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Start-up of R&D to Accomplish Fuel Cell Combined Cycle

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1. Governmental Measures:

(On May 14th, the Fundamental Issues Subcommittee of Advisory Committee on Energy and Natural Resources decided on 15% as a ratio for cogeneration system out of the whole generation amount projected for 2030. The previous estimation for self-generated energy consumption of cogenerated power breaks down into approximately 100 TWh for business and industrial facilities and approximately 17 TWh for domestic fuel cells, FCs. This time, the Agency for Natural Resources and Energy increased the previous estimation by 30 TWh to 150 TWh on the assumption that surplus electricity of cogeneration substitutes old thermal power generators such as oil-fired plants. As a result, the total generation of cogenerated power maintains 15% of total electricity generation without 36 TWh of domestic fuel cells in the estimation. 17 TWh of energy production is the equivalent of 5 million units of domestic FCs which have a total capacity of 4 GW. (The Denki Shimbun, May 16, 2012)

(2) New Energy and Industrial Technology Development Organization, NEDO

NEDO will start demonstrational smart grid projects in two areas, a housing estate in Albuquerque and Los Alamos, New Mexico, USA. Being ready for the experiment, the demonstration site in Albuquerque will have an opening ceremony on May 17th. As a joint project with Los Alamos National Laboratory of United States Department of Energy, local universities and local power suppliers, a 50 kW photovoltaic generator, a 90 kW storage battery, a 240 kW gas cogeneration, an 80 kW FCs and a thermal energy storage were installed into an existing commercial building in an urban area where is a difficult to place to set up a large facility. They will monitor the power control system which adjusts to the demand of the commercial grid and enable independent operation for disasters. Participants of the Albuquerque project from Japan are Shimizu Corporation, Toshiba, Sharp, Meidensha, Fuji Electric, Tokyo Gas, Mitsubishi Heavy Industries, Furukawa Electric and Furukawa Battery. The experiments in Los Alamos will start investigating smart houses at the top international level and a smart grid which is connected to storage batteries and many photovoltaic generators through demand responses this autumn. NEDO also plans other demonstrational experiments in Hawaii, China, France and Spain and all the results will be used to standardize activity of the Japan Smart Community Alliance which is aiming to export infrastructure systems. Completing a preliminary survey, NEDO will sign a memorandum with Málaga, Spain, on May 25th. The project is planned to test an infrastructure and a power supply system for large number of electric vehicles, EVs, with Japanese participants such as Mitsubishi Heavy Industries, Mitsubishi Corporation and Hitachi. (The Denki Shimbun, Architectures, Constructions & Engineerings News (Daily), the Nikkan Kensetsu Kogyo Shimbun, the Chemical Daily, May 10, 2012; the Nikkei Business Daily, May 11, 2012; the Nikkan Kogyo Shimbun, May 16, Nikkan Jidosha Shimbun, May 19, 2012; the Denki Shimbun, Architectures, Nikkan Kensetsu Sangyo Shimbun, the Nikkan Kensetsu Kogyo Shimbun, Japan Metal Daily, May 21, 2012; Japan Metal Daily, May 28, 2012)

2. Local Governmental Measures:

(1) Yokohama City

On May 17th, Yokohama city announced that FCs and storage batteries would be included in the subsidy scheme on energy saving facilities for its residents in order to promote its joint smart grid project with its residents "Yokohama Smart City Project". (The Nikkan Kogyo Shimbun, May 18, 2012)

(2) Saitama Prefecture

On May 31st, Saitama prefecture had a ceremony in the prefectural office for the agreement on "Smart

City Leading Model Project " which is a joint experimental project of Saitama prefecture, Koshigaya city, land owners and three local firms in the area near the south gate of the Koshigaya Lake Town station of Japan Railways Musashino Line. The project plan includes building several houses in the area with home energy management systems, HEMSs, Ene Farms, energy saving lighting and storage batteries. The generated electricity will be shared between houses controlled by communication networks. (The Saitama Shimbun, June 1, 2012)

