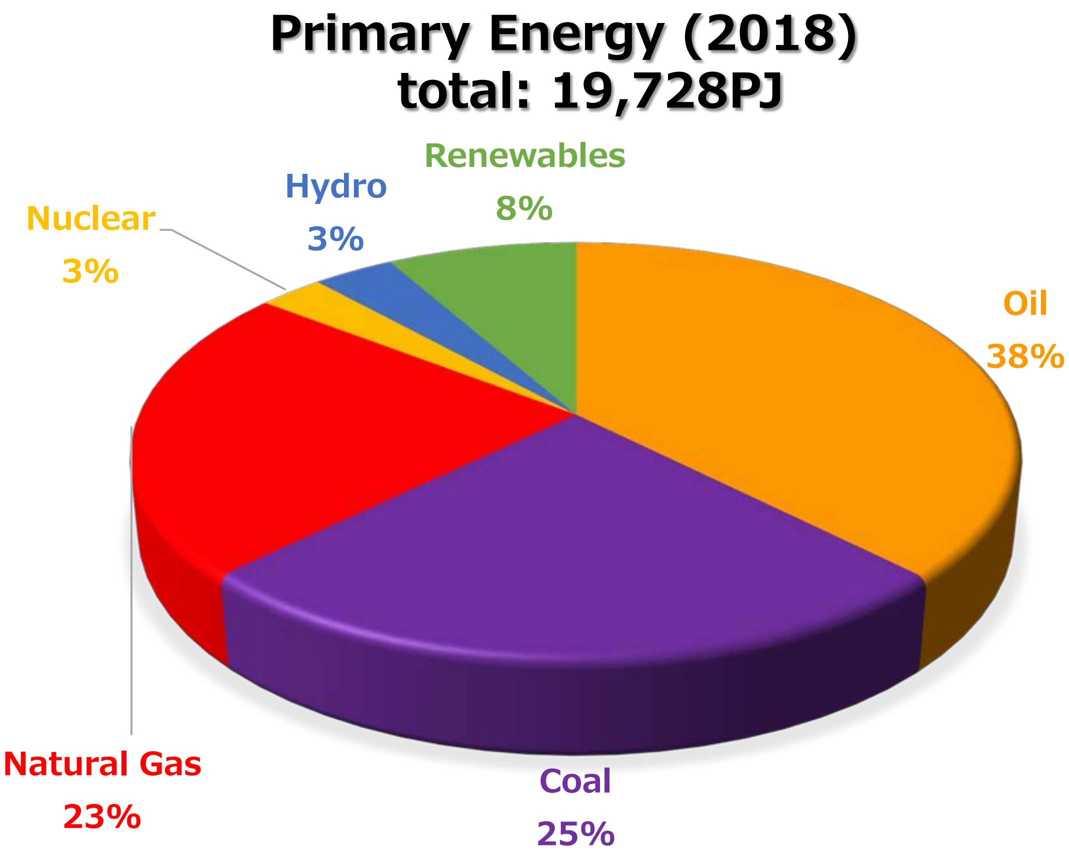
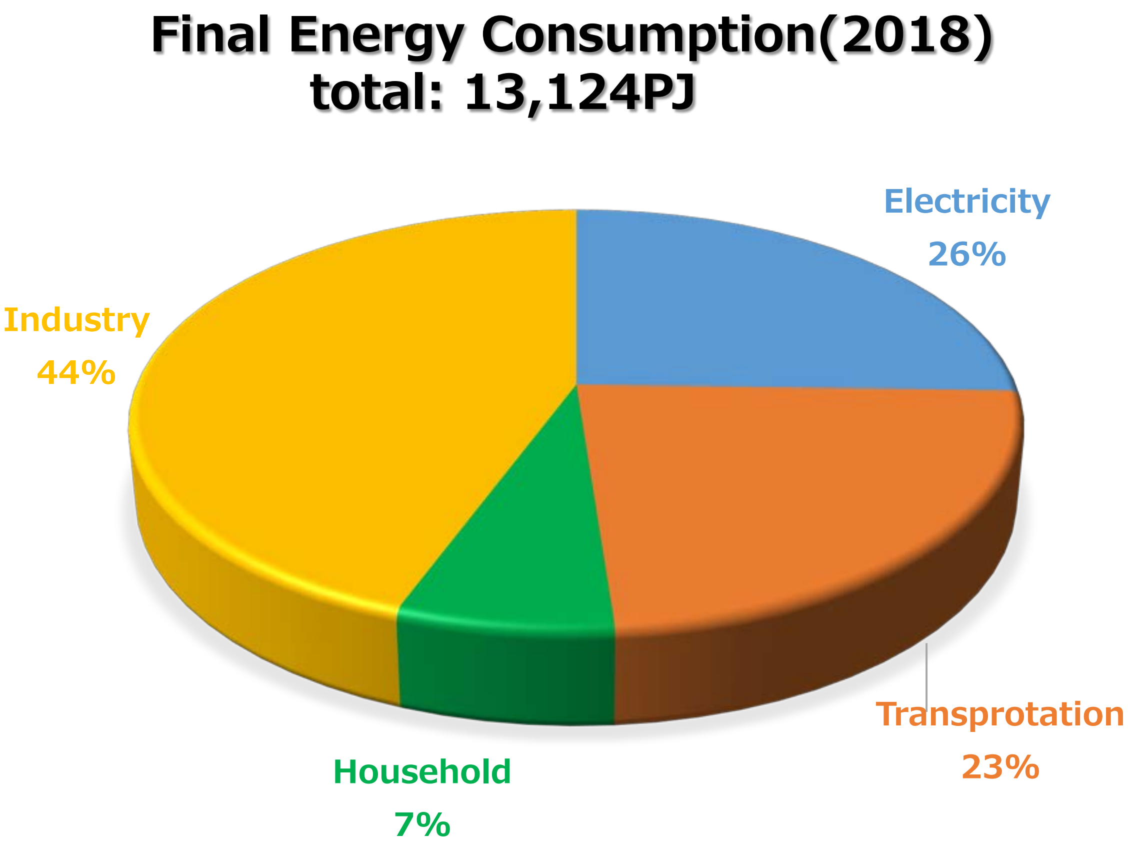
NEDO's approach to realize hydrogen based society

