Hydrogen Energy Ministerial Meeting

H2EM 2018

METI Ministry of Economy, Trade and Industry

NEDO

Summary Statement of the Hydrogen Energy Ministerial Meeting

Tuesday, October 23, 2018, in Tokyo

Ministry of Economy, Trade and Industry

New Energy and Industrial Technology Development Organization (NEDO)

The Hydrogen Energy Ministerial Meeting was held on October 23, 2018, in Tokyo. The meeting was chaired by Hiroshige Seko, Minister of Economy, Trade and Industry. Cabinet members and officials from 21 countries, regions, and organizations gathered together, and over 300 officials and researchers from hydrogen energy-related businesses and governments participated in the meeting. It was hosted by the Ministry of Economy, Trade and Industry and the New Energy and Industrial Technology Development Organization (hereinafter called *NEDO*).

In the morning, a ministerial meeting was held as a closed session, and the “Tokyo Statement” "was provided by Minister Seko as the chairman’s summary. In the afternoon, presentations were given by private and international organizations as an open session.

**No approval was obtained by the speakers for the following statements.*

1. Ministerial Session（Closed Session）

Participants list of Ministerial Session （random order、titles omitted）

Japan (Chairman)	Minister of Economy, Trade and Industry	Mr. Hiroshige Seko
Australia	Minister for Resources and Northern Australia	H.E. Matthew Canavan
Brunei	Minister of Energy and Industry	H.E. Dato Mat Suny Hussein
Italy	Undersecretary for Economic Development	H.E. Davide Crippa
Norway	State Secretary for Petroleum and Energy	H.E. Ingvil Smines Tybring-Gjedde
Netherlands	Vice Minister for Infrastructure and Water Management	H.E. Roald Paul Lapperre
New Zealand	Minister of Energy and Resources	Hon Dr. Megan Woods
korea	Vice Minister of Trade, Industry and Energy	H.E. Cheong Seung-il
Qatar	Minister of Energy and Industry	H.E. Dr. Mohammed Saleh Al-Sada
USA	Deputy Secretary of Energy	H.E. Dan Brouillette
EU	Vice-President for Jobs, Growth, Investment and Competitiveness	H.E. Jyrki Katainen
IEA	Executive Director	Dr. Fatih Birol
Canada	Assistant Deputy Minister (Energy Sector),Natural Resources	Mr. Jay Khosla
Germany	Deputy Director General for Energy Policy, German Federal Ministry for Economic Affairs and Energy	Mr. Ulrich Benterbusch

France	Minister-Counsellor for Economic Affairs, Embassy of France in Japan	Ms. Christel Péridon
China	Chief Economist of the National Energy Administration of China	Mr. Guo Zhi
Austria	Deputy Director General for Innovation at the Austrian Ministry for Transport, Innovation and Technology	Mr. Ingolf Schädler
Poland	Director of the Innovations and Technological Development Dept., Ministry of Energy	Mr. Szymon BYLIŃSKI
South Africa	Deputy Director-General, Department of Science and Technology	Mr. Mmboneni Muofhe
UAE	Undersecretary of Energy and Industry	Mr. Matar Hamed Al Neyadi
UK	Chief Scientific Adviser, Department for Business, Energy and Industrial Strategy	Mr. John Loughhead