3. Technology Development of FC Elements

(1) Nippon Kodoshi

Nippon Kodoshi (Kochi city), the biggest insulation paper (separator) producer, has developed an electrolyte membrane material for polymer electrolyte fuel cells, PEFCs. The material is an inorganic organic membrane combing polyvinyl alcohol, a general-purpose organic polymer, and inorganic oxide such as silicon and zirconium dioxides at molecule level. Nippon Kodoshi succeeded in archiving a large cost saving by choosing low price materials and easier production process. The membrane has the same level of conductivity of hydrogen ions as fluoride membranes, as well as twice the heat resistance, 200 □C, by adding inorganic oxide. Nippon Kodoshi has researched the product for more than 10 years, and established a mass production technology. (The Kochi Shimbun, May 16, 2012)

(2) Kobe Steel

On May 23rd, Kobe Steel announced its new titanium membrane which is low cost but has good conductivity for separators. The membrane reduces electricity loss in FCs by half; however, its cost is the same as conventional stainless steel membranes. Thin titanium foils, a high corrosion resistant metal, are coated with a low cost carbon material to give better performance. Due to the high corrosion resistance, the product allows a sixth of the thickness of carbon separators, which are currently the majority, which can make FCs lighter while retaining the same conductivity and cost level. With these advantages, the material is expected to be used in fuel cell vehicles, FCVs. (The Nikkei Business Daily, the Nikkan Kogyo Shimbun, Nikkan Jidosha Shimbun, Japan Metal Daily, May 24, 2012; the Sankei Shimbun, the Kobe Shimbun, May 25, 2012)

(3) Stanford University, USA

Nanoscale research at Stanford University produced a study showing that unzipped carbon nanotube may be used as catalyst material for FCs and metal-air batteries. They treated nanotubes, which are double layered sheets rolled into tubes, in a chemical solution that resulted in outer nanotubes partially unzip or damaged and which formed nanosized graphene pieces. Microscopic analysis showed these pieces clung to the inner nanotube. The catalytic activity of the nanotubes with iron and nitrogen impurities added on the outside is very close to platinum. The inside provides a path for electrons to move. The research group plans further study as to whether the nanotubes can become an alternative to platinum and other precious-metal catalysts. The material has already been sent to researchers aiming to produce as a trial product, a large capacity battery with longer life. (The Nikkei Business Daily, May 30, 2012)

(4) National Institute for Materials Science, NIMS

On May 29th, the Global Research Center for Environment and Energy Based on Nanomaterials Science, with special researcher Takuya Masuda, of NIMS revealed the mechanism of cocatalyst promoting platinum catalytic reaction in an electrode reaction in PEFC. The study group discovered cerium oxide particles on platinum particles brought better catalytic reaction several years ago. This time, the role of the cerium oxide was confirmed by in situ measurement X-ray absorption fine structure (XAFS) at Spring-8, a synchrotron radiation facility. With conventional platinum catalysts, the catalytic reaction proceeds with the platinum surface partially oxidized which prevents it archiving its intrinsic performance resulting in a reduction of the catalytic reaction. With electrons transferring partially from cerium to platinum, platinum showed its primary high catalytic reaction due to the cerium's oxygen storage capability making platinum difficult to oxidize at the measurement. (The Nikkan Kogyo Shimbun, May 30, 2012; Japan Metal Daily, June 1, 2012; the Denki Shimbun, June 4, 2012)

(5) National Institutes of Natural Sciences, NINS

A study group of Institute of Molecular Science of NINS has succeeded in getting real-time observations

of the structural kinetics of surface events on a cathode catalyst of platinum-cobalt, Pt-Co, alloy in a FC by Spring-8. The group consists of assistant professor Mizuki Tada of Institute of Molecular Science and Tomoya Uruga a sub- leader of Japan Synchrotron Radiation Research Institute where Spring 8 is located. Pt–Co alloy particles as a cathode catalyst gives better FC performance and durability than conventional Pt particles per Pt surface atom; however, the reason was unknown. The group investigated the surface events on a Pt-Co cathode catalyst in a FC by fast time-resolved X-ray absorption fine structure (XAFS), developed at Spring-8 with a time resolution of 500 ms. As a result, the reaction process speed of Pt-Co alloy particles on a cathode catalyst surface was clarified faster than a Pt catalyst; specifically, Pt-O (oxygen) bond breaking and Pt–Pt bond reformation were quicker. If Pt-O bond breaking is slow then Pt–Pt bond reformation becomes insufficient, and the bonds between Pt are left weak leading to breakage. The group plans to develop a more durable Pt alloy catalyst with a smaller amount of Pt. (The Chemical Daily, May 31, 2012)

