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Reduction in Platinum in PEFC Anode by 80%

Arranged by T. HOMMA

1. Governmental Measures

(1) Japanese Government

On September 7th, the Japanese government announced that the detailed project plan of "Fukushima Concept for a New Energy Society" that Fukushima Prefecture plays a model role to realize hydrogen society using hydrogen as the main power source. The key of the project is improvement of the grid in the prefecture to increase use of renewable energy such as wind power to produce hydrogen at a large-scale. The issues are growth of fuel cell vehicles (FCVs) and preparation of hydrogen supply bases. The project plan was decided at a joint meeting of public and private sectors such as METI, the Reconstruction Agency and electricity suppliers held in Fukushima Prefecture. The total expense amount allocated in the budget bill for FY2017 by related governmental bodies reaches ¥75.4 billion. The government will support installation of power cables in mountain and coast areas to make the prefecture a large producer of renewable energy including wind and solar power. The target is to produce hydrogen equivalent to fuel of 10,000 FCVs using renewable energy each year from 2020, and to supply Tokyo with hydrogen from the prefecture for FCVs during Tokyo Olympics and Paralympics. However, increase in hydrogen use is not easy. The FCV price is over ¥7 million, which limits the user range to within governmental bodies and the rich. The number of total FCV sales is about 400 at the end of 2015. Fuel cell (FC) buses and trucks have not replaced many of conventional ones due to their high cost. The largest factor for hydrogen energy use to grow is how to increase FCV users. The number of gasoline refueling stations is about 32,000 locations nationwide, while the number of hydrogen refueling stations stays at 80 locations. Another important factor is improvement of the refueling network for FCV users' convenience. (The Yomiuri Shimbun, September 8, 2016)

(2) IMO

The safety guideline for vessels to carry hydrogen in bulk is likely to be set soon. The expert committee of the International Maritime Organization (IMO) started a conference on September 5th, and the draft of safety standards submitted by Japan will be discussed to be an "Interim Guideline" there. Japan plans to bring the world's first liquid hydrogen tanker into commission between Australia. The conference of the Sub-Committee on Carriage of Cargoes and Containers is held from 5th to 9th in London, UK, to discuss standards for steel materials for liquefied natural gas (LNG) tanks and progress on regulations on gross weight of maritime containers as well as safety standards of liquid hydrogen tankers. To realize society using hydrogen in forms such as FCV, hydrogen needs to be stably produced at a low cost. Japan has picked up lignite which was previously considered as less useful as a measure. The plan is to produce hydrogen from lignite in the mining country, and to reduce the volume of the gas to 1/800 by refrigeration to transport to Japan. Kawasaki Heavy Industries (KHI) and Iwatani will form a research association to start commercial operation by 2020 after technological evaluation. Because this system allows using LNG tankers where Japan has an advantage in the technology, the government is giving proactive support to the plan. The Maritime Bureau of the Ministry of Land, Infrastructure, Transport and Tourism (MLIT) has led to set safety standards to add liquid hydrogen to the safety requirements of liquid gas by evaluating safety of tanks, piping joints and cargo handling operation. Japan aims to turn the Interim Guideline into official regulations after experimental operation. (Nikkan Jidosha Shimbun,

September 5, 2016)

(3) MLIT

On September, 12th, MLIT announced that the interim safety requirements for liquid hydrogen tankers suggested by Japan were approved by the committee of IMO. The ministry will organize the experimental operation between Australia, the first exporter of hydrogen to Japan. (Nikkan Jidosha Shimbun, September 13, 2016)

2. Local Governmental Measures

(1) Chiba Prefecture

On September 14th, Chiba Prefecture launched an organization of related businesses to promote the industry using hydrogen energy. This organization is to share the latest information on hydrogen, and will carry out research for demonstrations. The prefecture is considering setting a study group for each subject such as FCV promotion and the installation of hydrogen refueling stations. The members of the organizations are businesses such as automobile and house manufacturers, local governments in the prefecture and academic experts as well as energy related firms. (The Nikkei, September 15, 2016)

