Development and Social Implementation of Decarbonization Technologies to Contribute to the Realization of Carbon Neutrality◆

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Introduction

It goes without saying that it is necessary to mobilize various technologies to realize carbon neutrality. According to IEA, with a view to achieving net-zero emissions by 2050, CO_2 emissions that needs to be reduced by 2030 can mostly be reduced through the technologies that have already been rolled out in the market. However, about half of the emission reductions required to be achieved by 2050 needs to be reduced further through technologies that are currently in the demonstration or prototyping phases. Our greatest challenge is how we can accelerate the development and social implementation of decarbonization technologies.

The author of this paper served as the moderator for the First Session of the 7th IEEJ/APERC International Energy Symposium, where Japanese and American experts presented their opinions and engaged in a panel discussion on the topic "Development and Social Implementation of Decarbonization Technologies to Contribute to the Realization of Carbon Neutrality".I shall reflect on these discussions in the following sections.

Renewable Energy, Hydrogen

Firstly, Dr. Shigeru Niki (Director General, Sustainable Energy Unit, Technology Strategy Center (TSC), New Energy and Industrial Technology Development Organization (NEDO), Japan) explained that if only existing technologies are used, the marginal abatement cost for reducing global GHG emissions by 80% would be as enormous as approximately US$1,000/ t-$CO_2$. Taking a different angle from IEA's analysis, he pointed out that it is possible to reduce the cost of emissions reduction significantly by introducing more innovative technologies through discontinuous innovation; on other words, he emphasized the importance of technological development.

On top of that, Dr. Niki set out the following points concerning technologies related to renewable energy: (1) solar power; (2) wind power; (3) geothermal energy; (4) electricity storage technologies; and, (5) hydrogen.

(1) The cumulative installed capacity for solar power worldwide in 2020 exceeded 700GW, and annual installed capacity reached 112GW. As there is a limited amount of land suitable for the

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installation of solar power facilities, there are high expectations for the development of new modules that make it possible to install solar power panels on water, farmland, side-walls, and cars.

(2) The International Renewable Energy Agency (IRENA) predicts onshore and offshore wind power generation capacities to reach 5,044GW and 1,000GW respectively by 2050. Japan's offshore wind power vision plans to realize offshore wind capacity of 10GW by 2030, and aims to reduce power generation cost to 8-9 yen/kWh by 2030-2035.

(3) The adoption of geothermal energy is advancing at a pace of 400MW per year, but it now trends to stagnate in Japan. If we could utilize supercritical geothermal energy resources in Japan, we would be able to generate a projected scale of more than 100MW of electricity per region.

(4) Electricity storage technologies are vital in the adoption of variable renewable energy. Storage batteries are suitable for short-cycle variations, while pumped storage generation and hydrogen are suitable for long-cycle variations.

(5) Hydrogen is an important technology in decarbonization as it enables the storage and transportation of a large amount of energy over long distances. However, reducing the cost of CO_2-free hydrogen poses a challenge. To supply hydrogen cheaply, it is essential to lower the cost of mass production to begin with. Hence, one of our options is to produce hydrogen in countries with rich renewable energy resources, and then transport the hydrogen to Japan. Under the current circumstances, there are various issues from the production of hydrogen to its transportation and use. Costs need to be reduced in each area, with water electrolysis devices being a representative example. It is also important to reduce the cost of renewable energy.

Nuclear Power

Mr. John Kotek (Senior Vice President, Policy Development & Public Affairs, Nuclear Energy Institute (NEI), United States of America) presented a report on the nuclear power technology trends in the U.S. Of the total amount of power generated in the U.S. in 2021, 19% was generated by nuclear power. Many power companies have established greenhouse gas reduction targets, and in addition to electricity storage technologies and energy-saving, there is also a need for low-carbon power sources that are cheap and stable. Hence, they are focusing on nuclear power as one of such potential energy sources.

The Biden administration's policy is to significantly increase the capacity of nuclear power generation. Mr. Kotek introduced the Bipartisan Infrastructure Act, which covers a credit program for nuclear power plants that are in operation as well as financial assistance toward advanced reactor demonstrations, and the Build Back Better (BBB) Act, under which the government is reviewing tax deductions for nuclear reactors and clean power generation. The BBB Act was later enacted as the Inflation Reduction Act, which incorporates tax deductions for nuclear power generation (commencing in 2024 and ending in 2032, and allocation US$30 billion over a ten-year period). This can be described as generous support, accounting for approximately 20% (US$160.3 billion over a ten-year period) of the support needed to promote decarbonized power sources.

Various types of nuclear reactors are now being developed in the U.S., including micro-reactors, SMR, high-temperature gas reactors, liquid metal cooled reactors, and molten salt reactors, to name a few. Mr. Kotek introduced the following three examples of projects that are ongoing in the U.S.

(1) A sodium-cooled fast reactor is under development, with support from the Bipartisan Infrastructure Act. Its output is 345MW, and is capable of reaching peak output of 500MW through the storage of liquid sodium.

(2) The pebble-bed high-temperature gas reactor, which was selected for the Advanced Reactor Demonstration Program (ARDP), can produce output of 80MW by using tri-structural isotropic (TRISO) particle fuel. It is anticipated to be a potential industrial heat source as it is operated at high temperatures.

(3) NuScale's pressurized water reactor is made up of 4 or 6 small modular reactors (SMRs) or 12 SMRs, with each module producing an output of 77MW. The total output for 12 SMRs is 924MW. It is possible to adjust total output quickly by adjusting the output of each module.

