Research and Development Toward Saving Energy for Direct Air Capture With Available Cold Energy

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Implementing organizations : Nagoya University, Toho Gas Co., Ltd., Tokyo University of Science

R & D contents and goals

R & D contents		Outlines	Goals by FY2029	Organization
①Developing basic technology		(omitted)		Nagoya University
②Developing bench plant and pilot plant	Selection of steel type for sublimation tank	(omitted)		Tokyo University of Science
	Developing technology to **monitor the soundness of the sublimation tank**	● Selecting and evaluating sensors that can be used repeatedly under low-temperature & low-pressure / room temperature & high-pressure	● Completing development of a system to monitor the soundness of the sublimation tank for the pilot plant	Toho Gas (re-entrusted to the University of Tokyo)
③Developing a system for society	**Assessing economic and environmental friendliness**	● Building a model for process simulation ● Assessing energy, exergy and cost ● Evaluating parameters and optimizing the process	● Completing design of equipment for commercial use ● Extracting issues for introducing the system to society	Toho Gas (re-entrusted to the University of Tokyo and Chukyo University)
	Life cycle assessment of carbon cycle on Cryo-DAC	● Developing an method to assess influences for domestic environment and economy	● Completing assessment of carbon cycle	Toho Gas (re-entrusted to Chukyo University)

Main achievements

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The system that evaluates sensors to monitor the soundness of the sublimation tank at low-temperature has been developed.

Cryo-DAC process has been modeled. In addition, energy needed for Cryo-DAC and the environmental friendliness has been assessed.

Developing technology to monitor the soundness of the sublimation tank

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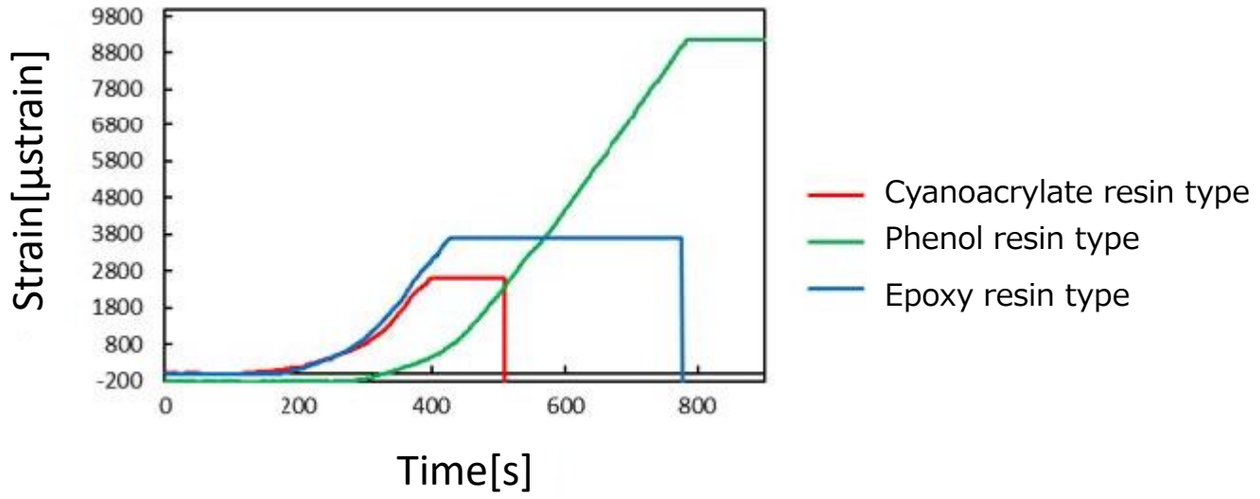
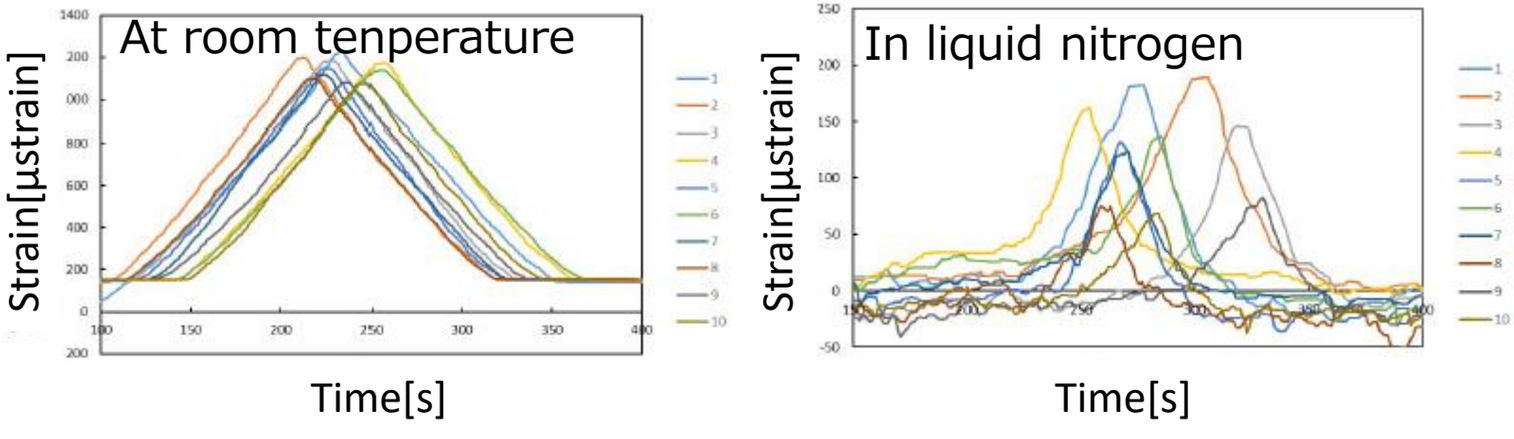
- Equipment that can evaluate a tensile test in liquid nitrogen has been established.
- Performance of candidate sensors, materials and structures has been evaluated at low-temperature under stress.