(2) Tochigi Prefecture

Tochigi Prefecture has launched a study group of industry, academia and public to promote FCVs in the prefecture. The number of cars in the prefecture is higher in Japan, and automobiles take a large part in the energy use. Because of this, the prefecture considers FCVs work to reduce energy and CO_2 emissions. This fiscal year, the group will compile measures including the preparation of hydrogen refueling stations in order to promote FCVs. Being named "Tochigi FCV Promotion Study Group", they have METI, the Ministry of the Environment (MOE), Utsunomiya University and local government such as Utsunomiya City as members as well as the prefecture. Toyota Motor, Nissan Motor, Honda and Ashigin Research Institute, a think tank, have joined the group. The members of energy providers are Iwatani, JX Energy, Tokyo Gas and NEZAS Holdings which has gasoline refueling stations as its members in the prefecture. (The Nikkei Business Daily, September 23, 2016)

3. FC Element Technology Development & Business Plans

(1) Osaka City University

A team of Prof. Tomoyuki Yatsuhashi and Guest Prof. Kimihiro Matsukawa at Osaka City University and Dr. Koji Mitamura has developed a simple synthesis method to dope high concentrations of fluorine to carbon particles. Fluorine containing carbon materials get attention as FC catalyst to replace expensive platinum. However, it needs a firing process at 1,000°C, which is an issue. Carbon particles processed by the new method have higher hydrophic properties, and are expected to be used in a medical area such as a contrast agent of magnetic resonance imaging (MRI) as well as a catalyst for FCs. The team synthesized carbon particles of 50 nm diameter by applying a "femtosecond laser" to emit light on a very short timescale of 10^{-15} seconds to hexafluorobenzene, an organic solvent. The analysis of these particles shows the ratio of fluorine is 40% on the particle surface and reaches 30% in whole particles. There is a research result of methods to synthesize fluorocarbon without using high temperatures. This method uses electrical discharge to achieve 5% fluorine bonded carbon, but a higher concentration of fluorine requires hydrofluoric acid or fluorine which is difficult to handle. The new method allows synthesizing fluorocarbon in an environment with air and large amounts of water at room temperature. Moreover, synthesized carbon particles can work well in cells containing a lot of water or living bodies, because it is dispersed in water in a stable state for a long period. FCs produce electric energy using a chemical reaction of oxygen and hydrogen, and use platinum which is a precious metal to efficiently reduce oxygen. Materials to replace platinum are being widely researched. (The Chemical Daily, September 12, 2016)

(2) Toyota Motor

Toyota Motor announced that a pure hydrogen FC system which directly uses hydrogen to generate power was installed and started its test operation at the building constructed in August on the premises of the Honsha Plant in Toyota City of Aichi Prefecture on September 12th. They aim to make the new building CO_2 emissions free by an energy management system combining a photovoltaic generator and a storage battery. This is the first for Toyota to use FC power for a building. This stationary pure hydrogen FC system

was developed by Toshiba for small offices, and outputs 3.5 kW. Used batteries from "PRIUS", a hybrid vehicle (HV), and photovoltaic generators are combined. The new building manages electricity usage of plants and office buildings in the Honsha Plant area. The target is to supply all the power in the area from the FCs and photovoltaic generators. The manufacturer plans to install FCs at its plants after the test operation results are studied. They announced the "Plant Zero CO_2 Emissions Challenge" to achieve no CO_2 emissions at their plants globally by 2050, and this hydrogen use is a part of the project. (The Nikkan Kogyo Shimbun, September 13, 2016)

