Life-cycle CO2 circulation of direct air capture and methanation: an input-output analysis

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Direct air capture is one of the future technologies that can reduce carbon dioxide from the atmosphere. Synthetic methane can be produced using methanation technology with carbon dioxide captured from the atmosphere and green hydrogen; since synthetic methane produced from captured CO2 possesses carbon reduction value, replacing LNG with this methane enables end-users to achieve zero CO2 emissions. Focusing on Cryo-DAC, a CO2 capture technology that uses the cold energy of LNG currently being developed by Nagoya University and Toho Gas Co., Ltd., we measure the life cycle CO2 emissions when producing synthetic methane mainly using an input-output model.

Cryo-DAC is a method for capturing CO2 from the atmosphere by absorbing it into a chemical absorption solution. However, while other DACs capture CO2 by heating the CO2-containing absorption solution, Cryo-DAC uses the cold energy of LNG to solidify the CO2 into dry ice, which is then captured using the resulting pressure difference. This eliminates the need for energy input during the CO2 capture process. This makes it highly energy efficient and is therefore expected to produce low CO2 emissions.

Furthermore, we consider a process for producing synthetic methane using CO2 captured by Cryo-DAC and green hydrogen as materials. Since synthetic methane is used as a raw material for city gas, CO2 is released back into the atmosphere upon consumption, thereby completing a CO2 circulation system. Because this synthetic methane is made from CO2 captured from the atmosphere, which is released back into the atmosphere upon consumption, CO2 emissions can be reduced to zero by using the synthetic methaneâ€”in other words, it is CO2-neutral. In reality, a certain amount of CO2 is emitted due to the energy input and capital goods production required to maintain this circulation system. To determine this magnitude, we calculate the lifecycle CO2 emissions.

There are two optional methods of Life cycle CO2 emissions how to aggregate and accumulate data; process based approach and economic input-output approach. The former is a bottom-up approach that compiles the inputs and outputs of energy and materials at each individual process, from the extraction of raw materials to disposal. It is highly accurate but requires a great deal of effort to collect the data. The latter is a top-down approach that uses national statistical data and other data to calculate environmental impact from economic activity (based on monetary value). While it is easy to cover the entire supply chain, it is characterized by the difficulty of grasping detailed differences at the individual product level.

Here, we use the CO2 emission coefficients from the 3EID database, developed by the National Institute for Environmental Studies, and 2020 Input Output table, both of which are the latest in the available ones in Japan. Since the emission coefficients of input-output tables are based on monetary amounts, it is necessary to consider price changes between the base year and the analysis year. Here we consider price changes by sector from the base year to analytical year. We discuss the characteristics of LC-CO2 emissions of our CO2 circulation system with Cryo-DAC and methanation.

In addition, we consider future changes in the input coefficients and direct CO2 emission coefficients in two sectors; â€œelectricityâ€• and â€œiron and steel,â€• which have high CO2 emissions. According to their decarbonization scenario, we consider their future impacts on the CO2 emissions of our circulation system.