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Electricity Storage Demonstration Using Hydrogen & FCs at Large-Scale

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1. Governmental Measures

(1) METI

The Ministry of Economy, Trade and Industry (METI) will work on demonstration projects of next generation technology and infrastructure in five subjects including the promotion of next generation cars such as fuel cell vehicles (FCVs), taking the 2020 Tokyo Olympics and Paralympics into account. The aim is to show advanced technology used in real life to the world as an achievement. The ministry plans to establish an investigation team to develop actual measures to be included in the revised growth strategy which is to be compiled by the government in June, and then to implement them. They will encourage the Tokyo Olympic Committee to use the most advanced FCVs and electric vehicles (EVs), which are made in Japan, for transporting athletes as part of a demonstration to develop society with advanced mobility. Preparation of hydrogen filling stations will also accelerate in large metropolitan areas. Furthermore, subsidy for "smart meters" will be investigated as a demonstrational project to develop smart community, next generation community infrastructure. Smart meters show the power consumption of buildings and houses on a real-time basis. Mr. Yoichi Miyazawa, the minister of METI intends to "use innovative technology in a real world", and to showcase Japanese society as a frontier next generation vision of this. (The Nikkan Kogyo Shimbun, January 1, 2015)

METI has decided to allocate a total of ¥351.5 billion for energy measures in its supplemental budget bill for FY 2014 which is an emergency economic stimulus approved by the Cabinet. The energy measures include ¥30.6 billion of support for infrastructure development for FCVs and EVs. The supplemental budget bill will be approved at the Cabinet meeting on January 9th. Also ¥22.2 billion will be budged for a subsidy scheme to support Ene-Farm installation. (The Denki Shimbun, January 8, 2015)

(2) Japanese Government

In June 2013, the Japanese government compiled a growth plan "Japan Revitalization Strategy" including a target ratio for next generation cars such as FCVs, plug-in hybrid vehicles (PHVs) and EVs in new car sales. The target will be raised from over 20% set in 2013 to 50 to 70% by 2030. They will prioritize budget for the growing area of industries. To hit the target, METI has developed a roadmap for hydrogen energy to grow in the market. The roadmap contains development of a subsidy scheme to support FCV purchase starting from FY 2015 and a budget request of ¥30 billion for subsidy schemes to promote clean energy cars such as EVs and PHVs. (The Nikkan Kogyo Shimbun, January 5, 2015)

On January 15th, Prime Minister Shinzo Abe tried FCV "MIRAI", which was purchased as an official car by the government, at his office in the afternoon. He showed an intention to investigate deregulation to enable hydrogen filling stations to be self-service in the Council for Regulatory Reform of the government. (The Yomiuri Shimbun, The Asahi Shimbun, The Mainichi Newspapers & others, January 16, 2015)

(3) MLIT

On January 7th, the Ministry of Land, Infrastructure, Transport and Tourism (MLIT) announced that the first taxi operation plan using FCVs had been approved as a promotion project of "Green Community Transport" to support the usage of EVs and FCVs. The applicants were five taxi operators including Kitakyushu Daiichi Koutsu Sangyo in Kitakyushu and Fukuoka Cities, Fukuoka Prefecture. Five fuel cell (FC) taxis are planned to be used. The scheme will support projects of five electric taxis, four electric trucks and one FC taxi. For EVs, one third of

the initial cost will be subsidized, and FCV project will receive half the initial cost. (The Denki Shimbun, The Nikkan Kogyo Shimbun & others, January 8 & 9, 2015)

2. Local Governmental Measures

(1) Aichi Prefecture

In FY 2015, Aichi Prefecture will set up a subsidy scheme to support installation and operation costs of hydrogen filling stations for FCVs to widely spread. With a governmental subsidy, applicable operators will be supported three quarters for the installation costs and five sixths of the operation expenses, which will leave them to cover ¥100 million for the installation and an annual ¥5 million operation costs. According to the prefecture, they are the second local government, after Tokyo, to subsidize both installation and running costs. (The Chunichi Shimbun, January 4, 2015)

(2) Tokyo

On January 5th, Tokyo decided to establish a subsidy scheme for FC bus purchase. The budget bill for FY 2015 includes ¥1 billion for bus operators to be able to buy highly-priced FC bus at a same level as a normal bus. Tokyo targets 10 FC buses to be used in its area by the 2020 Tokyo Olympic. (The Yomiuri Shimbun, The Mainichi Newspapers, The Nikkei & others, January, 6, 2015)

