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Highly Efficient Hydrogen Production Combining Microbe and Photocatalyst

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1. Governmental Measures

(1) METI & Local Governments

The Ministry of Economy, Trade and Industry (METI) and local governments which aim for growth of fuel cell vehicles (FCVs) have held a conference, and decided to research on leading projects of preparation of hydrogen refueling stations carried out by local governments to share the information. The ministry targets to increase the number of hydrogen refueling stations, currently at 80 locations including ones still in planning stage, to double by FY2020. They believe that cooperation of local governments and businesses is essential, and will support policies of local governments through the conference. The "Conference for Local Governmental Cooperation for FCV Promotion" was launched in May 2015, and the second meeting was held at the ministry. In the conference, the ministry explained related laws and the "Hydrogen/FC Strategic Road Map" which was revised this March. Then, issues and leading local governmental projects were discussed to spread hydrogen refueling stations. The conference will focus on promoting construction of hydrogen refueling stations, supporting their operation and having them more accepted by the public. The road map indicates target figures of 160 locations by FY2020 and 320 locations by FY2025, and also shows intention to make hydrogen refueling stations to be independent by mid-2020. For these objectives, roles of the Japanese government, local governments and businesses are required to be sorted and re-organized for construction and operation of those stations. The conference pointed out the need to find out ways to keep construction costs down such as using land owned by local governments or businesses, and to hold trade fairs to encourage related local businesses to enter the industry. Some participants gave an opinion that regional cities should also aim to use FC buses and taxis which use a large amount of hydrogen to make hydrogen businesses profitable early. METI's FC Promotion Office believes that "local governments' thorough policies are required to operate hydrogen refueling stations and for these facilities to be more publically accepted. The ministry will investigate leading local governmental projects to report at the third conference to be held this autumn. (Nikkan Jidosha Shimbun, May 18, 2016)

(2) NEDO

On June 1st, the New Energy and Industrial Technology Development Organization (NEDO) announced that a pre-experiment research of integrated coal gasification fuel cell combined cycle (IGFC), and development of related element technology would start. Two projects will be rolled out to establish element technology for a 100 MW class smaller system of gas turbine fuel cell combined cycle (GTFC), and to study applicability of coal gas to FC modules and to IGFC system. The project costs about ¥5.1 billion. The IGFC experiment will be carried out as the third phase of Osaki CoolGen Project by the Chugoku Electric Power Co. and J-Power (Electric Power Development) aiming to start the test operation by 2021. The results and developed technologies will be used in the Osaki CoolGen Project and additional technological development for commercial facility. NEDO plans to establish technologies for large-scale IGFC by 2025. Their targets are 55% of net electrical efficiency (higher heating value) and CO_2 emission of 590 g/kWh, an equivalent of 30% reduction of the current figure. The

development of GTFC will be commissioned to Mitsubishi Hitachi Power Systems (MHPS) and NGK Spark Plug, and carried out for three years until FY2018. On the other hand, the Chugoku Electric Power Co. and J-Power will be contracted for research on IGFC system, a part of applicability research project of FC coal gas. This project of IGFC system will make decisions on power generation capacity and trial design by researching and sorting the current state and issues over two years by FY2017. NEDO will commission J-Power to research applicability of coal gas to FC module. This project will investigate operability and function by supplying hydrogen enriched coal gas to FCs. Because FCs have not been operated with hydrogen enriched coal gas, the project will disassemble the equipment for research to find out issues during use. The research period is four years until FY2019. (The Denki Shimbun, June 3, 2016)

2. Local Governmental Measures

(1) Nerima-ku, Tokyo

Nerima-ku is offering subsidy for installation of photovoltaic generation system and domestic FCs (ENE-FARM) at home or business facilities in a drawing to promote renewable energy, and taking applications from residents and businesses in its area. The subsidy amount is ¥60,000. Power supplier from electric vehicle (EVs) to building has been added to the subsidy list. (The Yomiuri Shimbun, May 15, 2016))

