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Advancing Hydrogen Station R&D and Deployment

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1. Governmental Measure

The Japanese Government will ease the regulations on hydrogen filling stations. Regulations on buildings and safety will be relaxed to reduce installation costs to half. Supporting installation plans of energy firms by the deregulation, the government aims at 100 hydrogen filling stations nationwide in FY 2015. The private sector has been working on the hydrogen filling station businesses. For example, Seven-Eleven Japan will start opening convenience stores with hydrogen refueling facilities in FY 2015. Hydrogen is highly flammable, and the current regulations restrict businesses. As a result, hydrogen filling stations have only been planned for 45 locations throughout Japan including the ones already installed and 26 locations of the greater Tokyo area. The government will revise 12 related ministerial ordinances of the High Pressure Gas Safety Act and Building Standards Act by the end of FY 2015. The current regulations only allow filling stations to store hydrogen for seven fuel cell vehicles (FCVs) at each location. The revised regulations will enable filling stations to store hydrogen at a higher compression ratio, and eliminate the hydrogen storage restriction for filling stations. These changes will let business have more customers, which gives them a more financially stable operation. Also safety inspection of compressors will be made simpler. Although, for general safety reasons, hydrogen dispensers must be installed at least eight meters away from public roads, this distance will be most likely to be shortened to a minimum of four meters. The government plans to permit constructions of filling stations offering hydrogen produced on site by splitting water using power from photovoltaic generators. In Japan, construction of a single hydrogen filling station currently costs between ¥400 and 500 million, which is double the amount of the Western countries. The Japanese government aims to cut the cost to half by 2020 by deregulation.

The government's target for hydrogen filling stations is about double the building expense of a gasoline filling station which is about ¥100 million. As well as the deregulation, the Ministry of Economy, Trade and Industry (METI) has allocated ¥11,000 million for the subsidies to support two thirds of the construction costs of hydrogen filling stations in its budget request for FY 2015. (The Nikkei & others, December 10, 2014)

2. Local Governmental Measures

(1) Kobe City

Kobe City will work on expanding hydrogen energy use. On November 25th, Mr. Kizo Hisamoto, the mayor, announced at a press conference that the city would use FCV for its operation from March 2015. Toyota's Mirai will be purchased by the city, which is the first local government to utilize FCV in the Kansai area and the fourth in the whole of Japan after Muroran City of Hokkaido, Aichi and Fukuoka Prefectures according to the city. As well as general operation, the FCV will make an appearance at promotional events for. The city will prepare a hydrogen filling station in FY 2015, and start a subsidy scheme for business operators to support FCV purchases. A target figure for FCVs in the city will also be set as early as possible. Currently the supply method and location of the hydrogen filling station is under investigation. The location of the station will be chosen to fit the current regulations. For example, the High Pressure Gas Safety Act requires a filling station to keep a certain distance from roads. The city already has a "subsidy scheme to promote next generation cars", and FCV will be added to the scheme. Hyogo Prefecture targets 25,000 FCVs and 20 hydrogen filling stations by 2030 for the whole prefecture. (The Nikkei, November 26, 2014; The Nikkei Business Daily, November 27, 2014; The Nikkan Kogyo Shimbun, December 9, 2014)

(2) Yokohama City

On November 25th, Yokohama City revealed the location for its first and only mobile hydrogen filling station before the world's first retail sales of FCV Mirai starts on December 15th. A ceremony was held with a FCV to drive participants around to learn about an "ultimate eco car" which is expected to expand its market. A mobile hydrogen filling facility will be stored in a trailer to be operated by JX Nippon Oil & Energy Corporation at the pickup and drop off point of Osambashi Wharf Building in Naka-ku, Yokohama City from 2015. JX has decided to install stationary hydrogen filling stations in Asahi-ku and Izumi-ku by February 2015. (The Kanagawa Shimbun, November 26, 2014)

(3) Osaka Prefecture

On December 2nd, Osaka Prefecture announced that it had made a master agreement on the installation of a fuel cell (FC) generation system at the Osaka Prefectural Wholesale Market, Ibaraki City, with Bloom Energy Japan. The system with 1200 kW output, produced by US-based Bloom Energy, will be installed in FY 2014 to operate from FY 2015. The market will purchase electricity for its facilities such as refrigerators. (The Nikkan Kogyo Shimbun, December 3, 2014; The Suisan-Keizai, December 5, 2014; Japan Food Journal, December 8, 2014)