4. Technology Development and Business Plan for Phosphoric Acid Fuel Cell, PAFC:

Tokyo Gas has improved the energy consumption of its carbon dioxide, CO_2, capture and storage system to 12 kW from 28 kW per 100 kW generation of its PAFC for business users. This commercialized system may contribute to reducing CO_2 emission to a third by collecting 15.4 kg of CO_2 out of 51.4 kg emitted from 100 kW output PAFC per hour. Exhaust gas (flue gas) of the steam reformer from a FC goes to a pre-treatment unit to be dried gas by condenser and dehumidification, and then CO_2 is captured by pressure swing adsorption, PSA. The CO_2 is liquefied and placed into a liquid gas container so that it can be used for CO_2 welding and microparticulation solvent of chemicals. The captured CO_2 is utilized in "Plant Factory", where vegetables grow, in Chiba University. (The Nikkan Kogyo Shimbun, May 8, 2012)

5. Technology Development and Business Plan for Solid Oxide Fuel Cell, SOFC

On June 1, Mitsubishi Heavy Industries announced it would develop an element technology for a triple gas turbine combined cycle which is a fuel cell combined cycle, FCCC, system. FCCC is a natural gas generator having SOFC upstream of a gas turbine combined cycle, GTCC, to create electricity very efficiently. The generation efficiency can be 70% or more with several 100 MW level systems as well as 60% or more with several 10 MW level. Although western firms have been also researching the same system, they have not yet been introduced to the market due to the difficulty to improve SOFC's durability. The element technology to be developed by Mitsubishi is an interface technology between SOFC and gas turbines including examining characteristics and durability while SOFC is under high pressure as well as development and of the gas turbines and conversion of the combustor. In addition, the generation is planned to be tested by simulating the interface between SOFC and the turbines. Mitsubishi aims to commercialize a small system by 2017 and to move into the market fully with a larger system by 2021. This project is a chosen proposal to a public offer of NEDO for two years from the fiscal year 2012. With Hitachi, Mitsubishi intends to produce a 90 MW level system with 60% generation efficiency by the end of 2014. (The Sankei Shimbun, Fuji Sankei Business i, June 2, 2012; the Denki Shimbun, the Nikkan Kogyo Shimbun, the Nikkei Business Daily, the Chemical Daily, June 4, 2012)

6. Business Plans for Ene Farm and Home Energy Management System, HEMS:

(1) Mitsuuroko Group Holdings

Mitsuuroko Group Holdings has increased the sales target of Ene Farm to more than 500 units, 20% more than the previous year, and aims for 1,700 units, double the previous year, of photovoltaic generators for the fiscal year 2012. 424 units of Ene Farm were sold with the benefit of the additional subsidy due to the electricity shortage in the fiscal year 2011, which led Mitsuuroko to the top for the sales of the cogeneration system using liquefied petroleum gas. (The Nikkan Kogyo Shimbun, May 10, 2012)

(2) JX Nippon Oil & Energy

JX Nippon Oil & Energy will start a demonstrational experiment "ENEOS Renovation for Energy Creation" by installing independent and decentralized generation systems such as domestic FCs and storage

batteries in an apartment house in Yokohama city from June. The point is to use an existing building. This joint project with Toshiba and Mitsui Fudosan Residential is a part of "Yokohama Smart City Project", and a 40-year-old apartment house with 16 units was chosen. The house is for JX Nippon Oil & Energy employees, and the data will be collected with residents living in situ until the end of the fiscal year 2014. The energy facilities to be installed during the renovation of the building are roof filling solar panels (output: 20 kW), six units of 0.7 kW SOFC type Ene Farm (total output: 4.2 kW) outside and a lithium ion storage battery (capacity 30 kWh). The Ene Farm will be used as the major power and hot water supplier with round the clock rated operation. Additionally, the surplus electricity will be stored in the battery for use at night and used in the heat pump water heater to provide hot water. The target of the project is 80% energy self-sufficiency and 50% reduction in CO_2 emission. (The Nikkei, the Nikkei Business Daily, the Nikkan Kogyo Shimbun, the Kanagawa, May 18, 2012; the Chemical Daily May 2012; the Denki Shimbun, May 22, 2012; Jutaku Shimpo, May 29, 2012)