(3) Toshiba

Toshiba's 3.5 kW pure hydrogen FC system delivered to Toyota Motor has started its operation. This product is the first 3.5 kW level commercial system, and is in a test operation of energy optimization at an energy management building on the premises of Honsha Plant of Toyota Motor in Toyota City, Aichi Prefecture. This system installed for the building uses hydrogen directly as its fuel, which achieves no CO_2 emissions during power generation as well as short start-up. Electricity generated by the system using hydrogen will be sent to the energy management building for lighting and air conditioning, and also hot water coming out from the process is supplied to the building. Also, the system will be used in an experiment to develop more efficient operation method of energy combining photovoltaic generator and storage battery. As well as being a product supplier, Toshiba will join the experiment, and will develop technologies to optimize operation and to estimate thermal energy demand to contribute to highly efficient energy use. The hydrogen FC unit was developed in cooperation of Yamaguchi Liquid Hydrogen, Chofukosan and Iwatani as a project of "Yamaguchi Prefecture Industry R&D Strategy Subsidy" organized by Yamaguchi Prefecture in 2014. The project achieved commercialization of the 3.5 kW FC unit, and will research on further development to add more value to the system. (Dempa Shimbun, September 13, 2016)

(4) Tanita

Tanita, Itabashi-ku of Tokyo, has announced that a highly accurate FC alcohol detector with fewer false detections would be available for hiring to small-scale delivery operators. The product is expected to be used at delivery operators to check lorry drivers' alcohol level. The fee is from ¥15,000, excluding tax, for one year or 500 times of detections. This service will start from December 15th, and the manufacturer aims for contracts of 10,000 units in one year. They exclusively developed "Alblo FC-900", a FC alcohol detector, for renting operation. This product uses FC in its sensor, and does not easily react with other gases other than alcohol. It can precisely detect alcohol at 0.001 mg/L level in breath. Although FC detectors can accurately detect alcohol, they require maintenance in an every certain period or times of use as well as higher cost for purchase. The initial and maintenance expenses tend to be high, which puts off especially small-scale delivery operators with one to five drivers. This time, the manufacturer offers reduced price for initial cost. The contract will automatically renew every year or when the device needs a periodic check after the set number of use to send replacement. The firm tries to spread the use of the FC device by reducing initial and maintenance costs. (The Nikkei Business Daily, September 15, 2016)

(5) MHPS

On September 21st, Mitsubishi Hitachi Power Systems (MHPS) announced that it started an experiment of a combined power generation system of solid oxide fuel cells (SOFCs) and micro gas turbines for commercialization. The test system for industrial/business purpose was installed at the Senju Techno Station in Arakawa-ku, Tokyo, of Tokyo Gas, and the startup ceremony was held on the same day. They will evaluate technology of cogeneration systems, and expand test sites to four locations aiming for market introduction in FY2017. The experiment uses a pressurized combined power generation system, a hybrid system. The compressor of the micro gas turbine compresses air to supply SOFCs to generate power. Then, high temperature exhaust gas is sent to micro gas turbines, and the system uses the heat and pressure for power generation as well as natural gas. Pressurized SOFCs have an advantage of increased voltage by pressure, and the manufacturer uses this to improve generation efficiency. SOFC operates at 900 ºC. This hybrid system directly generates power by the reaction of oxygen in air and hydrogen and CO extracted from natural gas, the fuel. Unused natural

gas is used for power generation of micro gas turbines. The test system produces 250 kW at 55% generation efficiency. A prototype had test operation at Kyushu University in the spring of 2015. The new system in the test has an optimized cartridge, which is a collective of cell stacks, for better operation performance than the prototype. (The Denki Shimbun, September 23, 2016)

(6) Osaka University

A research group of Osaka University, the University of Tokyo and Panasonic has announced that it developed an anode which uses 80% less platinum for polymer electrolyte fuel cells (PEFCs). Platinum dispersed on porous material at a single atomic level can function as an excellent catalyst to oxidize hydrogen. The group discovered this fact, and used it for the anode. This anode achieves the same maximum output level of that of PEFCs using conventional electrodes of platinum particles. Platinum is also used in catalysts to clean automobile exhaust gas, and the new product can possibly reduce a large amount of this rare metal use in other products. An effective reduction method of platinum is to reduce particle size to increase specific surface area. Single atomic layer of platinum particles slows down a significant reduction. However, platinum tends to flocculate, and was previously difficult to disperse and support at single atomic level on electrode substrates. The group dispersed platinum at a single atomic level on a covalent triazine framework (CTF), a cross-linking polymer material with porous structure, through carbon atoms. They succeeded to make the material function as a redox electrode catalyst in 2014. This time, an anode was made using Pt-CTF to examine whether redox was promoted by platinum at a single atomic level and to evaluate PEFC output characteristics. Pt-CTF exhibited about five times the redox current of that of commercial catalyst which supports about the same amount of platinum particles. Even when the amount of platinum of the Pt-CTF was reduced by 80%, the catalyst performed the same maximum output of PEFC using conventional electrode supporting platinum of 0.1 mg/m^2. This is the first result reported of redox promoted by platinum at a single atomic level in the world. Commercialization of this catalyst can promote PEFCs, and the catalyst is expected to be used in variety of purposes including filtering automobile exhaust gas. (The Chemical Daily, September 23, 2016)

