October 7th, 2013
IEA, Global Industry Dialogue and Expert Review Workshop

Japanese Initiatives in Developing Innovative Technologies for the Environment and Energy

Shinichi Kihara
Director, International Affairs Division,
Agency for Natural Resources and Energy,
Ministry of Economy, Trade and Industry

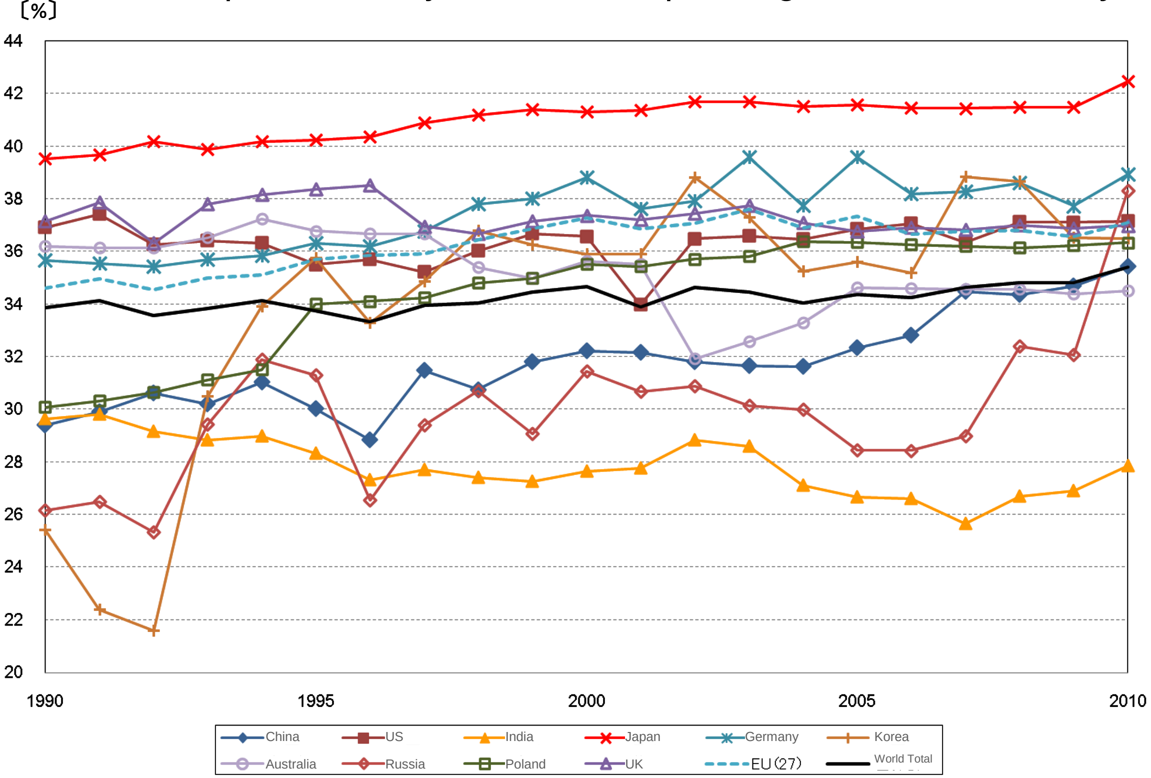
Background of Innovative Technology Development (1)

Seeking to promote the development of Japan's prominent environmental technologies and contribute to achieving the goal of halving global greenhouse gas emissions.

● At the 2009 L'Aquila Summit, G8 countries declared its support for the globally shared long-term goal of halving global greenhouse gas emissions by 2050 and reducing greenhouse gas emissions from developed countries by 80%. In order to achieve this goal, Japan seeks to promote the development of its prominent environmental and energy technologies and to disseminate this technology domestically, prior to global diffusion.

●In order to reduce global greenhouse gas emissions, it is important for Japan, which accounts for 4% of global greenhouse gas emissions, not only to promote domestic measures but also to achieve effective reductions across the world.

Coal-fired thermal power in major countries: power generation efficiency trends



Background of Innovative Technology Development (2)

The Japanese government formulated the “New Low Carbon Technology Plan” which includes a technology roadmap and measures for dissemination in order to develop innovative technologies in the fields of environment and energy.

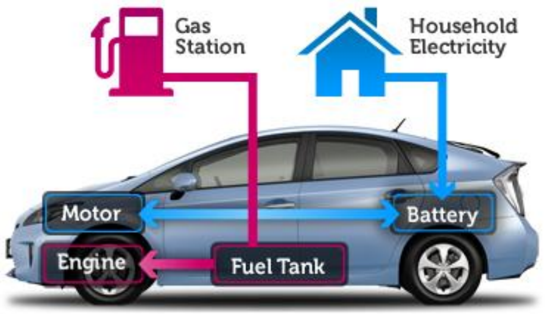
- In order to achieve both economic development and significant reductions in greenhouse gas emissions, it is essential to “develop and disseminate innovative technologies”. As part of the global effort to find solutions to this challenge, it is the responsibility of Japan, home to the world’s top-level technologies, to take international leadership in the development and dissemination of innovative technologies.
- Japan’s Environmental Energy Technology Revolution Plan compiled the following:

(1) Identifying innovative technologies that should be developed in the short- to medium-term and medium to long-term

(2) Challenges and roadmap for promoting technology development

(3) Policy measures required for international promotion and dissemination of innovative technologies

Examples of low-carbon technology-oriented products undergoing further development and dissemination



