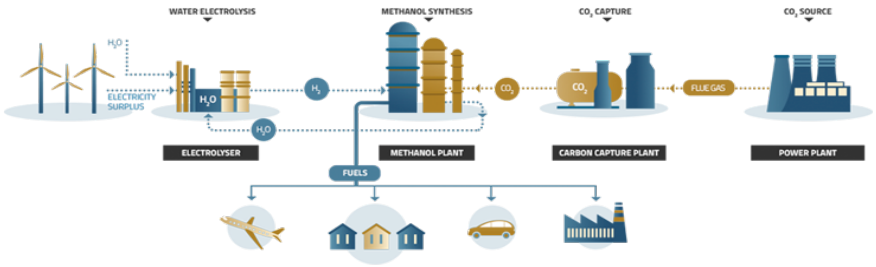
## Wind➔Synthetic $CH_4$➔GasP/L➔CNG vehicle




Hydrogen > Methane

$4H_2 + CO_2 \rightarrow CH_4 + 2H_2O$

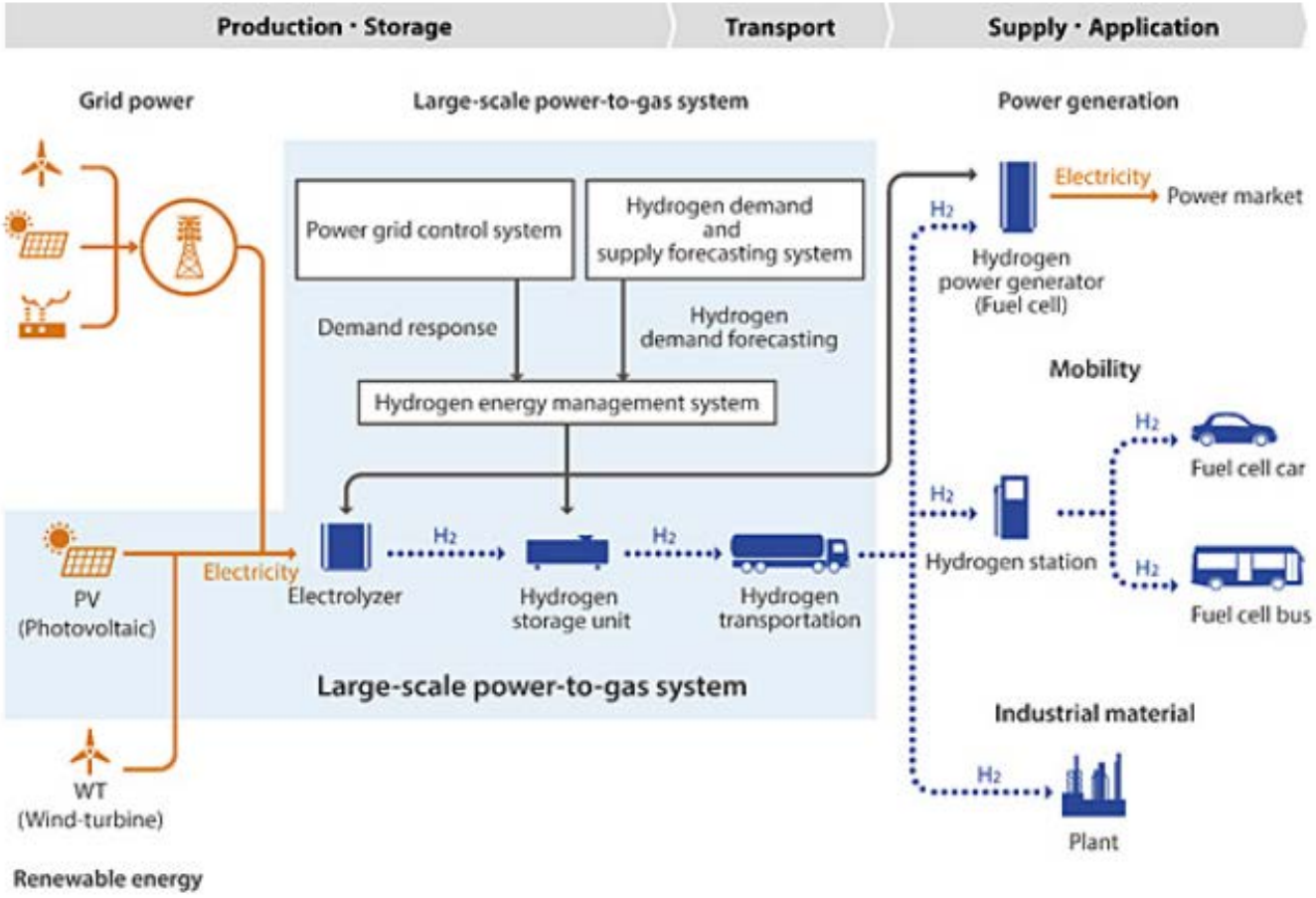
## Synthetic Methanol




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

Source: NEDO (https://www.nedo.go.jp/english/news/AA5en_100393.html)