Opening greeting by the Minister Seko

- Minister Seko expressed appreciation for the attendance of participants. It is the first time in the world a ministerial-level international meeting was held under the main theme of hydrogen energy. Many people are delighted to have this meeting with more participants than he expected, and this makes him feel confident that interest in hydrogen energy is increasing in the world.
- After the Paris Agreement was put into effect, the world trend of decarbonization has accelerated. We across the world must challenge it with a strong will to create a new era to achieve what we call the 2℃ goal, breaking all conventional rules. We would like to achieve energy transitions and create the next era by bringing wisdom together from throughout the world, driving innovation with technology, and changing the traditional energy system. In Japan, in the fifth Basic Energy Plan, we set utilization of hydrogen energy as the key to achieving energy transitions and decarbonization.
- Although there are many options to achieve them, we are convinced that hydrogen energy is the true key to opening the door to a new energy source. Hydrogen can become low carbon energy by combining Carbon dioxide Capture and Storage (CCS) into the process of producing hydrogen energy from fossil fuel. Moreover, renewable energy can be stored for a long time by producing hydrogen energy from renewable energy. Hydrogen energy can be used in the transportation, industrial, electricity, and other areas and realize decarbonization in various areas beyond the framework of traditional energy.
- The Japanese government developed the Basic Hydrogen Strategy last December as national strategy for the first time in the world and organized an action plan to achieve it, defining its future vision and goals, as well as the direction and vision that both public and private sectors have to share. In the country, over 270 thousand residential fuel cell systems and about 2,800 fuel cell vehicles are used and 100 hydrogen refueling stations, which is the largest number in the world, have already been installed.
- Japan is ready to provide and share its expertise and achievements and demonstrate its leadership in advanced initiatives and challenges in the world. These include the increase in production and use of hydrogen energy using renewable energy in Western counties due to the rapid expansion of renewable energies; potential use and production of hydrogen energy using oil, natural gas, and coals in resource-rich countries; and business tendency to increase adoption of fuel cell vehicles in Western and Asian countries. We can make a leap forward to the next stage by collaborating with each other, sharing knowledge and expertise, and stimulating each other.
- To make hydrogen energy as a new energy alternative, it is essential to create a market where

hydrogen energy is self-sustaining as business. It is important for ministers and corporate leaders to bring together the latest knowledge each other, demonstrate their individual leadership, and create a cooperation system. He expects this meeting to become a significant platform to achieve it.

- He announced the "Tokyo Statement", which consists of four items: (1) Promote technical collaboration and encourage standardization and harmonization of standards and regulations between countries and businesses; (2) define the direction of research and development that countries should collaborate to achieve hydrogen energy society including securing hydrogen safety and development of hydrogen supply chain; (3) study and assess potential economic effects of hydrogen energy use and effects of CO_2 reduction in order to attract investment and create business; and (4) emphasize the importance of education and PR activities which allows all citizens in the world to widely understand and accept hydrogen energy. By hearing and sharing opinions about them across the world, Minister Seko would like to create opportunities to make a new significant trend to achieve hydrogen energy society.
- In the G20 Summit hosted by Japan in June next year, the Ministerial Meeting on Energy Transitions and Global Environment for Sustainable Growth will be held in Karuizawa. We would like to discuss the role and significance of hydrogen energy in the summit and consider the outcome of today's meeting to be an input for the G20 Summit.

2. Presentations given by private and international organizations (Open Session)

Keynote speeches: Potential of Hydrogen Energy for Energy Transition

Keynote speeches were delivered on the importance of hydrogen energy towards energy transitions and decarbonization in countries and regions, cost analysis compared with other fuels, and the current status and future vision of hydrogen energy related technologies.

Mr. Yasuhiro Matsuyama, Director-General of Energy Efficiency and Renewable Energy Department, Agency for Natural Resources and Energy, Ministry of Economy, Trade and Industry, Japan

The meeting is the first international ministerial meeting focusing on hydrogen energy participated in by 19 courtiers, one region, and one international organization. He believes that it is a historical event that provides significant international platform to accelerate policies and business initiatives for realizing hydrogen energy society in the future.

In the morning session, intense discussions were held by delegates from countries about hydrogen energy promotion concerning (1) technology cooperation and standardization and harmonization, (2) international joint research and development, (3) market research for future, and (4) citizenship education. In the "Tokyo Statement" addressed by Hiroshige Seko, Minister of Economy, Trade and Industry of Japan at the end of the meeting, the significance and importance of hydrogen energy are shared among all parties involved in order to challenge global warming and achieve decarbonization society.

Today, many advanced challenges of hydrogen energy are seen throughout the world. The wish of those challengers is common, which is to create strong hydrogen markets in the world. It is to promote the use of hydrogen energy, gathering wisdom together throughout the world, using the world-leading technology, creating an integration of technology and business, and clearing hurdles worldwide. This generates dynamism to help expand business and investment and creates markets. Sharing this vision among world leaders and collaborating with each other are something we must do. He believes today's meeting to be the platform to bring it into action.