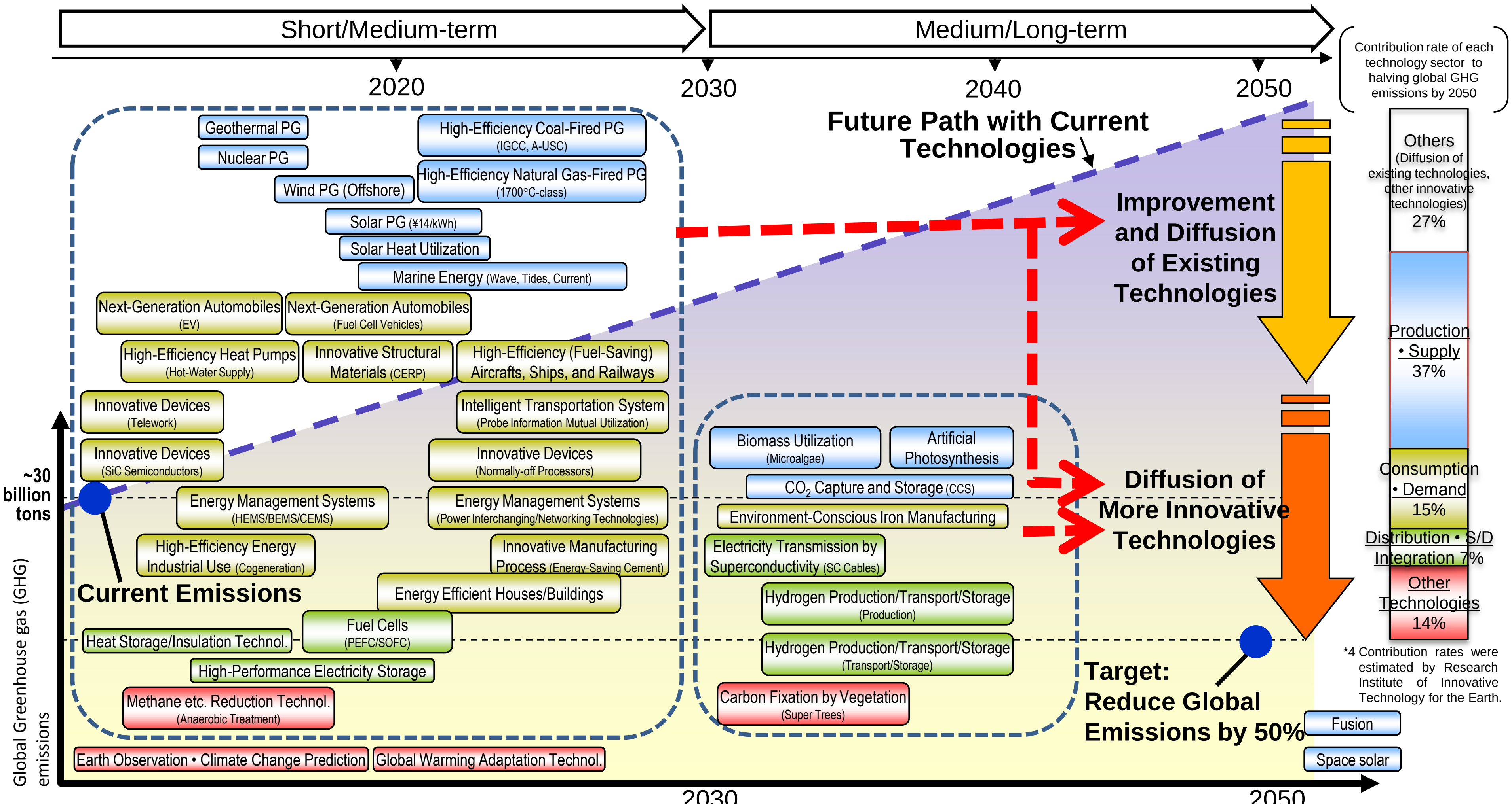
Plug-in Hybrid Vehicle

Electric Vehicle (EV) to Home

Residential polymer electrolyte fuel cell (PEFC) cogeneration system

Global Contribution of Japan's Environmental and Energy Technologies

Japan will continue to develop advanced environmental and energy technologies in the short/medium-term to medium/long-term, and will contribute to halving global greenhouse gas emissions by 2050 through global diffusion of such technologies.
It is necessary to promote developing more innovative technologies over a medium-to-long-term, due to difficulties in achieving this emission reduction target by improvement and diffusion of existing technologies.



*1 The horizontal position of environmental and energy technologies indicates approximate time of practical diffusion based on the roadmap of each technology.
*2 "Future path with current technologies" indicates approximate transition of global GHG emissions assuming no change in efficiencies for existing technologies (e.g., generating efficiency of coal-fired generation)
*3 The downward arrows for "Improvement and diffusion of existing technologies" and "Diffusion of innovative technologies" indicate both contributions are required to reduce global GHG emissions; they do not specify the amount of reduction by each contribution.

Legend
- Production • Supply
- Consumption • Demand
- Distribution • S/D Integration
- Other Technologies

*1 Center of bars indicates approximate time of practical diffusion.
*2 Parentheses show technology examples. Refer to the full text for details.

Target Technologies

Evaluation of Environmental and Energy Technologies

Technology Evaluation Axis

Global GH Gas Reduction Effect (2050)	A: 1 billion ton or more, B: 0.3-1 billion ton, C: Less than 0.3 billion ton
Global Market Size	A: 3 trillion yen or more, B: 0.3-3 trillion yen, C: Less than 0.3 trillion yen
Maturity Phase	Basic research, Applied research, Demonstration, Diffusion

Sector	Category	Subcategory	Global GH Gas Reduction Effect (2050)	Global Market Size	Maturity Phase
Production • Supply	Thermal Power Generation	1. High-Efficiency Coal-Fired Power Generation	A	A	Demonstration
		2. High-Efficiency Natural Gas-Fired Power Generation	A *1	A	Demonstration
	Utilization of Renewable Energies	3. Wind Power Generation	A	A	Demonstration-Diffusion
		4. Solar Energy Utilization (Solar Light)	A	A	Basic Research-Diffusion
		5. Solar Energy Utilization (Solar Heat)	A	A	Basic Research-Diffusion
		6. Marine Energy (Wave, Tides, Current)	B	B	Demonstration
		7. Geothermal Power Generation	B	A	Basic Research-Diffusion
		8. Biomass Utilization	A	A	Basic Research-Diffusion
	Nuclear Power	9. Nuclear Power Generation	A	A	Basic Research-Demonstration
	CO_2 Capture, Use, Storage (CCUS)	10. CO_2 Capture and Storage (CCS)	A	A	Demonstration
		11. Artificial Photosynthesis	*2	*2	Basic Research-Demonstration
Consumption • Demand	Transportation	12. Next-Generation Automobiles (HV, PHV, EV, Clean Diesel, etc.)	A	A	Diffusion
		13. Next-Generation Automobiles (Fuel Cell Vehicles)	B	A	Demonstration-Diffusion
		14. Aircrafts, Ships, Railways (Aircrafts)	B *3	A	Applied Research-Diffusion
		15. Aircrafts, Ships, Railways (Ships)	B *3	A	Applied Research-Diffusion
		16. Aircrafts, Ships, Railways (Railways)	C	A	Applied Research-Diffusion
		17. Intelligent Transportation System	*2	*2	Demonstration-Diffusion
	Devices	18. Innovative Devices (Information System, Lighting, Display)	A *4	A	Applied Research-Diffusion
		19. Innovative Devices (Power Electronics)	*2	C	Demonstration
		20. Innovative Devices (Telework)	*2	C	Applied Research-Diffusion
	Materials	21. Innovative Structural Materials	A *5	A	Applied Research-Diffusion
	Energy Utilization Technology	22. Energy Management System	A	A	Applied Research-Diffusion
		23. Energy Efficient Houses/Buildings	A *6	A	Applied Research-Diffusion
		24. High-Efficiency Energy Industrial Use	B *7	A	Applied research-Diffusion
		25. High-Efficiency Heat Pumps	B *8	A	Applied Research-Diffusion
	Production Process	26. Environment-Conscious Iron Manufacturing Process	*2	*2	Applied Research-Demonstration
		27. Innovative Manufacturing Process	A *9	A *9	Applied Research
Distribution • Supply/Demand Unification	Energy Conversion, Storage, Transport	28. Hydrogen Production, Transport, Storage (Production)	*10	C	Demonstration
		29. Hydrogen Production, Transport, Storage (Transport/Storage)	*10	C	Demonstration
		30. Fuel Cells	B	B	Demonstration-Diffusion
		31. High-Performance Electricity Storage	*10	B	Applied Research-Diffusion
		32. Heat Storage/Insulation Technology	C *11	B	Applied Research-Diffusion
		33. Electricity Transmission by Superconductivity	C	B	Demonstration
Other Technologies		34. Carbon Fixation by Vegetation	A	A	Demonstration-Diffusion
		35. Other GH Gas (e.g., Methane) Reduction Technology	C	A	Demonstration
		36. Global Warming Adaptation Technology	*2	A	Basic Research-Diffusion
		37. Earth Observation • Climate Change Prediction	*2	*2	Basic Research-Diffusion

(Note) The present table shows evaluation based on estimates using conditions and scenarios specific to individual technologies. Reduction effects cannot be simply added up because their overlaps among technologies are not eliminated.