(4) Tokushima Prefecture

Mr. Kamon Iizumi, the governor of Tokushima Prefecture announced that the prefecture would set up a "Liaison Committee for Hydrogen Grid Preparation (provisional name)" in January 2015 to promote hydrogen energy usage such as FCVs. The committee will be composed of producers and sellers of hydrogen, automobile related businesses and experts, and investigate issues relating to more hydrogen energy use. (The Tokushima Shimbun, December 4, 2014)

(5) Fukuoka Prefecture

Fukuoka Prefecture will subsidize FCV purchases of taxi operators to realize a hydrogen society and growth of FCV. The scheme supports operators of general passenger automobile carriers to use FCVs for their operation in the prefecture. The subsidy amount is planned at ¥1 million each case. The prefecture will choose operators which meet certain criteria by assessing their reports including due date of vehicle registration, retention period and usage state during legal durable years. The applications will be taken and assessed this month to choose five operators. (Nikkan Jidosha Shimbun, December 4, 2014)

(6) Fujisawa City

On December 11th, Fujisawa City of Kanagawa Prefecture will start taking public comments on "Promotion Plan of Locally Produced Energy Consumption (provisional name)" to encourage renewable energy use. The investigative commission of the promotion is currently compiling the plan and selecting actual measures to complete the plan with opinions from the residents by the end of February 2015. Land Brains was chosen to carry out the operation of compiling the plan by sending its proposal to the public tender. Fujisawa Sustainable Smart Town and operators in the city will cooperate for FC use expansion. FCV growth will be sought by cooperative work of public and private sectors as well as inviting hydrogen filling stations. (Architectures, Constructions & Engineerings News (Daily), December 9, 2014)

3. FC Element Technology Research & Development

A joint research group of the Japan Science and Technology Agency (JST) announced that it had found a control mechanism of an enzyme to catalyze the decomposition and formation reaction of a hydrogen molecule. This finding is expected to contribute to the development of next generation FCs and hydrogen production catalysts using enzymes. Currently Pt is used as a catalyst of commercial FCs. Ni-Fe hydrogenase is an enzyme found in microorganisms, and a promising decomposition and formation catalyst for hydrogen production. The hydrogenase functions as the catalyst at a normal temperature and pressure, and is also a couple of hundred times more efficient than Pt catalyst. However the mechanism is little known. When three reactive areas of Ni-Fe which are centers of catalysis appear during decomposition/formation of a hydrogen molecule, the state change occurs by applying light. The study team focused on this fact, and found out using Fourier-transform infrared spectroscopy that the change of state induced by the light application was an intermediate of the catalytic reaction. They also investigated the electron state of the FeS cluster

which is the closest cluster to the center and one of three catalytic reaction related clusters for electrons to go through. Their finding was that the catalytic reaction was only processed when the cluster was oxidized, but stopped when the cluster was reduced. This result suggests that the FeS cluster functions as a switch and controls catalytic reaction. (The Semiconductor Industry News, December 3, 2014)

4. SOFC Related Technology Development & Business Plans

(1) Mitsubishi Hitachi Power Systems

On December 4, Mitsubishi Hitachi Power Systems (MHPS) announced that Kyushu University had sent an order for its pressurized hybrid power generation system using solid oxide fuel cells (SOFCs) which operate at a high temperature of 900°C and a micro gas turbine (MGT). The system generates power by reacting hydrogen and CO, extracted from natural gas, with oxygen, and this is the second delivery of the system since a demonstrational system was delivered to Senju Techno Station of Tokyo Gas. Ito Campus of Kyushu University will be equipped with the combined generation system outputting 250 kW which is planned to start operation in the spring of 2015 to demonstrate an industrial FC system. The firm reduced the installation area of the existing product by 40% by improving cell stack package density. (The Denki Shimbun, The Nikkei Business Daily, The Nikkan Kogyo Shimbun & The Chemical Daily, December 5, 2014)

(2) Okayama University

Okayama University has shown productive research results on renewable energy by developing SOFC using biogas from livestock as the fuel. The FC successfully operated at 600°C to power a light-emitting diode (LED). The team started an experiment with a hydroelectric generator where water currents oscillate pendulums for generation, at a sewage treatment work in Okayama City. A start-up company will launch at the university to use power for charging electric vehicles (EVs). The study group is led by Prof. Michihiro Miyake of the Department of Environmental Chemistry and Materials, and has developed a system since 2009 to aim for over 50% use of biogas from waste material of pigs. However, SOFC using biogas as its fuel has a large problem of carbon eposition by biogas, and the group has researched a composition of catalyst which can control carbon deposition. In an experiment, a single cell operated at 600°C to light a LED using reformed biogas as its fuel, and carbon hardly deposited during the four hour operation. (The Chemical Daily, December 22, 2014)

