Series "Ushering in a New Era of Carbon Neutrality" (8)

New Technologies that Contribute to Carbon Dioxide Reduction

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Technologies that reduce the carbon footprint of fossil fuels

The progression of global warming is the result of carbon dioxide (CO_2) from fossil fuels being released into the atmosphere. In short, even if fossil fuels are used, it is possible to suppress global warming by preventing the emission of CO_2 into the atmosphere. Carbon capture and storage (CCS) is a technology developed based on this concept. This is a form of technology that captures CO_2 from power plants and industrial plants that use fossil fuels (such as steelmaking blast furnaces and cement plants), then stores it underground.

By harnessing CCS technology, it is possible to continue using conventional power generation and industrial facilities while reducing their carbon footprint. For example, if CCS is used in thermal power generation fired by coal or natural gas, it would be possible to reduce net CO_2 emissions from the power plants by as much as 80% to 90%. While hydrogen is drawing attention as an energy source for the realization of a carbon-neutral society, CCS is still vital for the production of hydrogen from fossil fuels. CCS has the potential to contribute to a wide range of sectors, including electricity, hydrogen, and industries.

There is a wide variety of technologies that can be used to capture CO_2 (Figure). Some representative methods are chemical absorption and physical absorption that make use of CO_2 absorbents, and membrane separation that uses a membrane for the selective permeation of CO_2. The characteristics of the gases that contain CO_2 (such as composition, CO_2 concentration, gas pressure) vary depending on the plant, so a suitable method is selected based on these characteristics.

Storage methods can be broadly categorized into the following: underground storage, in which CO_2 is pushed under the ground including in sea areas; dissolution at intermediate depths, in which CO_2 is dissolved in the ocean; and, seabed storage, in which liquid CO_2 is poured into deep-sea depressions. Of these, dissolution at intermediate depths and seabed storage are not accepted for practical purposes based on the London Convention, which is international law on marine pollution. For this reason, CO_2 storage methods are limited to underground storage.

Concerning underground storage in Japan, storage in the aquifer deep underground (a method that seals CO_2 in the ground by using, as a cover or "lid," strata that does not allow water or gas to pass through) has potential from a quantitative point of view. While there is a need to conduct a detailed study of the individual storage reservoirs, the storage potential

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in sea areas at a depth of 1,000 m or below is estimated to be 236 billion tons of CO_2 equivalent (about 200 years' worth of Japan's recent CO_2 emissions). The Government of Japan plans to select a suitable site around 2021.

In addition, proposals have also been made to store CO_2 by using CO_2 hydrate (a sherbet-like state consisting of CO_2 and water). This is a method that artificially generates CO_2 hydrate in the ground and stores it in solid state, while at the same time using that as a cover to seal in liquid CO_2 in the substratum. Operators in the private sector are engaged in research and development on this method, including power source development. As this method is not dependent on the geological structure of the ground and can also be applied to shallow strata, it is expected to deliver benefits in aspects such as increasing storage potential and reducing cost.

Possibility of lowering the average temperature of the world

Carbon neutrality is achieved when the emissions volume of greenhouse gases (GHG) corresponds to the volume of such gases that are absorbed or removed from the atmosphere, and fossil fuel-based CCS contributes to reductions in the emissions volume. In addition to the reduction of emission, CCS can also be applied to the removal of CO_2 from the atmosphere. From this perspective, it is increasingly coming under the spotlight.

CO_2 removal technology is also known as "negative emission technology." Specific examples include bioenergy with carbon capture and storage (BECCS), which combines biomass fuels with CCS, and direct air carbon capture and storage (DACCS), which combines direct air capture (DAC) with CCS. BECCS works in the following way: while biomass (such as plants) absorbs CO_2 in the atmosphere as it grows, if CCS is applied after the combustion of biomass, it will be possible to isolate this CO_2 that was absorbed from the atmosphere during the growth process, and store it in the ground. DACCS works in a similar way. DAC is a form of technology for capturing CO_2 from the atmosphere, so if this CO_2 were stored, it would effectively be removed from the atmosphere.

If methods such as BECCS and DACCS can be applied, it would be possible to offset the emissions from processes that cannot avoid releasing GHG. They could provide the solution in situations where alternatives are not viable, for example, in the case of fossil fuels that are used as raw material for chemical products (CO_2 is generated when the fossil fuels are incinerated as waste). Furthermore, if countries around the world were able to go beyond carbon neutrality to achieve "negative emissions," it would be possible to lower the average temperature of the world.

Challenges to CCS in Japan

The implementation of fossil fuel-based CCS, BECCS, and DACCS in Japan faces two common issues.

The first is the uncertainty of domestic storage capacity. There is a need to conduct a careful study into storage potential in the future, and there are factors that place constraints on expanding storage capacity, such as the number of rigs for excavating injection wells.

The second challenge lies in the legal system. For example, Japan currently only permits storage in underground strata for CO_2 recovered through the chemical absorption method (in accordance with the Law Relating to the Prevention of Marine Pollution and Maritime Disaster). Hence, there is a need to enable the use of a wide range of carbon capture technologies through the amendment of laws and other measures.

In addition, there are also challenges that are specific to each type of technology. Firstly, fossil fuel-based CCS is not a zero-emission method. Currently, it is possible to capture about 90% of the CO_2 generated from fossil fuels, so a part of the CO_2 generated is still released into the atmosphere even if CCS is utilized. As such, there is a need to offset the CO_2 that is emitted in order to progress toward a carbon neutral society. Next, the implementation of BECCS is constrained by the amount of biomass resources available in the country. If there are insufficient biomass resources in the country, importing biomass could be an option. However, it will be necessary to make use of biomass that was produced appropriately from the viewpoints of land use and the protection of ecosystems. As for DACCS, the development of DAC technology is still a work-in-progress. In Japan, DACCS was selected as one of the projects under the Moonshot Research and Development Program last year, and there is much uncertainty about cost levels in the future. Moreover, capturing CO_2 from atmosphere that has low CO_2 concentration consumes a large amount of energy, which in turn makes it necessary to procure low-carbon energy for that purpose.

In order to expand and popularize CCS in Japan, it will be important to overcome these challenges, and at the same time, consider a wider range of options going forward. For example, in the case of fossil fuel-based CCS, in addition to storage in Japan, there is also the possibility of transporting and storing CO_2 at suitable sites overseas, such as in oil/gas-producing countries. Furthermore, since CO_2 reduction is equally effective at any place on Earth, it would be economically rational to carry out BECCS or DACCS intensively at suitable sites overseas (such as countries that have rich biomass resources and are suited to CO_2 storage, or countries with low energy prices and are suited to CO_2 storage). Hence, there is a need to formulate strategies with a broad outlook without focusing overly on domestic implementation, and to design systems and put in place measures toward the realization of these strategies.

[Figure] Main carbon capture and storage technologies

Category	Main technologies
CO_2 capture	・CO_2 capture at plants, etc. that use fossil fuels or biomass fuels: Chemical absorption, physical absorption, membrane separation, solid absorption, physical adsorption, cryogenic separation ・CO_2 capture from the atmosphere: Direct air capture (Note)
CO_2 storage	・Underground storage: Storage in the aquifer, CO_2 hydrate storage,

	storage in depleted oil and gas fields, storage in coal seams ・Dissolution in intermediate strata ・Seabed storage

Note: A number of methods have been proposed in relation to direct air capture technology, and technological development is underway.

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