(3) Osaka Prefecture

Osaka Prefecture has a regulation to restrict trucks and buses which do not meet its emission standards to enter into a specified area, and it has amended the regulation to exclude EVs and FCVs which contains no combustion engines from the entry control list. This amendment eliminates the need of applying or displaying certification disks for EVs and FCVs including buses and trucks. The prefecture restricts certain types of vehicles without certification disks to drive into the controlled area of 37 cities and towns based on the "Osaka Prefectural Regulation of Environmental Well-being". Buses and trucks emit a larger amount of NOx and particulate matter (PM) which often come out from vehicles, and they are the subjects of the regulation. Since electric and FC trucks and buses are getting close to practical use, the prefecture changed the regulation to remove these vehicles from the control list on December 26th, 2014. (Nikkan Jidosha Shimbun, January 9, 2015)

3. FC Element Technology Development & Business Plans

(1) Teijin

Teijin will strengthen development of carbon alloy catalyst (CAC) for polymer electrolyte fuel cells (PEFCs). CAC is a non-Pt catalyst made of polyacrylonitrile (PAN) and iron. The manufacturer plans to establish a simpler production process to improve generation performance by miniaturizing the polymer, the initial material, and targets tenth the cost of Pt catalyst as well as commercialization by FY 2025. Currently CAC shows characteristics of about 0.4 V at a current density of 1A/cm^2, and 0.6 V is aimed. For durability, 5,000 hours of continuous operation is targeted. The firm is trying to get the product to be used in the third generation FCVs as well as expanding application to stationary FCs. They research and develop the product in collaboration with Tokyo Institute of Technology as a CAC project for FCVs organized by New Energy and Industrial Technology Development Organization (NEDO). Full commercialization of a non-Pt catalyst is under development by combining the polymer which is Teijin's core technology with carbon fiber technology. (The Chemical Daily, December 25, 2014)

(2) Yokohama National University & Others

A study group led by Yokohama National University plans to develop an innovative production process of Methylcyclohexane (MCH) and FC systems using MCH directly as its fuel. They are trying to establish a direct electrolytic hydrogenation process which adds hydrogen to toluene without the hydrogen production process. This allows simplifying the system. FCs using MCH directly as a fuel provide electricity, heat and hydrogen, which can also be an independent community energy station. This research and development is part of the project "Basic Technology for Using/Producing Organic Hydrides" of the Cross-ministerial Strategic Innovation Promotion Program (SIP) organized by the Japanese government. This research and development of electrolytic processes, hydrogenation catalysts and FC systems led by Prof. Shigenori Mitsushima at the Faculty of Engineering of Yokohama National University is shared among Shizuoka University, Kyoto University,

Osaka Prefecture University, Tokyo Institute of Technology, Waseda University, JX Nippon Oil & Energy and Permelec Electrode as well as Yokohama National University. The direct electrolytic hydrogenation process under development uses an industrial electrode for anode (oxygen production electrode), and an electrode structurally similar to a gas diffusion electrode of PEFC for the cathode (hydrogen production electrode). Proton exchange membranes divide the cathode filled with toluene, and the anode filled with a sulfuric acid solution. By applying electric current to the cell, toluene is converted into MCH by hydrogenation. (The Chemical Daily, December 24, 2014)

(3) Tokyo Institute of Technology

A study team of Prof. Takeo Yamaguchi at Tokyo Institute of Technology has developed a material to achieve a new automotive FC without using an expensive Pt catalyst and also to be able to take another fuel than hydrogen. The idea of the research is the development of strongly alkali resistant polymer membrane to allow a liquid such as ammonia solution to be used as a fuel. In the new alkaline fuel cell (AFC), hydroxide ions create current during the reaction. The inside of the cell becomes strongly alkaline, which allows metals other than Pt to be used as catalysts. AFC gives an option to use cheaper metals, which expands the development area of catalyst suitable for other fuels than hydrogen. This allows FCVs to run on different fuel, which eliminates the need for tanks of highly pressurized hydrogen gas to be transported that current FCVs require. The team aims the AFC to be tested on a vehicle within 10 years. (The Nikkei Business Daily, January 9, 2014)

(4) NIMS

Dr. Mitsunori Kurahashi, a chief researcher, and Dr. Yasushi Yamauchi, a group leader, at the National Institute for Materials Science (NIMS) succeeded in directly observing the function of electron spin of molecular oxygen in a metal oxidation reaction. The research proved that each oxygen molecule behaved like magnet and it mutually affected with a magnetized metal atom. Reaction of corrosion, catalyst and oxide film process can be accurately simulated, which means it enables detailed analysis of the reaction on a surface of a FC electrode taking oxygen in. (The Nikkan Kogyo Shimbun, January 12, 2015)