5. Ene-Farm Business Plans

(1) Saibu Gas

Saibu Gas has announced that an optional product for Panasonic's home Ene-Farm would be available. The option allows the FCs to generate power during power cuts. This function works even if the FC system is switched off when a power cut occurs. The optional product can start itself to activate the FC system to supply a home with power through a dedicated wall socket. If power consumption is less than 700 W during a power cut, power supply will last for up to four days. The optional product is compatible with Panasonic's Ene-Farm which is shipped from December 1st. (The Denki Shimbun, November 28, 2014)

(2) Osaka Gas

Osaka Gas plans to sell condominiums with SOFC type Ene-Farm which uses natural gas and generates power at a highly efficient rate in the Kansai area. To compete against solely-electric condominiums, each unit will be equipped with Ene-Farm, which is coming down in price, as a standard feature to reduce the energy bills of its residents. The gas provider plans to start with a higher grade apartment house with few dozen units, a small to medium size, in order to increase the number of apartment houses installed with FCs as a standard feature over a long period. (The Nikkan Kogyo Shimbun, December 9, 2014)

6. Cutting Edge Technology of FCVs & EVs

(1) Daimler

Germany-based Daimler will start its bus rapid transit (BRT) business in Japan. FC buses will be developed to not produce harmful emissions aiming for its market introduction in 2020. (The Nikkei Business Daily, November 26, 2014)

On December 1st, Germany-based Daimler announced that €100 million (approximately ¥15,000 million) investment would go to its subsidiary, a manufacturer of finished automobile batteries to

expand the production capacity. The automaker just dissolved a capital alliance with US-based Tesla Motors in October. By 2017, 10 plug-in hybrid vehicles (PHVs) are planned to be introduced into the market. Daimler clearly changed its strategy to its own battery development and production. Deutsche ACCUmotive, wholly owned by Daimler, will construct a new building at its lithium-ion battery (LIB) module plant in Saxony in eastern Germany. However, the production capacity has not been disclosed. The construction aims to be finished in mid-2015, and the area of the plant will be four times of that of 2011. The plant plans to provide battery modules to small EV "smart" and luxury range PHV "Mercedes-Benz". Additionally, the subsidiary focuses on developing business in the storage battery market aiming to sell its products to factories and homes. Daimler signed a capital and business alliance with Tesla in 2009, and worked on joint development of EV's as well as the purchase of Tesla's batteries. Their EV "B-Class", the symbol of their alliance, became available this year. Although Daimler's investment in Tesla was withdrawn, the established partnership is expected to last. Daimler switched to the development of its own battery by improving its production capacity of modules. (The Nikkei, December 2, 2014)

(2) Sumitomo Chemical Company

On November 26th, Sumitomo Chemical Company announced that its production capacity of insulation material for LIB would be tripled of that of 2015. The investment is expected to be few dozen of billion. The manufacturer will supply the material to Panasonic which will then provide batteries for EVs of Tesla Motors. Sumitomo Chemical will increase the annual production capacity of its separator, a key material for LIBs to 140 million m^2 by 2015. By gradually improving, the capacity aims to be over 400 million m^2. The manufacturer will mainly strengthen the production of "aramid resin" containing separators. As well as high heat resistance and improved safety, the separator can be used for high capacity batteries, which contribute to extending driving range. Tesla and Panasonic will build a large scale battery plant in Nevada, the USA, preparing for the full scale sales of EVs. Sumitomo Chemical will carry out the final process of separators in the plant. (The Nikkei, November 27, 2014)

(3) VW

Volkswagen (VW) has revealed a prototype of FCV "Golf HyMotion". This is the first time in nine years for VW to show a prototype of FCV. With maximum output of 100 kW, the prototype can drive 500 km on a tank full of hydrogen. (The Chunichi Shimbun, November 27, 2014)

VW plans to start FCV sales in Japan by 2020, and then to expand the business to the global market. Previously the automaker focused on "downsizing cars" which have smaller engines to reduce emissions as the key development of eco cars. However, FCV development has been accelerated to fit to environmental regulations which are being tightened in developed countries. The firm has developed its own cell stack for FCV to be able to drive 500 km on a full tank. They estimate Japan will prepare hydrogen filling stations at a faster rate. The range and price of the vehicle will be determined. (The Nikkei, December 6, 2014)

(4) Nissan & Renault

On November 26th, Nissan Motor and its capital alliance partner Renault announced that the combined accumulated global sales of EVs had reached 200,000. Nissan has sold just under 150,000 vehicles of Leaf, and Renault has sold a total of over 50,000 vehicles of four EVs including "Twizy". (The Nikkei, November 27; The Nikkei Business Daily, December 3, 2014)

