Series "Ushering in a New Era of Carbon Neutrality" (7)

Will Hydrogen be the Trump Card for the Realization of Decarbonization?

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Expectations for hydrogen

Hydrogen is a colorless, odorless gas, and is the lightest among all the elements. While there are vast quantities of hydrogen on Earth, most of it is present not in the form of hydrogen itself but combined with oxygen (O) in the form of water (H_2O). Hydrogen was discovered by a British chemist about 250 years ago. Since then, it has been used across a wide range of applications, for example as the gas for making balloons and airships float, in the synthesis of ammonia for use as a raw material for fertilizers, and the refining of petroleum products and production of fats and oils.

Today, amid the trend of decarbonization, hydrogen has come into the limelight as a form of energy that is vital for the realization of a carbon-neutral society. It is highly rated for its properties of not emitting carbon dioxide (CO2) during use, and its relatively higher calorific value per unit mass when compared to fossil fuels.

In addition, hydrogen can be produced from various resources using a wide range of methods, and some of these methods do not emit CO_2 in the production process. A specific example involves harnessing renewable energy as electricity in the process when water is electrolyzed to extract hydrogen. The hydrogen that is produced through this method is known as "green hydrogen." On the other hand, hydrogen that is produced from fossil fuels, such as natural gas and coal, is known as "grey hydrogen" when the CO_2 generated from this production process is released into the atmosphere, and as "blue hydrogen" when this CO_2 is captured and stored. Most of the hydrogen currently produced in the world is grey hydrogen, but there are growing moves, particularly in Europe, to popularize green hydrogen to achieve carbon neutrality.

There are also growing expectations for hydrogen to play an important role for storage and transportation. Variable renewable energy, such as wind power and solar power, presents a challenge as it is unable to provide a stable power supply corresponding to demand. To address this problem, there are ongoing efforts to develop energy storage technologies such as storage batteries. It is possible to ensure stable supply by storing renewable energy. This can be achieved by converting surplus electric power from renewable energy into hydrogen through water electrolysis. Moreover, converting renewable energy to hydrogen also makes it possible to transport renewable energy in areas that are far from the areas of demand, without being constrained by the limitations of the power grid.

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Hydrogen strategies of various countries

Amid the rising expectations for hydrogen, many countries are formulating hydrogen strategies that set out the policy and measures toward the active utilization of hydrogen. Among these, Japan has moved ahead of other countries to establish a national strategy on hydrogen.

Japan unveiled the Strategic Roadmap for Hydrogen and Fuel Cells in June 2014 and formulated the Basic Hydrogen Strategy in December 2017, setting out the country's comprehensive policy for hydrogen. It aims to achieve the goals of building an international hydrogen supply chain and establishing hydrogen production technologies for obtaining hydrogen from domestic renewable energy sources by 2030. The plans also set out measures to realize costs that are on par with gasoline and liquefied natural gas (LNG). The Strategy for Developing Hydrogen and Fuel-Cell Technologies, formulated in September 2019, identifies the priority areas for promoting technological development.

In Europe, hydrogen strategies were announced successively by various countries in 2020 (Figure). Germany established the goal of reaching a hydrogen production capability of 5GW by 2030 and 10GW by 2040 for hydrogen derived from renewable energy, through the introduction of water electrolysis equipment. It is also putting in place measures such as providing subsidies to water electrolysis-based hydrogen production facilities as an incentive to produce green hydrogen, and exemption from renewable energy taxes and levies on the renewable energy that is required in the process of generating green hydrogen. France has set out the goals of installing 6.5 GW of water electrolysis equipment by 2030, as well as promoting an annual green hydrogen production volume of 600,000 tons.

In July 2020, the European Commission unveiled its Hydrogen Strategy and Energy System Integration Strategy. This Hydrogen Strategy divides the timeline from 2020 to 2050 into three phases and sets out targets for each of the phases, such as the capacity and number of water electrolysis equipment installed and green hydrogen production volume. Furthermore, it also sets out measures to support the expansion of investment and hydrogen demand, as well as measures to strengthen cooperative relations with neighboring countries in hydrogen-related areas. The Energy System Integration Strategy establishes initiatives toward achieving carbon neutrality in sectors such as electricity, gas, and heating. It also presents the stance of shifting toward decarbonization for the whole of the energy system by supplying green hydrogen to sectors such as the steel and chemical industries, which face technological challenges in realizing decarbonization through electrification. These strategies reflect its aim of advancing decarbonization by popularizing renewable energy in a cross-sectoral manner, while using hydrogen as the medium.

Challenges in aspects such as production cost and transportation

While ambitious hydrogen strategies are being established by various countries, there are also wide-ranging challenges that need to be overcome to achieve the practical application of hydrogen in society. The first is production cost. Hydrogen retail price at hydrogen stations in Japan is set at 100 yen/Nm^3 based on the policy, but there is a need to reduce costs significantly to popularize hydrogen. The Government of Japan has set out the target hydrogen retail price for imported hydrogen at 30 yen/Nm3, which it aims to achieve by 2030, but there is a long way to go before hydrogen can secure cost competitiveness against natural gas and LNG prices. Particularly in the case of producing green hydrogen, the key lies in reducing the cost of electricity generated from renewable energy sources, and in scaling up and enhancing the efficiency of water electrolysis equipment.

The second challenge is transportation. In the case of transportation by pipelines, the small atomic radius of hydrogen means that it could leak easily, and this, in turn, gives rise to high costs in laying and maintaining pipelines. On the other hand, there are also other methods including compressing or liquefying hydrogen or converting it to organic hydride, ammonia, or methane for transportation. For each of the methods, technological development and demonstration projects are ongoing in various parts of the world. However, as each method has its advantages and disadvantages, there is a need to review the respective methods based on factors such as the conditions at the site of production, means of utilization in the areas of demand, and existing infrastructure.

Other challenges include the need to review regulations related to the use of hydrogen as well as the need to develop infrastructure. It is to be hoped that the public and private sectors will work together on initiatives to overcome these challenges.

[Figure] Hydrogen strategies of key European countries

Announced in	Country	Overview
April 2020	Netherlands	To introduce 500 MW of renewable energy-based water electrolysis equipment by 2025, and 3 – 4 GW of equipment by 2030. While the focus is on green hydrogen in the long-term, it aims to utilize a certain amount of blue hydrogen in the short- to medium-term while reducing the cost of green hydrogen.
May 2020	Portugal	To introduce 2 – 2.5 GW of renewable energy-based water electrolysis equipment by 2030. It will invest 7 billion Euros into expanding the use of hydrogen and exporting hydrogen to other European countries.
June 2020	Germany	To introduce 5 GW of renewable energy-based water electrolysis equipment by 2030, and 10 GW of equipment by 2040. While it is prioritizing the popularization of green hydrogen, blue hydrogen will also be utilized where necessary.
June 2020	Norway	Emphasis will be placed on the utilization of blue hydrogen as well as green hydrogen. It will promote the use of CO2 capture and storage technology (CCS) for blue hydrogen.
September 2020	France	It aims to introduce 6.5 GW of water electrolysis equipment by 2030, and to achieve annual green hydrogen production of 600,000 tons. The assumption is to produce green hydrogen using renewable energy and electricity generated through nuclear power.

Source: Prepared by the author based on the “Interim Report on the Future Issues of the Hydrogen Policy and Direction of Response (Draft)” by the Agency for Natural Resources and Energy, Ministry of Economy, Trade and Industry, and other publicly available materials.

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