(2) Toyama Prefecture

The Toyama Hydrogen Energy Introduction Promotion Council has started working on installation of hydrogen refueling stations of which preparation is slower in regional cities. Although installation is in progress for the Tokyo Olympics, these facilities are only considered to be installed in four big cities due to hydrogen supply issue. Hydrogen is made from electrolytic soda production as a by-product in Toyama. Also, Toyama is in the FCV driving range from the greater Tokyo, Nagoya and Osaka areas. Hydrogen supply belt is expected to reach there. Aiming installation by 2020, the council will publish a vision and road map in this year. (The Chemical Daily, May 19, 2016)

3. FC Element Technology Development & Business Plans

(1) Hitachi Zosen

Hitachi Zosen Corporation installed an experimental 20 kW level solid oxide fuel cell (SOFC) system at its Chikkou Works in Taisho-ku, Osaka City, and has started experiment. For business/industrial purpose, they have already tested a 10 kW SOFC system, and aim to develop 20 kW level system to achieve over 50% of net electrical efficiency with the results of the established system. The target area is supermarkets and convenience stores which consume power about a couple of 10 kW, and the system is planned to be introduced into the market in FY2017. The firm aims at ¥10 billion sales by FY2024. The pilot system uses plate cell stacks (each stack outputs 1kW) by NGK Spark Plug as its core component. Hydrogen is produced by converting natural gas, and sent to react with air coming through blower to generate power. The system operates at about 600°C. The firm will develop technology with the medium class pilot system of 20 kW, and increase the generation capacity in the future. Bio fuel will be considered to be used by taking an advantage of their wood biomass power generation. The firm started development of SOFCs in 2010. Element tests were carried out using natural gas as fuel, and the FC stack was analyzed. Then, they have stepped up to examine power generation with the 10 kW level pilot system to analyze in various ways. (The Nikkan Kogyo Shimbun, May 16, 2016)

(2) Kita Koudensha

Kita Koudensha Corporation which operates electrical installation in Sapporo City will start power supply business using FCs from 2018. FCs using natural gas will be installed at users with certain power demand such as office buildings in order to supply power. “On-site power generation” produces electricity at a place of consumption, and allows energy to be used more efficiently. The firm expects this system to be more in demand, and plans to develop the business to supplement decreasing installation businesses of photovoltaic generators, its core products. On-site power generation is to install small power generator at user such as buildings and factories, and an external service provider manages the private power generation. With this system, heat

from power generation can be used, and has less discharging power loss. The system gets attention as an efficient method to use energy source. (The Nikkei Business Daily, May 20, 2016)

(3) Shimadzu

On May 23rd, Shimadzu Corporation announced that an instrument to measure oxygen concentration in polymer electrolyte fuel cells (PEFCs) on a real-time basis was developed, and the sales started. The world's first method to measure oxygen concentration in depth direction of gas diffusion layer (GDL) was developed and commercialized. The new instrument is expected to contribute to optimizing gas flowing paths, selecting and designing parts in FCs to improve generation efficiency. The firm aims to sell a total of 20 units over three years by FY2018 in Japan. Being named FC-3D monitor FCM-3D-Oxy, the instrument is sold to measure oxygen concentration in PEFC on a real-time basis. The project of "Development of Equipment to Three-dimensionally Visualize Reaction Distribution inside FCs" was carried out as a part of the Development Program of Advanced Measurement and Analysis Technology and Equipment of the Japan Science and Technology Agency (JST) by University of Yamanashi as its leader, Waseda University, Keio University, Mizuho Information & Research Institute, Panasonic and Shimadzu. Shimadzu used the results to commercialize the instrument. The key feature is to measure oxygen concentration in each given depth and position in GDL. A probe of 50 μm diameter with fluorescent reagent which reacts to oxygen is directly inserted in GDL to measure oxygen in depth direction by fluorescence strength. The products contain five sets of probes which allow to measure maximum five positions at the same time. Because these probes have a function to calculate their tip positions automatically, the product can also record temporal change and each position of oxygen concentration. The controller is united to the main unit, and the product achieved a small size of 1 m by 1 m. It does not require a dark room, which is an advantage to boast for simpler use. The firm has started the sales also to parts producers of FCVs, a next generation eco car. The product including new software sells for ¥30 million excluding tax. (The Chemical Daily & The Nikkei, May 24, 2016)

