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New Electric Storage Material to Improve MFC (Microbial Fuel Cell) Efficiency

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1. Governmental Measures

(1) METI & Agency for Natural Resources and Energy

The Ministry of Economy, Trade and Industry (METI) and the Agency for Natural Resources and Energy will work on commercialization of the technology to convert renewable energy into hydrogen. Reduction in load to the grid has been an issue to solve, and using excess power from photovoltaic generation for hydrogen production is a solution. Also, produced hydrogen is expected to be used for industrial purpose, such as power production and fuel cell (FC) power generation. In May, a working group was set up to study economic viability, technical and schematic issues, and will compile a road map in late January, 2017, aiming for commercialization in 2020's. Being named "Power to Gas (P2G), the technology converts renewable energy into hydrogen to be stored and transported for use, and is being tested in Germany where overflowing renewable energy noticeably causes a problem in the grid operation. For examples of the technologies, hydrogen is produced by electricity from wind turbines to be supplied in communities, and some operators store and use hydrogen through gas supply chain. In Japan, some projects are under contemplation to use hydrogen for FCs and busses for the 2020 Tokyo Olympics and Paralympics. Also, a project is being considered to use renewable energy from 10 MW level wind turbines to produce hydrogen in Fukushima Prefecture. The Agency for Natural Resources and Energy is trying to establish a CO_2 free hydrogen supply system including P2G, hydrogen transport from abroad and hydrogen power production by 2040. In Japan, the earliest end of feed-in tariff (FIT) payback for domestic photovoltaic generators will come in 2019, which leads to another issue of power use. The working group will investigate whether renewable energy including those photovoltaic generators can be used economically viable and efficient for hydrogen production in various scenarios. Storage battery technology contends with hydrogen as a method to store renewable energy, and the group will analyze and compare these technologies to find out advantages. Hydrogen has a technological issue. Producing hydrogen using renewable energy loses more energy than using electricity stored in batteries. To cover this disadvantage, water electrolysis efficiency of hydrogen production needs to be improved. The group plans to hold seven meetings in this year, and to discuss a draft of the road map in mid-December. Their draft is planned to be brought to the "Hydrogen/FC Strategic Committee", the parental group, in late January 2017. (The Denki Shimbun, June 10, 2016)

(2) METI

On June 30th, METI and Tohoku University will open a research center to develop most advanced materials. The research center will publish promising basic research results in a form that businesses can easily use the results to develop their products. The university has extensive results in math, and the ministry expects the results to be used for technological development of smart phones and FCs. To achieve this, the National Institute of Advanced Industrial Science and Technology (AIST) will open the center in the university to work together. This is the third research center of industry, government and academia working together after the Nagoya University and the University of Tokyo. The ministry plans to increase the number of this type of research

centers to over 10 by 2020. Tohoku University has an advantage in technology to numerically estimate material structures. AIST has a good simulation technique using computational chemistry, and synergy is expected to be brought out by combing their technologies. The joint research subjects are expected to be a thin and flexible display for smart phones and a special membrane to separate hydrogen from natural gas for home FCs "ENE-FARM". AIST, a public research institute, and the university will provide study results for businesses to develop new products. Germany is successfully carrying out synergetic projects to connect universities and businesses, and is the model of the plan that the Japanese government and AIST are trying to achieve. (The Nikkei, June 23, 2016)

On June 27th, METI revised the Japanese Industrial Standards (JIS), so that SUH660 which is a high-strength metal for high pressure containers of hydrogen refueling stations can be used in a wider range of operating temperatures. Due to this amendment, the technology standards of the High Pressure Gas Safety Act is hopefully to be revised for the operation temperature range which is currently limited to 50 °C to be increased to 120 °C. Generally, a review of technology standards often takes about six months. The JIS revision became effective on June 25th. Because the metals for hydrogen refueling stations for FCVs likely to become brittle in high pressure hydrogen, there is a list of the metals meet the technology standards of the act as examples. JIS is used for the example list, and to use any non-listed metals needs permission. (The Denki Shimbun, June 28, 2016)