(5) Biocoke

Biocoke, an environmental technology developer in Tokyo, has developed a portable FC generator which is made more lightweight and compact, and will sell it for less than half the price of its existing product from April. A cartridge with magnesium hydride holds hydrogen as fuel of the generator, and hydrogen is released to react with oxygen in air in order to generate power. The product can charge five smartphones, and will sell for ¥200,000 or less. The firm aims at 1,000 unit sales in this year. (The Nikkei Business Daily, January 15, 2015)

4. Hydrogen Infrastructure Related Element Development & Business Plans

(1) Nitto Kohki

Nitto Kohki has developed "HHV Cupla", a connecting coupling, which is essential for dispensing high pressure hydrogen. The product consists of a hydrogen dispenser nozzle and "receptacle" to fit into the inlet of FCVs. It seals tightly to avoid leaking hydrogen, and offers stable quality and functionality. Dispensing parts are heated to 90°C at 70 MPa by the pressure while filling hydrogen into a FCV tank. As sealing function goes down in cold environments such as in winter, the firm repeatedly tested the product in actual use conditions. The HHV Cuplas is produced at their subsidiary factory in Sakura City, Tochigi Prefecture. Because hydrogen makes metal brittle, the product uses special stainless steel which is hard and difficult to cut. However, the firm is well prepared to meet the current demand. (The Nikkan Kogyo Shimbun, December 23, 2014)

(2) Toshiba

Toshiba will set up a "Hydrogen Energy Research and Development Center" with around 10 engineers in its Fuchu Complex by March 2015. The laboratory will work on a highly efficient FC and development of a system to split water using electricity from photovoltaic generators to produce hydrogen to be stored for a long period. (The Nikkei, December 24, 2014)

Toshiba will commercialize a large-scale power storage system using hydrogen by 2020. The basic technology has been already developed to produce hydrogen by breaking down water and store, and

generate power and heat by FC using stored hydrogen as needed. The system allows for a longer period of energy storage more easily than conventional storage batteries while cutting installation and operation costs in half. Renewable energy suppliers and local governments will have more options to store power. As a start, the firm plans to release a system to store 40 MWh which can supply 10,000 households with power for eight hours. This system will consist of FC, electrolysis equipment and hydrogen storage tanks in an approximately 600 m^2 piece of land. The electrolysis equipment splits water to produce hydrogen which then goes into the tanks to be used by the FCs for power generation. The energy conversion efficiency reaches 80%, outperforming pumped hydroelectric generation of 70% efficiency. Although common storage batteries perform at the energy conversion efficiency of around 80%, they require a considerable amount of electrode materials for scaling up. Installation costs of a 40 MWh level storage battery system costs nearly ¥2 billion. These batteries also discharge power slowly when not in use, which is a problem for long term storage. On the other hand, the hydrogen storage system can be scaled up by adjusting size of its tank as long as safety technologies such as being leak proof are secured, which can reduce total costs from installation to operation to half that of conventional storage battery system. Renewable energy production, such as solar and wind power, will soon exceed the level that the grid can take, and a stricter power output control will start for renewable energy in 2015. Systems to store excess power at a low cost allow renewable energy providers to offset the risk of renewable energy being prevented from going into the grid. They are also expected to be used by local government as emergency power sources for disasters. The firm will install small-scale testing equipment to hold 0.35 MWh of power combining with a photovoltaic generator as an emergency power source at a public facility in Kawasaki City in the spring of 2015. Results of the test operation including the equipment will be used to produce a large amount of hydrogen at and improve efficiency of FCs in order to commercialize at a large-scale system. (The Nikkei, January 16, 2015)

(3) Osaka Gas

On December 25th, Osaka Gas announced that a facility to produce hydrogen from liquefied petroleum gas (LPG) would be released on January 5th, 2015. This facility will be installed at hydrogen filling stations for FCVs. The gas provider aims at 100 units, 10% of hydrogen filling stations in Japan, for the sales of the new product and hydrogen production facilities using natural gas by 2025. (The Nikkei and others, December 26, 2014)

(4) Orion Machinery

Orion Machinery, a manufacturer of industrial machines in Suzaka City, Nagano Prefecture, has started to develop a smaller heat exchanger to refrigerate hydrogen to refuel vehicles in order to expand its business in the FCV related market which is expected to grow. In cooperation of Shinshu University, the product is planned to be commercialized in FY 2016. The firm expects to reduce production costs to a third by a reduction in size and weight, and it is enthusiastic about increasing sales to hydrogen filling stations which are to be prepared at more locations. (The Nikkei, January 5, 2015)

(5) Kyushu Electric Power

On January 13th, Kyushu Electric Power revealed a possible plan of hydrogen production business on a remote island. Hydrogen will be produced using excess electricity to supply FCVs with fuel. The electricity provider will investigate profitability with the operation, and consider introducing the system in the Kyushu main land. The experimental operation will examine the feasibility of hydrogen production and storage using surplus electricity, hydrogen power generation and hydrogen fuel. However, the schedule of the operation is to be determined. (The Nishinippon Shimbun, January 14, 2015)