4. Hydrogen Energy Lifeline Development & Business Plans

(1) Kita Koudensha

Kita Koudensha Corporation, Sapporo City, has announced that demonstration of new hydrogen production system using a small wind power generator from this autumn. Equipment to demonstrate will be built at their training facility in Ishikari City with investment of ¥40 million. Since power generation systems using hydrogen get more attention, the firm will develop knowhow for commercialization in the future. Hydrogen will be produced by electrolysis using power from their ready built 11 kW output small wind turbine. Hydrogen storage alloy will temporary store hydrogen, and FCs will generate electricity using hydrogen from the alloy as needed. Wind power production fluctuates with weather, which is a down side. The new system will improve the usability of wind power generation by converting the power into hydrogen. (The Nikkei Business Daily, May 16, 2016)

(2) Toshiba

Toshiba has made a combined system of trucks and a power generator which produces hydrogen from water. This system allows producing hydrogen for power supply anywhere the trucks stay. A photovoltaic generator can make hydrogen to be stored in one place, and the system can generate electricity in another place. The system is expected to supply building with power every day, and to move to event place for an event or evacuation center during emergency. The manufacturer proposes the system as a driving "energy self-sufficient system" to local governments. The system uses two trucks to load required equipment for hydrogen "production", "use" and "storage". Hydrogen is produced by electrolysis equipment on a truck to split water, and stored in the storage tank. FCs are installed on the other truck to generate power. Hot water can be produced by heat from FCs. The hydrogen storage capacity is 250 Nm^3 and FCs outputs 9.9 kW. With full tank of hydrogen, the system can operate for 80 hours. As well as grid power, renewable energy can be a power source to achieve CO_2 free hydrogen production emitting no CO_2. Recently, the firm carried out an experiment to produce hydrogen using hydropower at a dam in Niigata Prefecture. (The Nikkan Kogyo Shimbun,

May 18, 2016)

(3) Kyushu University

A team of Prof. Tatsumi Ishihara and Dr. Yuki Honda at Kyushu University has succeeded a theoretical experiment to efficiently produce hydrogen using a combination of photocatalyst and microbe. Energy efficiency of this method is a couple of ten times higher than the conventional technology using metal, and the new method is expected to produce hydrogen stably for a long period. This research can lead to development of new supply system producing hydrogen using microbe. The study team made a genetically modified Escherichia coli to have a gene for enzyme to produce hydrogen. The microbe was mixed in water with titanium oxide, a photocatalyst. When light is applied to titanium oxide, electrons are removed. "Methyl viologen", a chemical substance, dissolved in the water takes and transports electrons to inside the microbe. The microbe uses the electrons to break down water to produce hydrogen by the enzyme. In the experiment, 1% energy equivalent of ultraviolet rays was converted into hydrogen. Chemical reaction of microbe enzyme produces energy using less energy. This makes the energy production more efficient than that of metal catalyst which is the current major method. Microbes reproduce themselves with food, and produce hydrogen by making own enzyme. With appropriate management, they are expected to keep producing hydrogen for a long time without degradation unlike metal catalyst. (The Nikkei, June 6, 2016)

(4) Hitachi Zosen

On June 6th, Mr. Takashi Tanisho, the CEO of Hitachi Zosen Corporation, revealed a plan to invest more in research and development for new business after its core business of plant and social infrastructure. Their Technology Development Headquarters in Chikkou Works, Taisho-ku, Osaka City, will work on business development of wind power generation and hydrogen energy to achieve ¥50 billion sales as early as possible. They will also invest in information technology for waste power generation, and plan to increase their research and development budget from current 2% to 5% of the consolidated net sales over a long period. (The Nikkei, June 7, 2016)

(5) Tokuyama

Tokuyama Corporation will develop a hydrogen production package using renewable energy in cooperation with Choshu Industry, and aims to commercialize the system. An electrolysis system is under development to combine with photovoltaic generator of which power production largely fluctuates, and it is being tested in the Tokuyama Factory. The system is expected to be in demand as a supplemental power source. The firm launched a project to use unused hydrogen produced at Tokuyama Factory with Shunan City and local businesses to expand hydrogen supply and use. This development of hydrogen production package is a part of the project, and Tokuyama aims to establish business by next financial year by combining its own electrolysis technology developed over the years and photovoltaic and power storage systems of Choshu Industry. The system is to achieve reduction in size by packaging the components, which is also suited as a supplemental power source for business continuity planning. The hydrogen production unit under development uses a zero-gap type electrolytic technology to split water. The firm efficiently produces hydrogen by salt water electrolysis using the zero-gap method which is an originally developed technology to reduce electricity consumption. They also believe oxygen can be sold to hospitals. (The Chemical Daily, June 7, 2016)