(References) The following materials were referred to in compilation of the present table.
• IEA, Energy Technology Perspectives (ETP) 2012 (2012); IEA, Energy Technology Perspectives (ETP) 2010 (2010); Council for Science and Technology Policy, Innovative Strategy for Energy and the Environment (2008); Japan Revitalization Strategy Short- to Mid-term Progress Schedule (2013); Comprehensive Strategy on Science and Technology Innovation Progress Schedule (2013); NEDO Renewable Energy Technology White Paper (2010); NEDO Fuel Cell and Hydrogen Technology Development Roadmap 2010 (2010)

1. High-Efficiency Coal-Fired Power Generation

Outline of Technology

- ○ High-efficiency coal-fired thermal power generation technologies, including technologies at the research stage, include the following: ultra-supercritical (USC) power generation, which requires high-temperature high-pressure steam conditions for coal dust-fired power generation; advanced ultra-supercritical (A-USC) power generation; the integrated coal gasification combined cycle (IGCC), where power is generated after converting coal to gas; and the integrated coal gasification fuel cell combined cycle (IGFC), which combines IGCC with fuel cells.
- ○ If CCS can be commercialized and introduced in the future, CO_2 emissions can be reduced to almost zero.
- ○ Estimates show that if coal-fired thermal power technology which has already been commercialized in Japan (USC) were to be introduced at coal-fired thermal power generation plants overseas in the United States, China and India, energy-origin CO_2 emissions could be reduced by 1.5 billion t.

Trends and Challenges in Japan's Technology Development

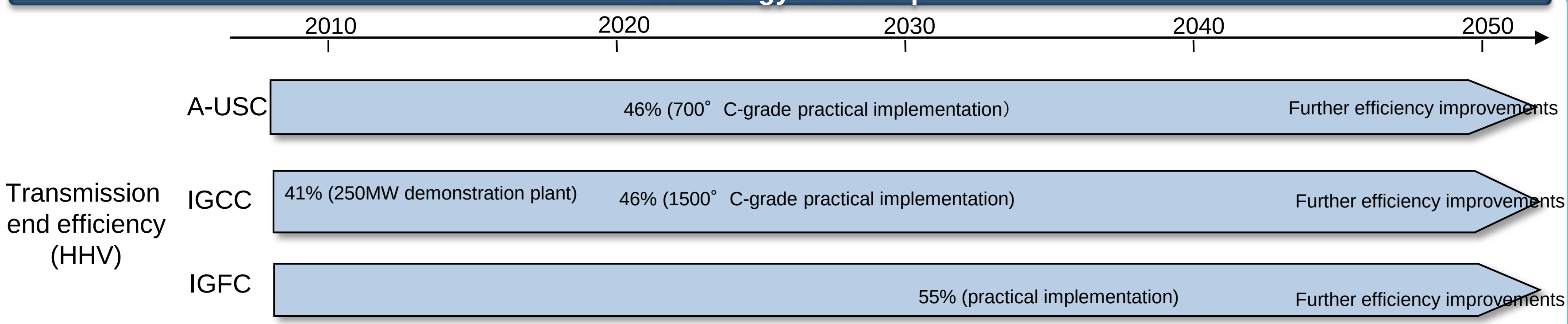
○ Technological development support has been provided for A-USC since fiscal 2008. The main challenges are the development of large-capacity boiler-turbine systems for power industry use and high-temperature valves. The development of materials that can withstand high-temperature steam of more than 700° C is another challenge.

○ Regarding IGCC, demonstration tests have been carried out in Fukushima Prefecture for air-blown IGCC, and the remaining challenges include the development of high-efficiency gas turbines and combustor technology.

○ Regarding IGFC, demonstration tests to improve the reliability of the overall oxygen-blown IGCC system - a key technology - are currently underway at Chugoku Electric Power Co.'s Osaki Power Station. Future tasks include compatibility evaluation of gasified coal gas with fuel cells.

○ It is important that technology development is conducted with a view to improving the efficiency of power generation, utilizing various coal types and reducing power generation costs.

Technology Roadmap



○ Enhance collaboration between basic research on materials and catalyst technologies conducted at universities and large-scale projects aiming to demonstrate private sector-led plants at the system-level.

○ Promote technological development by fostering a wide range of human resources.

(* Related technological roadmap: 30. Fuel Cells)

International Trends

Level of dissemination

○The majority of the world's coal-fired thermal power stations are concentrated in the in the United States, China and India, and many of these plants have a low power generation efficiency of less than 35%. USC has already become very common in Japan, and its introduction has recently began at large-scale coal-fired thermal power stations in China. In India, SC has been introduced at some coal-fired thermal power stations but conventional low-efficiency models remain prevalent.

Technology development trends

○Europe is conducting various elemental tests using steam at 700° C under the AD700 project led by power companies and manufacturers. Its clean coal policy involves promoting a funding support program for 1) carbon capture and storage (CCS) and 2) integrated coal gasification combined cycle (IGCC) and 3) promoting the engagement of EU companies in the joint development of USC (ultra-supercritical) and A-USC (advanced ultra-supercritical). Commercial use of CCS is targeted for beyond 2020 and field tests for A-USC will be completed in 2016.

○In the US, the Clean Coal Power Initiative (CCPI) and the Clean Coal Technology Demonstration Program aim to achieve coal-fired thermal power generation with zero or close to zero emissions in the future.

Japan's International Competitiveness

○The average generation efficiency of coal-fired thermal power generation facilities in Japan is currently around 41% (generation end, HHV), which compared to a 30-39% range in other countries, is the highest level in the world .

12. Next-Generation Automobiles (HVs/ PHVs/ EVs/ clean diesel etc.)

Outline of Technology

- ○ Hybrid vehicles (HVs) are vehicles that use an internal combustion engine and a motor as power sources. Plug-in hybrid vehicles (PHVs) operate on a combination of a motor charged at home and an internal combustion engine. Electric vehicles (EVs) run solely on a motor powered by electricity stored in batteries instead of an internal combustion engine.
- ○ HVs can reduce CO_2 emissions to approximately half or a third, and EVs, by approximately a quarter, compared to gasoline vehicles. EVs, in particular, can make major reductions in CO_2 emissions from power generation and running by using electricity with a high rate of renewable energy contribution.
- ○ According to the IEA's Energy Technology Perspectives 2012 (ETP2102), estimates reveal that the development and dissemination of next-generation vehicle technology (PHV/ EV) will potentially lead toCO_2 emission reductions by approximately 1.7 billion tons globally by 2050.