5. Ene-Farm Business Plans

(1) Osaka Gas

Osaka Gas will introduce a service to sell and buy electricity to and from Ene-Farm users as part of electricity sales for households starting from 2016. Power from the FCs is not included in the feed-in tariff (FIT); however, the gas provider will buy excess power from the FCs and sell electricity as households need. Excess power will be sold to households as the gas provider's electricity business in order to increase sales of Ene-Farm by offering a profit making scheme

to consumers. They aim at 1 million level accumulated sales of Ene-Farm, currently at a 0.03 million unit level, by 2030, and plan to create 700,000 kW level of a power source, a large-scale thermal power station output and 1 million units of the FC system producing 0.7 kW. Although their tariff is undecided, it is planned to be an incentive for consumers to buy Ene-Farm. The price range is expected to be the same level as governmental FIT or higher. (The Nikkan Kogyo Shimbun, December 30, 2014)

(2) Tokyu Land

Tokyu Land Corporation will start selling the condominiums "Branz City Shinagawa Katsushima" under development in Katsushima, Shinagawa-ku in Tokyo, for the third time in the second term. To focus on environment, disaster prevention and socializing in a community, these condominiums for sales are all equipped with Ene-Farm which is designed for apartment units and can independently start up to produce power during power cuts. The option of an independent startup function was developed by a cooperation of Tokyo Gas and Panasonic. Ene-Farm will give each household approximately 49 % less CO_2 emissions. Also a home energy management system (HEMS) allows its users to check electricity consumption by PC or smartphone. EVs are ready for residents to hire for short term usages. The whole development is designated as a "Low Carbon Building" which is an architectural structure to reduce CO_2 emissions by the government, and preferential tax schemes such as the mortgage tax break can be applied. This time 15 units out of a total 356 units of the development will be sold. The unit area is between 72.03 to 90.23 m^2 with three or four bedrooms and a living, dining and kitchen area. They are planned to be sold for between ¥39.1 to 66 million. The apartment building consists of 18 stories with single story of basement. (The Nikkei Business Daily & Architectures, Constructions & Engineerings News (Daily), January 8 & 9, 2015)

(3) Tokyo Gas

On January 13th, Tokyo Gas announced that its accumulated Ene-Farm sales had reached 40,000 units on 9th. The FC system was introduced into the market in May, 2009, and the gas provider is the first seller to achieve 40,000 units. (The Denki Shimbun, January 14, 2015)

6. Cutting Edge Technology of FCVs &EVs

(1) Mitsubishi Motors

Mitsubishi Motors developed its own FCV, and has started building a prototype at its Research & Development Center in its Okazaki factory at its Nagoya Plant. The market introduction is aimed for by 2025. Their FCV drives on a storage battery charged at home, and FCs supplement power for long distance driving. The automaker plans to show its presence with a different idea from other major automakers including Toyota Motor. "Our target FCV is closer to an EV", said Osamu Masuko, the Representative Director. (Dempa Shimbun & others, December 28 & 29, 2014)

(2) Nissan Motor

Nissan Motor will expand its ranges of EVs and hybrid vehicles (HVs). As well as the release of two EVs by FY 2016, their core small car "Note" will have a hybrid version. The automaker has sold globally the largest number of EVs, and now plans to improve cost and performance by using its expertise and the sales result to take a lead in the eco car race. Nissan's EV "LEAF", the best-selling EV, was released in 2010, and has sold over 150,000 vehicles worldwide outdistancing German-based VW and US-based Tesla Motors in the global EV market. Nissan currently only sells LEAF as a passenger EV, but plans to introduce a successor of LEAF and an EV which is under development using a small car of less than 660 cc as the base in cooperation with Mitsubishi Motors into the market in late FY 2016. The successor of LEAF will have a longer driving range than that of LEAF, 228 km while being priced lower than LEAF's ¥2.87 million. The EV under development with Mitsubishi will drive a shorter distance than LEAF on a full charge, but the price will be set halfway between ¥1 to 2 million to give options to consumers. Electricity for an EV to drive 200 km is around ¥300, which is a quarter of a current gasoline car using for the same driving distance. However, a gasoline car runs 700 km on a full tank while an EV goes only over 200 km on a full charge. The higher vehicle price is another issue. California, USA, has the world most advanced "Zero Emission Vehicle (ZEV) Regulation" which requires automakers to sell a certain

percentage of ZEV in their total sales. Additionally, New York plans to follow California; emission regulations are expected to be tightened worldwide. For this movement, Toyota and Honda determine FCV as key of next generation car, and Nissan is also developing its own FCV. However, the number of refueling facility to provide FCVs with hydrogen fuel is limited. For the favorite of eco cars, Nissan decided on EVs which have plenty of charging spots comparing to FCVs as well as domestic wall sockets, and HVs which can use established technologies such as battery and motor for now. (The Nikkei, January 3, 2015)