H.E. Dan Brouillette, Representative of the International Partnership for Hydrogen and Fuel Cells in the Economy (IPHE)

The IPHE consists of government officials and considers feasible policies in order to achieve hydrogen energy society in the future. Hydrogen can be flexibly used as a chemical raw material to fuel such as FCV, and the IPHE has continued discussing the enhancement of its use since the establishment in 2003. He places expectations on Japan, which has previously chaired the organization. As the current chair country, the United States is defining goals to establish a vision for sustainable energy. For example, in H2@SCALE, it is aiming for cost reduction by collaboratively using hydrogen energy in all sectors from manufacturing to transportation, storage, and utilization in order to lead to its extensive use.

The IPHE would like to engage in outreach activities to citizens, placing importance on collaboration with various parties involved. They would especially like to utilize today's ministerial meeting results in dialogues with existing groups.

Dr. Fatih Birol, Executive Director, the International Energy Agency (IEA)

This Ministerial Meeting picks up the right topic as a theme at the very right time. The IEA has been engaged in hydrogen-related activities for many years. When we think about energy trying to balance between security and cost and placing importance on energy sustainability, hydrogen energy will be one of the solutions. Also, although most of hydrogen energy are currently produced in chemical and oil industries, the IEA would like to promote its use in various industries using renewable energies.

Although the amount of CO_2 emissions in the world had temporarily stopped increasing around 2016, it again started increasing in 2017. In response to this situation, it is important to promote various research and create competitive workplaces. To widely promote the use of hydrogen energy, the biggest barrier is the cost beside some technical issues. Also, in order to create a new market, it is important to remove and harmonize barriers to hydrogen energy promotion, including regulatory issues. The IEA develops close relationships with relevant parties such as the Energy Business Council, keeps up-to-date with hydrogen-related technical information, and develops various initiatives collaborating with businesses in the world.

Dr. Klaus Bonhoff, Managing Director, NOW, Mission Innovation

Mission Innovation established in 2015 consists of 23 countries and EU members. It strives to double investment for research and development and to expand clear energy innovation in the industrial world until 2020 and expand clean energy innovation in the industrial world.

In an integrated energy system that covers industrial processes, such as electricity, heat, and transportation, hydrogen energy has potential to become a strong solution to reduce CO_2 and is an important factor for energy conversion. It is making water electrolysis technology more important.

Recently, the Renewable and Clean Hydrogen Challenge (IC#8) has just started at the Third Mission Innovation Meeting. IC#8 aims to accelerate the development of world hydrogen markets by identifying and overcoming major technical barriers related to the production, distribution, storage, and utilization of gigawatt-level hydrogen energy. Mission Innovation will especially promote cost reductions in the large-scale use of hydrogen energy, implementation of large-scale demonstration projects, and international information sharing.

Mr. Pierre-Etienne Franc, Co-Chair of the Hydrogen Council, Vice President of Air Liquide

The Hydrogen Council is an organization established under an agreement of CEO level at the Davos Conference in 2017. It consists of members from truly 13 industries including energy and transportation and aims to encourage various businesses to work together to achieve a hydrogen energy society. The Council considers it important to deepen the understanding of investors by striving to reduce costs by increasing the use of hydrogen energy and developing safety-net

systems, including insurance to minimize risks with the use of hydrogen energy. It also aims to make hydrogen energy industry grow in collaboration with high-level international organizations and in line with policies in the world. In the 2018, Global Action Summit held in San Francisco, it agreed with 100% carbon free hydrogen production for its use in the transportation area by 2030. The council plans to promote the creation of a hydrogen energy development roadmap worldwide and deepen discussions on economic efficiency in the future.

Mr. Hiroaki Ishizuka, Chairman of the New Energy and Industrial Technology Development Organization

In Japan, NEDO largely promotes two initiatives to achieve a hydrogen energy society with METI. The first initiative is to increase the recognition of hydrogen energy by introducing residential fuel cell system into the market, develop rules for the use of hydrogen energy in the real world through fuel cell vehicles and hydrogen refueling stations, and start full-scale operation by using a lot of hydrogen energy to reduce the cost. The second initiative is to integrally promote technology development and develop regulations and standardization. To be more specific, NEDO rapidly provides feedback of issues identified through technology verification in real world to basic researches, accumulates data on safety to develop new rules including regulations, and links it to operational issues. In order to promote these two initiatives, NEDO encourages various projects, such as on technologies of fuel cells and hydrogen refueling stations, gas turbine energy generation using hydrogen fuel, and system technology combining renewable energy (solar power) in Fukushima and hydrogen energy. NEDO also makes efforts to promote international cooperation through the International Partnership for Hydrogen and Fuel Cells in the Economy (IPHE), IEA, and other organizations.