**1 "JHFC General Efficiency Review Results" Report*

Trends and Challenges in Japan's Technological Development

- ○ The Ministry of Economy, Trade and Industry (METI) is conducting technological development for further performance improvements in Li-ion batteries with the aim of diffusing EVs and PHVs; conducting research and development on innovative batteries for the full-scale development of electric vehicles with travelling performance comparable to gasoline vehicles; and developing common evaluation methods for materials that importantly contribute to improving the performance of batteries.
- ○ Japan is also engaged in projects to develop innovative high-performance magnets which do not rely on rare earth, soft magnetic materials with low energy loss, and high-efficiency motors that harness the high performance of the novel magnets / new soft-magnetic materials.
- ○ The Ministry of Education, Culture, Sports, Science and Technology (MEXT)is developing post-Li-ion batteries, the assessment of which is being conducted in partnership with METI, with the goal of practical application in the 2030s.

Technology Roadmap

EV, PHV

		2010	2020	2030	2050
PHV batteries	Energy density	30-50 Wh/kg	200 Wh/kg		
	Cost	100,000-150,000 yen/kWh	20,000 yen/kWh		
EV batteries	Energy density	60-100 Wh/kg	250 Wh/kg	500 Wh/kg	700 Wh/kg
	Cost	70,000-100,000 yen/kWh	Less than 20,000 yen/kWh	Approx. 10,000 yen/kWh	Approx. 5,000 yen/kWh
Mileage of EV charge		200 km	350 km	500 km	700 km
EVs		- Performance improvement of Li-ion batteries		- Development of post Li-ion batteries etc.	

(* Related technology roadmaps: 31. High-Performance Power Storage

International Trends

Level of dissemination

○Total global HV/PHV/EV sales in 2011 are estimated to have been approximately 2.5 million vehicles, most of which were manufactured in the US and Japan. Sales of mass-produced EVs and PHVs have only recently started and consequently the number of EVs and PHVs on the market remains limited but are expected to increase. The development of charging infrastructure being crucial to the diffusion of EVs and PHVs, it is underway in many countries, including Japan.

○Clean diesel vehicles have already been widely introduced in the EU, where approximately half of sold new cars a clean diesel vehicles.

Technology development trends

○The US has supported the technology development – for example, the development and demonstration of Li-ion batteries, the development of vehicle simulation software, the cost reduction and durability improvement of fuel cells, the establishment of H2 production technologies - through grants from the American Recovery and Reinvestment Act (ARRA) and Department of Energy (DOE). In his 2013 State of the Union Address, President Obama declared that the US would increase the number of next-generation vehicles to 1 million by 2015 and that he would establish a new technology development fund to promote research and development.

○The EU has allocated a 1-billion-euro research and development fund for vehicle technology, including EVs and internal combustion engines through its Seventh Framework Programme (FP7). It also aims to commercialize innovative electric vehicles by 2025 under the its Green Car Initiative.

Japan's International Competitiveness

○Japan has played a leading role in the introduction and dissemination of HVs and Japanese manufacturers enjoy an overwhelming market share. Japanese companies also possess technological advantages in terms of EVs and PHVs, for which Japan was the first to launch sales of mass-produced vehicles.

13. Next-Generation Automobiles (fuel cell motor vehicles)

Outline of Technology

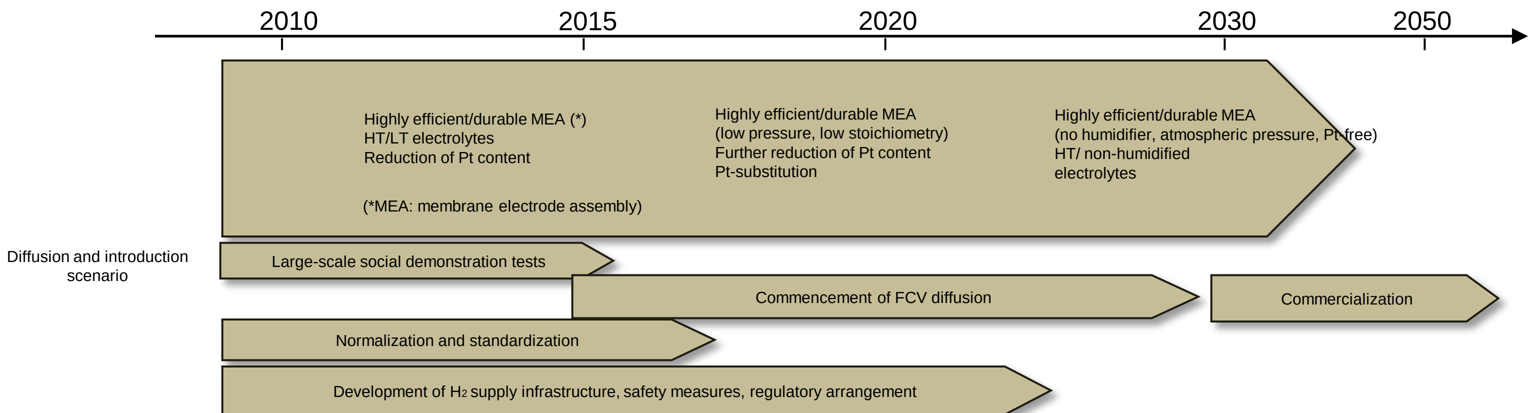
- ○ Fuel cell vehicles (FCVs) run on electricity generated in the reaction of H_2 (fuel) and O_2 in the air.
- ○ FCVs may reduce CO_2 emissions to around one-third compared to emissions from conventional gasoline cars [*1]. CO_2 emissions during H_2 production can be significantly reduced by using electricity with a high percentage of nuclear and renewable energy contribution
- ○ Challenges include developing high-performance fuel cells, high-volume hydrogen storage technology and the establishment of H_2 supply infrastructure.
- ○ According to the IEA's Energy Technology Perspectives 2012 (ETP2012), estimates reveal that developing and disseminating FCV can potentially reduce CO_2 emissions by approximately 700 million tons globally by 2050.

**1 "JHFC General Efficiency Review Results" Report*

Trends and Challenges in Japan's Technology Development

- ○ Sales of mass-produced vehicles have yet to start, but some rental cars and demonstrative buses have been introduced in some areas. In 2011, leading Japanese car manufacturers and oil and gas companies announced a joint statement declaring that they would promote the development of vehicles and hydrogen refilling infrastructure in order to enable the dissemination of mass-produced FCVs from 2015.
- ○ The Ministry of the Environment will develop a zero-CO_2-emissions system that combines small-scale solar hydrogen stations and fuel cells, and fuel cell buses for operation on major routes.
- ○ In order to reduce costs related to polymer electrolyte membrane fuel cells, the fundamental technology and power source for FCVs, the development of technologies for high temperature/low-humidified (HT/LH) electrolytes, the reduction of platinum content and platinum-substitute catalysts is essential.

Technology Roadmap



(* Related technology roadmaps: 28, 29: Hydrogen Production, Transportation and Storage; 30. Fuel Cells

International Trends

Level of dissemination

Sales of mass-produced vehicles have yet to be launched even at the international level.