(3) Japanese Government

On June 14th, the Japanese government decided to reorganize a part of METI at the cabinet meeting. The Agency for Natural Resources and Energy of METI will set up a "New Energy System Division" in its Energy Conservation and Renewable Energy Department to strengthen policy making for a new energy system combining technologies of energy saving and new energy. Also, the "Gas Market Division" of the Electricity and Gas Industry Department will be reorganized to "Gas Market Office". The cabinet ordinance will be announced and will go into effect on June 17th. The New Energy System Division will work on preparation of negawatt market, virtual power plant (VPP) business and promotion and expansion of hydrogen infrastructure network. At the same time, the Industry Social System Promotion Office and FC Promotion Office will be closed, and a "Hydrogen/FC Strategy Office" will be established in the same division. METI is designing a system for negawatt market to launch in 2017. The VPP development project started in FY2016 to aim to establish controlling technology for over 50 MW level VPP over five years until FY2020. (The Denki Shimbun, June 15, 2016)

On June 16th, the second meeting of public and private sectors was held to discuss a draft of the "Fukushima Concept for a New Energy Society" to make Fukushima Prefecture to be a model area for renewable energy and hydrogen society. The members are from the Japanese government, local governments, power supplier, and organization of renewable energy businesses. The draft was approved there. The key points are, the power grid fortification accommodating a larger amount of renewable energy, hydrogen production using renewable energy and usage and development of smart community. The final draft will be decided in the next meeting to be held in between July and August. The budget for related projects will be put together to be allocated in the FY2017 budget request as the "budget for projects related to Fukushima Concept for a New Energy Society". Ministries and governmental agencies will seek ways to give priority to these related projects. In the draft, a large-scale renewable energy plant of 10 MW output level power source to produce hydrogen is to start its operation by 2020, and is possibly to be used during the 2020 Tokyo Olympics and Paralympics. Hydrogen refueling stations and fuel cell vehicles (FCVs) will be prepared in Fukushima Prefecture to expand hydrogen use. METI and Fukushima Prefecture will set up a meeting to study actual plans to demonstrate technology to produce, transport and store a large amount of hydrogen in the prefecture in this financial year. The third flouting wind turbine of 5 MW output will be installed off the shore of Fukushima in this year to start the demonstration of power generation system at full-scale. Tokyo Electric Power Company (TEPCO), Tohoku Electric Power Company, Fukushima Prefecture, and operators of wind and

solar power plants will consider establishing a firm to prepare and manage efficient power grid to expand wind power generation in the Abukuma Mountain Country and coastal area where good wind blows. (The Denki Shimbun, June 17, 2016)

(4) MLIT

On June 27th, the Ministry of Land, Infrastructure, Transport and Tourism (MLIT) decided to make obligation of "pedestrian alarms" to give pedestrians warning noises of approaching quiet cars such as hybrid vehicles (HVs) to new cars from March 2018. Currently, some cars legally have a function to stop these alarms. However, this function will be banned to reduce risks for pedestrians to be unaware of approaching cars which possibly cause accidents to increase safety. MLIT submitted an amendment draft to its expert meeting on the same day, and the draft was approved. The target products are newly sold motor driven cars from 2018 such as HVs, electric vehicles (EVs) and FCVs. Because the models which are already in the market need design change, the obligation will apply for these from October 2020. The regulation will not be applied to used cars. Safety standards of the Road Trucking Vehicle Act will be amended this October. According to the ministry, pedestrian alarms are currently installed in newly sold HVs, EVs and FCVs in the market as a standard feature. However, these cars have a function to stop the alarm for users who prefer quiet driving, and organizations of people with visual impairment have requested to ban this silent driving function for safety. The international standards still allows the silent driving function at the moment, but the ministry will request the change to the UN organization. (The Denki Shimbun, June 28, 2016)