The retail sales of EV started in 2009 with i-MiEV in Japan followed by Leaf's entry into the market in 2010. Although the market is now four to five years old, the accumulated sales are about 60,000 vehicles. Nissan and its capital alliance partner Renault together target at 1,500,000 EV sales globally by FY 2016. In October, Nissan started a service which offers customers unlimited use of quick chargers often found on Expressways as well as ones at Nissan dealers for a monthly fee of ¥3,000 (excluding tax). With a monthly fee of ¥1,429, the previous all you can use plan was limited to the chargers of Nissan dealers. For the new plan, approximately 4,100 chargers will be ready for the service by March 2015. Being made more affordable, the cheapest Nissan Leaf has been reduced from ¥2.98 million to current ¥2.26. According to Fourin, a research firm, Leaf took 80% of EV sales for 2013 in Japan. (The Nikkei, December 4,

2014)

(5) Toyota Media Service, Toyota Industries & Nihon Unisys

On November 27th, Toyota Media Service, Toyota Industries and Nihon Unisys announced that they would cooperate in a business platform to support and encourage consumers to use EVs. These firms will develop and offer a service to provide information on charger locations, management of multiple charger operation and an estimate number of waiting EVs for chargers. The system will be tested from February 2015 in Aichi Prefecture. Toyota Media Service will develop an "EV/PHV Promotion Platform" to provide information about chargers including the facilities with chargers and where to enjoy, while EVs are charged, through smart phones. Toyota Industries will develop a control system to level electric load among multiple chargers at a single facility. Nihon Unisys will develop a function to estimate the number of EVs waiting to recharge using big data. Basically the platform also is to be designed for information management of hydrogen filling stations for FCVs. (The Nikkan Kogyo Shimbun, November 28, 2014; The Denki Shimbun & others; December 2, 2014)

(6) Nichicon

Nichicon, Kyoto City, has announced that its EV Power Station (EVPS) had been able to work with Toyota Motor's FCV "Mirai". EVPS allows cars to be an emergency power source, and Mirai can now supply building or home appliances with power. Nichicon developed EVPS for Nissan's EV "LEAF" and introduced it into the market in 2012. The product expanded its compatibility to Mitsubishi Motors' EVs in July 2014. (The Semiconductor Industry News, December 3, 2014)

(7) GLM

In July, GLM, a venture from Kyoto University, started delivery of the first sports type EV in Japan. Having launched in 2010, they have used research results on an EV project of Kyoto University as the base, and developed the sports EV employing technologies of local component manufacturers in Kyoto such as OMRON and GS Yuasa Group. Orders for 99 EVs have been already sent to the manufacturer in Japan, and the business aims to expand to export to other Asian regions. Mr. Yasuhiro Koma, the CEO, showed his enthusiasm for global deployment from Kyoto. (The Nikkei, December 4, 2014)

(8) Mitsubishi Motors

Mitsubishi Motors will install quick chargers for EVs and PHVs at its 700 dealers nationwide by March 2016. The majority of the chargers will be available 24 hours a day. The sales of EVs and PHVs have been slow, and the market is unforeseeable due to oil prices falling. The quick charger of Mitsubishi Motor charges approximately 80% in 30minutes. The charging membership of the industry offers a monthly fee of ¥1,000 to use these chargers. The automaker will also consider introducing a new payment plan, and the EV "i-MiEV" and PHV "Outlander" are available from them. (The Nikkei, December 4, 2014)

(9) Toyota

Toyota Motor will triple the current annual production capacity of FCV "Mirai" by the end of 2015. Approximately ¥20 billion will be invested in their two plants in Japan to increase the capacity as early as possible to meet the strong demand in Japan as well as export to the US. Toyota can currently produce 700 FCVs each year. According to their dealers, the number of orders is expected to exceed the production capacity before the official sales starts on December 15th. Toyota's official says delivery dates will be determined later. The automaker plans to export FCVs from the summer of 2015, which requires an even larger number of the product. California in the USA has the zero emission vehicle (ZEV) regulation that cars which do not produce harmful emissions are required to take a certain percentage in the total car sales there. Toyota plans to expand sales of Mirai there to meet the requirement. Because the current production capacity cannot meet the demand of Japan and the US, the firm will increase the production of the FC stack, the power source, and hydrogen tank at the Honsha Plant, Toyota City. Two lines will be installed there to triple the annual production capacity. Also, their Motomachi Plant, an assembly factory in Toyota City, will enhance its facilities. The firm plans to sell a total of 400 vehicles of Mirai in Japan by the end of 2015, and 3,000 vehicles in the US by the end of 2017. For Europe, 50 to 100 vehicle sales are expected by 2016. The automaker determines the US as the prime market. (The Nikkei, December 6, 2014)

On December 15th, Toyota Motor released FCV Mirai.