4. Hydrogen Infrastructure Element Technology Development & Business Plans

(1) Siemens

German-based Siemens will start an experimental project of hydrogen production using renewable energy, for power generation and FCVs in Japan. They are already working on a large-scale evaluation in Germany in cooperation with related businesses. Because Japan determines hydrogen as a core of next generation energy, Siemens sees a business opportunity here. Their hydrogen supply is planned to start by 2020. The project in Japan will buy renewable energy including wind power to produce hydrogen, and the firm is looking for a project location to start the experiment by 2020. Cost competitive hydrogen production is expected to be achieved by using "excess production" of renewable energy that the utility firms do not take. They make water electrolysis systems and combustors of natural gas mixed with hydrogen. In Mainz, Germany, a project is carried out to electrolyze water using wind power to produce hydrogen in cooperation of businesses including Linde, a major industrial gas producer. Siemens is also looking for partners in Japan. (The Nikkei, September 14, 2016)

(2) Hitachi Zosen

Hitachi Zosen has won an order for hydrogen production equipment to electrolyze water from the Institute of Advanced Industrial Science and Technology (AIST). The equipment is for a joint experiment of AIST and Shimizu Corporation, and a part of an energy system to convert excess production of renewable energy into hydrogen to store and use hydrogen as needed. The price is about ¥50 million. Hitachi Zosen developed a container package system for this experiment to allow the system to be installed outside and easily transported. The ordered hydrogen producer "Hydro Spring" will be installed at Fukushima Renewable Energy Institute of AIST. The experiment will be carried out for one year from January 2017. Hitachi Zosen is in charge of design, production and test operation of the hydrogen producer, and the system will be produced in its

Kashiwa Works. The system produces hydrogen at 5 Nm^3/h by electrolyzing water using power from solar and wind power. Hydrogen is stored in a tank made of hydrogen storage alloy, and the FC system generates power using the gas as a part of power supply for the building as needed. The hydrogen production system is stored in a 12 feet container with ventilation, and can be transported as it is. The firm developed a container package to be able to install in for a building and to reduce installation work. Renewable energy production fluctuates by climate. The system uses anodes and cathodes which have polymer membranes in between for electrolysis to make the hydrogen ion movement smooth. This allows hydrogen production to efficiently follow renewable energy production. Europe is leading in the area to store fluctuating renewable energy production such as solar and wind power in a form of hydrogen, but Japan is also working on this more. Toyota Tsusho and Kawasaki Heavy Industries (KHI) are working on a test in Hokkaido, and German-based Siemens is considering a project in Japan. (The Nikkan Kogyo Shimbun. September 15, 2016)