5. ENE-FARM Business Plans

(1) Fuji Keizai

Fuji Keizai has published the research results of trend of energy producing houses which are installed with power production systems such as "ECOWILL" to generate electricity by using engines and ENE-FARM. For FY2015, the number of households newly installed with power generation equipment went down by 14.3% from FY2014, because the feed-in tariff (FIT) was cut down for photovoltaic generation. Power generating houses have grown by support of the start of the FIT for renewable energy and energetic promotion of housing manufacturers. However, the new installation hit the peak in FY2013, and started declining. Although the FIT is expected to be cut down further, major housing manufacturers will try more to standardize net-zero energy houses (ZEHs). Because the gas suppliers determine ENE-FARM as the key product, Fuji Keizai expects

that housing manufacturers will keep the businesses at a certain level and ZEH is to expand for a long haul. (The Chemical Daily, May 31, 2016)

(2) Osaka Gas

On June 1st, Osaka Gas announced that its total ENE- FARM sales reached 50,000 units. This number of the FC systems is worth reduction in CO_2 emissions of an equivalent of about 5.3 million Japanese cedars by cutting down electricity use. Their ENE-FARM sales started in June 2009. They introduced a new smaller system to be installed in apartment units, which led the sales increase. Their accumulate sales target is 63,340 units by FY2016. (The Nikkei, June 2, 2016)

6. Cutting Edge Technology of FCV & EV

(1) NEDO

On May 18th, NEDO announced that research on next generation storage battery for EVs to be commercialized in cooperation with Toyota, Panasonic and Kyoto University. The Japanese government will support ¥15 to 18 billion over five years by FY2020. They aim to make EVs to be able to drive between Tokyo and Osaka, about 500 km, on a single charge by 2030. Additionally, Nissan, Honda R&D, Mitsubishi Motors, Hitachi, Sony, the University of Tokyo, the National Institute of Advanced Industrial Science and Technology (AIST) and RIKEN will join the project. The fundamental research was carried out until FY2015, and the results of the research will be used to develop next generation technology to significantly go over the performance of current major lithium-ion battery (LIB). The group will make a pilot product of zinc–air battery, the most promising product, and investigate safety and durability issues for commercialization. (The Nikkei, May 18, 2016)

(2) Disco Corporation

Disco Corporation, a manufacturer of semiconductor production equipment, has bought two EVs from US-based Tesla Motors. As well as their business operations, their employees can use these EVs for recreational purposes with families and friends. The firm aims to stimulate employees' motivation for research, development and innovative ideas by letting them feel the most advanced EVs. Each EV costed about ¥12 million. (The Nikkei, May 20, 2016)

(3) Panasonic

Panasonic will increase the workforce for its automobile business by 30% by FY2018. The manpower of the automobile business will be 13,000 workers by transferring from other departments and new experienced employment. The firm aims at ¥2 trillion, a 50% increase of that of FY2015, for its automobile business sales by FY2018. The personnel will be concentrated to the department to achieve sales growth of storage battery for EVs. LIB is the core product of the automobile business of Panasonic. Their new plants will start operation in the US and China between 2016 and 2017. The manufacturer aims to increase its share in the global automobile battery market from 20 to 30% by FY2018, and will hire foreign sales representatives. They also employ experienced engineers for the new plants as well as sending their engineers from plants for other operations in Japan. (The Nikkei, May 24, 2016)