New Energy and Industrial Technology Development Organization (NEDO)

Background: Japan's Energy Situation



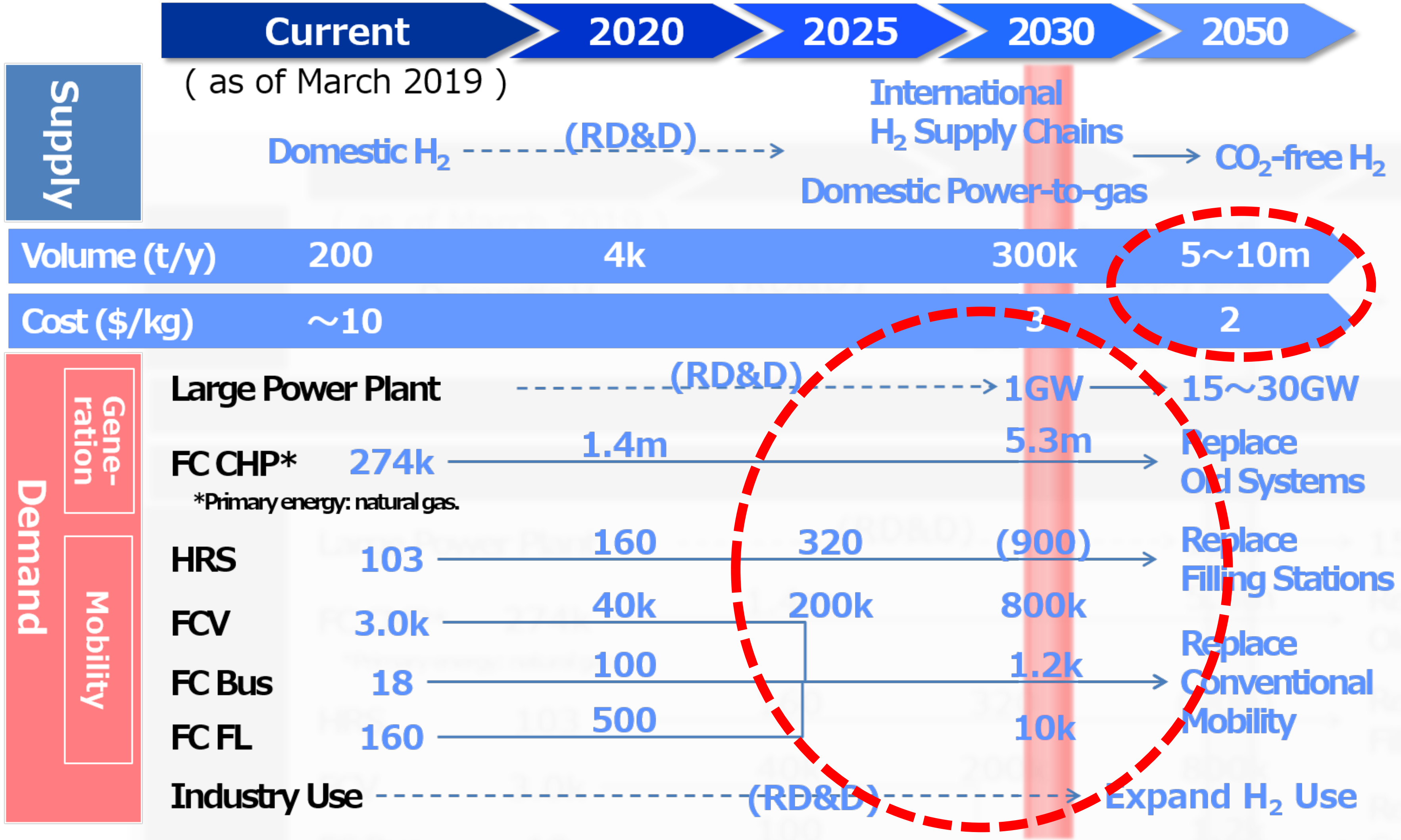


- Japan's target: GHGs: <u>▲26% in 2030 / ▲80% in 2050</u>
- Increasing renewables is key, but not enough

“Basic Hydrogen Strategy” (Dec, 2017)

NEDO

Clarify the future direction, with the consensus of stakeholders.