✓ A glue for strain sensor, Phenol resin type, has been selected.



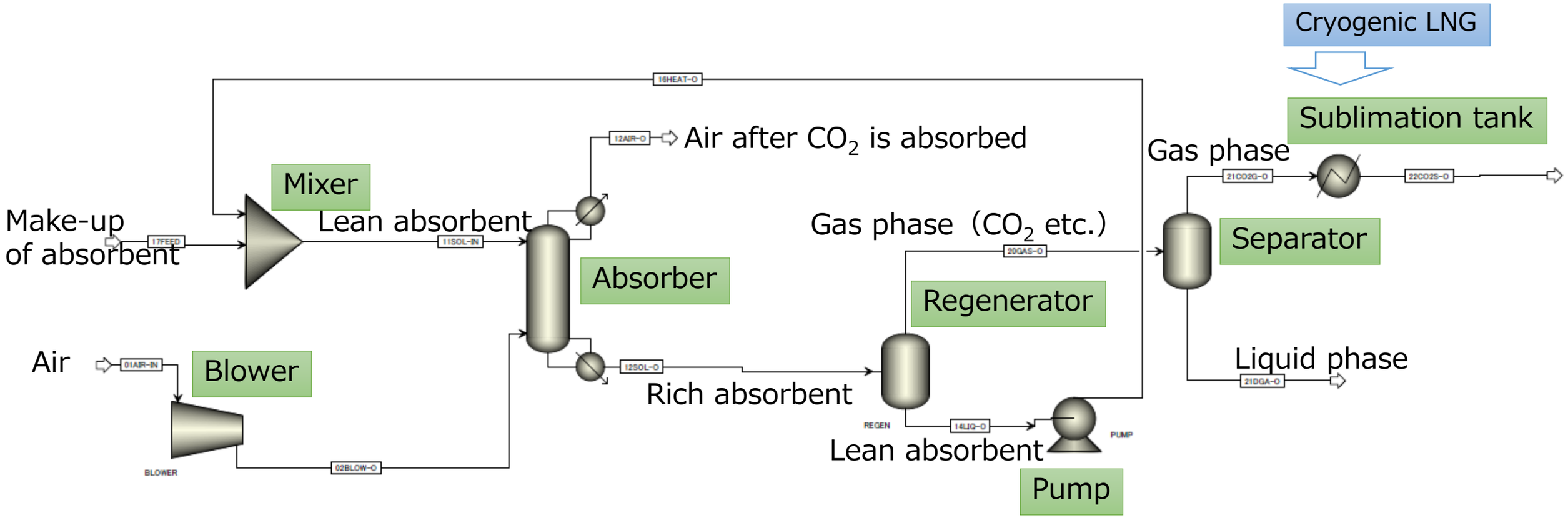
✓ That a strain sensor works in liquid nitrogen has been confirmed.