(5) MLIT & METI

On June 30th, MLIT and METI announced the start of the international mutual recognition for FCVs. The related laws were amended, and the regulations of the international agreement set by the World Forum for Harmonization of Vehicle Regulations (WP.29) entered enforcement on the same day. This allows reduction in process and costs of import and export between countries which have signed the agreement, and eliminates the need of the unit test in Japan of compressed hydrogen containers which are made from the materials indicated in the Japanese standards. (Nikkan Jidosha Shimbun, July 1, 2016)

2. Local Governmental Measures

(1) Osaka Prefecture

Osaka Prefecture will support smaller businesses to enter EV or FCV related market. Established or establishing smaller businesses in the prefecture can be provided with subsidies up to ¥5 million for development of EV and FCV related products, the infrastructure and the market development. The local government aims to create new industry and business in the prefecture by backing up smaller firms and ventures. They use the "Active Osaka Promotion Fund" to support smaller companies and ventures with promising research and technologies to develop and enlarge businesses. "Next Generation Electric Vehicle Development Project" started in 2013 to support the EV and FCV area together, and support has been provided specifically to the area of next generation electric powered vehicles. The target includes businesses of components/parts including their pilot systems for EVs and FCVs and development of motors, storage batteries, electronic control units (ECUs), systems for wireless power charging infrastructure and hydrogen infrastructure such as refueling station including the component. The maximum support is ¥5 million for each project, and the subsidy must not take over two thirds of the project cost. The applications will be accepted until July 11th. (Nikkan Jidosha Shimbun, June 8, 2016)

Osaka Prefecture will establish an organization to promote FCVs as hydrogen energy use in cooperation of industry, academia and government in August. An international conference will be held in September in Osaka City, and will temp businesses to enter the related market by providing talks on technological trend of hydrogen by experts from all over the world. The outline of the conference was revealed on July 6th, and the prefecture started to take applications. This organization of industry, academia and government is named "H2Osaka Vision Promotional Committee (provisional)". The first conference will be held early August, and about 20 large firms, METI Kansai, the Research Institute of Innovative Technology for the Earth (RITE) have been asked to participate. Study groups will be set up in the committee for buses and ships running on FCs in this financial year.

"International Conference on Battery and Hydrogen / Fuel Cell" will be held from September 6th to 8th at Osaka International Convention Center. Mr. Reuben Sarkar, a deputy assistant secretary of the US Department of Energy (DOE), will give a keynote address on 6th. The fee is ¥10,000, and the first 300 participants will be accepted. (The Nikkei, July 8, 2016)

(2) Fukuoka City

Fukuoka City has started the first technological development of FC truck and test of freight transport in cooperation with automobile developers. The plan is to develop a FC truck to use hydrogen refueling station in Fukuoka City Central Sewage Treatment Center, and to test freight transport in FY2018. The city aims to reduce environmental impact of freight transport by working on this project. Fukuoka City promotes the "Hydrogen Leader City Project" which has been tackling advanced subjects. As a part of this project, the city formed a joint research group with Kyushu University, and the group is carrying out an experiment of the world first commercial level hydrogen production from sewage biogas. The city will work on further to experiment of FC truck in cooperation with Tokyo R&D which researches and develops automobiles for other firms in Chiyoda-ku, Tokyo, the group member Pues in Atsugi City, Kanagawa Prefecture and Tenjinchiku Kyodo Yuso in Higashi-ku, Fukuoka City. This is selected as one of the Technology Development and Experiment Projects for Reducing CO_2 Emission for FY2016 of the Ministry of the Environment (MOE). The detailed plan is to study specifications and to make the basic design of the FC truck in FY2016. The detailed specifications and vehicle production are planned in FY2017. Then, the test drive and freight experiment are to be carried out in FY2018. (Nikkan Jidosha Shimbun, June 23, 2016)

(3) Kobe City

On July 7th, Kobe City held a completion ceremony of "Kobe Renewable Energy Hydrogen Station" to supply FCVs with hydrogen produced using renewable energy. Because hydrogen is produced by splitting water using solar or wind power, no CO_2 is emitted in the hydrogen production through use. This system is the first to be operated in the Kansai area. The small station was jointly developed by Iwatani and Honda, and is located in "Kobe Kankyo Mirai Kan", a children's museum in the city. The station can produce hydrogen at 1.5 kg per day using the photovoltaic generator at the museum. (The Nikkei, July 8, 2016)