Because the number of production is limited, the automaker has not provided dealers with an actual vehicle. Some dealers tell their customers that delivery of the car would take one to two years. Toyota started the world's first retail sales of FCV, and the FCV has large attention. Because FCVs still have issues to be solved such as preparation of hydrogen filling stations, the market of FCV, an ultimate eco car, opened quietly. Toyota started the production at a planned rate of annual 700 vehicles this month. Initially they targeted for approximately 400 FCV sales. When sales of Mirai were announced on November 18th, orders for approximately 200 vehicles had already been posted mainly from businesses and public organizations. At the time, the estimated delivery was around 6 months. The automaker has kept receiving orders which are more than they expected. According to a dealer, the number of ordered vehicles has reached 1,000. "We don't know when an actual FCV comes for display", says a member of staff of a dealer in the Kansai area. Currently, only two retail hydrogen filling stations are available in Amagasaki City, Hyogo Prefecture, and Kitakyushu City, Fukuoka Prefecture. The number of planned station to be prepared with subsidy is still 43 locations. Mirai sells for ¥7.236 million, and the price including subsidy comes down to ¥5.2 million, which does not seem affordable. (The Nikkei & others, December 16, 2014)

(10) China

Production of new energy cars has kept expanding in China. The Ministry of Industry and Information Technology of China has reported that the production was approximately 56,700 vehicles for 11 months from January to November 2014, 3.2 times of that of whole 2013. The production of passenger vehicles was 25,800 EVs and 13,600 PHVs, and the breakdown of commercial vehicles is 7,363 EVs and 9,949 PHVs. (The Chemical Daily, December 8, 2014)

(11) Hino Motors

Hino Motors plans to release a FC bus in FY 2016, and has released a development plan including a driving range of 200 to 300 km on a tank full of hydrogen. The driving range is to be extended to 50% longer than that of the previous test bus to be able to perform as a transit bus. The layout of components will be reviewed to expand passenger space. For the sales, the firm targets Tokyo Metropolitan government which is enthusiastic about using FC buses for the 2020 Olympic Games. (The Nikkei Business Daily, December 8, 2014)

(12) NTN

NTN developed own EV "Q' mo" which can rotate on the spot or drive sideway, and has announced that the EV obtained a registration number enabling the vehicle to drive on public roads. The EV will be tested in various places, and give test rides to advertise the technologies. (The Nikkei, December 10, 2014)

(13) Hyundai Motor

On December 16th, Hyundai Motor Group revealed a plan to release 22 eco cars such as hybrid vehicles (HVs) by 2020. As well as HVs, the plan includes new FCVs and EVs. The firm aims to compete against other automakers in Japan, Europe and the US by developing a wider range of eco cars and investigating the mainstream of environmental technologies. Including development of Kia Motors, a group member, the breakdown of 22 vehicles is 12 HVs, six PHVs, two FCVs and two EVs. Currently, seven eco cars are available from them, and four HVs have sold 210,000 for 2014 which puts them in the fourth place in the global sales. (The Nikkei, December 17, 2014)

7. FCV Component Development & Maintenance Businesses

(1) Aichi Toyota & Nagoya Toyopet

Aichi Toyota and Nagoya Toyopet will sell Toyota's FCV "Mirai", and will prepare facilities for inspection and maintenance of the vehicle. To look after FCVs well, full maintenance centers will be able to carry out overhauls such as the removal and reinstallation of hydrogen related components such as fuel tanks, and standard maintenance centers will perform free and annual inspections. Aichi Toyota will open a full maintenance center at its Takatsuji branch which is located in the headquarters under reconstruction in Showa-ku, Nagoya City. The maintenance center will operate with a dedicated inspection area for FCVs from February when the branch reopens. In FY 2014, Nagoya Toyopet will prepare three full maintenance centers at Atsuta branch which is in its headquarters in Atsuta-ku, Nagoya City, Toyota-Tsuchihashi branch and Kariya-Higashiura branch, and four standard maintenance centers at Toyohashi-Shimoji branch,

Seto branch, Ichinomiya-Sumiyoshi branch and Minami branch in Minami-ku, Nagoya City. (Nikkan Jidosha Shimbun, November 27, 2014)