Technology development trends

The US is conducting research and development under the DOE Hydrogen and Fuel Cells Program, with an aim to fabricate thin film electrolytes for fuel cells, improve the performance of catalysts and improve fuel cell stacks. In his 2013 State of the Union Address, President Obama declared that the US would increase the number of next-generation vehicles to 1 million by 2015 and that he would establish a new technology development fund to promote research and development.

Under the Joint Programme on Fuel Cells and Hydrogen, the EU will support the large-scale demonstration testing of vehicles and refilling facilities, the development of bipolar plates, the development of auxiliary equipment for refilling facilities, the quality assurance of hydrogen, etc. totaling 68.5 million euro (FY2013).

Japan's International Competitiveness

With the sales of mass-produced vehicles yet to be launched, domestic manufacturers have been promoting the development of FCVs with a view to major diffusion. In recent years, joint development based on international technological cooperation has also been observed.

25. High-Efficiency Heat Pumps

Outline of Technology

- The efficiency of air conditioners (AC) and hot water systems (HWS) for residential and commercial use has improved over the years, but further energy savings can be expected from improvements made in heat pumps and the utilization of power electronics and new coolants.
- Unlike AC and HWS that are fossil fuel combustion-oriented, the active use of solar heat via air-heat and geothermal heat will achieve efficiencies far exceeding 100%.
- This can be applied to AC and HWS, which collectively account for approximately half of the CO_2 emissions from the residential and commercial sector. Greater emission reductions are expected as a result of significant improvements in the efficiency of heat pump technology. The technology is also applicable in the industrial sector for AC, process cooling and heating.
- According to the IEA's Energy Technology Perspectives 2012, estimates have revealed that the development and dissemination of high-efficiency AC will potentially reduce global CO_2 emissions by 1.1 billion t by 2050

Trends and Challenges in Japan's Technology Development

- Technological development, including developing new coolants and improving heat pump efficiency is promoted under projects such as NEDO's "Technology Development of High-Efficiency Non-fluorinated Air-conditioning Systems," etc.
- Challenges faced by heat pump technology include cost reduction and efficiency improvement. The development of elemental technologies such as improved efficiency in coolants and heat exchangers promise to reduce costs by one-fourths and increase efficiency by 1.5 times from current levels by 2030 and to halve costs and improve efficiency by twofold by 2050.
- Other technological challenges include size reduction for better installability and saving the amount of materials used, further adaptation to cold regions (heating, hot water supply and snowmelt)for wider application, expansions in the applicable temperature range. Initiatives are required to overcome these challenges. The utilization of unharnessed heat is another promising way to achieve improved efficiency Higher efficiency is also being sought in GHP, which can be used as a way of achieving power peak shaving and BCP support.

Technology Roadmap

2010 — 2020 — 2030 — 2040 — 2050

＊Reference

AC APF 6.6
HWS COP 5.1

AC ¥200,000
HWS ¥500,000

Equipment efficiency (Period average): X 1.5 (2030) → X 2 (2050)

Cost: X 0.75 (2030) → X 0.5 (2050)

Cooling: Expansion power recovery; Separate sensible and latent cooling → Next-generation cooling → Ultra high-efficiency AC heat pump

Heating: High-efficiency heat recovery technology (Simultaneous cooling and heating) → Ultra high-efficiency AC/HWS heat pump

Hot water supply: Heat pump for snowmelt → Ultra high-efficiency heat exchange → Ultra high-efficiency AC/HWS heat recovery heat pump

Cold heat, high-temperature heat pumps: 80→160℃ COP≥3.5, ≤75℃ heat source −10℃ supply → 100→200℃ COP≥3.5, ≤60℃ heat source −10℃ supply

- Promotion of technology introduction through subsidies and beneficial tax treatment etc.
- Provision of information to the general public
- Promotion of technology development through partnerships among industry, government and academia

(* Related technology roadmap: 32. Heat Storage and Insulation Technology)

International Trends

Level of dissemination

- Even at current levels, Japanese household heat pump AC have a COP of 6 or higher, which is much more efficient that the typical European or American level of 2.2-3.8. This was noted in the IPCC Fourth Assessment Report.
- Japan has been a leader in the introduction of high-efficiency heat pumps.

Technology development trends

- The US Department of Energy (DOE) is developing AC/ventilation systems optimized for heat exchange and data mining for geothermal heat pumps, as part of its AC-related research and the development of .
- EU's "Common Vision for Renewable Heating and Cooling 2020-2030-2050" states that the EU will be able to cover all AC demand in the EU using biomass, solar heat, geothermal heat and air heat by 2050.
- The IEA's "Technology Roadmaps: Energy-Efficient Buildings: Heating and Cooling Equipment" sets out the goal of reducing CO_2 emissions originating in buildings by 2Gt by 2050 using improved AC technology. The IEA will promote research and development on high-efficiency AC heat pump systems and components and reduction of initial costs.

International competitiveness of Japan

- Japanese heat pump AC has achieved an extremely high level of efficiency compared to the EU and US. Japanese manufacturers providing comprehensive software/hardware services have exhibited a strong presence in the global market. Recently, Japanese companies have started to commercialize high-efficiency large-scale turbo refrigerators.
- Japan's heat pump HWS technologies are globally top level. Japan was a pioneer in the practical application of CO_2 coolant high-temperature HWS and 1 million units were introduced in only 6 years. Japan's business is globally developing through exports and offshore production
- The first country to succeed in developing CO_2 coolant heat pump hot water heaters, Japan leads the world in this technology.

26. Environmentally-Aware Iron Manufacturing Process

Technology Overview

- About 70% of CO_2 emitted by the iron and steel industry is attributed to the iron manufacturing process using blast furnaces. Therefore, a significant reduction of CO_2 through drastic TD is an urgent task. Japan's current iron manufacturing process has the highest energy efficiency in the world. Further improvement of energy efficiency requires development of innovative groundbreaking technology.
- Specifically, TD will be conducted for reduction of iron ores using both cokes and H_2 that is included (~50%) in the heated gas generated during manufacturing of cokes, new absorbent to separate CO_2 from high-CO_2 blast furnace gas, physical adsorption, new CO_2 separation/capture (S/C) technology utilizing the unused low-temperature waste heat generated at steelworks.
- IEA's ETP 2012 estimates the global CO_2 emission reduction potential of development and diffusion of various innovative iron manufacturing technology to be ~1.6 billion tons in 2050.

Trends and Issues in Technology Development in Japan

- "Environmentally Harmonized Steelmaking Process Technology Development (COURSE 50)", in which all major Japanese steel manufacturers participate, commenced its projects in FY 2008, and conducted elemental TD for H_2-reduction iron manufacturing and CO_2 S/C. (Phase 1 Step 1)
- Future activities include building a small test blast furnace in the scale of 10m^3 and comprehensive evaluation of the laboratory-level results obtained in Step 1, to establish reaction control technology with maximum H_2 reduction effects. For CO_2 S/C, the chemical absorption method will be developed through linked operation with the test furnace and high-performance chemical absorbent, and physical adsorption method will be developed through detailed planning of actual processing, aiming at 'comprehensive development' including acquisition of scale-up data to demonstrative test furnace in phase 2. (Phase 1 Step 2)
- COURSE 50 aims at establishment and practical application of technology that reduces CO_2 emissions from steelworks by 30% by 2030.

