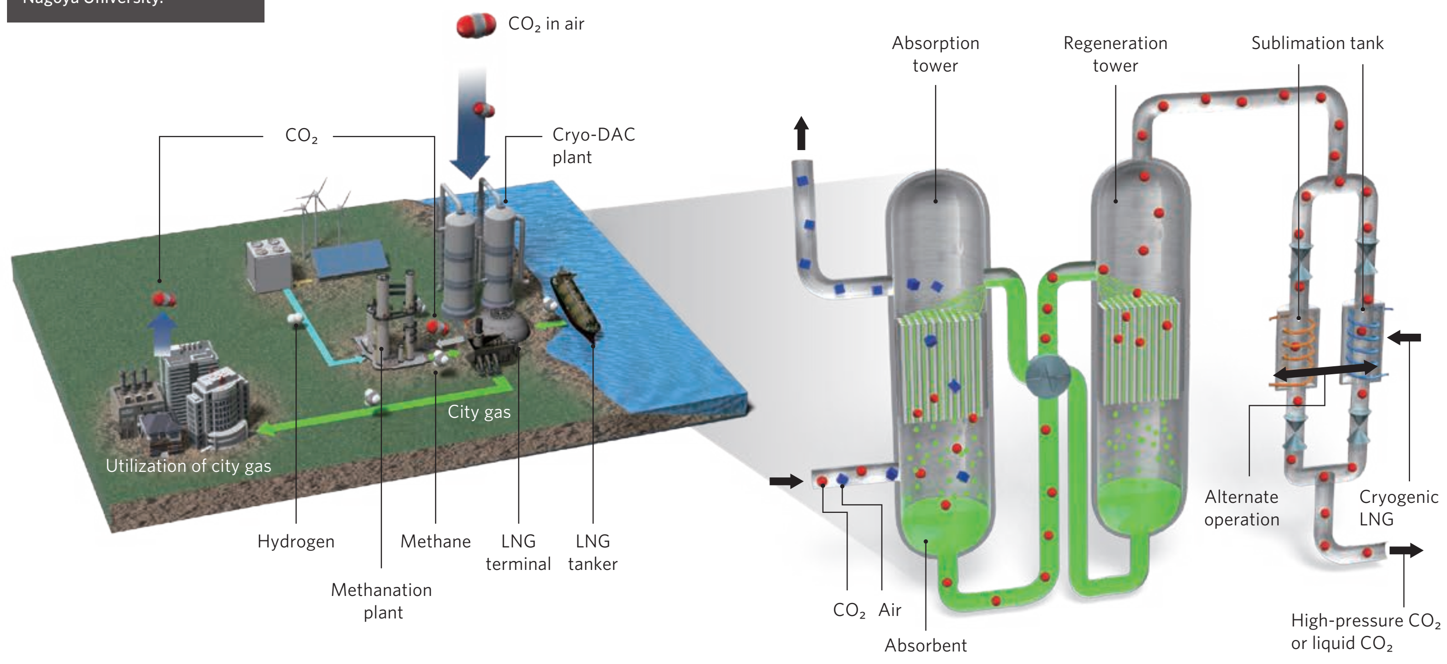
ADVERTISEMENT FEATURE

Making direct air capture more efficient

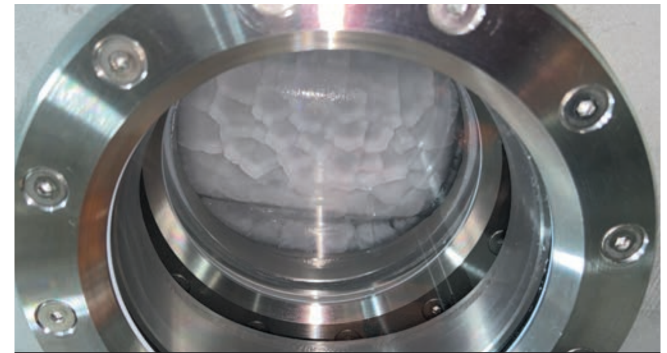
A new process for turning atmospheric carbon dioxide desorbed from an absorbent into dry ice **REDUCES THE ENERGY INPUT NEEDED FOR CARBON CAPTURE**.

Diagram depicting the carbon cycle (left) of Cryo-DAC (right), the direct air capture technology developed by researchers at Toho Gas and Nagoya University.

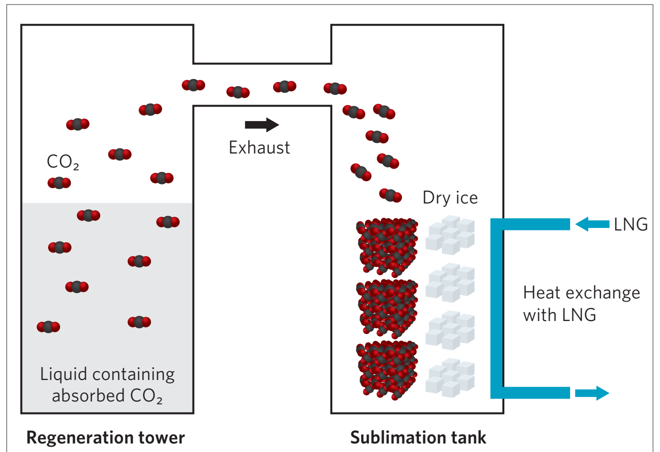


Carbon cycle of Cryo-DAC

Schematic diagram of Cryo-DAC



Photograph of dry ice in the sublimation tank.