Panasonic and Chinese major automaker Beijing Automobile will jointly produce a core component for EVs in Tianjin. By investing a couple of 10 billion, the facility will supply Beijing Automobile with the product. Because the Chinese government promotes EVs to solve a severe environmental issue, China became the global largest market of EVs in 2015. Panasonic aims to expand its EV business in China by starting local production of core component early. Mr. Kazuhiro Tsuga, the president of Panasonic, visited China in May, and agreed to establish the joint venture with Beijing Automobile in 2016. Two automobile component manufacturers from the Beijing Automobile group will invest 54% in total, and Panasonic's Chinese operation will devote 46%. The product is an electric compressor, a core component for EV air conditioners, and the commercial production is planned to start by 2018. The electric compressor will be made with different specifications from the one for gasoline cars, and uses power from storage battery to efficiently control cooling and heating. The better performance the component has the longer driving range the EV has. The component is a key factor for the driving range. This joint venture is the first deal for Panasonic with local carmaker making final products. Panasonic plans to get the venture on track early by securing a stable trade channel. Also, sales to other carmakers will be sought. They made a decision

to pull out from TV panel business. By contrast, their business to business has been expanded mainly in the automobile and housing areas. They have increase sales target from ¥1.3 trillion for FY2015 to ¥2 trillion for FY2018 for the automobile business. They specifically put more effort in the rapidly growing EV market in China, and plan to start operation of the plant for automobile LIB in Tianjin in 2017. Beijing Automobile is a government-owned company started in 1953, and is in the fifth place for the Chinese new car sales in 2015. For EVs and plug-in hybrid vehicles (PHVs), it is chasing the leader BYD. Beijing Automobile plans to produce 400,000 EVs for 2020. (The Nikkei, June 12, 2016)

(4) Tesla Motors

New EV, "Model 3" from US-based Tesla Motors has been ordered for 325,000 vehicles in a week, making it great hit. California has led the stricter environmental regulations in the US promoting sales of zero emission vehicles (ZEVs) of which the core product is EV. Because of this policy, automakers are fortifying their development of EVs in haste, which is creating fierce competition for the main next generation eco car. As well as California, nine environmentally conscious states including New York will make the regulations tighter. From 2018 models, conventional hybrid vehicles (HVs) without plug-in charging function will be removed from the ZEV list. Also, FCV in the list has an issue of lack of refueling infrastructure. In reality, major automakers will try to sell their EVs as much as possible, and buy credit to emit greenhouse gasses from other firms such as Tesla to fit in the regulations. Although this scenario shows rosy future of Tesla on a glance, its commercial production system still has an issue. Thorough preparation is required for the firm of which sales for the previous year was over 50,000 vehicles to establish and be well under way a system in order to efficiently produce high quality EVs in a short period. Their plan is to launch the commercial production line in a very tight schedule, because they expect to be flooded with orders for EVs in 2018. (The Nikkei, May 24 & June 7, 2016)

Tesla Motors will release luxury sedan "Model S" which can easily extend the driving range after purchase. The EV will be available globally including Japan, and will be delivered from August. After purchase, the firm will offer upgrades of battery and quick charger function with additional cost. Users can apply for the upgrade by phone or internet, and the software will be updated by the communication function. The function will be remotely adjusted without physical work to the EV. Tesla will sell the convenience to consumers by allowing cars to easily add function like IT products. The entry model which drives about 400 km on a single charge, and the price of it is kept $66,000 (¥8.841 million) without subsidy. The minimum price has been reduced to previous $71,500, about an 8% decrease. Users can apply for the function expansion of additional $9,000 (¥1.1127 million including tax in Japan) which can extend driving range by 20% by downloading software. The total price is about $500 more than buying a higher model of which driving range is 20% longer than Model S. The entry model is designed to have a shorter driving range than the actual performance by software controlling the battery. However, the acceleration performance is not limited. (The Nikkei, June 10, 2016)

(5) Asahi Kasei

On May 25th, Asahi Kasei Corporation announced that the production capacity of its separator for LIB would be increased to 1.1 billion m^2, a double of that of current capacity, by 2020. The total investment is estimated between ¥21 to 26 billion, and a new facility will be built by spending about ¥6 billion in Shiga Prefecture as a start. This plant is to accommodate growing sales for smart phones and automobiles. The firm will build a new facility of 60 million m^2 production capacity in the plant in Moriyama, and plans to start the operation in early 2018. The product will be supplied for electric devices such as smart phones and PCs, but they will consider providing the product for automobiles by 2020. (The Nikkei, May 26, 2016)