Session 1: Expansion of Hydrogen Use – Mobility & H_2 Infrastructure –

A panel discussion was made after presentations were given mainly on mobility and H_2 infrastructure, including the future outlook of hydrogen energy and fuel cell technology, recent activities, issues relevant to disseminating such technologies, and matters on developing proper regulations and standardization, and join research and development. Dr. Sunita Satyapal, director for the Fuel Cell Technologies office in the DOE, played the moderator.

(1) Presentation

Dr. Wen Ling, President & CEO China Energy Investment Cooperation

In China, Hydrogen Alliance consisting of diverse members such as State Grid, SAIC, Baosteel, CRRC, CSIC, Dongfeng Motor, FAW, and Tongji University was established in February 2018 with a support from many government departments including MOST, MIII, and the Chinese Academy of Sciences.

The alliance engages in various activities related to hydrogen energy including publication of the China Hydrogen Energy White Paper, development of innovation platform of hydrogen energy industry, and enhancement of international cooperation, aiming for development of an international cooperation platform as a national level organization of hydrogen energy and fuel cell technology. Its goals are implementation of 1 million FCVs into the markets and 1,000 hydrogen refueling stations by 2030 and making hydrogen energy a major energy source that covers more than 10% of the total energy consumption by 2050. Although in China, there are barriers to definition of standard certification, development of safety technologies for hydrogen energy infrastructure, and mass-construction of hydrogen refueling stations, the alliance would like to promptly address them by obtaining international collaborations. As for international cooperation, it deepens cooperative

relationships with relevant players in the world, such as IPHE, H2USA, and Japan H2 mobility.

Mr. Joel Ewanick, Founder & CEO First Element

First Element established in 2013 is a company specializing in the distribution of hydrogen energy and develops hydrogen energy grid in California. It has already received a 63.5 million-dollar grant from California and 27 million-dollar assistance from Toyota and Honda. It opened 19 hydrogen refueling stations for consumers and is currently constructing 12 more stations.

True Zero, its retail brand of hydrogen energy supply stations is enhancing brand power. Its hydrogen energy sales increased by 150% compared with the previous year with sales of over 1,800 kg a day. Its current issue is the cost of hydrogen energy. By reducing the cost by upgrading its hydrogen energy supply equipment and improving operational efficiency, First Element aims to lower the price to the same as gasoline, which is a 10 USD/kg level. To be more specific, for example, it plans to shift the use of compressed hydrogen to liquid-hydrogen. As compressor is replaced by pump, it can save 0.75 USD/kg from the cost.

Mr. George Hansen, Director, GM Collaboration, Global Fuel Cell

GM's Triple Zero vision is a world with zero crashes, zero emissions, and zero congestion, and it expects all vehicles will be electric vehicles in the future. It therefore focuses on the development of FCVs and EVs; it understands these developments are not in confrontational relationships but complement each other as the respective advantages. For example, FCVs have the advantage of shorter energy fill time than EVs (Fill time of FCVs is 100 miles/minute, which is suited to larger vehicles, and that of BEVs is 6 miles/minute, which is suited to small vehicles). GM and Honda have just integrated their respective hydrogen energy-related projects together last year and established a joint venture company aiming to manufacture fuel cell systems by around 2020.

They expect fuel cell technology will be applied to various uses to not only trucks and busses but also sea, air, and military vehicles. Hydrogen energy is important as an energy carrier that connects renewable energy and electricity to realize decarbonization, and it is important to establish a system where the energy is economically rational.

Dr. Saehoon Kim, Vice president, Hyundai Motor Company

Hyundai develops various environmentally responsive vehicles and manufactured 1,000 FCVs in five years after the test marketing of the first FCV in 2013 and contributed to increasing the number of hydrogen refueling stations.

NEXO, which was added to its line-up this year, specifically represents Hyundai's technology. It has achieved a significant improvement in system efficiency, power, and travel distance and has durability comparable to existing vehicles. FCVs are superior to EVs in cost effectiveness for large vehicles.

To promote fuel cell technology further, we have to put more effort in development of safe infrastructure, rationalization of regulations, cost reduction, and investment.