Technology Roadmap

	2010	2015	2020	2030	2050
COURSE 50 :	Phase I (Step 1)	(Step 2)	Phase II		
H_2 reduction **(Partial substitution of cokes with H_2)**	• Reduction basic study • Clarification of blow in method • H2 magnification in bench test	• Small test blast furnace partial qualification test	• Test blast furnace qualification test & actual furnace partial qualification test		• Practical application & diffusion
CO_2 S/C from blast furnaces	• Evaluation at process evaluation plant • Comprehensive evaluation with low temperature exhaust heat collection	• Compatibility development between S/C facility and small test blast furnace	• Integrated operation of several hundred ton/day facility and test blast furnace		• Practical application & diffusion

(* Related roadmap: CO_2 capture and storage (CCS))

International Trends

Current extent of diffusion

- US DOE is conducting development of a novel iron making process, direct injection process of iron ore into blast furnace, alternative fuels, etc.
- EU Ultra Low Carbon Dioxide Steelmaking Program is conducting activities aiming at reduction of CO_2 by 50%.

Trend in technology development

- EU HORIZON 2050 is to conduct improvement of cokes-free steelmaking, cost reduction and demonstration (includes CCS) of furnace top gas circulation blast furnace, and research on electrolysis methods.
- Australia is conducting TD of heat recovery, etc., from biomass and melted slag.

International competitiveness of Japan

- Japan's steelmaking industry possesses world-class energy efficiency due to its globally preeminent iron making process, which will be further strengthened through promotion of COURSE 50 and broad diffusion of its outcome in Japan.

27. Innovative Manufacturing Process (Other Manufacturing Process)

Technology Overview

○ Japan's manufacturing industry boasts the world's highest energy efficiency. In order to further improve energy efficiency, development of an innovative manufacturing process is required. Specifically;

- Energy-saving petroleum refining process technology
- Radical efficiency improvement technology for nonferrous metals manufacturing process
- Low pressure drop separation membranes that reduce pump power
- Energy-saving ammonia manufacturing technology (catalysis, electrolysis, etc.)
- Energy-saving cement manufacturing process technology etc.

○ IEA's ETP 2012 estimates the global CO2 emission reduction potential of development and diffusion of innovative manufacturing process technologies in 2050 to be ~1.6 billion tons for chemicals manufacturing process and ~1.1 billion tons for cement manufacturing process.

Trends and Issues in Technology Development in Japan

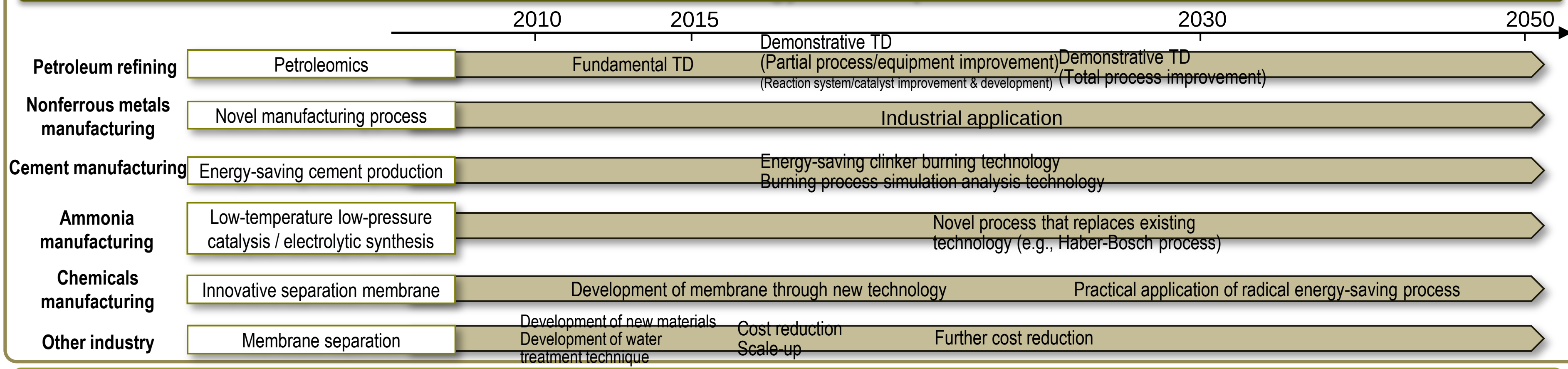
○ Petroleum refining industry is conducting development of "Petroleomics Technology" that consists of petroleum molecular structure analysis technology (petroleum is a highly complicated multi-component system), reaction path simulation technology, etc., in order to establish an innovative refining process.

○ METI's "Fundamental TD of an Innovative Cement Manufacturing Process" focuses on reduction of temperature or time of the clinker burning process that accounts for 80-90% of energy consumption. Tasks include TD for complicated thermal reaction simulation, TD for temperature condition, etc., measurement, and development of clinker burning temperature reduction materials.

○ NEDO "Development of Innovative Separation Membrane Technology" project promotes development of energy-saving RO membranes and NF membranes, and currently in industrialization consideration phase.

○ MEXT is conducting development of novel catalysts for low-energy ammonia production, aiming at practical application in 2030.

Technology Roadmap



International Trends

Current extent of diffusion

○ EU is assisting TD for individual technology element as part of FP7, aiming at reduction of GH gas emission by 80% by 2050.

○ For the petro chemistry field, construction plans of new/additional petrifaction raw material (ethylene) facilities using cheap natural gas are in progress in North America.

Trends in technology development

○ Assisted by DOE, The US is conducting TD for processing exhaust (contains CO_2) from cement manufacturing facilities. To reduce CO_2 in papermaking process, The US is conducting development of new material membranes, research on reducing steps from 5 to 3 for the black liquor evaporation process, pulp washing technology using steam cycles, etc.

○ EU FP7 assists development of latest technology to produce cement and clean aggregates from construction wastes, new microbial carbonates technology for producing improved strength, economy and environmental cement, green concrete for more sustainable construction business, etc. FP7 also promotes practical application of light-weight multi-functional paper products by utilizing nanocellulose and development of dimethyl ether production technology by gasification of black liquor.

International competitiveness of Japan

○ Japan is conducting comprehensive and systematic R&D of the "Petroleomics Technology" in anticipation of viewing practical application.

○ The base processes of nonferrous metals manufacturing technologies have not been revamped since the invention of the currently used process. Japan is aiming at development of novel manufacturing process with improved productivity.

○ Japan's membrane separation technology leads the world in its technology level.