(6) Toshiba

Toshiba has developed a medium-size electric bus using own LIB which can be charged contactless without cables. The battery advantageously outputs high power for a long period, and the electric bus is the first contactless one to drive on express ways in Japan. The test drive will start from June 1st in cooperation with Kawasaki City and All Nippon Airways. (The Nikkei, June 1, 2016)

(7) Changan Automobile

On June 6th, Chinese major automaker Changan Automobile revealed its plan to invest a total of 18 billion CNY (about ¥300 billion) to develop a new eco car over the period until 2025. Over next 10 year, a total of 34 EVs and PHVs will be introduced into the market to aim at 2 million vehicle sales in total. This movement is to follow the Chinese governmental policy to expand eco car use, and the firm concentrates the operating resources in the area to win the competition. Mr. Huarong Zhu, the president of Changan Automobile, revealed the plan at the Global Automotive Forum held in Chongqing. The carmaker will add new eco car sedans and sport utility vehicles (SUVs) in Chang'an, thier own brand, and Chana for business use. 80% of these new cars are expected to be EVs. Mr. Zhu also said that "they would work on commercialization of advanced technologies such as auto pilot". As well as developing own technologies, they will have support from US-base Ford Motors, a partner for their venture, for the core technologies such as battery and controlling system. According to him, they are researching and developing eco cars globally at a fast pace having bases in the UK, Japan and the US. They will ask for cooperation to wide range of suppliers of core components including Japanese firms. Changan Automobile's own low cost cars are rapidly taking shares in the market. Their sales target for Chang'an/Chana is 3.4 million vehicles, over a double of that of current figure, by 2025 by adding eco car range, and the firm aims to get in the top 10 group in the global market. (The Nikkei, June 7, 2016)

(8) Mai Linh Taxi

Mai Linh Taxi, the largest taxi operator in Vietnam, will buy 20,000 EVs by 2021. The majority of the EVs is expected to be imported "Zoe" of French-based Renault. Mai Linh is the first operator to use EVs at a full scale in Vietnam. (The Nikkei, June 11, 2016)

(9) Daimler

On June 13th, Germany-based Daimler announced that over €7 billion (about ¥840 billion) would be invested in development and production of electric powered cars, an environmental technology, over next two years. Their first commercial FCV which can be recharged from an external power source will be introduced into the market in 2017, and their EV range will also be expanded. They will allocate a half of the total investment to the environmental area to chase Japanese firms which are leading in commercialization of electric powered cars. Daimler's FCV will use SUV "GLC" under Mercedes-Benz brand as its base, and, their own automobile battery will be combined to the FCV to be released. With fully charged hydrogen tank and battery, the FCV can drive 500 km. The PHV version will be rolled out first. They have been working with Nissan Motor and US-based Ford Motors for FCV development. Since reduction in costs is sorted, Daimler will try to catch up Toyota and Honda. The price has not been announced. (The Nikkei, June 14, 2016)

(10) Nissan

Nissan has a different eco car strategy from other competitors including Toyota Motors. The competitive landscape of next generation eco cars falls into EV led by US-based Tesla Motors and FCV that Toyota and Honda have gone ahead. Nissan has concentrated a large part of its operating resources in EVs. Their core EV "LEAF" was released in Japan and the US in December 2010, and reached 220,000 vehicle sales in total. They believe that they are still the leader in the EV market. Five years past since the release, the sales, however, has started slowing down. The current model of LEAF drives 280 km at most after recharge, which is a half the distance between Tokyo and Osaka. It also takes eight to 11 hours to fully charge the EV at home, which restricts it to be larger. The automaker is currently working with German-based Daimler and US-based Ford Motors, but actual commercialization has not been planned yet. Now, the EV is possibly to be able to extend its driving range significantly by using a new technology developed by Nissan allowing bio fuel to be loaded in a tank to supplement power. The firm will keep its strategy of EV as the key of next generation eco cars by using the new technology to complement power. Their plan is to cover the downsides of EV such as short driving range by the FC technology using bio ethanol. They aim to expand their share in the eco car market by accommodating various consumer needs. (The Nikkei, June 15, 2016)