(2) Toray Carbon Magic

On December 5th, Toray Carbon Magic, a subsidiary of Toray, started to produce carbon fiber components in Japan at double the level of the previous capacity. Carbon fiber is characteristically light and strong, and does not rust. The manufacturer supplies Toyota Motor with its products for FCV "Mirai". (Gifu Shimbun & The Yamaguchi Shimbun, December 6, 2014; Nikkan Jidosha Shimbun, December 9, 2014)

(3) Pacific Industrial

Pacific Industrial has developed a new "explosion proof valve" to be used for high pressure hydrogen tanks as a safety device. If the pressure level of the tank rises exceedingly, the valve releases gas to avoid an accident. The manufacturer developed the product using its expertise of tire pressure monitoring system (TPMS) and tire valves, and produces the product for FCV "Mirai". The product is produced at Kita Ogaki Plant, and delivered to Toyota's production center in Aichi Prefecture. (Nikkan Jidosha Shimbun, December 9, 2014)

(4) Ube Industries

On December 8th, Ube Industries announced that its own nylon resin was employed for Toyota's FCV "Mirai". The resin is used inside tanks to store hydrogen at a high pressure, and withstands rapid temperature changes during refueling and supplying hydrogen as well as holding hydrogen securely. In cooperation with Toyota, Ube Industries developed the material which easily endures impacts in a very cold environment. (The Nikkei Business Daily, The Nikkan Kogyo Shimbun, The Chugoku Shimbun & The Chemical Daily, December 9, 2014; Nikkan Jidosha Shimbun & Dempa Shimbun, December 10, 2014)

(5) Nissha Printing

On December 15th, Nissha Printing announced that a hydrogen detector of its subsidiary was employed for Toyota's FCVs. A hydrogen detector is an essential component to ensure that there is no leakage of hydrogen in order to avoid it accidently catching fire. Since the product is used in the world's first retail FCV, Nissha Printing aims to expand the sales of the detector to other automakers. A sensor and microcomputer are combined in the detector. Each Toyota Mirai uses two detectors. Once a leak is found, the detector stops either the hydrogen supply or the engine. The development was carried out by FIS, Hyogo Prefecture, which was acquired by Nissha Printing in June. The new product has improved the durability by three times and the detection time to one third that of an existing product. Directly trading with Toyota as a tier-one supplier, FIS has a large share in the global market of alcohol detectors and sensors for air quality control. Nissha Printing plans to bring on the product as a core business by targeting other automakers which are rapidly developing retail FCVs. (The Nikkei & others, December 16, 2014)

(6) JTEKT & Sumitomo Riko

On December 16th, JTEKT and Sumitomo Riko (ex. Tokai Rubber), car parts manufacturers, revealed their products were used in Toyota's FCV Mirai. These manufacturers proposed new products developed with established technologies. The FCV employs JTEKT's valves to supply hydrogen from high pressure tanks and seal the tanks, and to reduce pressure of hydrogen to the usable level. These products were developed with a technology to control highly pressurized oil obtained from their own hydraulic power steering development. Sumitomo Riko developed a "gasket for cells", a rubber sealing material for FC cell stacks. Having been developed with technologies for their rubber parts, the core product, the product secures channels for hydrogen and oxygen in stacks while improving drainage performance. (The Nikkan Kogyo Shimbun, December 17, 2014)

8. Hydrogen Filling Station Development and Business Plans

(1) Osaka Gas

On December 2nd, Mr. Hiroshi Ozaki, the president of Osaka Gas, said in an interview that the firm expected an increasing demand of hydrogen filling stations for FCVs. He also showed their intention to build one to two hydrogen filling stations each year including outside their normal business area, the Kansai area. The gas provider plans to open a hydrogen filling station in Ibaraki City, Osaka Prefecture, next spring. (The Mainichi Newspapers & another, December 3, 2014)

(2) Yamato Sangyo

Yamato Sangyo, a manufacturer of pressure controllers in Osaka Prefecture, has developed a simplified hydrogen dispenser unit. A common hydrogen filling station costs ¥400 to 500 million to build. On the other hand, the new refueling unit uses own ultra-high pressure valves to reduce its price and size to one tenth. From December, the manufacturer will propose the product to car dealers and road service operators. The product needs to be connected to hydrogen tanks, and uses a pressure less than 35 MPa. It takes over 10 minutes to fill a FCV tank. In contrast, a common hydrogen dispenser uses about 70MPa, which gives shorter filling time of three minutes. Yamato's small refueling unit will sell for about ¥7 million, and a unit with compressor will sell for about ¥50 million. The product can be used for mobile stations. Their subsidiary Yamato H2Energy Japan will carry out the actual production and sales. (The Nikkei, December 8, 2014)