Mr. Shigeki Terashi, Executive Vice President, Toyota Motor Corporation

In order to realize sustainable society in the future, Toyota thinks that maximum use of renewable energies and optimum use of fossil fuel are the keys. As for mobility, it expects various vehicles, including EVs, FCVs, PHVs, and HVs, will be deployed depending on the use.

Hydrogen energy can be produced from various primary energy sources, and FCVs are not only zero emission vehicles but also have various advantages in such as refueling time, drive range, and performance at low temperatures. Toyota would like to apply this fuel cell

technology obtained from FCV development into other commercial vehicles including powertrain units.

Hydrogen energy society can only be achieved by many stakeholders working together and engaging in research and development. Toyota would like to not only utilize FC as its product but also develop relationships with a diverse range of stakeholders in the future. Also, Toyota thinks it important that many countries should share future visions and promote harmonization (sharing of standard certification) for hydrogen energy to be widely accepted by society. MIRAI can store power equivalent to running an average household for several days, and this FCV can be helpful in times of disasters. By combining with self-driving, MIRAI can lead to creation of concept cars.

Mr. David Whyte, Vice President, Ballard

Because of the recent improvement of fuel cell performance, the government and industries started providing generous support, and expansion of fuel cell use is becoming mega-trend. Considering these, Ballard thinks the direction of hydrogen energy society is changing from before from economic perspective.

Ballard has been a pioneer of fuel cell technology for over the last 40 years and recognizes more demands are coming from existing markets. Therefore, it promotes researches on hydrogen energy use for not only traditional vehicles including cars, busses, trains, and forklifts but also marine vehicles, unmanned aerial vehicles (UAVs), ships, and trains. Ballard would like to continue investing to this area and work strategically in economic society where hydrogen fueled vehicles are more common.

(2) Panel discussion

For wide acceptance of hydrogen mobility and H_2 infrastructure, the following opinions were expressed by the presenters.

- When we expand the use of hydrogen mobility and H_2 infrastructure to local regions, it is important that the central governments provide adequate support to prevent standards and procedures from being different depending on local governments.
- We must establish a collaboration platform where countries in the world can discuss based on the same standards.
- To reduce cost on hydrogen energy, realizing its mass-consumption society is effective. In order for hydrogen energy to have sustainable economic rationality, we need to reduce the cost to the level of being competitive with existing fuels such as gasoline and stop relying on public subsidies.
- We must make an appeal to society in an appropriate manner that hydrogen energy is an effective energy source and that we should not focus on only the risks.

Session 2:
Upstream & Global Supply-chain for Global Hydrogen utilization

With Masakazu Toyoda, Chairman and CEO of the Institute of Energy Economics, Japan (IEEJ), as a moderator, presentations were delivered on hydrogen production and supply chains for the promotion of the use of hydrogen in the world to introduce the outlook for the related technologies, recent activities, challenges related to the spread of such technologies, and topics related to joint research and development. After that, a panel discussion was held.

(1) Presentation

Ms. Hege Rognø, Manager, Technology Management, Equinor

Equinor is a multinational energy company based in Norway. Recently it has been working on multiple projects on hydrogen technologies related to power generation, heat, and maritime transport, although it is still in the basic research phase.

In the H2M-Magnum, a project conducted in the Netherlands, it is evaluating the possibilities of converting an existing gas power plant into a hydrogen-powered plant. If this plant operates at full capacity, the potential CO_2 emission reductions by hydrogen combustion are estimated to be 4 million tons per year, equivalent to emissions from 2 million cars. Furthermore, in H21, a project conducted in northern England, they are working to replace natural gas with hydrogen in the field of heat utilization in England. It is also considering the possibilities of utilizing hydrogen in the maritime sector.

As a clean hydrogen value chain is inseparable from a sustainable CO_2 value chain, Equinor, as a company with more than 20 years of experience in carbon capture and storage (CCS) and CO_2 utilization in the North Sea, aims to contribute to the creation of a clean hydrogen value chain. In the future, the public and private sectors will have to work together to reduce costs and risks, streamline regulations, and establish global standards.