Reducing hydrogen costs to the same level of conventional energy

Setting target toward 2030

Action Plan: "Strategic Roadmap for HFC"

		Goals in the Basic Hydrogen Strategy		Set of targets to achieve	Approach to achieving target
Use	Mobility	FCV 200k b y2025 800k by 2030	2025	● Price difference between FCV and HV (¥3m → ¥0.7m) ● Cost of main FCV system (FC ¥20k/kW → ¥5k/kW; Hydrogen Storage ¥0.7m → ¥0.3m)	• Regulatory reform and developing technology
		HRS 320 by 2025 900 by 2030	2025	● Construction and operating costs (Construction cost ¥350m → ¥200m; Operating cost ¥34m→¥15m) ● Costs of components for HRS (Compressor ¥90m → ¥50m; Accumulator¥50m → ¥10m)	• Consideration for creating nation wide network of HRS • Extending hours of operation
		Bus 1,200 by 2030	Early 2020s	● Vehicle cost of FC bus (¥105m → ¥52.5m) ※In addition, promote development of guidelines and technology development for expansion of hydrogen use in the field of FC trucks, ships and trains.	• Increasing HRS for FC bus
	Power	Commercialize by 2030	2020	● Efficiency of hydrogen power generation (26%→27%) ※1MW scale	• Developing of high efficiency combustor etc.
	FC	Early realization of grid parity	2025	● Realization of grid parity in commercial and industrial use	• Developing FC cell/stack technology
Supply	Fossil Fuel +CCS	Hydrogen Cost ¥30/Nm3 by 2030 ¥20/Nm3 in future	Early 2020s	● Production: Production cost from brown coal gasification (¥several hundred/Nm3→ ¥12/Nm3) ● Storage/Transport：Scale-up of Liquefied hydrogen tank (thousands ㎥→50,000㎥) Higher efficiency of Liquefaction (13.6kWh/kg→6kWh/kg)	• Scaling-up and improving efficiency of brown coal gasifier • Scaling-up and improving thermal insulation properties
	Green H2	System cost of water electrolysis ¥50,000/kW in future	2030	● Cost of electrolyzer (¥200,000m/kW→¥50,000/kW) ● Efficiency of water electrolysis (5kWh/Nm3→4.3kWh/Nm3)	• Designated regions for public deployment demonstration tests utilizing the outcomes of the demonstration test in Namie, Fukushima • Development of electrolyzer with higher efficiency and durability

Hydrogen & Fuel Cells Technology Development Strategy

NEDO

10 priority items in 3 fields

Hydrogen and Fuel Cells Technology Development Strategy

Field	Technology Items	Technical challenges
Field ① **Fuel Cells**	✓ Fuel cells for vehicles ✓ Stationary fuel cells ✓ Auxiliary equipment, tanks and related systems	● Substantial **reduction or elimination of Pt in catalysts** ● Development of the fuel cells to realize **higher efficiency over 65 %** for significant cost savings
Field ② **Supply Chain**	✓ Large-scale hydrogen production ✓ Transport / Storage ✓ Hydrogen power generation ✓ Hydrogen refueling station	● Development of **insulation system** ● **Control of flashback, combustion oscillation and NOx emission** ● Development of **fueling protocol** to reduce construction and operation costs
Field ③ **Water Electrolysis and the others**	✓ Water Electrolysis Technologies ✓ Industrial Applications ✓ Discontinuous innovation	● **Break through of degradation mechanism** in Electrolyte-materials

Road Map for Hydrogen and Fuel Cells

Approach to achieve goals (Action Plans)	
Reduction of precious-metal contents in catalysts Development of **fuel cell stack technologies for higher efficiency and higher power density** **Integrate promotion of regulatory reform and technological development**	Mobility / Stationary
Development of **high-efficiency combustor**	Power
Development of **large-scale storage tanks for liquefied hydrogen**	Fossil fuel + CCS
Durability improvement of water electrolysis system	Green H2

Accelerate International Momentum

Accelerate International Momentum

Tokyo Statement:
Identified the area to be collaborated internationally
-Harmonization of RCS
-Joint research to expand hydrogen utilization
-Study and evaluation of hydrogen potential
-Communication, education, outreach