(2) Seven-Eleven Japan & Iwatani

Seven-Eleven Japan and Iwatani will cooperate to open convenience stores with hydrogen filling stations. Two shops will be open in Tokyo and Aichi Prefecture in the autumn of 2015 as a start. These firms plan to increase the number to 20 by FY 2017 to attract more consumers as eco car centers. Iwatani will pay the costs of the hydrogen filling stations and operate them. The convenience stores will be open 24 hours, and the hydrogen filling stations will operate in the day time on weekdays. Seven-Eleven Japan will share its real estate information and expertise of retail shop development with Iwatani, so that they can efficiently find favorable locations. They target major roads with a large amount of traffic in suburban areas for shops with refueling facilities. (The Nikkei & others, December 10, 11 & 12, 2014)

(4) Fujitsu

On December 15th, Fujitsu made an announcement of the start of its new system to manage information for automakers of hydrogen filling stations for FCVs. In the system, operators of hydrogen filling stations enter their locations and operational statuses into Fujitsu's cloud. Then automakers provide the latest filling station information to FCV users through car navigation systems and smart phones. (The Nikkei & The Chemical Daily, December 16; The Denki Shimbun, December 17, 2014)

(5) Honda & Iwatani

Honda Motor and Iwatani have installed a small hydrogen filling station which supplies FCV with hydrogen produced from water in Kitakyushu City, and its test operation started on December 15th. The station achieved significant reduction in its size by eliminating the need for a compressor to dispense hydrogen to fuel tanks at a high pressure. FCV owned by Kitakyushu City government will be used to investigate problems to be solved for commercial operation. Having been developed with the cooperation of both firms, Smart Hydrogen Station is 3.2m wide, 2.4 m deep and 2.4 m high which is about the size of a 10 ft. container. Honda developed an own high-pressure electrolysis system to produce hydrogen at a rate of up to 1.5 kg each day. The station directly stores hydrogen in a high pressure tank at 35 MPa to achieve remarkable reduction in size. Also the installation completes by simply fixing the system on to a facility, which reduces the installation period to a day. The system can store 18 kg of hydrogen which fills four to five FCVs. (The Nikkei Business Daily, December 16, 2014)

(6) Tokyo Gas

Tokyo Gas is restructuring its business to adapt to full liberalization of electricity and gas supply for consumers coming in two to three years. On December 18th, they opened the first hydrogen filling station in Kanto area. "We are very interested in realizing the hydrogen society, and see hope in it", Mr. Yutaka Kunigo, an executive vice president of Tokyo Gas, emphasized at the opening ceremony. Toyota's FCV "Mirai" was released on December 15th, and the gas provider plans to take a lead in preparation of infrastructure. (The Nikkei, The Nikkan Kogyo Shimbun and others, December 19, 2014)

9. Hydrogen Production Related Technology Development

(1) Hiroshima University

A study team led by Prof. Yoshitsugu Kojima, the head of the Institute for Advanced Materials Research of Hiroshima University looks into a process to synthesize ammonia using hydrogen produced by splitting water by solar heat. Ammonia is used as a hydrogen carrier to fuel FCVs and hydrogen power

generators. The research is a part of the Cross-ministerial Strategic Innovation Promotion Program (SIP) organized by the Japanese government. A number of universities, businesses and research organizations are working on this research which started this year and will last five years. The study group plans to test a demonstrational system by FY 2018. The team led by Prof. Kojima is developing a "Basic Production Technology of Hydrogen and Ammonia". Ammonia is a promising hydrogen carrier. This project aims to create a process to make a large amount of hydrogen, which takes the majority of the production costs of ammonia, at a low cost. The technology is to collect solar heat to directly break down water highly efficiently by the heat. (The Chemical Daily, November 27, 2014)

(2) Okayama University & Riken

Okayama University and Riken has uncovered the mechanism of catalyst for plant photosynthesis. This result will contribute to the development of "artificial photosynthesis" to convert sunlight into chemical energy. The group determined the native (three-dimensional) structure of the photosystem II (PSII) which is a complex system consisting of proteins and catalysts in chloroplasts. PSII uses energy from sunlight to break down water into oxygen and hydrogen ions. The team analyzed PSII with SACLA, an analyzing facility of the world's highest ability, and discovered the accurate native structure of the complex system containing catalysts including manganese and 19 proteins. The catalyst part forms the shape of a deformed chair, and breaks down water efficiently. The result will contribute to the development of catalyst molecules required for artificial photosynthesis. Hydrogen production using artificial photosynthesis is useful for FCs. Previously, the group determined the structure of PSII in 2011 using SPring-8, a large synchrotron radiation facility. However, the catalyst was damaged by a long-period of exposure to radiation, which prevented an accurate analysis of the structure. (The Nikkei Business Daily, November 27, 2014)