(3) Hashimoto Sogyo

Hashimoto Sogyo will promote zero energy houses. Having converted their training center into a zero energy building in Shinonome, Taitoku (Tokyo), they attract small and midsize building firms with the package of photovoltaic generator, FC and storage battery among others with a theme of integration of an EV and a house. The package contains 24 polycrystalline photovoltaic cell modules of 190 W output (total 4.56 kW) by Mitsubishi Electric, Ene Farm of Panasonic (1 kW) and lithium ion battery, LiB, of Eliiy Power (2 kWh). Hashimoto Sogyo will also bring in better insulation systems, light-emitting diode (LED) lighting and energy saving photocopiers. (Architectures, Constructions & Engineerings News (Daily), May 22, 2012)

(4) Sekisui House

On May 28th, Sekisui House announced its participation in the "Smart City Leading Model Project" with a model zone development which has energy sharing network between next generation energy saving houses "Smart House" and a shop building with facilities such as a photovoltaic generator in Koshigaya city, Saitama prefecture. The model zone, of approximately 3800 m^2, is to be open in December in an area near the Koshigaya Lake Town station south gate of Japan Railways. The development plan is to build seven smart houses with photovoltaic generators, FCs, storage batteries and HEMS and an energy saving shop building "Smart Shop". (The Nikkei Business Daily, May 29, 2012)

(5) Lemon Gas

On May 28th, Lemon Gas, Hiratsuka city, announced the completion of its energy independent apartment house "ALFY Hashimoto" in Midoriku, Sagamihara city. The apartment house has LPG cogeneration systems, LPG Ene Farm, photovoltaic generator and storage batteries to supply heat. Approximately 70% of electricity is provided as well as most of gas during power cuts and interruption to the coal gas supply due to the independency of LPG. (The Nikkan Kogyo Shimbun, May 29, 2012)

(6) Toshiba

On May 18th, Toshiba and Toshiba Lighting & Technology, Yokosuka city, announced their HEMS complying with ECHONET Lite, the standards for home appliance network, would be available from June 11th. The system allows users to monitor the power of photovoltaic generators and FCs and the consumption of gas and water as well as the remote control and measurement of energy consumption of home appliances following the standards. The individual products are an energy measuring unit and an IT access point which control electronic devices throughout the network. The package of these products "HEMSB Pack 01" is subject to a subsidy of 100,000 yen at installation. (The Nikkan Kogyo Shimbun, the Denki Shimbun, Denpa Shinbun, May 29, 2012)

(7) Tanaka Kikinzoku Kogyo

On May 29th, Tanaka Kikinzoku Kogyo announced that its shipments of catalysts for FCs had marked a record-high. As a result of boosting demands for both automobile and domestic FCs, the shipments of the fiscal year 2011 were 2.4 times that of the fiscal year 2004. More than a 67% increase of the previous year was recorded for the shipments of catalysts with platinum thanks to a brisk demand for Ene Farm of which sales have been also led by the electricity shortage. 5.4 times that of the fiscal year 2004 shows

the upsurge in domestic cogeneration systems. On the other hand, the shipments for FCVs have been slightly dropping since its peak came in 2006 and 1.4 times the increase of the fiscal year 2004 was recorded for the fiscal year 2011. (The Nikkei Business Daily, the Nikkan Kogyo Shimbun, Japan Metal Daily, the Chemical Daily, May 30, 2012; Nikkan Jidosha Shimbun, June 1, 2012)

(8) PanaHome

On May 29th, PanaHome revealed its houses in "Smart City Sakai Hatsushiba" which is a residential area composed of environmentally conscious dwellings in Sakai city to the press. Facilities such as a dual generating system of a photovoltaic generator and a FC were advertised as well as "ECO Mone System" which allows residents to monitor electricity consumption and the amount bought by the utility firm on an indoor screen. The area is planned to have all 58 houses built by November. (The Mainichi Newspapers, the Sankei Shimbun, the Nikkei Business Daily, the Nikkan Kogyo Shimbun, May 30, 2012)