Furthermore, in order to utilize nuclear power and expand its use, including the aforementioned new types of reactors, it is important to give investors a sense of security. There is also the issue of how to attract financing, and the question of how to ensure the proper implementation of the final disposal of nuclear waste cannot be ignored. Mr. Kotek explained that in introducing new types of reactors, it is essential to develop technologies to make them even safer than existing reactors, and to present thorough explanations so that society can accept such new types of reactors.

Consumers and governments seek low-carbon electricity. Hence, there are growing expectations of nuclear power generation that can supply clean electricity cheaply, and of nuclear power as a source of hydrogen and heat. In addition, the global market is also focusing on nuclear power from the perspective of energy security.

Last but not least, with regard to nuclear power and the need of reducing dependency on Russia in the face of the Ukraine crisis, the U.S. also depends on Russia in some aspects of nuclear fuel supply, such as resource production and fuel manufacturing. In this respect, Japan-U.S. cooperation should be an effective countermeasure. Also, Europe's nuclear power supply-chain somehow depends on Russia, and the need to change suppliers is likely to emerge in the future. When that happens, the Japanese and U.S. nuclear industries will be required to play an even greater role, and it will present a good opportunity for both countries.

Carbon Capture, Utilization and Storage (CCUS)

Mr. Yoshikazu Kobayashi (Senior Economist, Manager, CCUS Group, Fossil Energies & International Cooperation Unit, IEEJ, Japan) presented a report on Japan's initiatives in the areas of carbon capture and utilization (CCU) for using CO_2, and carbon capture and storage (CCS) for storing CO_2.

Mr. Kobayashi explained the following points with regard to CCU.

(1) Among the various CCU methods, Japan is putting effort into carbon recycling, which involves manufacturing products by chemically changing CO_2. Carbon recycling technologies include converting plastics and chemical fibers into raw materials, manufacturing of synthetic fuels known as "e-fuels," and mineralization to enable the absorption of CO_2 into concrete or other materials.

(2) The government has announced its roadmap for carbon recycling technologies. By 2030, it will promote the adoption of relatively cheap technologies that do not use hydrogen, such as mineralization technology. By 2040, it aims to introduce technologies such as synthetic fuels, which require high costs but are also highly effective in reducing emissions. To introduce these technologies, the government will provide support by utilizing the Green Innovation Fund of 2 trillion yen. Carbon recycling products cost more for the same quality, so creating a market to evaluate their environmental value is an issue.

He explained the following points with regard to CCS.

(1) Japan stored 300,000 t-CO_2 at Tomakomai in Hokkaido from 2016 to 2019. By 2024, it plans to conduct demonstration experiments of transporting the CO_2 generated by multiple domestic coal-fired power generation plants by ship, and storing them.

(2) The government has also formulated a roadmap on CCS. It plans to commence the operation of CCS by 2030 with a view to storing 120 – 240 million t-CO_2 in 2050. To realize the full-scale adoption of CCS, there is a need to establish laws and regulations concerning CCS. There is an increasing number of CCS projects by individual corporations in Southeast Asia and Australia, so there is also the prospect of transporting and storing CO_2 overseas in the future.

(3) Concerning the social acceptance of CCS, it is important to encourage acceptance by thoroughly explaining the importance of CCS. When doing so, it is also necessary to explain the vital need of CCS in order to fill the gap between the climate change targets and what can be achieved in practical terms by building upon existing technologies. Also, regions where petrochemical industries have been the mainstay will lose their economic infrastructure for the future. By reconsidering CCS as a green industry, however, they can potentially transform their economic base, changing it to the CCUS industries.

Furthermore, Mr. Kobayashi explained the following points that CCU and CCS have in common.

(1) The Asia CCUS Network was established to share knowledge about CCUS, and it has built an international CCUS network comprising 13 national governments and more than 200 corporations. To deploy CCS/CCUS technologies, we face the challenges of reducing costs, monitoring storage, introducing measurement and verification systems, and securing storage locations in Japan.

(2) As for the question of where to capture CO_2 from, it is important to prioritize and narrow down the targets for carbon capture. If we were to regard CCUS as a last resort, it seems effective to use it in hard-to-abate industries. It is inefficient to introduce both CO_2 capture and ammonia co-firing in coal-fired thermal power, so it is likely that only one of the two will be adopted.

Conclusion

While we could not cover all the technologies in this session, I think we were successful in holding in-depth discussions on renewable energy, hydrogen, nuclear power, and CCUS. With regard to technological development, we can say across the board that there is a need to first explore the potential of a wide range of technologies from a technology-neutral perspective, without trying in vain to decide on the winner. In promoting new technologies, the predictability of investments is an important point. Under the current circumstances, in order to promote hydrogen despite its high cost, it is also necessary to put in place measures to reduce the risks to business operators, such as the Contract for Difference (CfD) scheme implemented in the UK. In the U.S., in addition to the government's proactive stance toward nuclear power, the Congress has also demonstrated rare bipartisan support, which in turn provides nuclear power developers with a sense of security. Even if the Inflation Reduction Act included support measures for nuclear power generation, if there were any risks of project cancellations due to changes in the administration, it seems highly unlikely that any developers will decide to make huge investments in nuclear power. Furthermore, with regard to new types of reactors and new technologies such as CCS, it is extremely important to ensure social acceptance for promoting their widespread adoption.

Writer's Profile

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Mr. Sakamoto worked for policy planning and implementation on energy, climate change and industry competitiveness for 30 years at the Ministry of Economy, Trade and Industry or METI, the Japanese Government. After leaving the METI, he engaged in renewable and hydrogen energy businesses at two private companies, and thereafter was appointed to the current position in June 2020.