(3) Panasonic

Panasonic's "cylindrical high capacity lithium-ion battery (LIB) for EVs" has been chosen for "Nikkei Excellent Products & Services Award for 2014" with another 15 items. With battery technologies for laptops, this cylindrical LIB is developed to have 30% larger capacity than common LIBs with double the durability. Also, its separator, a core part of the battery, is processed to be insulated to reduce risk of it catching fire, and the battery is developed to solve the down side of EVs which is a short driving range. US-based Tesla Motors' luxury sedan "Model S" solely uses the Panasonic's LIB. The top end model can drive 502 km, over double the distance of a common EV, on a single charge. Since the model is selling well, both firms together decided to build a large-scale battery plant in Nevada, USA. (The Nikkei, January 5, 2015)

(4) Toyota

On January 5th, Toyota Motor announced that all its 5,680 patents on FCVs would be freely shared. They judged that their solitary effort was insufficient and needed to lower the barrier to create more competition in FCV development in order to establish the market. These patents are solely held by Toyota, but patents owned by Toyota group members of component manufacturers are not included. A total of 5,610 patents for cell stack (generator), fuel tank and control system will be freely open to use until the end of 2020. Approximately 70 patents for hydrogen filling station will be shared indefinitely because they are highly beneficial to the public. The automaker will produce FCV MIRAI entirely in Japan, and focus on California in the US sales. The export to Europe will also start this summer. (The Nikkei, The Denki Shimbun, The Nikkei Business Daily, The Nikkan Kogyo Shimbun, Dempa Shimbun, Nikkan Jidosha Shimbun, The Chemical Daily & others, January 6 & 7, 2015)

Toyota Motor will increase the production capacity of FCV "MIRAI" to annual 3,000 vehicles, over four times that of the current capacity, by 2017. Although production capacity it was already decided to an increase to annual 2,100 vehicles by the end of 2015, the figure was raised again to attain to accommodate an upturn of orders. FCV contains a cell stack, generator, and tank to store hydrogen as core components. Their Honsha Plant, Toyota City, produces these components and the car is assembled at their Motomachi Plant in Toyota City. The automaker revealed the specifications of MIRAI in mid-November, 2014, and the annual production capacity of cell stack was set at 700 at the time. However, the number of orders posted by local governments has gone up, and this pushed Toyota to plan an investment of about ¥20 billion prior to the start of vehicle sales on December 15th, 2014 in order to scale up the production to 2,100 vehicles by the end of 2015. The sales of FCV is still going strong, and the automaker will invest more in these two plants to be able to produce 3,000 vehicles each year from 2017. According to a car dealer, the FCV attracts the rich individuals as well as governmental organizations and businesses, and the number of orders has already reached 1,400. They advise their customers that delivery will take three years under the current production capacity. The automaker will introduce the FCV into the European and US markets this year. Since California, USA, will tighten regulations to require car makers to sell ZEV there, and Toyota plans to sell over 3,000 FCVs in the states by the end of 2017. (The Nikkei, January 15, 2015)

On January 15th, Toyota Motor announced that about 1,500 orders for FCV MIRAI had been posted in Japan in a month after the release. Approximately 60 % of purchasers are public organizations and businesses. The main sales areas are Tokyo, Kanagawa, Aichi and Fukuoka Prefectures. (The Nikkei, January 16, 2015)

(5) International CES

On January 6th, International CES, the world's largest consumer electronics show, will start in Las Vegas, the USA. The exhibition will have more

products and technologies which are related to automobiles and expected to grow. This will make the exhibition more like a motor show. As an automobile product, Toyota will display its FCV "MIRAI". Panasonic will bring LIB for EVs and a music player which is operated by human voice. Toshiba will introduce electric parts for image recognition which is required for safety driving systems. (The Asahi Shimbun & others, January 6, 7 & 8, 2015)

(6) Hino Motors & Toyota

On January 8th, Toyota Motor and Hino Motors announced that they had developed a FC bus containing the FC system of MIRAI. From 9th, the FC bus will commercially operate on a route in Toyota City, Aichi Prefecture. Two FC stacks and motors are on board to improve power, and eight high pressure hydrogen tanks are also installed. The automakers enhanced a power supply system to provide appliances with electricity during disasters. Toyota developed the FC system, and the main body such as chassis was made by Hino Motors. The bus takes 77 passengers. (The Nikkei Business Daily, Nikkan Jidosha Shimbun & other, January 9, 2015)