7. Development of FCV & EV Components & Parts

(1) Toray

Toray has revealed an intention to launch a joint

venture to produce high pressure hydrogen tank fortified by carbon-fiber for FCVs in Japan with Mitsui & Co. and Hexagon Lincoln (Nebraska, US). The three firms will sign an agreement on the joint production, and will investigate its profitability. Toray aims for domestic production of high pressure hydrogen tanks by using Hexagon Lincoln's technology for container production. This joint venture will combine Hexagon Lincoln's production technology of high pressure containers, client assets and sales capability of Mitsui and Toray's technology to develop and supply high quality carbon-fiber to win the competition. With an expectation of the FCV market to be properly launched around 2020, the firms plan to produce hydrogen storage tanks in Japan. To aim its business expansion, the venture is to produce carbon fiber reinforced high pressure hydrogen tank to accommodate needs for reduction in weight of vehicles. (Nikkan Jidosha Shimbun, May 31, 2016)

(2) Nissan

On June 14th, Nissan Motor announced that a technology was developed for automobile FCs to use bio ethanol derived from plants such as sugar cane. This technology allows EVs to triple the driving range without recharge. A van for business use, such as delivery vehicles, is the first product to use the technology, and the vehicle is planned to be introduced into the market by 2020. In "e-Bio Fuel-Cell" system, the new technology, a reformer decomposes bio ethanol into hydrogen and CO_2, and a FC stack generates power using hydrogen from the reformer. Nissan is the first car producer in the world to use the advantage of solid oxide fuel cells (SOFCs) for automobiles. SOFC can generate power with lower purity hydrogen from ethanol. Then, power is stored in the storage battery for EV to drive using the motor, which is the conventional system. The new power system enables the driving range on single charge to be extended up to 800 km. This is a triple of that of the driving range of the current EV. Although Bio ethanol which caught Nissan's eye releases CO_2 during driving, sugar cane, the production material of bio ethanol, uses CO_2 in the growing process. The whole system produces no additional CO_2, which is a counter global warming measure. According to Mr. Hideyuki Sakamoto, an executive vice president of Nissan, "ethanol is already available in Brazil and the US, and easier to buy there". The automaker estimates that the running cost can be low as the current model of its EV. Their estimation of running cost for EV with the new technology is ¥3.1/km. This is the same level as the current EV (¥2.9/km), and cheaper than that of gasoline engine car (¥9/km). The manufacturer has started a test drive of a pilot product using the new technology, and plans to unveil the car this summer. The price at the start of commercial sales in 2020 is planned to be kept at the same level as the current EV to target for the developed countries where the next generation eco car market has launched as well as emerging countries such as Thailand. (The Nikkei, June 15, 2016)

8. Hydrogen Refueling Station Elemental Technology Development & Business Plans

(1) Next Generation Vehicle Promotion Center

More locations have been selected for hydrogen refueling stations for FCVs. Iwatani will install a stationary hydrogen refueling station in Sendai, which is the first facility for the Tohoku area. Also, installations are now planned in regional cities including Hiroshima, Shizuoka and Takamatsu Cities. Currently hydrogen refueling stations are either operating or in contemplation at 80 locations. The Japanese government plans to double the figure by FY2020, and tries to increase the number of FCVs in use by expanding the refueling facility network and encouraging more business to operate these facilities. The Next Generation Vehicle Promotion Center (NeV) operates subsidy schemes for hydrogen refueling stations, and decided on subsidies for constructions of hydrogen refueling stations at nine locations. Although, the Japanese government determines the four urban areas as the strategic areas, over half the locations are chosen from regional cities this time. Also, some of the stations will be built and operated by local business leaders such as Hiroshima Toyopet (Hiroshima City), Takamatsu Teisan (Takamatsu City, Kagawa Prefecture) and Shizuoka Gas. This makes a difference from the earlier trend. Previously, Iwatani and JX Nippon Oil & Energy took 70% of hydrogen refueling station projects. Construction costs of hydrogen refueling station is between ¥400 to 500 million, and the subsidy scheme finances up to ¥290