Global Action Agenda of Tokyo Statement:
- Sharing global target (e.g. “Ten, Ten, Ten”)
- Promoting international standards
- Developing technologies for promoting hydrogen use in various fields
- Study on hydrogen demand forecasts
- Information sharing and public outreach

Current status: Hydrogen Applications

Items		Japan's Target (Year)	Current status (as of Mar-2020)
Residencial Fuel Cell			
	Instration number	5.3 million (2030)	350k
	Pay back period (price)	5 years (2030)	PEFC: 7.9 years (JPY 900k / EUR 7.5k) SOFC: 9.5 years (JPY 1,110k / EUR 9.3k)
Mobility			
	Nubmer of Passenger Vehicle	800k (2030)	3,757
	Nubmer of Fuel Cell Bus	1.2k (2030)	57 (mainly in regular operation)
Hydrogen Refueling Station			
	Nubmer of Station	900 (2030)	117 (public stations)
	Installation cost (in JPY)	200 million (2025)	310 million (EUR 2.6 million)
	Operation cost (in JPY)	15 million (2025)	31 million (EUR 260k)


New Products

Toyota unveiled the “new MIRAI”

30% increasing driving range (over 800km w/full fueling)

Will be launched late 2020 / early 2021 in Japan

Tokyo Gas released “Ene-Farm Mini” on 10 Oct. 2019

400W power, 80% total efficiency (LHV)

Kyocera’s SOFC Unit (W800mm × D350mm × H700mm)
(Heat unit: W480mm × D250mm × H750mm)

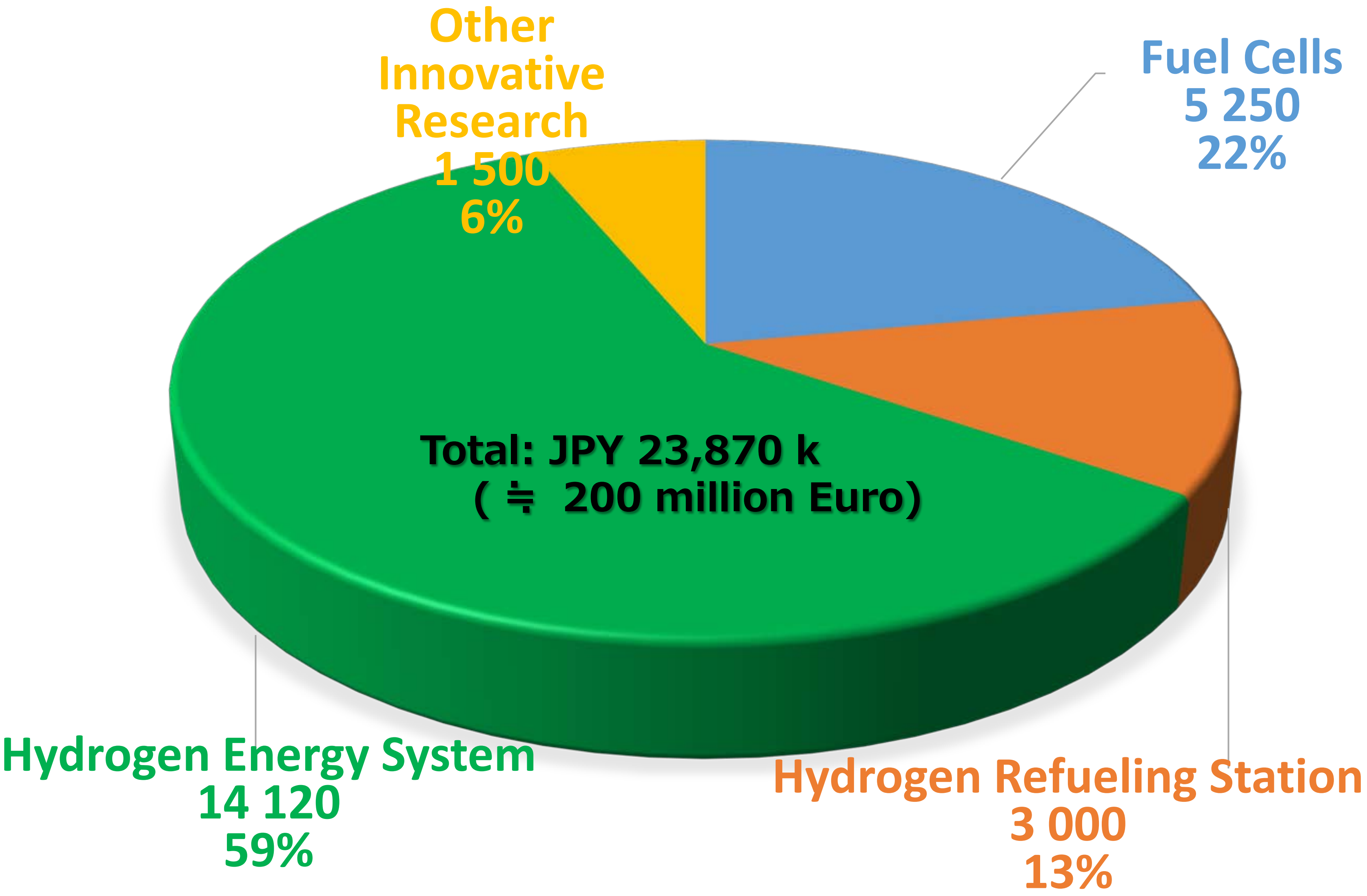
Policy Measures for introducing New Technology

Promoting Research, Development & Demonstration activities

Market Adaptation
(Suitable Regulation, Code & Standard)

Financial Support/ Incentives
(Subsidy, Tax Exemption, etc.)