(7) Tesla Motors

On January 8th, Tesla Motors revealed a plan to increase EV production capacity of its plant in California, USA, by 50% by the end of 2015. The current production capacity is 35,000 vehicles, and it will be raised to 52,500 vehicles by the end of 2015. Their luxury sedan "Model S" is selling well in the market. They plan to bring out a sport utility vehicle (SUV) "Model X" the autumn of 2015, and the plant aims to accommodate production increase of the new car. On the same day, the firm opened added facilities such as an automated line to the media. Their assembly line was fortified with additional robots as capital investment in the autumn of 2014; however, the investment amount is undisclosed. To be ready for increased production, 342 new contract employees have been allocated to the plant, and about 4,000 workers are currently in operation in the plant. The manufacturer changed the layout of the assembly line for large robots to transfer vehicle bodies efficiently. The time to fix parts and components was reduced by 50%, 10 of the latest robots were added for welding. Tesla's EV uses Panasonic's LIB containing approximately 7,000 cells. Tesla installed robots to process battery cells and to fix them to body, and can process 1 million battery cells each day. (The Nikkei, January 10, 2015)

(8) GM

General Motors (GM) unveiled a new version of eco car "Bolt", which is close to PHV released in 2010, at the North American International Auto Show started on January 12th. Bolt drives approximately 80 km, extended by over 30 %, solely on battery, and the battery has higher power storage capacity to reduce weight. The automaker also brought out a concept car of "Chevrolet Bolt" which is planned to drive 320 km on a full charge. (The Nikkei, January 13, 2015)

(9) China

In China, the new energy car production has been largely increasing. According to the Ministry of Industry and Information Technology of China, production in December, 2014 ended approximately 27,200 vehicles, triple that of the same month for 2013. The total production for 2014 was approximately 83,900 vehicles, just under four times that of 2013. The breakdown of the figure is approximately 37,800 EVs and 16,700 PHVs for passenger vehicles, and 15,700 EVs and 13,800 PHVs for commercial use. The Chinese government is working on promoting new energy cars, and has set targets of 500,000 vehicles of accumulated production and sales for EV and PHV by 2015, and over 5,000,000 accumulated production and sales by 2020 as well as production capacity for 2,000,000 vehicles. (The Chemical Daily, January 14, 2015)

(10) Honda

Honda plans commercial sales of self-developed FCV in FY 2015. Also, their engine plant in Ohio, USA, will get ready with $340 million (approximately ¥40,000 million) investment to produce a new fuel saving engine. The automaker plans to introduce new EVs and PHVs into the US market by 2018 to accommodate tightening regulations by expanding the line of environmentally-friendly cars. (The Nikkei, January 15, 2015)

Honda will introduce a five-seater FCV in March 2016 into the market in Japan. The FCV will be released in North America by the end of 2016. The plan was revealed by Mr. John Mendel, the executive vice president, at the press conference on January 13th, for the North American International Auto Show. (The

Asahi Shimbun, January 15, 2015; The Nikkan Kogyo Shimbun & others, January 16, 2015)

(11) VW

Volkswagen Group Japan, a member of German-based Volkswagen (VW), aims for over 70,000 vehicle sales, just less than a 4% rise from 2014, and to hit record sales. They will take orders for the EV "e-up!", announced last year, from February and for "e-Golf" in this year. All their dealers will be equipped with chargers by early 2015 to encourage consumers to buy EVs. They will operate 270 shops, a 10% increase as of the end of 2014, by opening small shops in minor cities and rural areas. (The Nikkei, January 15, 2015)

7. FCV Component Development

(1) Denso

Denso has started supplying four components which were exclusively developed for Toyota's FCV "MIRAI" such as an air conditioner. These dedicated air conditioner, FC starter and high pressure hydrogen sensor and electric control unit (ECU) for hydrogen refueling were designed to contribute to an improvement of FCV fuel efficiency and optimal control of the core system. This was the first component development for commercial FCVs by Denso. Additionally, they also supply components such as an electric water pump and radiator which were originally designed for HV and made compatible with the FCV. The largest number of components is supplied by the firm among all suppliers of the FCV. (Nikkan Jidosha Shimbun, December 27, 2014)

(2) Toyota Industries

Toyota Industries has started to prepare increased production of air compressors for FCVs. A FC stack needs an air compressor to feed oxygen. Toyota Industries' air compressor can adjust the flow volume, from small to large amounts, and efficiently compress oxygen to send it to a FC stack. The manufacturer will develop a new highly efficient commercial production technology to produce the world's first helical roots rotor with six rotary vanes. A new process line will be installed in the next one to two years at their Obu Plant, Obu City in Aichi Prefecture. Currently a cylindrical aluminum rod is cut into the shape of a helical roots rotor by using a gear hobbing machine. However, the manufacturer will use forged workpieces for cutting to increase production efficiency and establish a production capacity of monthly 100 to 1,000 units. They have just started to supply FCV components, but are already trying to raise the production. Their air compressor is exclusively produced for the brand new FCV "MIRAI". (Nikkan Jidosha Shimbun, January 9, 2015)