3. FC Element Technology Development & Business Plans

(1) NGK Insulators

NGK Insulators will launch a trial production line of three batteries including solid oxide fuel cell (SOFC) as new business in the term ending March 2017. The "Ceramics Cell Project" started in April to use firm's resources without barrier, and will be in charge of the trial production line. This team will collect expertize from departments and sections other than the research and development teams that worked on the three products to start full-scale preparation of commercial production. The products are aimed to be commercialized and released by March 2018. The firm plans to bring these three products to a couple of ¥10 billion sales business. These products to be commercialized are a SOFC, zinc secondary cell and chip-type ceramics secondary cell. The cross-sectional team will make decisions on the production line including installation place and scale. This trial production line will make a progress on preparation of commercial production. Previously, the firm aimed to commercialize SOFC by the term ending March, 2019. However, Mr. Taku Oshima, the president, has indicated to move up the target of the commercialization by saying "We will release the three products in the term ending March 2018." SOFCs are expected to be used for houses and apartment units. Zinc secondary cells are aimed for storage batteries to be used at home, buildings and commercial facilities. Chip-type ceramics secondary cells are expected to be used for wearable devices. The cells are being tested for their performance aiming for those expected purposes. (The Nikkan Kogyo Shimbun, June 8, 2016)

(2) Shizuoka University

A team of Prof. Hiroyuki Futamata at the Faculty of Engineering of the Shizuoka University has found a new substance to improve power generation efficiency of "microbial fuel cell (MFC)" which produces power using microbes. MFC has issues of low power output

and power storage capacity. By adding this substance, MFC potentially increases power production to 100 times of that of the conventional ones. Also, power storage capacity will give the FCs a large step forward for commercialization. The team ensured that a black conductive substance was produced when microbes digest organic matter. Their analysis revealed that this substance was composed of oxygen, titanium, phosphorus and iron, and a new material with power storage capacity. This is the first material produced by microbes to have been confirmed to exhibit power storage capacity. This substance added MFC can produce power at 100 times of that of conventional ones. The team will study further to find out the mechanism of material production as well as analysis to aim for steady production of the material and higher power output. Experimental power generation using microbes currently carried out can only produce electricity while food waste and sewage are fed to the microbes to digest. Also, the power is very low. The new substance exhibits power storage capacity, which allows steady power supply. (The Nikkan Kogyo Shimbun, June 15, 2015)

(3) NEC

Nano-carbon products are expected to be new industrial materials, and their development has been accelerated. The typical products are carbon nanotubes (CNTs). In this category, multi-walled nanotubes (MWNTs) have become essential materials for lithium-ion batteries (LIBs). Also, single-walled nanotubes (SWNTs) have better functions, and are researched for their applications. In this circumstance, NEC has announced that "carbon nano-brush" was discovered. This material can be used in a wide range of industrial products. It is highly dispersive, adsorptive and conductive, and its commercial production is easy. Characteristics of LIBs and FC sensors can be significantly improved by this new material. The firm aims to supply samples by FY2017 in cooperation with material producers. (The Chemical Daily, July 1, 2016)

(4) Kyoto University

A team of Prof. Koichi Eguchi has developed a FC to generate power by reaction of oxygen in air and ammonia, and succeeded to produce 200W. The product is SOFC which is already commercialized for industrial and domestic purposes, and uses ceramics in its power generation parts. Ammonia leaks at sealing parts of materials can cause corrosion, which is an issue. The FC is coated by a special glass developed by Noritake to prevent leaks. A 1 kW level FCs will be developed by 2020 to experiment as a domestic system. (The Nikkei, July 4, 2016)