Mr. Ryosuke Shimizu, CSO and Director of Corporate Planning Division, Chiyoda Corporation

Chiyoda Corporation has been proposing energy transport using the liquid organic hydrogen carrier (LOHC) system aiming at stabilizing the power output fluctuations of renewable energy and improving the efficiency of the transport of energy to consuming areas. This method is characterized by its proprietary dehydrogenation catalyst. The LOHC system uses methyl-cyclohexane (MCH) and toluene. As both MCH and toluene are liquids that are easy to handle at ordinary temperatures and pressures like oil, existing tanks and means of transportation can be used.

Today, a hydrogenation plant and a dehydrogenation plant are being constructed, respectively, in Brunei and Japan as part of the global hydrogen supply chain demonstration project. This demonstration is implemented by the Advanced Hydrogen Energy Chain Association for Technology Development (AHEAD), an association comprising four companies as part of a NEDO project.

Chiyoda Corporation plans to examine their technologies and system feasibility by conducting a one-year global supply chain demonstration in 2020 to prepare for the commencement of the commercialization project. They aim to work on a supply chain for large-scale power generation by LNG-hydrogen co-combustion as part pf the semi-commercialization project in 2025 and undertake a full-scale commercial supply chain project for large-scale power generation by hydrogen single-fuel combustion in 2030. In addition, they are considering working on electrolytic technologies and artificial photosynthesis technologies.

Mr. Aqil Jamal, Chief Technologist, Carbon Management Research & Division, Saudi Aramco

Saudi Aramco, a Saudi Arabian national oil giant, is the world's largest crude oil producer and exporter. They produce 332.9 billion barrels of crude oil and condensate equivalent to 10.2 million bpd of crude oil and consider themselves an integrated energy company.

According to the IEA scenario, it is necessary to reduce CO_2 emissions by more than 50% from today's levels to achieve so-called 2℃ target. Thus, the transport sector, accounting for 57% of global oil use, will play a critical role.

Today, there are various power trains, such as PHV, EV, and FCV other than existing internal combustion engines. FCV power trains, in particular, can be used for various vehicles from small to large vehicles if cost issues can be solved; they are receiving a lot of attention because they could contribute to the expansion of the utilization of hydrogen. Hydrogen demand in 2050 is estimated to be about 10 times higher.

Technologies, such as steam methane reforming, gasification, and electrolysis, are used in today's hydrogen production. Though Saudi Aramco is considering commercial export of

hydrogen using steam methane reforming technology, the cost of exporting hydrogen to Japan will be high.

Mr. Akimasa Muyama, CTO, Head of Power & Energy Solution Business Headquarters, Head of Power Systems Service Headquarters, Mitsubishi Hitachi Power Systems, Ltd.

In the future, humankind will need to address highly complex special problems that are difficult to solve. In order for companies to continuously contribute to society and citizens, constant reform is required. Thus, Mitsubishi Hitachi Power Systems developed a strategy called MHI FUTURE STREAM. The hydrogen business is its core component.

Considering the future prospects of hydrogen, fossil fuels in combination with CCUS will be the core materials for hydrogen production in the medium term. Hydrogen produced from fossil fuels in combination with CCUS can trigger the expansion of the use of hydrogen. In the long term, it is expected that hydrogen will be produced mainly by utilizing renewables energies due to cost reductions and technological innovation. In addition, in the efforts to reduce CO_2 emissions at thermal power plants in Japan, natural gas-hydrogen co-combustion will be realized first, and there will be a shift to hydrogen single-fuel combustion in the future. When a 400 MW turbine runs all year, the amount of hydrogen consumed will be equivalent to that of 200 FCVs. Power generation is directly linked to a large consumption of hydrogen and contributes to cost reductions.

In order to realize global hydrogen supply chains, a new level of cooperation is required among the concerned parties on supply chains, utilization of hydrogen energy, global agreement on CCS, and government-to-government agreement among multiple countries. Mitsubishi Hitachi Power Systems believes that they can provide new solutions by combining their various products and technologies. They also participate in Europe's ALIGN-CCUS project, the Hydrogen Council, the Green Ammonia Consortium, and the AHEAD to share information with other companies and build a global cooperative structure. In order to further activate hydrogen supply chains, they are not only promoting the development of hydrogen gas turbines and ammonia-based GTCCs with government assistance but also undertaking projects for commercialization of SOFCs and hydrogen single-fuel GTCCs.