(9) Nishiyama

Nishiyama (Tokyo), a technology developing trading firm, has developed a plastic water tank for domestic FCs as a replacement for stainless steel water tanks. The tank has a three-layer structure of an inside modified-Polyphenyleneether, m-PPE, and outside aliphatic polyamide, PA, bonded together with a newly developed adhesive resin, which makes it light but durable to shocks and scratches. Nishiyama has created an 80 L tank to withstand 80C and 1.2 MPa, and established the technology to produce up to a 150 L container. The significant reduction in weight, which is 11 kg for an 80 L tank, was made by using plastic materials only. Another advantage is that the tank keeps its mechanical property by gluing m-PPE and PA together with the adhesive resin, and lasts at least 4000 hours. Nishiyama plans property evaluations such as an affection of 10 to 15 year usage for commercialization. (The Chemical Daily, June 1, 2012)

(10) Toho Gas

On May 31st, Toho Gas completed its smart energy house "Asparagus House" in its research and development center for studying on efficient way of using energy by controlling a FC, a photovoltaic generator and a storage battery with HEMS using information and communication technology. The demonstration experiment will be carried out from July to the fiscal year 2013 aiming for early commercialization. Toho Gas intends to establish a technology to reduce 63% of the primary energy consumption such as natural gas and oil compared to conventional households. (The Nikkan Kogyo Shimbun, the Chunichi Shimbun, Fuji Sankei Business i, June 1, 2012; Architectures, Constructions & Engineerings News (Daily), June 4, 2012)

7. Cutting Edge Technology of FCVs and EVs:

(1) Intelligent Energy, UK

Intelligent Energy, which is a spin-off company of Loughborough University developing FC systems, will participate in a new project "UKH2Mobility". Gathering three governmental departments, a number of firms such as infrastructural service providers including a coal gas supplier and automakers together, the group works out its action plan for anticipated roll-out to consumers in 2014 to 2015. (The Nikkei Business Daily, May 10, 2012)

(2) Nissan Motor

On May 15th, Nissan announced that an EV "e-NV200" under development with Aeon, a large supermarket chain, would be used for delivery as an operation test. Suitable for short trips taking advantage of EVs' silence, the vehicle will be examined for its practicality as a delivery car. Driving data will be collected around the clock for further development. (The Nikkei, May 16, 2012)

On May 23rd, Nissan announced its Barcelona factory planned to manufacture e-NV200 to supply globally from Spain by the fiscal year 2013. The vehicle, Nissan's second EV after Leaf, is scheduled to be introduced into the market by 2014. The Sunderland plant in UK will produce LiB, a main component, and the Barcelona plant will carry out the assembly. (The Nikkei, May 24, 2012)

On May 29, Nissan installed its system to supply electricity from its EV "Leaf" to a public facility "Oppama Administration Center" of Yokosuka city. Using the vehicles as storage batteries, the system helps to reduce 4%, 6 kW, of the building's electricity consumption in the peak time in summer by providing stored energy in the vehicles as well as an emergency

power source.

On May 30th, Nissan announced that its home power supply system "EV Power Station" would be introduced into the market in mid-June. The home power supply system developed by Nichicon will be sold at Nissan dealers, and Nissan aims for 10,000 units of sales in the first year with the price of approximately 330,000 yen including subsidy. The system charges a vehicle at double the speed of that directly from a socket, and allows a full charge from four hours. The cost saving may be about 4,400 yen in a month by charging the system with cheaper electricity at night. With 24 kWh of storage performance, Leaf supplies electricity for approximately two days to an average house hold. (The Nikkei, May 30-31, 2012)

(3) Daimler, Germany

On May 24th, Mercedes-Benz, a division of Daimler, announced it would start to sell its small two-person EV "Smart". The vehicle is the first EV of Mercedes-Benz and its suggested regular price is about 2.95 million yen. The delivery is expected to start from December. With 17.6 kWh LiB, the car drives more than 140 km on a full charge but takes an only normal charge, no quick charge function. Having started taking orders since last year in Europe, Mercedes-Benz intends to expand its environmentally friendly car sales by appealing its fine design. (The Nikkei, May 25, 2012)