4. Hydrogen Infrastructure Element Technology Development & Business Plans

(1) Panasonic

Panasonic has started an experiment of pure hydrogen FCs combined with photovoltaic generator in cooperation with Yamanashi Prefecture. The firm aims to commercialize the pure hydrogen FCs which are fed with hydrogen directly to generate power in 2020 or later. The prefecture will develop an energy management system to compensate the gap between power supply and use by converting electricity derived from renewable energy into hydrogen. Both aim to commercialize the new system for coming hydrogen society that hydrogen is to be supplied to houses and buildings. Pure hydrogen FCs do not have a hydrogen extraction process to remove hydrogen from natural gas, which achieves quick startup. This characteristic enables easy generation adjustment to follow rise and fall of power use. Toshiba and Panasonic are working on this kind of systems, and Toshiba already started a test. Panasonic installed a 700 W output pure hydrogen FC system at Yume Solar-kan Yamanashi in Kofu City, Yamanashi Prefecture. Two more units will be installed in this autumn. The firm will establish a technology to control these three units to work as a single system to produce a large amount of power. Solar panels on the facility roof generate power for water electrolysis to produce hydrogen. The FCs will generate CO_2 free power to be used in the facility. The prefecture uses the facility to test technology to moderate fluctuation of renewable energy production. The facility solely operates on electricity from renewable energy, and excess power from the photovoltaic generator will be stored in a hydrogen form for expected later electricity shortage. Momentary fluctuations to disturb frequency and voltage will be moderated by charging in capacitors. (The Nikkan Kogyo Shimbun, June 15, 2016)

(2) AIST

The National Institute of Advanced Industrial

Science and Technology (AIST) has developed a photocatalyst which exhibits sunlight energy conversion at 1.7 times of that of conventional ones. Previously, the most efficient photocatalyst had a narrow range of wavelength to absorb, and does not efficiently use visible rays. The organization focused on bismuth vanadium oxide which can absorb longer wavelength, and found out that conversion efficiency could be largely increased by adding gallium to adjust preparation conditions. The sunlight energy conversion efficiency of artificial photosynthesis using iron ions to split water reached 0.65%. The research institute will improve the photocatalyst targeting at 3% of conversion efficiency. Research is carried out to experiment hydrogen production by water electrolysis using renewable energy such as photovoltaic and wind power generation. For example, a project uses established gas infrastructure to distribute methane produced combining electrolyzed hydrogen and CO_2. Another project studies to use hydrogen to generate electricity using FCs as an emergency power source. These projects are in spotlight. However, the hydrogen production cost is much higher than hydrogen extraction from fossil fuel because the power generation is expensive. The power of electrolysis instrument is calculated by "electricity current multiplied by voltage". Hydrogen production rate is proportionate to electric current. Therefore, the current cannot be reduced. Since the current technology faces limit in reduction in overvoltage, an innovative technology to reduce voltage is being sought. The Advanced Functional Materials Team of the Research Center for Photovoltaics of AIST developed a hybrid system combining water electrolysis, cheap photocatalyst of oxide powder and iron ion redox, and the study is underway. This system can significantly reduce electrolysis voltage by efficiently using energy stored in iron ions by the photocatalytic reaction. Because it can reduce electricity which pushes up hydrogen production cost, and the final production cost is potentially reduced significantly. Sunlight conversion efficiency is required to be 3% for this system to produce hydrogen at a price level of fossil fuel conversion system. (The Denki Shimbun, June 21, 2016)

On June 28th, Toyota Motor Kyushu and Fukuoka Prefecture announced that a project would start to use hydrogen fuel produced by photovoltaic generation in a plant. In FY2016, the firm will install a photovoltaic generator of 500 kW on the roof of its Miyata Plant, Miyawaka City, Fukuoka Prefecture. Electricity will be used to produce hydrogen for FC forklift. According to the firm, this is the first plant to use solar power to operate a hydrogen production system in Japan. Toyota Tsusho and Kyuden Technosystem will join the project for system operation and maintenance respectively. The project will examine effects of the operation for two years. In FY2017, a stationary FC system will be installed for lighting in the promotional facility to examine supply and demand. The total project cost is ¥730 million in total, and METI's subsidy will be contributed to it. (The Nikkan Kogyo Shimbun, June 29, 2016)