Mr. Peter Verbeke, Hydrogen Business Development Manager, Royal Dutch Shell

In order to realize a supply chain for liquid hydrogen, it is important to produce, liquefy, and transport hydrogen at low cost. As liquid hydrogen can be stored in a similar way to LNG, the existing storage facilities can be used.

As the biggest problem related to liquid hydrogen is that the cost of liquefaction is so high that it is difficult to acquire regular customers, the necessity of public assistance and the role of a carbon tax were discussed in today's morning meeting. In order to further lower the cost of liquid hydrogen in the future, it is necessary to bring down initial investment by using larger devices and improving technologies.

(2) Panel discussion

Listed below are the major views the presenters offered about hydrogen production and supply chain creation.

- As a means to produce low-carbon hydrogen, a combination of natural gas steam reforming and CCS seems cost efficient at the present stage. If the technologies are advanced and enough revenue is generated to offset the cost in the future, water electrolysis powered by renewable energy will also be an option.
- Existing natural gas pipelines may be used to transport hydrogen. Though there are chemical hydrogen sources, such as MCH and ammonia, the dehydrogenation process decreases overall energy efficiency.

- Though energy efficiency of power generation using ammonia as a fuel is almost at the same level as natural gas-fueled power generation, NOx emissions are a major concern.

Session 3: Renewable Energy Integration & Sectoral Integration

With Bart Biebuyck, Executive Director of the Fuel Cells and Hydrogen Joint Undertaking (FCH JU), as a moderator, presentations were delivered mainly on the integration of hydrogen with renewable energy to introduce the recent trends and challenges related to the development of water electrolysis technologies. After that, a panel discussion was held.

(1) Presentation

Mr. Tudor Constantinescu, Principal Adviser to the Director General for Energy, European Commission

The European Commission has set ambitious policy targets to drastically increase the proportion of energy from renewable sources not only for 2030 but also for 2050. As energy systems are becoming more complex with advances in technology, it can be said that hydrogen is highly smart because it is a flexible energy carrier that can be used in various fields, such as power generation, transport, and storage.

When it comes to regulations and policies related to the utilization of hydrogen in the energy market, the European Commission also places importance on optimization of the tax system for the Clean Energy Package, establishment of a system for energy pricing and network cost sharing, certification for the formation of a market of low-carbon gas (P2G), and development of a mechanism to link energy storage with other economic sectors (transport and industry). They think hydrogen can serve as a bridge between energy storage and other sectors.

Mr. Jon André Løkke, CEO, Nel

Because the power output of most renewable energy sources fluctuates depending on the time, day, or season, coordination with power grids should always be considered. Thus, energy companies need to deal with highly fluctuating electricity prices. Specifically, it is effective to convert the spot power that has low value when there is an oversupply of power with high-value hydrogen that can be used for many purposes.

Nel has a wide range of water electrolysis devices from laboratory-level small-scale facilities to large plants and has been rapidly reducing their costs in recent years. In addition, there have been advances in flexible, clean energy carriers, simple and effective energy storage technologies, and technologies related to ever-increasing renewable energy sources.

Nel has also established more than 40 hydrogen refueling stations in approx. 10 countries in the past 15 years. They consider it essential to make sure hydrogen will be used not only as a fuel but also for various purposes as Power to X in order to reduce the costs to the extent that price competition will occur between hydrogen and existing fossil fuels.

Mr. Mario Savastano, Executive Vice President, Global Head of Business Development, Hydrogen Business Unit, ENGIE

ENGIE is working on projects with a focus on the following four areas to put energy systems that use renewable hydrogen into practical use. They expect that the export of energy from countries with surplus renewable energy to those short of energy will be encouraged by building a hydrogen energy society (production and transport of green hydrogen, multi-purpose use (power, heat, cooling, transportation, storage, etc.) in regions). ENGIE considers that scale expansion is important.