(3) Tohoku University & JST

Tohoku University and JST have developed an electrode to produce hydrogen by splitting water without using platinum catalyst. The electrode can contribute to a significant cost reduction in producing hydrogen fuel at filling stations. The study team coated a three-dimensional conformation made of grapheme, a carbon sheet, with nitrogen and sulfur by vapor deposition. Investigation results of catalytic function showed that hydrogen was more efficiently produced as the amount of nitrogen and sulfur increased. Three -dimensional conformation increased the surface area, and the new catalyst worked at the same hydrogen production level per volume as nickel which is expected to replace platinum. Although sulfur appears to play an important role in hydrogen production, the detailed mechanism is still unknown. The study team plans to develop the new catalyst to be used in electrodes for hydrogen production by adding nickel to the catalyst to outperform platinum. (The Nikkei Business Daily & The Chemical Daily, December 10 & 12, 2014)

(4) Asahi Kasei

Asahi Kasei plans to develop a low cost hydrogen production system. They will use their own technologies gained from ion-exchange membrane for chloralkali processes as the base of the development of new alkaline water electrolysis process in order to produce hydrogen at a cheaper rate. Alkaline water electrolysis generates hydrogen and oxygen by applying electricity to electrodes in a cell filled with a potassium hydroxide solution. The focus of the research is development of electrode and membrane, system up-scaling, cost reduction and matching to wind power generator. This joint development is a contract project of the New Energy and Industrial Technology Development Organization (NEDO) with Fuji Electric and The Japan Steel Works, and will test a small-scale system in the research period of four years. After the project, Asahi Kasei plans to experiment further in a larger scale for commercialization. (The Chemical Daily, December 17, 2014)

10. Hydrogen Infrastructure Related Technology Development & Business Plans

(1) Press Kogyo

Press Kogyo will start a business for FCVs from 2015. Hydrogen supply equipment for filling stations is under development in cooperation with energy related manufacturers, and the earliest expected commercialization of the product is the autumn of

2015. Press Kogyo aims to expand its business to the environmental area, which is expected to grow, by developing a different item from its core product of structural parts such as axles and frames for large vehicles. The product under development is to extract hydrogen from an organic hydride, which is a chemical compound consisting of hydrogen and toluene such as methylcyclohexane (MCH). The firm plans the product to be mobile, which enables the equipment to be used at multiple refueling facilities. The organic hydride is very stable at normal temperatures unlike hydrogen which evaporates. This nature allows the organic hydride to use the conventional infrastructure such as gasoline tanks for storage. (Nikkan Jidosha Shimbun, December 11, 2014)

(2) JX Nippon Oil & Energy

JX Nippon Oil & Energy will prepare a hydrogen supply system for FCVs. Hydrogen production is planned to start at 10 locations in Japan by 2020. As a sales aspect, hydrogen refueling facilities will be gradually installed at approximately 2,000 key filling stations. Preparation of hydrogen filling stations in local cities needs solving, and JX's deployment of hydrogen refueling facilities nationwide will help in the task. In late December, their first hydrogen refueling facility will start operating at an established filling station in Ebina City, Kanagawa Prefecture. The firm plans to prepare hydrogen refueling facilities at 40 locations, mainly in the greater Tokyo area, by the end of FY 2015. To fit with the FCV growth trend, these refueling facilities will be installed at 2,000 established filling stations which can accommodate hydrogen storage tanks and dispensers. The production and transport cost is targeted to be reduced to less than half that of the current cost by introducing new technology. The firm plans to develop a low cost hydrogen production technology by 2018. The new production facilities are planned to be installed at their 10 production bases including seven refineries in Japan to make hydrogen widely available throughout Japan from Hokkaido to Kyushu. As well as extraction from oil and natural gas, a large amount of hydrogen is included in exhaust gas coming out from production processes of steel and chemical goods. Hydrogen is separated from the exhaust gas and impurities using catalysts. To increase the collection rate from the current 70% to 90%, the new technology is to use a special membrane to efficiently remove impurities. The firm also plans to commercialize a new technology allowing hydrogen to be transported at normal temperatures and pressures in a liquid form. This technology enables to be carried 2.5 times of hydrogen at once compared to the conventional method of transporting highly compressed hydrogen gas. Because tank trucks and vessels for gasoline and diesel transport can be used for the new method, the method requires less investment. The gasoline business in Japan is expected to shrink, and the energy firms will possibly seek new businesses to grow with eco cars. (The Nikkei, December 22, 2014)

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