Strains of a strain sensor on repeated tensile test
(Experimental condition: strain 0.01 x 10 times)

Process simulation

- Cryo-DAC process (process flow diagram and the characteristic of absorbent) has been modeled by a process simulator, Aspen Plus.
  - The absorption and regeneration system is a general flow.
  - The sublimation tank where CO_2 turns into dry ice is put after regenerator.
  - The separator is put between the regenerator and the sublimation tank to separate the solvent.



※Rich absorbent: absorbent where CO_2 is absorbed
※Lean absorbent: regenerated absorbent

Process simulation calculation conditions & results

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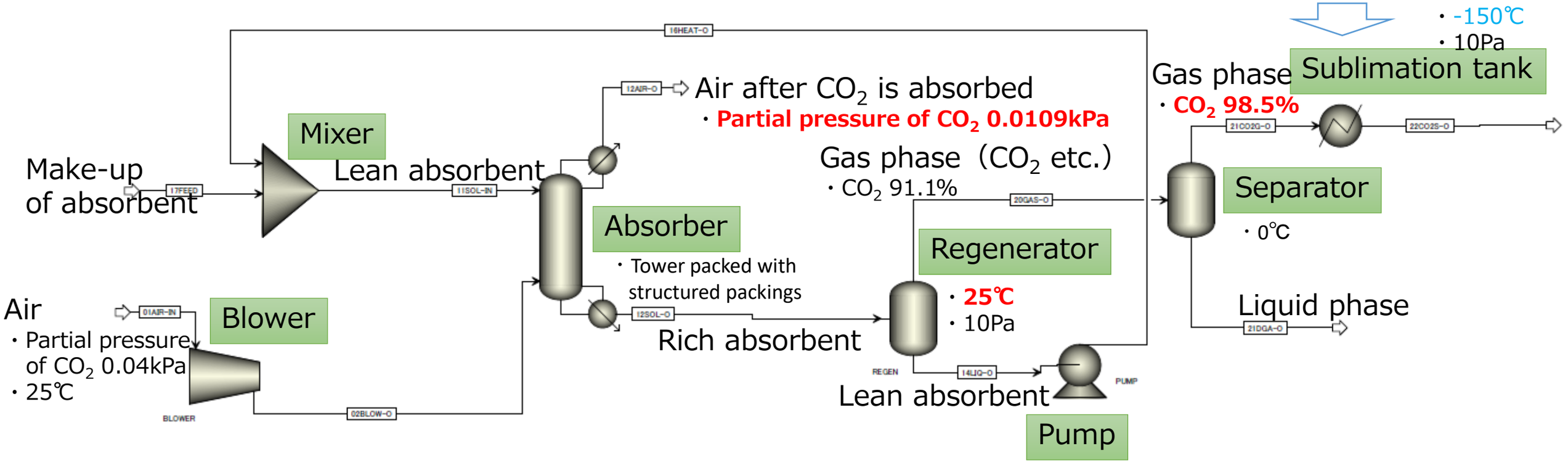
- Cryo-DAC process has worked under **the regeneration temperature of 25℃.**
- **CO_2 recovery ratio: 73.1%** (Equilibrium assumptions, 75%, has been mostly achieved)
- CO_2 concentration after recovery: 98.5%