(3) Hiroshima University

Hydrogen gas is difficult to be turned into liquid, and also hard to be stored and transported. On the other hand, ammonia can be easily made into liquid, and the required infrastructure is ready. Prof. Yoshitsugu Kojima at Hiroshima University has developed a technology to efficiently extract hydrogen from ammonia using precious metal ruthenium which can be used as catalyst for chemical synthesis. This technology can be used in material development to remove ammonia which is an unwanted substance from solution to extract hydrogen, and the team aims to establish a basic technology. (The Nikkei, July 4, 2016)

5. ENE-FARM Business Plans

(1) Hokkaido Gas

Hokkaido Gas will offer purchase service of excess electricity which is generated from gas home generator for heating "Coremo" and home FCs "ENE-FARM" to its customers from 2017. Users of these products can make profit from the gas supplier by selling unused electricity while their consumption is low. The gas supplier promotes distributed power sources by providing a benefit. These products in use in total is planned to be increased from 1,465 units at FY2015 to 9,000 units for FY2020. If the all purchasers of the home generators use this service, the firm is likely to gain around 10 MW capacity. Osaka Gas also offers to buy excess power from home distributed power sources for new ENE-FARM

purchasers. (The Nikkei Business Daily, June 8, 2016)

(2) Toho Gas

On June 8th, Toho Gas announced that its accumulated ENE-FARM sales reached 10,000 units on 7th. This product was released in 2009, and housing manufacturer increasingly using it. This 5-digit figure was achieved in about seven years. The gas supplier sold 2,419 units, the highest, for FY2015, and is working on sales aiming at 3,300 units for FY2016 to advance the previous figure. Their sales methods are strongly promoting the product for consumers who buy newly built houses or condominiums and for established houses when the residents replace boilers to achieve the target for FY2016. (The Denki Shimbun, June 9, 2016)

6. Cutting Edge Technology of FCV & EV

(1) Tokyo R&D

Tokyo R&D develops and produces next generation cars and vehicle prototypes for research in Chiyoda-ku, Tokyo, and announced that a FC truck would be tested in FY2018. The firm and its group member Pues in Chiyoda-ku, Tokyo, will jointly develop the FC truck for actual delivery operation as the experiment in Fukuoka City. Data will be collected from the experiment, and analyzed. The firms aim to start small-scale production of FC truck in FY2019. As well as FC truck development, basic performance of the truck and practicality for logistic purpose will be examined to design a FC truck porotype to be widely used. This project is selected as one of the "Technology Development and Experiment Projects for Reducing CO_2 Emission for FY2016 of MOE". (Nikkan Jidosha Shimbun, June 7, 2016)

(2) Toyota CV Company

Mr Keiji Masui, a senior managing officer and president of CV (commercial vehicles and mini-van) Company of Toyota Motor, told Nikkei that they would work harder on development of commercial vehicle with autopilot function and FCs. They expect these technologies can largely contribute to improvement of transport efficiency mainly in logistics, and their effort will be made further to expand the product range and for human development. He emphasized "the CV Company can pull up the latest technologies such as autopilot and FCV". He also pointed out advantages of commercial vehicles. Autopilot can reduce stress of drivers. Hydrogen refueling stations can be used more efficiently in warehouse where a number of trucks gather. Toyota Motor introduced an in-house company system in April, and each company is responsible for planning, designing and producing of a particular car range. (The Nikkei Business Daily, June 8, 2016)