million for each project. For this financial year, projects for 20 locations are planned to be supported, and NeV will put out to the second tender. Operation of hydrogen refueling station is estimated to cost ¥33 million each year, and the organization will offer maximum ¥22 million for the operation as the "New Demand Creation Project" from this financial year. On top of these schemes, automakers offer financial support. With the subsidies, events are expected to be held more often to promote hydrogen energy. METI targets for 160 locations for the number of hydrogen refueling stations by FY2020 and 320 locations, a double, for FY2025 which are shown in the "Hydrogen/FC Strategic Road Map" revised this March. Also, they show a plan to "expand the refueling network to outside the four urban areas, regional cities". (Nikkan Jidosha Shimbun, May 16, 2016)

(2) Honda

Honda has installed "Smart Hydrogen Station (SHS)" package using originally developed high pressure electrolysis system at its Aoyama Head Office, and this is the first installation in the commercial area in Tokyo. To supply power for the hydrogen production system, a new photovoltaic generator was installed. The package system can produce 1.5 kg of hydrogen in 24 hours at 40 MPa at most without compressor. About 19 kg of produced hydrogen can be store. The core components are packaged in a unit to fit in an area of 7 m^2. Hydrogen will be supplied to FCVs owned by Honda to start with, and the firm will investigate a wide range of the system usage for locally produced hydrogen. (The Chemical Daily, May 25, 2016)

(3) Toyota & JX

Major automaker and energy firms including Toyota Motor and JX Nippon Oil & Energy are now making discussion on launching a joint venture to prepare hydrogen refueling stations for FCVs, a next generation eco car, nationwide. Currently these stations are prepared by energy firms individually, and the current figure of installations is largely below the target. With automakers' help, the refueling network will be built in haste to backup FCV growth. The details will be discussed at METI's "Hydrogen/FC Strategic Committee" of which members are Toyota, Honda, Nissan, JX, Iwatani and Tokyo Gas. Their preliminary plan is to establish the joint venture for installations of hydrogen refueling stations by FY2017. Manufacturers of components for hydrogen refueling stations, such as a compressor, will be asked to join the committee. The total investment is possibly to exceed ¥10 billion. The new venture will install hydrogen refueling stations, and energy firms such as JX, Iwatani and Tokyo Gas will operate them. The Japanese government will not invest in this venture, but provide the venture with subsidy. The governmental subsidy will be more generous than the subsidy scheme for individual projects to support the venture. Toyota released the first FCV in 2014, and Honda introduced its FCVs into the market in March 2016. METI targets at 40,000 FCVs in use by 2020 in Japan, but the actual sales figure is around 600 vehicles at the moment. The bottleneck is lacking of hydrogen refueling stations. The ministry targeted at 100 locations of hydrogen refueling stations by FY2015 in Japan. Although JX and Iwatani are working on the preparation, the current figure stays around 80 locations. The majority of the stations are installed in the urban areas such as Tokyo and Nagoya, and many prefectures have no hydrogen filling facilities. The installation of each hydrogen refueling station reaches ¥400 million, and the operation costs about ¥40 to 50 million each year. Because of this, operators of hydrogen refueling stations hesitate preparation of these stations in regional areas where the demand is low. The point of this project is to prepare the facilities at a faster speed by sharing the cost among Japanese business leaders. (The Nikkei, May 30, 2016)

(4) Hitachi Automotive Systems

Hitachi Automotive Systems, Chiyoda-ku, announced that its group member had delivered a hydrogen dispenser for a hydrogen refueling station installed by Iwatani for FCVs. The dispenser achieved 40% smaller size than that of the existing model by integrating a highly performing heat exchanger. Hitachi Automotive Systems Measurement, the group member in Yokohama City, installed "NEORISE", a small dispenser, at the 'Iwatani Hydrogen Station Osaka Morinomiya" which was opened this month in Osaka City. This is the 18th station for Hitachi Automotive Systems Measurement to deliver the dispenser. They aim to expand their share in the

market by selling the small size which gives more flexibility as a point. Hydrogen refueling stations are prepared in 78 locations at the end of April in Japan. The government targets at 160 locations by FY2020 and 320 locations by FY2025. (The Nikkei Business Daily, June 1, 2016)

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