NEDO's Budget for H_2 in 2020



Current Direction of NEDO's Program

First Step: Promoting fuel cell application

Fuel Cells:

(1) PEFC: for mobility

Target:

	2030	2040
Power Density	6kW/L	9kW/L
Max Voltage	> 0.6V	0.85V
Max Temperature	< 100℃	120℃
Cruse range	800 km	> 1,000 km
System Cost	< US$40 / kW	US$20 / kW

- Improving productivity (Catalyst, MEA, other materials, Tank, etc.)

New applications (Ship, Heavy/Middle duty Vehicle, Drone, etc.)

(2) SOFC: for stationary use

Efficiency > 65% (mono-generation) , Durability > 130,000 hrs.

- New technology such as Proton-Conducting SOFC

Current Direction of NEDO's Program

First Step: Promoting fuel cell application

Hydrogen Refueling Station:

Reducing CAPEX / OPEX: make it half by 2025

- To address regulatory reform on FCV/HRS in Japan

  ex. Unmanned operation with remote monitoring, Risk assessment on HRS, etc.

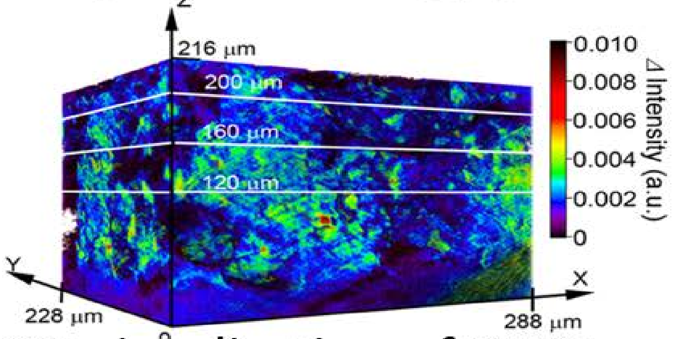
- Developing low cost equipment (incl. Electro-chemical compressor, polymers, etc.)

Preparing for Heavy Duty Vehicles

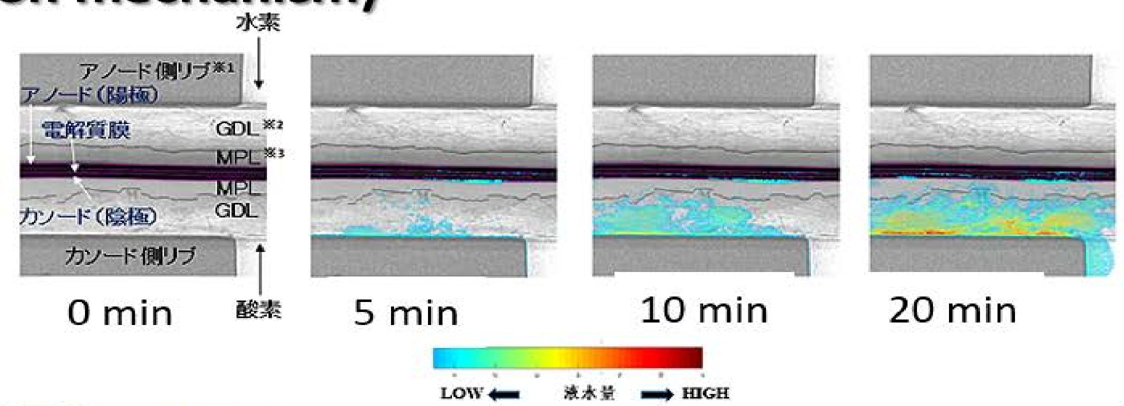
- Developing refueling protocol, hydrogen metering, etc.