8. Hydrogen Filling Station Development & Business Plans

(1) Osaka Gas

Osaka Gas will buy a vehicle of Toyota's FCV "MIRAI" in April, 2015. This vehicle will use a hydrogen filling station to be open at the same time in Ibaraki City, Osaka Prefecture, to promote FCVs. Osaka City has been picked as a possibility for their second hydrogen filling station after 2015 expecting the cooperation of Iwatani or JX Nippon Oil & Energy. Osaka Gas will prepare infrastructure for FCVs in the Kansai area. (The Nikkan Kogyo Shimbun, December 23, 2014)

(2) Tokyo Gas

Tokyo Gas has opened a hydrogen filling station in Nerima-ku, Tokyo. This is the first commercial hydrogen refueling facility in the Kanto area. The facility is installed at an established natural gas filling station; this is the first combination in Japan. The gas provider plans efficient use of land and reduction in cost by placing hydrogen and natural gas facilities on the same premises. The opening ceremony was held on December 18th. The address is 1-1-34 Yahara, Nerima-ku, and the land area is 2104 m^2. This off-site production type station is supplied with hydrogen from plants, and stores hydrogen gas in accumulators to dispense to FCVs. The facility fills a FCV with hydrogen in three minutes. Another commercial hydrogen refueling facility is planned to be installed at an established natural gas filling station in Urawa-ku, Saitama City, after the one in Nerima. (The Nikkan Kensetsu Kogyo Shimbun, December 24, 2014)

On January 8th, Tokyo Gas announced that its hydrogen would be sold for FCVs at ¥1,100/kg. The price was set at the same level as the gasoline cost of HVs using the fuel efficiency information of "MIRAI", the FCV released by Toyota. Although this price does not make profit, the gas provider prioritizes the

growth of FCVs. Their hydrogen is sold at their first commercial hydrogen refueling facility which became available in Nerima-ku, Tokyo, last December. (The Nikkei, The Nikkei Business Daily, The Denki Shimbun & others, January 9, 2015)

(3) Taiyo Nippon Sanso

Taiyo Nippon Sanso, a major industrial gas producer, plans to develop a mobile hydrogen filling station which reduces the current initial cost by half. By 2016, the initial cost of the filling station aims to go down to a ¥100 million level which is close to that of construction costs of a gasoline filling station. The manufacturer targets at about 300 units of sales including exiting products to filling station operators by 2025. Their mobile hydrogen refueling facility "Hydro Shuttle" can eliminate the need of land costs to bring down the preparation costs. They also use expertise from industrial gas production to develop a hydrogen chiller and "dispenser" to fill FCVs. A common stationary hydrogen filling station most likely costs ¥400 to 500 million. On the other hand, a mobile filling station needs ¥200 by cutting costs of equipment due to its smaller size. Furthermore, the gas producer will revise the design of its mobile hydrogen filling station in phases to bring the installation costs closer to approximately ¥100 million which is the installation costs of a gasoline filling station by 2017. In order to promote Hydro Shuttle, a new firm is planned to be launched to operate mobile hydrogen filling stations in cooperation with Toyota Tsusho and Sumitomo Mitsui Finance and Leasing Company. Taiyo Nippon Sanso targets at 300 units by 2025, and a 30% share in the market of mobile and stationary hydrogen filling stations. Currently the majority of hydrogen filling stations are static. By contrast, Hydro Shuttle requires registration, but can flexibly go to where the fuel is needed, which is an advantage. (The Nikkei, December 26, 2014; The Nikkan Kogyo Shimbun, January 13, 2015)

(4) JX Nippon Oil & Energy

On December 25th, JX Nippon Oil & Energy announced that its first hydrogen filling station was open in Ebina City, Kanagawa Prefecture. The price is set at ¥1000/kg. Toyota's "MIRAI" can drive 700 km on 5 kg of hydrogen. The filling station operator plans to install hydrogen refueling facilities at 23 locations, mainly in the greater Tokyo area, in FY 2014, and 40 locations by the end of FY 2015. Hydrogen refueling facilities will be installed at 13 locations in FY 2014, where filling stations are run with shops, throughout Japan including nine locations in four prefectures in the Kanto area such as Tokyo and Kanagawa Prefecture. In detail, three stations will solely supply hydrogen, and the rest of the locations are established filling stations to be equipped with hydrogen refueling facilities. Furthermore, 10 mobile hydrogen filling stations will be open. Iwatani sells hydrogen at ¥1100/kg at its two hydrogen filling stations, and JX plans to beat the rate. Although currently hydrogen filling station business draws out money rather than gaining, JX expects the business to break even by a combination of further development of technologies for production and transport and achieving the level that each filling station is regularly used by 2,000 FCVs. (The Nikkei, The Nikkei Business Daily, The Nikkan Kogyo Shimbun & others, December 26, 2014)