(4) Volkswagen, Germany

Volkswagen plans to introduce its first EVs into the Japanese market by mid-2013. The vehicle will have a CHAdeMO connector for quick charge. Two types, "Up" and "Golf", will be available in Japan. (The Nikkei, May 31, 2012)

8. Technology and Business Plans for Hydrogen Filling Station:

Associate professor Kazuhiro Kajikawa of the Research Institute of Superconductor Science and Systems of Kyushu University developed a pump with superconductor and succeeded transferring liquidized hydrogen under normal pressure with it. The superconducting motor in the pump is the only power required for the transfer. The group developed superconducting motor and liquid-level gauge with magnesium-diboride, MgB_2, which becomes superconductive, with no electrical resistance, in liquidized hydrogen, and demonstrated them with liquidized hydrogen. Composed of these parts, the MgB_2 superconductor pump system sends hydrogen to another container by rotating the motor with an impeller. The liquidized hydrogen was transferred from a metal cryostat to a glass dewar with a driving frequency of 60 Hz and the maximum speed of 6.5 L per minute. Currently liquidized hydrogen is compressed to send from a liquidized hydrogen tank lorry but it may be transferred easier by pressing a button of the pump installed in a tank. The main target for the pump is hydrogen filling stations. (The Nikkan Kogyo Shimbun, May 15, 2012; the Nikkei Business Daily, May 22, 2012)

9. Technological Development of Refining Hydrogen Production

(1) BioHydrogen Technologies

A director of BioHydrogen Technologies (Chigasaki city) Shigeharu Tanisho also known as a professor emeritus of Yokohama National University developed a technology to produce hydrogen efficiently by fermenting glucose, starch and mannitol, a type of alcohol, from larger seaweeds such as kelps and wakame and molasses, a by-product of processing sugar cane. BioHydrogen Technologies prospects to generate electricity with 25 yen per kWh by calculating cost of FC electricity generation with hydrogen produced from molasses, Okinawa's specialty.

"It's highly possible to find more efficient yeast, and fermentation is the closest way to produce large volume of hydrogen." Dr. Tanisho expects. (The Nikkei Business Daily, May 11, 2012)

(2) Kanagawa University

Kanagawa University will start its experiment to produce fuel and chemicals by using the Sun. Hydrogen will be produced by shining sun light into water to be converting it into fuel for FCs and vehicles. The university also plans to develop a medicine from substances created by photosynthetic activity of marine organisms. A catalyst will be developed to help to convert water more efficiently into hydrogen by visible rays which are 40 to 50 % of the sun rays, because the conventional catalysts using ultraviolet rays, which are only 3% of the sun rays, is inefficient.

The material for the catalyst will be metal complex compounds in which metallic atoms are surrounded by carbon and hydrogen atoms. (The Nikkei Business Daily, May 14, 2012)

10. Development of Microbial Fuel Cells, MFCs

Associate Professor Tadashi Hibino of Department of Social and Environmental Engineering of Graduate School of Engineering at Hiroshima University developed a MFC which is a device to generate electricity by collecting electrons from the metabolic activity of microorganisms in sediment. Two electrodes of carbon fiber cloth attached to each end of an insulating pole stuck into sediment sludge, the simple structure allows the production of the device for approximately a few million yen. Firstly, more than 0.4 V of electricity was generated only with sediment by studying shapes of the device and ion exchange. Secondly, red LEDs were successfully lit by 1.7 V with further improvement of adding calcium and iron to sediment. Moreover, a river in Japan was illuminated as an experiment with a few dozens of the MFCs. A larger experiment including clarification of sediment will be carried out in the western part of Japan. Looking for firms to support development and sale, Hibino plans to introduce the MFC by 2013. (The Chemical Daily, May 23, 2012)

11. Green Business Plan

NTT DOCOMO has completed its pilot version of Green Base Transceiver Station using renewable energies such as FCs and storage battery. Green Base Transceiver Station is powered by commercial electricity as well as a photovoltaic generator, a wind generator and a bio-FC which are managed by an electricity controller optimally providing this power with a LiB to lead efficient usage. Beginning its evaluation test in June, 10 Green Base Transceiver Stations will be installed by the end of the fiscal year 2012 for improvement for the full-scale network. (The Nikkan Kogyo Shimbun, June 1, 2012)

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