(3) Toyota Moto, Toshiba & Iwatani

Kanagawa Prefecture, Yokohama City, Kawasaki City, Toyota Motor, Toshiba and Iwatani will start an experiment to supply forklifts with hydrogen produced using wind power this autumn. Their aim is to create an environmentally-friendly society by developing hydrogen supply chain emitting no CO_2. The experimental project is commissioned by the Ministry of the Environment (MOE), and will install a system to produce hydrogen by electrolyze water using wind power and to compress to store hydrogen on the premises of "Hama Wing", a wind farm in Yokohama city. Then, hydrogen will be transported to vegetable and fruit wholesale market, factory and warehouses in Yokohama City and Kawasaki City using a simple hydrogen dispensing truck for FC forklifts to use. Mr. Shigeki Tomoyama, a senior managing officer of Toyota, explains "CO_2 emissions in the supply chain of FC forklifts can be reduced by over 80% compared to the supply chain of gasoline and rechargeable forklifts. With a supply chain to produce hydrogen using renewable energy, to be compressed for storage and transport, a large reduction in CO_2 emissions is largely expected in the future. Toshiba will provide water electrolysis equipment in this project. The wind farm will power the equipment to produce hydrogen. The system can deal with fluctuation in wind power production and hydrogen demand for its optimized operation to supply hydrogen. A power storage system by Toyota Turbine and Systems, Toyota City, will take the hydrogen compression and storage work. The system can store hydrogen worth for two-day use for stable supply. Used batteries of HVs are used in the power storage system to be environmentally-friendly. Iwatani's simple hydrogen dispensing truck for forklifts will be used for hydrogen transport for the first time in Japan. Hydrogen usage is always noted to accommodate users' demand in detail by optimized transport. Toyota Industries will provide FC forklifts which only produce water but no CO_2 during operation. It takes about three minutes to refuel, and these forklifts can operate for about eight hours. Rechargeable forklifts require six to eight hours for recharge. FC forklifts will be used in the main market of Yokohama City Central Wholesale Market, Yokohama plant of Kirin Brewery Company, Kawasaki FAZ Logistics Center in Kawasaki City of Nakamura Logistics, and Higashiogishima Logistics Center of Nichirei Logistics Group. The wholesale market and Namamura Logistics will use FC forklift each from this autumn as the start of test operation. From next spring, three FC forklifts each will be used in the four facilities, making the total number of the forklifts in operation 12 as the full-scale operation. The full-scale experiment will start by FY2018. A large problem is the high cost of hydrogen using renewable energy and power storage systems. Iwatani says that "the costs would be evaluated in details through the experiment." During the experiment, technologies for cost analysis and reduction will be studied and evaluated. "Hydrogen projects need to be independent from subsidies. Japanese businesses are often criticized that they win in technologies but loose in business. We want to avoid this situation by developing a strong industry and academia cooperation for final commercialization. (Fuji Sankei Business i, September 26, 2016)

(4) Showa Denko

Showa Denko will start an experiment to produce hydrogen using domestic "waste". The experiment will use the firm's own facility to produce synthesis gas of

hydrogen and CO_2 using used plastic, plastic waste. The firm plans to sell hydrogen from the gas as a business, and is working on it with local governments and university. When you go into a building at the Kawasaki Office of Showa Denko in the Keihin Industrial Complex, you will notice a slightly different smell from normal chemical plants. The source of the smell is 1 m^3 blocks stacked by the building showing sweets bags and shampoo bottles. Weighing 250 to 300 kg each, they are compressed plastic waste from homes collected by local governments in the greater Tokyo area. The firm gets rid of metal mixed in the waste and shreds the plastic. The machine looks like a large noodle maker, and prepares plastic into cylindrical shapes of 2.5 cm diameter and 5 cm long. The plastic is fed to an original gasification facility, "Kawasaki Plastic Recycle (KPR)", of which the internal temperature is over 1,400ºC, and the facility produces a synthesis gas of hydrogen and CO_2 gas. The company produces ammonia by extracting hydrogen from the synthesis gas. A new project started this year with KPR to use hydrogen made from plastic waste to operate FCVs with the Japanese and local governments' assistance. Hydrogen can be produced by various methods including water electrolysis and using biomass as well as extraction from natural gas. Hydrogen for ammonia production is not suitable to fuel FCVs. Hydrogen purity required for ammonia production is 90%, whereas hydrogen for FCVs needs to be 99.97% purity. The firm is building a facility to refine hydrogen by "sieving molecules" at the Kawasaki Office. They are also working on a plan to prepare a pipeline of 70 m in the industrial complex by 2017 to supply hydrogen refueling station operator. Once the hydrogen refining facility and pipeline for transportation are ready, FCVs will be driving on plastic waste from 2018. (The Nikkei Business Daily, September 28, 2016)