- ✓ Development of hydrogen refueling stations in the mobility field (Zero Emission Valley):1,000 FCEVs, 20 hydrogen refueling stations, 15 electrolysis systems

- ✓ Provision of hydrogen for industry (EffiH2): Trial provision of on-site hydrogen production and supply package for clients with electrolysis systems of over 1 MW for industrial use in France
- ✓ Incorporation of hydrogen into gas networks (GRHYD): Production of new fuel gas "Hythane (combination of hydrogen and natural gas)", injection of green hydrogen into the grid (eco-region: approx. 100 houses and buildings) at a level of 20% by volume
- ✓ Demonstration of energy storage (REIDS initiative in Singapore): Hydrogen production by electrolysis, hybrid power storage (combination of storage battery and hydrogen storage), fuel cells of over 2 MWh, hydrogen refueling stations that can refuel 20 FCEVs per day

Mr. Simon Bourne, Chief Technology Officer, ITM Power

ITM Power is a provider of integrated hydrogen energy systems. With the aim of supplying hydrogen to FCEVs, they have developed a growth model and set the targets of production capacity of 3 tons/day, filling capacity of 7 tons/day, and hydrogen price of £10/day.

Standardization of modules, innovation of PEM technologies, rapid expansion of scale, and the acceleration of reactions are keys to putting hydrogen energy systems into practical use. ITM Power provides hydrogen energy systems of 2 MW to 10 MW. Furthermore, though most PEM electrolysers have been relatively small, such electrolyser systems are becoming larger, which leads to cost reductions. ITM Power expects that the system price will fall from today's £1,000/kW to approx. £500/kW in the mid-2020s. They also think that they can reduce costs by promoting the standardization of the devices.

As part of the LIGHTHOUSE PROJECT in cooperation with Shell, ITM Power plans to demonstrate the technology to inject hydrogen into natural gas pipelines by introducing 10-MW PEM electrolyser systems at Shell's refinery. Expansion of scale and formulation of comprehensive development strategies are required to promptly put hydrogen energy systems into practical use.

Mr. Eric Klein, Vice President Sales, Hydrogen Solutions, Siemens

Many of the existing hydrogen production processes generate a large amount of CO_2. Water electrolysis technologies play an important role in reducing CO_2 emissions, and sector coupling and P2X are gaining attention.

As a reliable provider of hydrogen value chains (renewable grid service→electrolytic reduction→daily use), Siemens is examining the possibility of future industrial use of hydrogen in the three fields of industry, mobility, and energy at Energiepark in Mainz, Windgas in Hassfurt, the production site in Hamburg, and H2Future in Lintz. In addition, a hydrogen refueling station will be built on the Siemens Campus in Erlangen in 2019.

Siemens expects that their water electrolysis portfolio will scale up every four to five years and considers electrolysis technologies are cost competitive.

(2) Panel discussion

Listed below are the major views the presenters offered about cost reduction and scaling-up of hydrogen energy systems.

- ➢ As for water electrolysis, the installed capacity of 20 MW is the break-even point where the cost curve can be flattened. Thus, systems may spread sooner than expected.
- ➢ When it comes to realizing energy systems, it is necessary to consider not only costs but also global warming prevention.
- ➢ Automation and standardization are required to scale up hydrogen energy systems, and it is necessary to consider scaling-up carefully from a long-term perspective.
- ➢ In order to create a profitable market, it is necessary to reduce costs by easing regulations.

For example, in Japan, if companies accept standards of other countries and integrate their standards with global standards, competition will occur, and it will be possible to lower the price.

Closing speech

Mr. Taizo Takahashi, Commissioner, Agency for Natural Resources and Energy, Ministry of Economy, Trade and Industry, Japan

- We are grateful that there were many participants. In the ministerial meeting, we discussed the direction of the policies and the issues to be solved to realize a global hydrogen society and shared recognition of the importance of cooperation among countries. As a result, with a shared understanding of the importance of technical collaboration and international joint research among countries, the "Tokyo Statement" was released as the chair's statement.
- In the afternoon session, in accordance with the "Tokyo Statement", international organizations and global leading companies delivered presentations on the latest trends and outlook related to hydrogen. In the plenary session, international organizations, such as the IEA and the IPHE, introduced world trends. The presentations by the mobility/hydrogen infrastructure companies in Session 1 enabled us to share how to expand the utilization of hydrogen. In Session 2, we discussed the establishment of global supply chains that are inseparable from large-volume use of hydrogen and found that there is high expectation for hydrogen as energy. In Session 3, we gained useful insights about the trends in hydrogen production using renewable energy.
- By discussing the importance of the role of hydrogen at the G20 Summit to be hosted by Japan in June 2019, a big international momentum for the promotion of energy transition and decarbonization around the world can be created.