# Hydrogen 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**

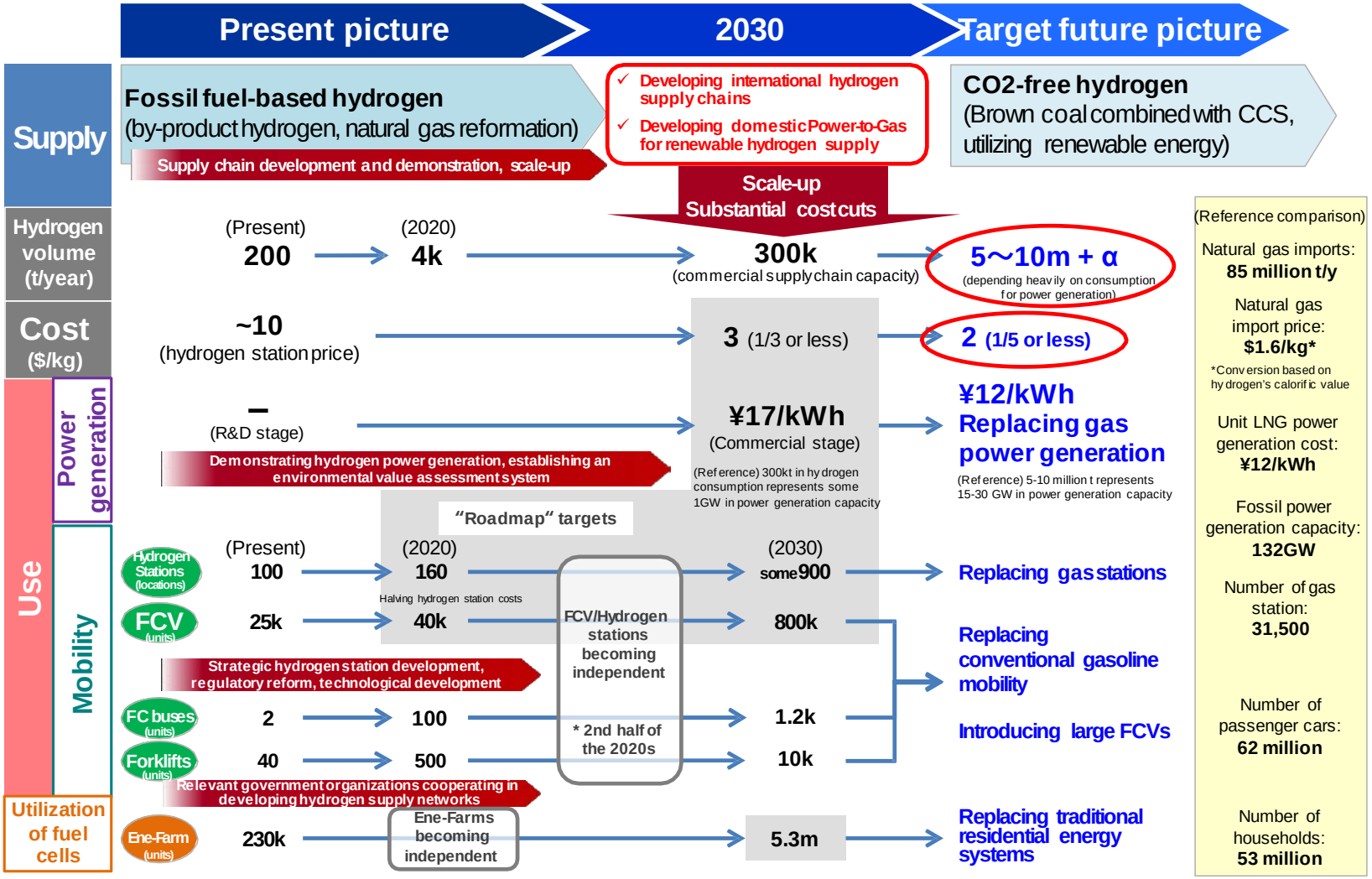
【Demand】 ・・・ ③ **Mass usage** (Mobility ⇒ Power Generation ⇒ Industry)

- **Key Technologies to be Developed**

| Production | Transportation | Use |
|---|---|---|
| • Electrolysis System<br>• Brown coal gasification + CCS | • Energy Carrier ($LH_2$, MCH, $NH_3$, etc.) | • Fuel Cells (Mobility, Stationary)<br>• $H_2$-fired Generation |

Source: Ministry of Economy, Trade and Industry (METI)