(5) Toshiba, Tohoku Electric Power & Iwatani

The Japanese government has decided a hydrogen society concept is to be one of the keys for Fukushima's reconstruction, and the main players for the concept were decided on September 28th. Toshiba, Tohoku Electric Power and Iwatani will invest around a couple of ¥1 billion to build the world's largest class hydrogen production plant in Fukushima Prefecture to produce 900 tons, an equivalent of fuel for 10,000 next generation cars, each year. The operation is planned to start by 2020 when the Olympics and Paralympics are to be held in Tokyo which are determined as a symbol of recovery. Prime Minister Shinzo Abe visited Fukushima Prefecture this March. "We want to make Fukushima to be a pioneer to open up hydrogen society" he announced. METI, the electricity supplier and the prefecture set up an expert committee to start research. As a project commissioned by METI, Toshiba will construct the plant, and Iwatani will work on hydrogen storage and distribution as well as a power grid to be prepared by Tohoku Electric Power. The plant will use electricity to split water to extract hydrogen in order to transport the material to refueling stations for next generation eco cars. Because the electricity for electrolysis will be produced at surrounding solar and wind farms, the system has an advantage of no CO_2 emissions from power and hydrogen production to energy use. The prefecture was devastated by the Great East Japan Earthquake and the nuclear power station accident, and its recovery is slower than the other prefectures affected by the earthquake. The project will create employment in the community by building the plant and reviving the local industries, and also aims to contribute to the recovery. The current hydrogen supply for hydrogen eco cars stays at just under 100 tons each year. This is because the supply mainly uses by-product hydrogen from another chemical production or steel works, and eco car use stays at about 1,000 vehicles. However, the Paris Agreement, the new global framework convention on climate change, is expected to be adopted in this year, which should bring an attention to hydrogen which gives less impact to the environment. The ability to produce hydrogen at a large-scale is likely to support hydrogen power stations that METI aims to commercialize in the late 2020's. Nikkei BP Clean Tech Institute estimates the global hydrogen related infrastructure market including hydrogen power plants and FCVs will achieve a significant growth from ¥6.8 trillion for 2015 to just under ¥160 trillion by 2050. (The Nikkei, September 29, 2016)

5. ENE- FARM Business Plans

Tokyu Land Corporation has developed "Smart Wellness House", a ready-built house to care for its

residents' wellbeing, in cooperation with Juntendo University. They added medical advantages such as round the clock ventilation to the houses, and provide online videos to build muscle in cooperation with their group members. This product will be used for "Branz Garden Seta", a total of nine houses for sales in Setagaya-ku of Tokyo, and the construction will be completed in between September and October. The show house will be open in early October. The houses have improved energy saving performance and safety functions. ENE-FARM and under floor heating will be installed as well as external sunshades. There will be storage areas for emergency kit including food and tools. The development will provide services such as emergency earthquake reports through TV and security and after school children care programs in cooperation with over 10 Tokyu Group members. (The Nikkei, September 6, 2016)

Tokyu Land Corporation will install energy systems using next generation ENE-FARM as the standard feature to all 25 houses for sales under development as "Branz Garden Shinminou" in Hakushima 3 Chome, Minou City, Osaka Prefecture. This is the first project to use ENE-FARM as a standard feature for over 10 ready-built houses for sale in Japan. The energy system produces electricity at the world's highest efficiency level, and excess power production will be sold to Osaka Gas. The development is walkable distance from "Shin-Minou Station (provisional name)" which will be open as the Kita-Osaka Kyuko Namboku Line is to be extended about 2.5 km north from Senri-Chuo Station in FY2020. There will be wooden two-story houses of floor area between 150 and 158 m^2. The gross floor area is between 105 and 122 m^2. At the end of July, the construction of 15 houses was completed. The sales will start from mid-September. The houses will sell for from ¥69 to 80 million; the price increases by ¥1 million. (Jutaku Shimpo, September 6, 2016)