Schematic diagram of the cryopump used in Cryo-DAC.

Carbon capture is playing an increasingly prominent role in plans to combat climate change. A new process for direct air capture, which involves capturing carbon dioxide (CO_2) from the atmosphere, promises to greatly enhance the efficiency of the technology.

"Direct air capture has great potential for removing CO_2 from the atmosphere on massive scales," says Soichiro Masuda at the R&D/Digital Division of the Japanese energy-provider Toho Gas. "And it has evolved rapidly in the past several years."

"DIRECT AIR CAPTURE TECHNOLOGY IS A KEY PART OF OUR CORPORATE STRATEGY"

Direct air capture complements other technologies that capture carbon from industrial emissions, but the lower levels of CO_2 in atmospheric air make it considerably more challenging. "Efficiency has continued to be a challenge for direct air capture, as the steps that isolate CO_2 from atmospheric air require the input of energy," says Masuda. "Burning fossil fuel to provide the energy input ends up creating more carbon emission for the sake of capturing carbon."

"Direct air capture technology is a key part of our corporate strategy to reach carbon neutrality by 2050," says Masuda. Now, Toho Gas and Nagoya University, have started research and development into realizing carbon neutrality and have devised a way to largely overcome the problem of capturing carbon with an improved direct air capture technology called Cryo-DAC.

NO NEW INFRASTRUCTURE NEEDED

A key advantage of recycling carbon by Cryo-DAC is that it can use existing infrastructure such as ports for ships that transport liquefied natural gas, along with the associated infrastructure used to prepare city gas for industrial and household use. Natural gas is imported in liquefied form at about −162 degrees Celsius. Japan is one of the world's major importers of liquefied natural gas, accounting for nearly 20% of global imports.

"Ever since Japan first imported natural gas in 1969, we've been exploring ways to exploit the cold energy of liquid natural gas," explains Masuda. "We think we've finally found a solution." Liquefied natural gas is vaporized by exchanging heat with seawater; the cold energy generated in this exchange is used for industrial purposes such as liquefying industrial gases. Large amounts of the cold energy, however, was wasted.

Cryo-DAC uses cold energy, thereby minimizing the thermal energy needed for the process. Of the various types of direct air capture being developed worldwide, Cryo-DAC employs a method that captures and isolates CO_2 with chemical absorbents. "The scalability of the chemical absorption method is well suited for collecting massive amounts of CO_2," says Masuda. "This involves collecting atmospheric air, absorbing CO_2 in a solvent, and then isolating the CO_2 from the solvent. This last step, however, requires large amounts of heat, creating carbon emission."

USING DRY ICE TO CREATE A VACUUM

The research team designed a new process that has a chamber in which CO_2 is sublimated into dry ice by using the cold energy of liquid natural gas. The new chamber is connected to another in which CO_2 is absorbed in solvent; the phase change from CO_2 to dry ice lowers the pressure inside, which causes the solvent and CO_2 to evaporate. "As a result, CO_2 can be recovered from the solvent at near room temperature, minimizing the thermal energy needed," explains Yoshito Umeda, a professor at Nagoya University.

The output of Cryo-DAC is high-pressure CO_2 gas. Toho Gas plans to use the captured CO_2 as a raw material for city gases that the company provides to its customers. "High-pressure CO_2 is needed to produce methane, the main component of city gas, that can be obtained by reacting CO_2 and hydrogen. While CO_2 for methanation is typically prepared with compressors, Cryo-DAC has the potential to separate CO_2 from air and generate high-pressure CO_2 at low cost. Although city gas leaves a carbon footprint when burned, direct air capture with Cryo-DAC could offset these emissions," says Masuda. "The International Energy Agency predicts that the demand for natural gas will continue to increase until 2050, unlike other major fossil fuels like oil or coal. We thus see Cryo-DAC as a key part of future gas infrastructure with net-zero carbon emission."

The research is now a part of Japan's Moonshot Research and Development Program, the Cabinet Office's initiative to fund high-risk, high-impact research projects. The team includes collaborators at Tokyo University of Science, Chukyo University and the University of Tokyo, who are enhancing the materials and processes used in Cryo-DAC. The group is currently developing a solvent with higher absorption capabilities, as well as trying to achieve a continuous flow from CO_2 sublimation to the output of high-pressure CO_2. The aim is to establish the core technology by 2022 so that the system can operate continuously with a capacity of 1 tonne of CO_2 per year in 2024. The group also aspires to design equipment for commercial use, and create detailed plans for implementing the system in a real-world setting by 2029.

"By using existing infrastructure for gas-consuming appliances and pipelines, we expect to transition smoothly to carbon neutrality without imposing a significant burden on our customers or the wider society," says Masuda. ■

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