29. Hydrogen Production, Transport, Storage (Transport/storage)

Outline of Technology

○ Technology used to transport and store H_2 for use in fuel cell vehicles and stationary fuel cells

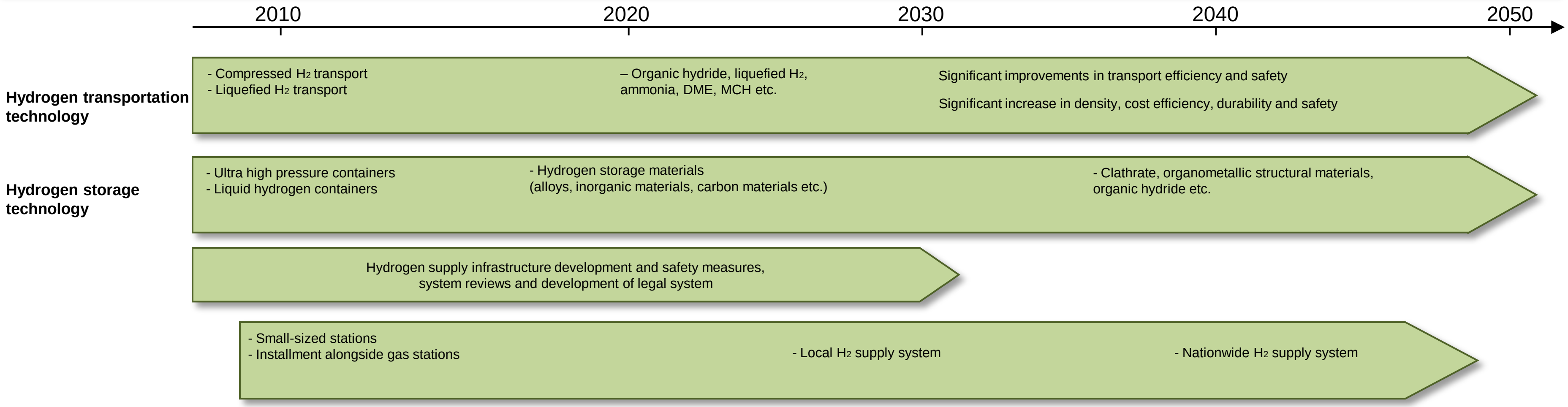
○ Methods for transporting hydrogen include compressed hydrogen transportation, liquid hydrogen transportation, organic hydride transportation, transportation of hydrogen in the form of ammonia, and pipeline transportation.

○ The technology is expected to be useful in the event that a large volume of renewable energy is introduced.

Trends and Challenges in Japan's Technology Development

○ NEDO has carried out technology demonstrations for FCV/ hydrogen supply infrastructure in conditions close to real use with a view to beginning dissemination in 2015, as well as launching a "Technological and social demonstration of regional hydrogen supply infrastructure" to verify user-friendliness, commercial viability and social acceptance.
○ In organic hydride, a test plant has been constructed at a private sector base for the hydrogenation and dehydrogenation of toluene.
○ The Ministry of the Environment has developed the practical application of independent high-efficiency hydrogen treatment and storage systems using hydrogen storage alloys.

Technology Roadmap



(* Related technology roadmaps: 13. Next-Generation Automobiles (Fuel Cell Vehicles); 28. Hydrogen Production, Transport and Storage (Production); 30. Fuel Cells

International Trends

Level of dissemination

○H2 suppliers have indicated that they seek advance establishment of H2 supply infrastructure in approximately 100 locations by 2015 to meet the expected number of mass-produced FCVs .

Technology development trends

○In the US, solutions for H2 transport includes low-cost pipelines for gas transport and pipelines for liquefied transport. H2 storage solutions include high pressure gas storage, absorption materials and carbon materials, H2-occulsion alloys..

○EU plans to demonstrate H2 as power source fuels using large-scale underground storage sites, develop alternative storage methods using cost-competitive solid materials, demonstrate the feasibility of mixing H2 into existing natural gas supply networks (5%).

Japan's International Competitiveness

○The performance level of Japan's elemental technologies, which are required for H2 transport are expected to reach global standards. Economic assessments need to be conducted in specific transport routes in order to identify the most beneficial method.

30. Fuel Cells

Outline of Technology

○ Fuel cells directly generate electricity and heat through the chemical reaction of H_2 and O_2. This theoretically results in higher generation efficiency than thermal power generation because electrical energy is directly acquired from chemical energy. Moreover, under little impact from the system size, it bears the advantage of being feasible not only for large-scale power generation but also for small-sized power generation devices installed in general households.

○ Fuel cells include polymer electrolyte fuel cells (PEFC), which use a polymer membrane as the electrolyte and operate at low temperatures, and solid oxide fuel cells (SOFC), with a ceramic electrolyte and high operating temperature , and therefore high generation efficiency. Other types of fuel cells include molten carbonate fuel cells (MCFC) and phosphoric acid fuel cells (PAFC).

Trends and Challenges in Japan's Technology Development

○ Both PEFC and SOFC are commercially available in household systems. Diffusion initiatives, including technology development with a view to reducing costs and improving reliability as well as international standardization are being comprehensively promoted.

○ In terms of PEFC, the development of low-Pt technology and new catalyst materials to replace PT catalyst in order to reduce cost is underway, as well as technology development for improved CO tolerance, improved impurity tolerance and HT/LH electrolytes.

○ In terms of SOFC, the development of quick durability assessment methods for achieving both cost reduction and high durability is in progress and the identification of issues obstructing practical application is conducted through demonstrations using medium-capacity systems for commercial use and high-capacity systems for industrial use .

Technology Roadmap

		2010 – Around 2015	Around 2020	Around 2030 – 2050
Polymer electrolyte fuel cells (PEFC)	Low-capacity fixed systems	HT/LH adoptive Improved CO tolerance Low platinum catalysts Fuel diversification	MEA robustness – Improved durability Platinum alternative catalysts technology Fuel diversification	Improved stack performance Expansion in applicable fields
Solid oxide fuel cells (SOFC)	Low-capacity fixed systems Medium-capacity fixed systems	Improved durability and reliability Material/component cost reduction Fuel diversification	Creating high-durability for stacks Improved stack module performance / economy System optimization	Improved next-generation stack performance/durability Mass production technology
	Medium-capacity hybrid systems	High pressure operation Combined generation system control	Fuel diversification Large-capacity combined generation system optimization	
	High-capacity hybrid systems	Stack capacity increase	Stack capacity increase	Coal gasification gas clean-up systems optimization (IGFC)

(* Related technology roadmaps: 1. High-Efficiency Coal-Fired Power Generation; 13. Next-Generation Automobiles (Fuel Cell Vehicles); 28, 29. Hydrogen Production, Transport and Storage)

International Trends

Level of dissemination

○The global market (actual) in 2011 was 49MW for commercial / industrial use (NA 36.3MW, Asia 11.2MW) and 10.8MW for household use (Japan 10.5MW).

Technology development trends

○Under its Hydrogen and Fuel Cells Program, the US DOE conducts research and development regarding priority issues, such as researching deterioration mechanisms. The DOE aims to establish mobile fuel cell technology with energy density of 900Hh/L by 2015, and 1-10kW class fuel cells with a combined efficiency of more than 45% by 2020.

○Under its Seventh Framework Program (FP7), the EU conducts research and development on advanced multi-fuel reformers etc. for fuel cell CHP with a view to the commercialization of fuel cells for household use (≤5kW) and 5kW-1MW class CHP units that use H_2, natural gas and biogas.