6. Cutting Edge Technology of FCVs & EVs

(1) Toyota Industries

On September 6th, Toyota Industries announced that it would introduce FC forklift of which the market release in November had been announced at "Logis Tech Tokyo 2016" to be held at Tokyo Big Sight in Ariake, Tokyo, from 13th to 16th. Also, their FC towing tractor will be brought as reference. They will demonstrate a logistics improvement example of their own car component production line. They currently have purchase offers for 10 FC forklifts from users including the Kansai International Airport which is already equipped with hydrogen infrastructure. It is 60 years since Toyota Industries started its sales of forklifts. The first forklift made in 1956 will be displayed in their booth. (The Nikkan Kogyo Shimbun, September 7, 2016)

(2) GM

On September 13th, US-based General Motors (GM) announced that its new EV "Chevrolet Volt EV" to be released at the end of this year, achieved a driving range of 238 miles, about 383 km" on a full charge. The EV outruns "Model 3" to be released in 2017 from US-based Tesla Motors which drives about 345 km, and has the longest driving range among the mid-price range EVs. Volt is a five-door small car, and its price is expected to be $37,500, about ¥3.83 million, or less. Taking $7,500 EV purchase subsidy into account, the actual consumer price is likely to be less than $30,000. This is an affordable EV price range for majority of consumers, and Tesla sets the price of its Model 3 to $35,000 excluding subsidy. EVs have a shorter driving range than gasoline cars, which is stopping the growth. However, automakers are working on research and development of battery for capacity increase and reduction in costs. GM has succeeded in extending driving range by using a high capacity battery of South Korean based LG Chem. Mr. Alan Batey, the executive vice president and president for North America, on the day said that "Volt would change the EV market", and showed their confidence to sell better than Tesla and Nissan which are leading in the market. EVs take only few percent in the whole automobile market in the US, but EV development is unavoidable since the fuel efficiency regulation will get stricter towards 2025. Also, Nissan is currently trying to extend EV driving range from 172 km. German-based VW is considering to introduce EV, and the competition is getting fiercer. (The Nikkei, September 14, 2016)

(3) Ford

On September 14th, Ford announced that its pre-tax profit for whole FY2017 was expected to be a decreased from that of FY2016. The reason of the

decrease is that $4.5 billion, ¥460 billion, will be invested in EV business over the period until 2020, which presses the immediate profit. To accommodate tightening regulation on fuel efficiency in the US for 2025, they plan to introduce new 13 EVs by 2020 by the investment. (The Nikkei, September 15, 2016)

(4) Yasukawa Electric

On September 15th, Yasukawa Electric, a major industrial robot producer, announced that it formed a capital alliance with EV venture GLM, Kyoto City. Using Yasukawa's own motor technology, two firms will jointly develop a motor which allows electric sports cars to drive fast by excellent acceleration while sustaining rotative force. The motor is planned to be used for the next generation commercial car of GLM, and Yasukawa expects this to lead to find demand of driving unit for electric sports cars. Yasukawa already accepted private placement of new share conducted by GLM. The investment amount is closed. Yasukawa will use "QMET Drive" which is a technology to switch coils to send current while a motor rotates, and will develop driving motor and inverter in cooperation with GLM. Normally, a rotating force of motor tends to stop increasing when rotative speed goes up. QMET Drive adjusts the number of coils to send electricity depending on rotative speed, which achieves both high torque and high rotation. (The Nikkei, September 16, 2016)

(5) Toyota Industries

Toyota Industries unveiled a concept model of FC towing tractor to bring cargo containers to airplanes in airports for the first time in the world at the Logis Tech Tokyo 2016 stared from September 16th. The tractor was developed using the unit of the FC forklift to be released in November, and the firm is enthusiastic about carrying out experiments in an airports using the tractor during the 2020 Tokyo Olympics. The tractive performance is exhibited at the same level as an internal combustion engine, and the issue is extension of driving range. The firm is working on research and development of FC unit suitable for towing tractor to achieve performance to withstand daily operation. The automobile industry determines that the Tokyo Olympics to be held in 2020 is a showcase to advertise new mobility to the world. They want to show the potential of working vehicle in a new era to the world by FC tractor towing containers around in an airport, an entrance from abroad. (Nikkan Jidosha Shimbun, September 17, 2016)