Fuel Cell Deployment

Analysis Technology (PEFC reaction mechanism)



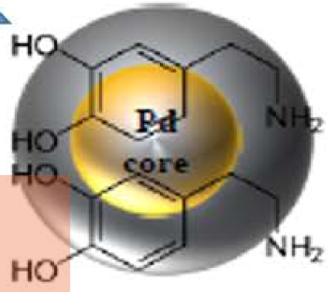
3D visualization of PFEC anode catalyst degradation



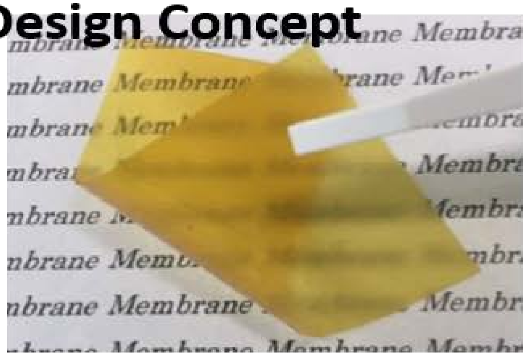
Water distribution in PEFC

PEFC performance evaluation

Material Design Concept



Catalyst



Membrane

Developing Fuel Cell R&D Platform

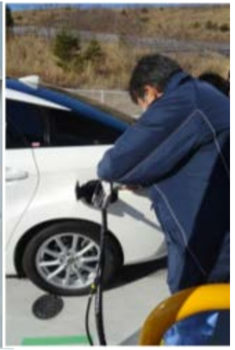
Fuel Cell Deployment

Demonstration at “Real Environment

- Testing a new equipment
- Refueling protocol
- Metering etc.

Total System Analysis for cost reduction

Education & Training



Current Direction of NEDO's Program

Second Step: Develp H2 demand & Integrate w/ energy system

Hydrogen Supply Chain / Gas Turbine:

- Developing combustor for Hydrogen Gas Turbine
  Control of combustion for low NOx, back fire, etc.
- Realizing large scale hydrogen supply chain
  Hydrogen carriers for long distance transportation

Power to Gas:

- Developing System Technology
  System Operation, Energy management, Demand response
- Improving electrolysis technology
  Analyzing reaction mechanism, developing lifetime evaluation, etc.
  Scaling-up, durability, dynamic operation

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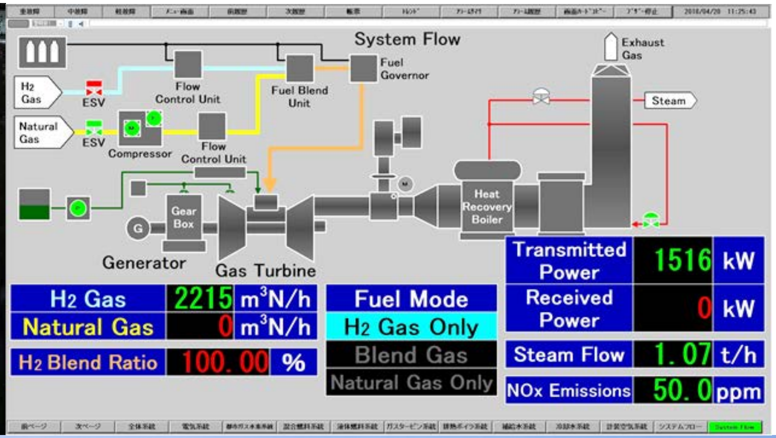
Hydrogen Scaling-up