(3) Nissan

Nissan Motor will introduce an EV of which price is 30% cheaper than the current model into the Chinese market. The development will be carried out in cooperation with their partner Dongfeng Motor Group, a major Chinese automaker. China is making all-out effort to promote EVs in order to solve air pollution and to develop industry. Expecting possible rapid growth of the EV market, Nissan plans to offer an affordable model to catch the demand. They developed "Venucia e30" using "LEAF" as the base, and introduced it into the Chinese market in 2014. The new model will be produced in China to be released as early as this summer, and will sell for 200,000 CNY (about ¥3.15 million), 20 to 30% cheaper than e30. Nissan will expand use of locally produced core components including battery. Imported components will be reduced to cut down costs of customs and transport to level with the price of local manufacturers' EVs. Nissan aims at 100,000 to 150,000 CNY with governmental subsidy which is the price range of gasoline cars in the same class. Their share in the EV market is 2% for 2015, and they target at 5 to 10% in a couple of years by adding cheaper EV. The Chinese government determines EVs and plug-in hybrid vehicles (PHVs) as new energy cars. Their subsidy scheme provides EV purchasers with maximum 55,000 CNY, and the total subsidy reaches 110,000 CNY including local governmental subsidy separately given. The annual new car sales is 330,000 for 2015, and the Chinese government plans to increase the accumulated sales of these cars to 5 million by 2020 by the subsidies. The high price and unprepared infrastructure are the obstacles in Japan, the US and Europe. Mr. Carlos Ghosn, the president of Nissan, thinks that the "Chinese EV market is possibly to make a rapid growth by the governmental leadership". (The Nikkei, June 20, 2016)

Nissan will explore usage of EV as a power source together with Aizu Laboratory, a venture from

University of Aizu in Aizuwakamatsu City. This project will develop a system for drone to be connected to EV as mobile power source, and this system is to check the large area of crops from sky for a long period. Automaker's imagination is limited, but Nissan tries to add new value to EV by developing new application to established ones such as a power source at home or for emergencies. (The Nikkei, July 9, 2016)

(4) DeNA

On July 7th, DeNA announced that it will start a transport service using automated driving bus without drivers in August. The bus service will be operated on private roads in commercial facilities, plants and university campuses as a start. The firm plans to expand the operation to public roads in future, and will sign a partnership with NTT Docomo. As automated driving technology requires to process a large amount of data, this type of business gets more new comers from unconventional industries such as IT and communications. The automated driving bus was developed by French venture Easymile, and is named "Robot Shuttle". In this mini electric bus, 3 passenger seats are arranged face to face. The maximum speed is 40 km/h. The first operation will start in Aeon Mall Makuhari Shin-Fukutoshin in Chiba Prefecture. The DeNA will consider expanding the operation to public roads in the future. Driving on public roads requires technologies for "vehicle-to-vehicle communication" to connect cars and "vehicle-to-infrastructure communication" to transmit data between vehicles and transport infrastructure. The firm will start an experiment with same bus in cooperation with NTT Docomo in Fukuoka City. (The Nikkei, July 8, 2016)

7. Development of FCV & EV Components & Parts

(1) Sunwa Trading

Sunwa Trading sells fiber reinforced stampable sheet in Japan, and the sales of this product has been expanding. The product is used for rear bumper beam of "CLARITY FUEL CELL", a FCV released in this March by Honda. Sunwa Trading uses this application to sell its product to the automobile industry. (The Chemical Daily, June 15, 2016)

(2) Panasonic

From November, Panasonic will start commercial production of automobile battery at the plant which is under construction with US-based major EV manufacturer "Tesla Motors" in Nevada, the US. Since orders for Tesla's new model is rising strongly, Panasonic will move up the start of commercial production and investment for increase in production. The firm will also start joint production of EV core component with Beijing Automobile, a major Chinese automaker. Panasonic will accelerate joint businesses in the US and China where the EV markets are growing, and has increased annual sales target for the automobile area to ¥2,000 billion, 1.5 times. The operation start was expected to be early 2017 because the battery plant operation for Tesla's EVs was to start in FY2016 in the previous plan. However, more orders are placed for Tesla's small sedan "Model S" to be sold from 2017, Tesla must have requested earlier production start to Panasonic. The new plan will open in July, and produce "cells", the core part of the battery from November. Panasonic previously planned to invest maximum $1.6 billion gradually in eight times for the plant, but decided to make early increase in production capacity by moving up the investment timing. According to their executive, they do not want to stop EV production flow due to battery shortage. Joint production of "electric compressor", a key component for EV air conditioner, will start in cooperation with Beijing Automobile in China, the largest EV market. Beijing Automobile sold about 2.5 million vehicles in 2015 in China, giving it the fifth place in the market. They started as an automobile component manufacturer, and established as an automaker in 1958. German-based Daimler and South Korean-based Hyundai Motor are also partners of Beijing Automobile to produce luxury range, and the Chinese car producer is making more effort in eco cars such as EV. The partnership with Beijing Automobile is important to Panasonic to expand EV related business in China, and they will discuss to expand the partnership to another product. Panasonic's sales of products for automobiles were about ¥1,300 billion for the term ending March 2016. They plan to develop EV related business that their advantage can be used to be a core profit maker, and to increase the target to ¥2,000 billion for the term ending March 2019. (The Nikkei, June 21, 2016)