(6) Honda

Honda will put more weight on model based development (MBD) which uses simulation model for efficient design process of cars. From the summer of 2017, a new facility will operate in Honda R & D in Tochigi Prefecture to virtually analyze cars to reduce the number of prototypes by function such as body, engine and control system. Since environmental regulation has impact on product development, Honda will shift to more efficient development methods. MBD uses collected date from previous model development to simulate component design, including engine using computers to check performance. This allows more precise design in early stage and reduction in design change at the final stage. The automaker aims to compress time and costs in development of commercial vehicles and to allocate workforce and budget to next generation technology. Electric powered cars are planned to take two thirds of Honda' product range by 2030. They are developing all sorts from FCV, EV, plug-in hybrid (PHV) to HV. This gives more work in new product development. For example, because of variety added to range, the data of engine control are evaluated by systems such as direct injection and HV. This gives 10 times more work to that of 10 years ago. They will go for full use of MBD for efficient development process. (The Nikkei, September 24, 2016)

(7) BMW

On September 26th, German-based BMW unveiled a prototype of its FCV for the first time in Japan. The prototype uses their "5 Series" and Toyota Motor's FC stack. BMW aims to commercialize FCV for 10% price difference from the gasoline version of the same series by 2020. The prototype's driving range is up to 700 km, and the maximum speed is 180 km/h. BMW and Toyota are partners of the joint development of FCV. (The Nikkei, September 27, 2016)

On September 27th, the Japanese arm of German-based BMW released renewed EV "i3". They extended the driving range to 390 km, 1.7 times of that of the old version, by improving materials and shape of the lithium-ion battery (LIB), the power source. The new version sells for ¥4.99 to 6.07 million,

and the minimum price has stayed the same. BMW Japan will start offering free recharging for one year from October 1st in Japan. Users can use normal and quick chargers of Nippon Charge Service, Minato-ku Tokyo, which is funded by major Japanese automakers and electricity suppliers. (The Nikkei, September 28, 2016)

(8) FC Train

Train manufacturers are working on improvement of fuel efficiency and reduction in costs worldwide. The reason behind this is that the stagnated global economy pushes users to focus on more "cost efficiency". InnoTrans, a trade fair of railway transport, was held in Berlin from September 20th to 23rd, and FC train was displayed there. "Coradia iLint" from French-based Alstom got attention. Because it uses FCs and runs on hydrogen, no CO_2 is produced. According to European media, the train will start its commercial operation in Northern Germany in December 2017. (The Yomiuri Shimbun, September 28, 2016)

7. Hydrogen Refueling Station R&D & Development

Aichi Steel will accelerate strategy to its stainless steel business to be outstanding. They will develop and promote steel material for the coming hydrogen society by spreading use of FCVs. Also, their promotion and product development will be more proactive expecting more demand on shaped stainless steel and round bar for disaster preparation and replacement of old infrastructure such as roads and bridges. The manufacturer mainly produces shaped stainless steel and round bar as their stainless steel business. Currently, hydrogen refueling stations are being constructed, and FCV is expanding use. During this, more technologies are used and improved. To fit with this situation, the firm launched Stainless Steel Development Team, Stainless AE Team, and Stainless Steel and Titanium Market Creation Team in the Technology Development Department. Also, Stainless Steel Technology Office is set up in the Production Technology Department. The company is fortifying its organization to cover all direction of the stainless steel business by connecting sales and production departments. As use of FCV and hydrogen refueling station are expanding, they are working on technological development and sales activity on stainless steel AUS316L-H2 for high pressure hydrogen. The product is used in Toyota Motor's FCV "MIRAI". Furthermore, they are developing budget versions of popular products. "Toyota is working on the plan to produce 30,000 FCVs annually by 2020. At the same time, hydrogen refueling stations are planned in 1,000 locations. More stainless steel is in demand" they expect. (Japan Metal Daily, September 12, 2016)

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