1MW Hydrogen/Natural Gas dual fuel gas turbine system

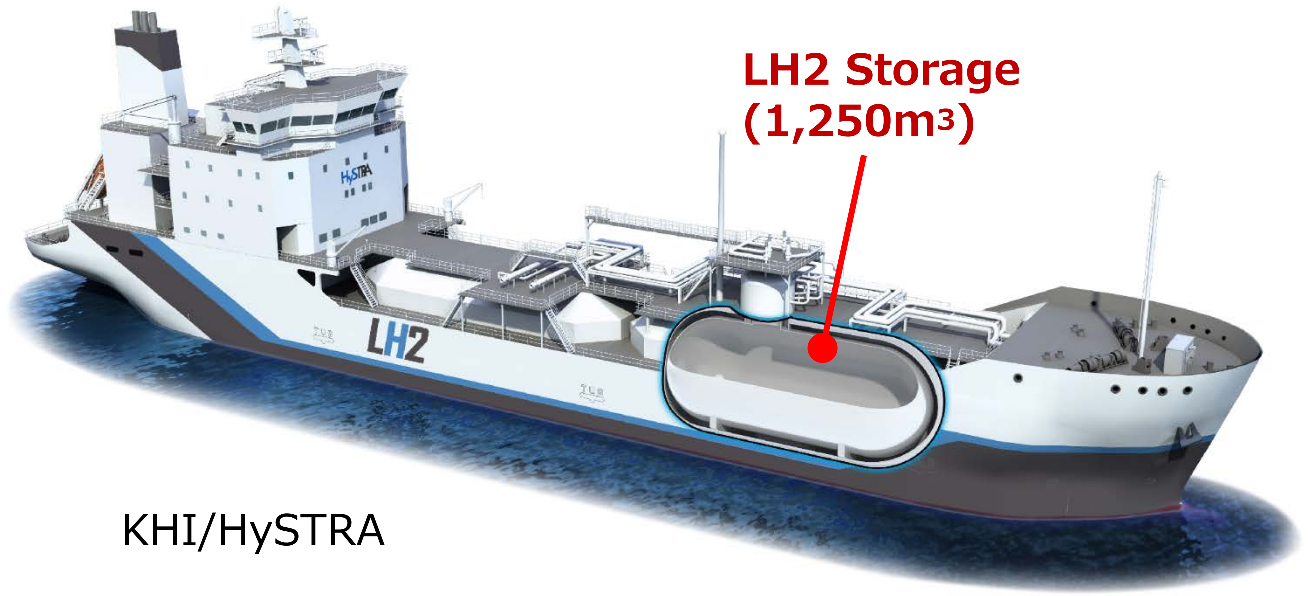


■ Capacity
Electricity: 1,100kW
Thermal: 2,800kW

Hydrogen Scaling-up

Demonstration with would 1st hydrogen tanker

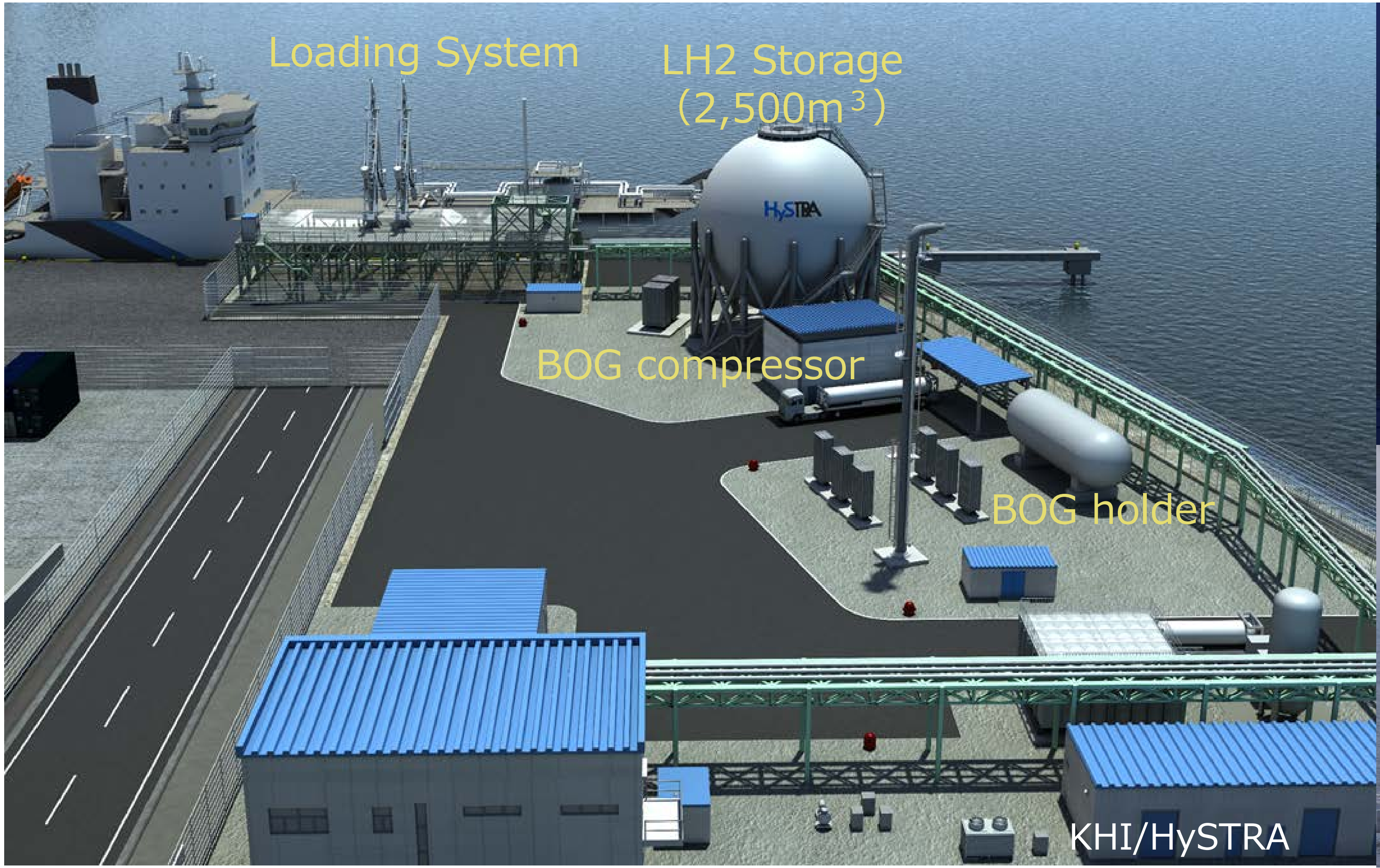
Length	116m
Width	19m
Propulsion	Motor
Cruising range	11,300 n. m.
Cruising Speed	13 knot