(3) Nisshinbo Chemical

Nisshinbo Chemical will try to sell FC carbon

separator to the automobile industry. Currently metal separators are used in FCVs, but the manufacturer will sell the advantage of easy flowing channel forming of its product. Their separator has high handling ability for stacking, which will be emphasized for an issue of the product becoming cracked easily. While they organize joint research closely with their partner Ballard Power Systems, a FC producer, they aim for commercial production of separator for automobiles by optimizing technology for batteries. The cost will be reduced to the level that users want, and their separator business aims for ¥7 to 8 billion sales in 10 years. In the target figure, automobile use is planned to take ¥1 to 2 billion. The manufacturer has a large share in the market of carbon separators for home FCs. According to Mr. Hajime Sasaki, the president, the business environment is progressing as expected, and the separator business is planned to turn positive in FY2017. The product application is planned to be expanded from domestic to stationary and automobile. Specifically, they will strongly promote their separator for automobile for business growth in 10 years. (The Chemical Daily, June 28, 2016)

8. Hydrogen Refueling Station Elemental Technology Development & Business Plans

(1) Iwatani

Iwatani will increase the production capacity of liquid hydrogen in Japan by 50% by March 2019. A new line of liquid hydrogen plant will be added, and the capacity will be raised to 18,000 L/h. Liquid hydrogen is increasingly in demand for industrial purposes such as semi-conductor production. Supply is required to be expanded for coming FCV growth. The manufacturer estimates annual ¥5 billion investment in average for hydrogen related business over three years until the term ending March 2019. They operate hydrogen refueling stations at 20 locations, and will increase the number of the stations with the investment. Also, the investment will be used for construction of liquid hydrogen production plant. They dominate the liquid hydrogen market in Japan, and estimate about 50 million m^3 sales for the term ending March 2016. Hydrogen will be increasingly in demand at a fast pace as hydrogen society including FCVs and hydrogen power generation develops. Annual 600 million m^3 of hydrogen including compressed one is estimated to be in demand in Japan for 2025. (The Nikkan Kogyo Shimbun, June 17, 2016)

(2) Aska

Aska's subsidiary, Okayama International Circuit will install hydrogen refueling facility for FCVs in July. The facility will be a simpler system to dispense hydrogen from transport lorry to FCVs by decreasing pressure. Aska aims to catch the demand of FCV test driving since Toyota Motor and Honda started commercial sales of FCVs. Racing circuits hardly have hydrogen refueling facilities installed. Hydrogen is compressed in a lorry tank at 20 MPa, and the pressure is reduced to 15 MPa to fill FCV by the pressure difference between lorry tank and FCV tank. This system can refill to a fifth of hydrogen tank capacity which is equivalent of 100 km driving. Refueling requires about 40 minutes including preparation. Regular hydrogen refueling stations fully fill FCVs with hydrogen at 70 MPa in three minutes. The facility for the racing circuit is expected to be for supplemental use. Producing automobile framework as its core product, Aska has operated motor racing and test driving since the acquisition of the racing circuit operator in 2012. "We will promote attraction of cars to consumers through the racing circuit." Mr. Yoshinori Katayama, the president, says. (The Nikkan Kogyo Shimbun, June 20, 2016)

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