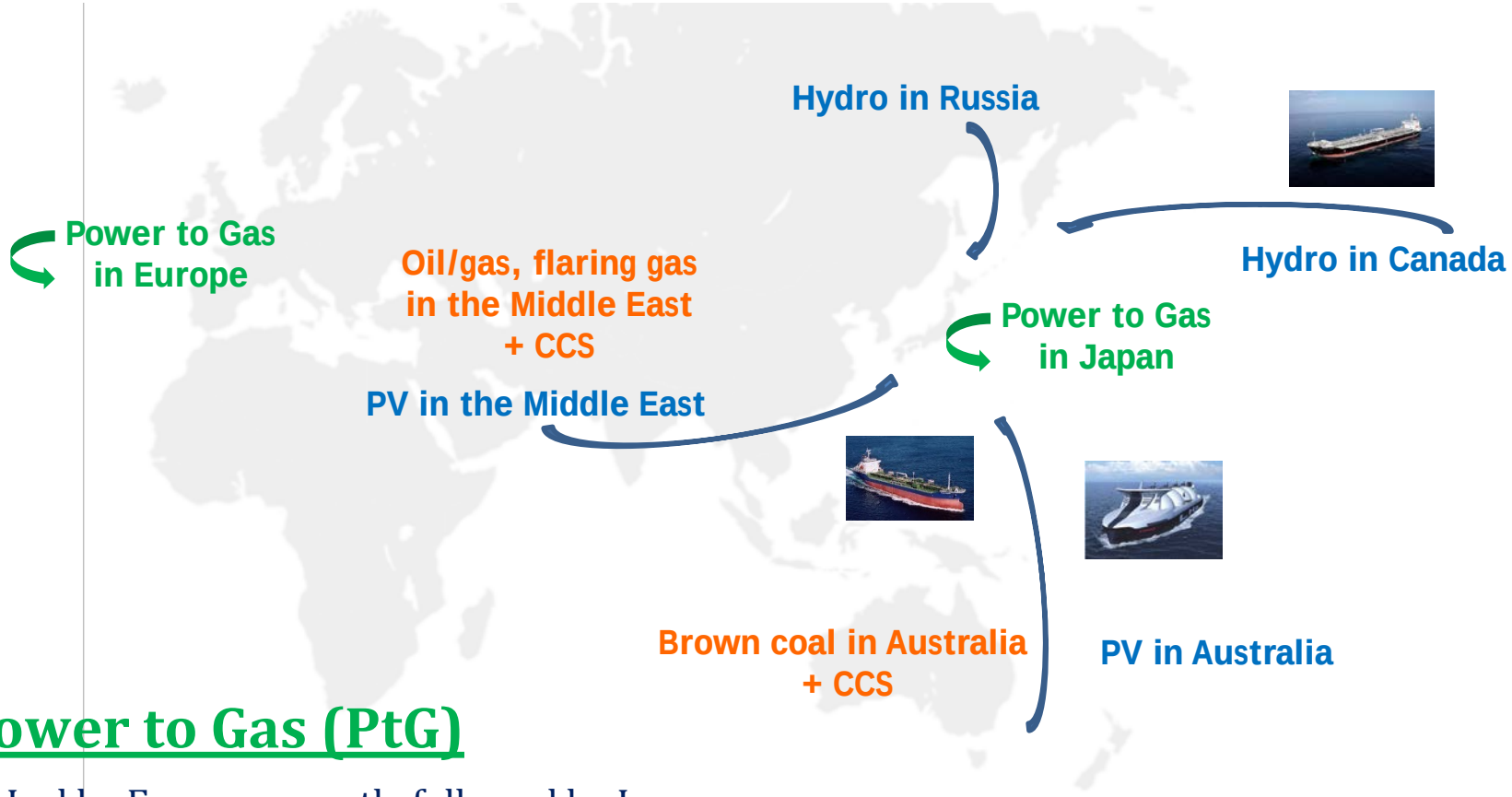
# Japan's hydrogen strategy: Basic Hydrogen Strategy




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)
  - ✓ CO2 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.

# Japan's hydrogen strategy: private sector

## HySTRA: commercialization of hydrogen supply chain

J-POWER, Shell, Iwatani, Kawasaki Powering your potential, Marubeni

Source: http://www.hystra.or.jp/en/

## AHEAD: commercialization of hydrogen supply chain

CHIYODA CORPORATION, Mitsubishi Corporation, MITSUI&CO., NYK LINE NIPPON YUSEN KAISHA

Source: https://www.ahead.or.jp/en/organization.html

## JHyM: Japan $H_2$ Mobility, hydrogen refueling station

TOYOTA, NISSAN, HONDA, JXTGエネルギー, IDEMITSU, Iwatani, エネルギー・フロンティア TOKYO GAS, 東邦ガス, Air Liquide creative oxygen, 根本通商株式会社 NEMOTO, SEIRYU POWER ENERGY, 豊田通商, DBJ 日本政策投資銀行, JA三井リース, 損保ジャパン日本興亜, SMFL 三井住友ファイナンス&リース, NEC NECキャピタルソリューション株式会社, SPARX スパークス・グループ株式会社

Source: https://www.jhym.co.jp/en/partners/

# Thank you very much!