(5) Fujitsu

Fujitsu has started a service to provide information on the locations of hydrogen filling stations and operational status on real-time basis for automakers. The service uses Intelligent Society Solution SPATIOWL, a cloud service collecting positional information, as its base, and provides FCV user with information such as locations of stationary and mobile hydrogen filling stations and their operational status, which come from hydrogen filling station operators, through car navigation systems and smart phones. (Information Industry and Market News, January 1, 2015)

(6) Iwatani

Iwatani plans to expand hydrogen business to supply FCVs with fuel. Liquid hydrogen production plants will be constructed to cover the greater Tokyo, Nagoya and Osaka area and Kitakyushu region in a few years. In the same period, the firm will start manufacturing hydrogen gas production facilities in Japan using technologies of German-based Linde as the base. From the spring of 2015, two of Toyota's FCV "MIRAI" will be used to build operational know-how of hydrogen filling stations. Iwatani targets 20 hydrogen filling stations to be constructed by FY 2015, and it plants to keep raising the number after FY 2016 to leap ahead of others in the integrated hydrogen business from fuel production to sales. The new liquid

hydrogen plant will be the fourth for them after three in Nishi-ku (Sakai City), Ichihara City (Chiba Prefecture), and Shunan City (Yamaguchi Prefecture). As the base, Linde's compressor will be used to build on-site hydrogen gas production equipment from liquid hydrogen at a lower cost in Japan. This reduces construction costs of hydrogen filling stations by, ¥300 to 400 million, a couple of dozen percent. Furthermore, a method will be established to reduce hydrogen gas production costs by using liquid hydrogen which cuts down volume to a third to store. MIRAI will be deployed each to Amagasaki City, Hyogo Prefecture, where the gas producer opened the first commercial hydrogen filling station in Japan, and in Minato-ku Tokyo where another filling station is to finish its construction in May. (The Nikkan Kogyo Shimbun, January 8, 2015)

9. Hydrogen Detecting System Development & Business Plans

(1) NGK

NGK Spark Plug has developed a sensor to detect hydrogen leaks for FCVs. A sensor is essential to prevent explosion by hydrogen leaking and catching fire. Their product has improved accuracy and durability compared to existing ones. The manufacturer has the largest global share in spark plugs for car engines. Their entry to the FCV parts market will create more competition in product development. Hydrogen has no color or odor, unlike gasoline, and a slight leak from hydrogen tanks must be detected to immediately stop hydrogen supply to FCs. NGK's sensor determines hydrogen leak from an amount of heat drawn by hydrogen, and can recognize a low hydrogen concentration of 0.2 to 2%. According to the firm, this sensor degrades less by aging than products which detects chemical reactions of catalyst with hydrogen, and more accurate. Technology of micro electro mechanical system (MEMS) is used in the product. (The Nikkei, December 27, 2014)

(2) Nireco

Nireco will expand its line of surface inspection systems for electronic materials. A cheaper version of "Mujiken", a plain surface inspection system, and an inspection system which can process electrode sheets of secondary cells and FCs at four times the speed of conventional systems will be introduced into the market by March. The manufacturer expects more investments on equipment to be ready for FCV market growth, and aims for sales growth with the early product introduction. The inspection system checks defects of base layers, coatings and uncoated parts on electrode sheets for cathodes, anodes and separators of secondary cells and FCs as well as width, length and deformation of coated parts. (The Chemical Daily, January 9, 2015)

(3) Takano

Takano will explore the automobile market as a new area for its inspection equipment business. The new business will use various technologies developed from inspection equipment for liquid-crystal displays. The manufacturer will focus on development and sales of an inspection system for FC materials which is expected to be used in cars. (The Chemical Daily, January 15, 2015)

10. Global Investment Trend of FCVs

KPMG, an international audit firm based in Netherland, has carried out direct research on global automakers and car component manufacturers. The results show a significantly increasing intention of investment in FCVs. Although this was the lowest in five core power technologies in the survey in 2013, Toyota's introduction of MIRAI into the market stimulated interests pushing FCV to the second place in the survey in 2015. The most interested power technology for investment over five years was downsizing engines at 32%. The number of firms which answered FCV was 19%, double that of 2013. (The Nikkei & The Nikkei Business Daily, January 9, 2015)

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