Japan's International Competitiveness

○Japan leads the world in the proactive technical development and the introduction support of fuel cells. In 2009, Japan was the first country in the world to make PEFC for household use commercially available. In 2011, it also introduced SOFC for household use into the market. Cumulative installation marked 37,000 units at the end of 2012, exceeding all other countries

○The US has taken the lead in terms of medium-capacity systems for industrial use. Japanese companies have become more activated in an attempt to catch within a few years. High-capacity systems remain at elemental research levels both domestically and overseas.

34. Carbon Fixation by Vegetation

Outline of Technology

○ High-efficiency, low cost processing method centered on anaerobic treatment (e.g. methane fermentation etc.), requiring no aeration power and producing less excess sludge.
○ Microorganisms responsible for the anaerobic treatment of waste water are enriched (optimized) and sustained in order to reduce treatment time and stabilize waste water.
○ Methane generated during anaerobic digestion is recovered and effectively used as energy.
○ Water quality is improved by combining aerobic treatment, which does not require aeration power as a result of using gravity flow
○ These technologies will achieve significant reductions in GHG reductions originating in the treatment process .
○ The GHG reductions resulting from waste water/fluid process optimization are 8.07 Mt-CO_2 p.a. in Japan and 250 Mt-CO_2 p.a. in Asia (converted to CO_2, estimates by MoE)

Trends and Challenges in Japan's Technology Development

○ The Ministry of Agriculture, Forestry and Fisheries (MAFF) conducts research on livestock wastewater treatment technology and feed that reduces methane emissions of ruminant livestock origin. MAFF also promotes the development of N_2O reduction technologies in the agriculture field.
○ Under its B-DASH project, the Ministry of Land, Infrastructure, Transport and Tourism (MLIT) conducts demonstration testing on GHG emissions reduction (e.g. CO_2, N_2O) at sewage treatment plants
○ The Ministry of the Environment (MoE) and other organizations conduct demonstration testing on anaerobic treatment etc.
○ Anaerobic treatment faces challenges in reducing heating energy (methane fermentation temperature reduction), treating low concentration/high concentration waste water, treating hard biodegradable components and avoiding fermentation inhibition. Technology development relevant to these challenges is promoted and technologies for reducing costs are also called for.
○ MBR and UASB-DHS (anaerobic-aerobic) technologies are being developed in order to reduce the level of electricity consumed during waste water treatment.
○ Progress has been made in converting from CFCs and HCFCs to HFCs (e.g. coolant for refrigerators and AC). Measures against leakage during use and disposal will be required in the future.

Technology Roadmap

Demonstration testing for shochu waste liquid treatment

Method to stably process concentrated liquid waste (effluent) and water (municipal sewage and low-concentration industrial waste water) to which anaerobic treatments (energy-saving/ generation treatment) are difficult to apply were developed, demonstrated and established.

2010 | 2015 | 2030 | 2050

Commencement of technology application from 2011

Improved stability of process performance by 2020

Optimization of technology in accordance with the local features of applied area (temperature, economy etc.)

Examination of policies to encourage the accumulation of knowledge relating to greater efficiency and stability of technology and the introduction of energy-saving treatment systems.

Solution of problems regarding actual-scale application, technological development for the efficient reuse of acquired resources, scaling-up etc.

International Trends

Level of dissemination

○Methane fermentation facilities are spreading in the US and Europe to treat livestock wastewater and sewage. In Europe, a total of approximately 7,500 methane fermentation (biogas) plants are in operation as of 2012 (including non-waste water treatment plants).

○The introduction of high-efficiency wastewater treatment technology has also started in Southeast Asia and other regions.

○Japan was the first country in the world to adopt non-fluorocarbon refrigerators

Technology development trends

○Europe and the US continue to develop high-efficiency and energy-saving anaerobic aerobic wastewater treatment technologies.

Japan's International Competitiveness

○Japan's development of anaerobic treatment technologies and its research on control and optimization of microbial community are the most advanced in the world.

○ Further reductions in processing energy and CO_2 emissions are possible by applying the technology to unapplied areas (e.g. industrial waste water/fluid and city sewage) and by improving its efficient. Secondary effects (carbon neutrality) are also expected from the recovery and effective use of generated methane.

○Advanced wastewater treatment technologies including nitrogen treatment need to be introduced to developing countries.

Enhancing measures for the Japanese Government's promotion of technology development

The Japanese Government will promote technology development on a timely basis in the short and long term and encourage dissemination through domestic institutional reforms.

- Perspectives for policies aimed at technology development

(1) A strategy in line with the maturity and timing of practical application of the technology

Formulate technology development strategies to fit short-term and medium-term timeframes based on the roadmap for practical application of the technology through 2050.

(2) Far-sighted strategies based on future market anticipations

Anticipating future markets, promote technology development based on clearly defined needs in the country of application and promote the combination and systemization of multiple technologies

- Policies for domestic dissemination

(1) Product and technology policies

Encourage investment promotion measures (including tax-related measure), regulatory methods (e.g. Top-Runner System) and purchasing incentives for low-carbon products (e.g. carbon footprint system).

(2) Cross-sectional system/social system innovation

Promote efficient environmental assessment methods and a rational review of security regulations.

- Enhancement of policies aimed at the sound promotion of research and development

Japan should promote regulatory reforms to encourage innovation, the use of a research and development tax system, and the pursuit of high-risk, high-return transformative research.

International Promotion

The dissemination of innovative technology is essential to halving greenhouse gas emissions. Therefore, the introduction of mechanisms to evaluate environmentally outstanding technology is encouraged.

● Measures for overseas promotion and dissemination of innovative technology

(1) Bilateral credit systems (JCM: Joint Credit Mechanism)

Promoting systems in which the volume of reduced and absorbed greenhouse gases resulting from the dissemination of low-carbon technology is regularly assessed and recognized as credit.

(2) Formation of a market that has a preference for technology featuring high environmental energy performance

Providing support for the establishment of a system that can appropriately assess energy-saving performance and a framework for implementation to ensure the sound assessment of outstanding technologies and products.

(3) Support measures to encourage international development

Reducing tariffs for environmental goods based on the APEC List of Environmental Goods

(4) Promotion of multilateral international cooperation in relation to energy

Enhancing measures implemented under the Clean Energy Ministerial (CEM) Meeting, the International Partnership for Energy Efficiency Cooperation (IPEEC) and the Global Superior Energy Performance Partnership (GSEP).

(5) Employment of LCA (Life Cycle Assessment) methods

Utilizing LCA methods in order to promote reductions in greenhouse gas emissions from a product’s entire life cycle and help “visualize” its total contribution to reductions.

● Partnerships in R&D with other countries and international institutions

Making active contributions to IEA projects and other projects, reinforcing bilateral energy collaborations, and using the Conference of the Parties (COP) to raise awareness at a global level.

Conclusion

- Japan seeks share the ideas set out in Japan's New Low Carbon Technology Plan widely with both developed and developing countries so that the world can proactively address policy measures.
- We hope that this Plan is welcomed with enthusiasm at the IEA.

New Low Carbon Technology Plan (Japanese)

http://www8.cao.go.jp/cstp/output/ikengushin.html

New Low Carbon Technology Plan (English)

http://www8.cao.go.jp/cstp/english/doc/new_low_carbon_tec_plan/index.html

(The page is currently under construction but will be updated in the near future.)