KHI/HySTRA

Hydrogen Scaling-up

Demonstration with would 1st hydrogen tanker (LH2 Base @Kobe)

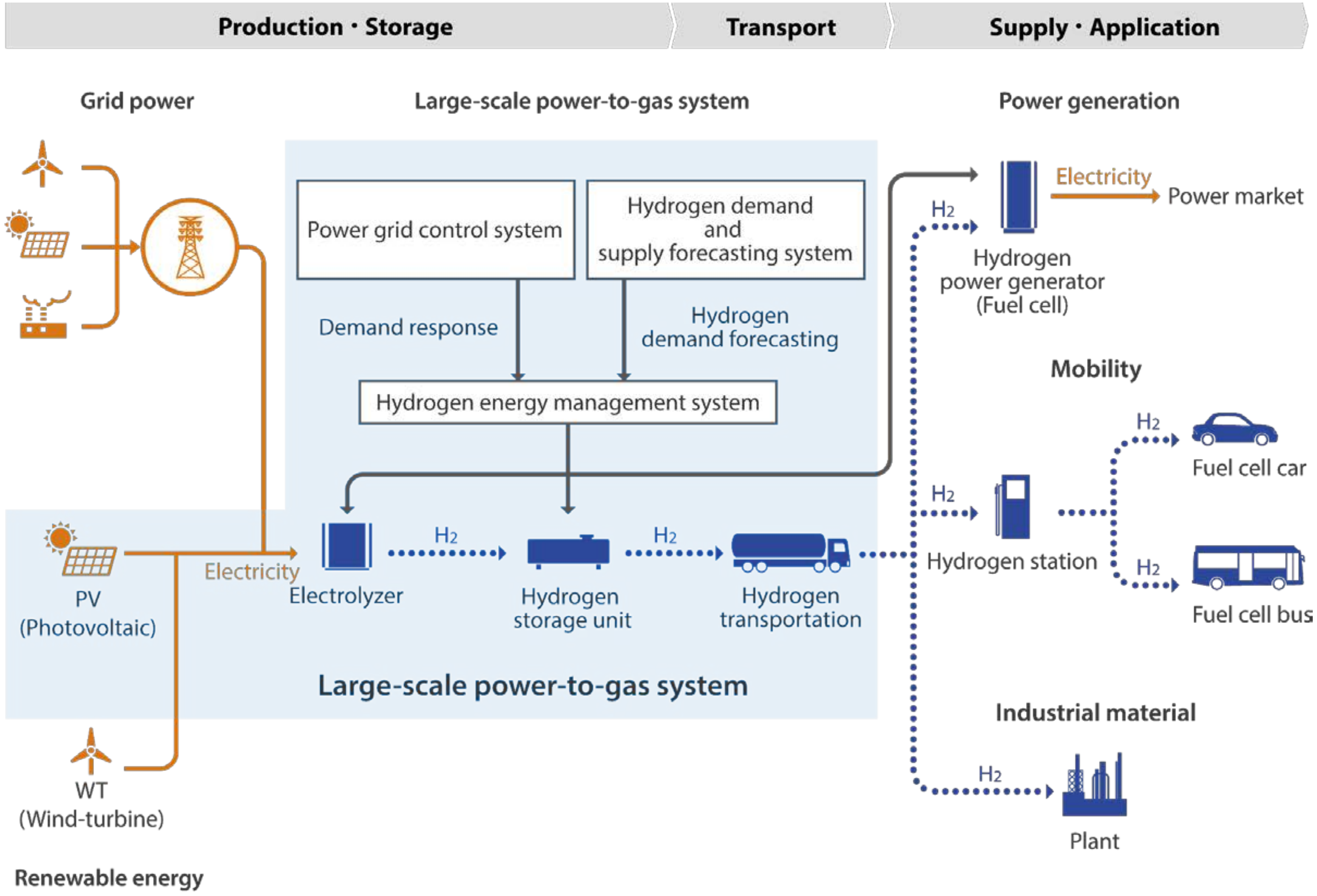


Hydrogen Scaling-up

Demonstrating with world's largest power to gas system with 10MW Alkaline electrolysis and 20MW PV

Hydrogen Scaling-up

System Overview



Item	Specification
Function	(1)Produce・Storage・Supply of hydrogen (2)Balancing the supply and demand of the electricity grid
Annual producing capability (Rated output)	900t-H2／year
Input power (Electrolysis)	(Max.) 10MW (Rated) 6MW (Range) 1.5MW ～ 10MW
Hydrogen Storage / transport (Compressed hydrogen)	(1)Tube Trailer 2,642Nm3, 19.6MPa (2)Curdle 265.8Nm3, 19.6MPa

Conclusion

- *Japanese Government strongly promoting hydrogen*
  - *with Prime Minister's leadership*
  - *recognizing importance of international collaboration*

- *Just started market penetration*
  - *need to enhance application, improve technology*

- *Developing low-carbon energy system*
  - *scaling-up technology*
  - *integrating with other energy*