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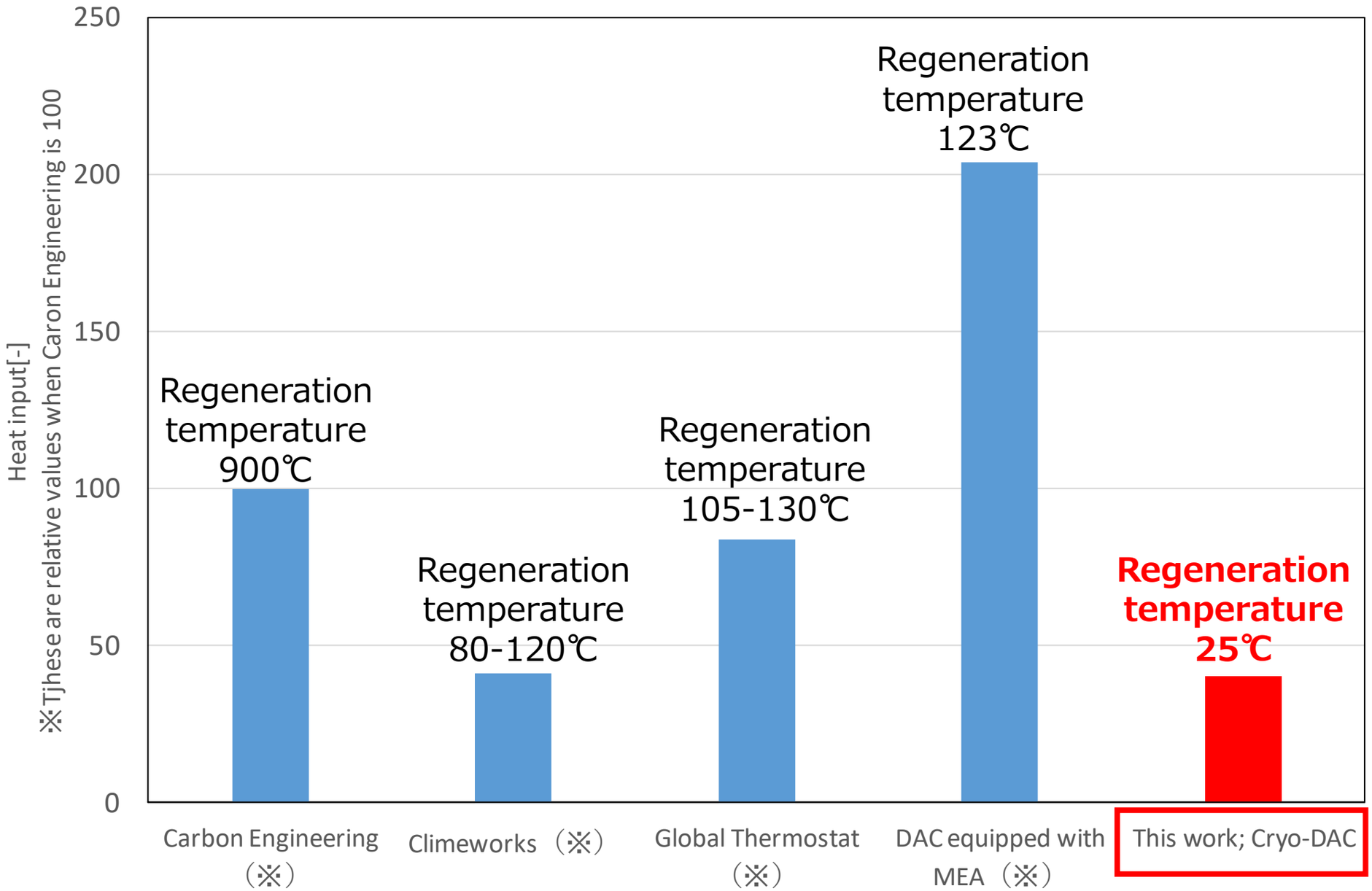
Comparing with preceding DAC

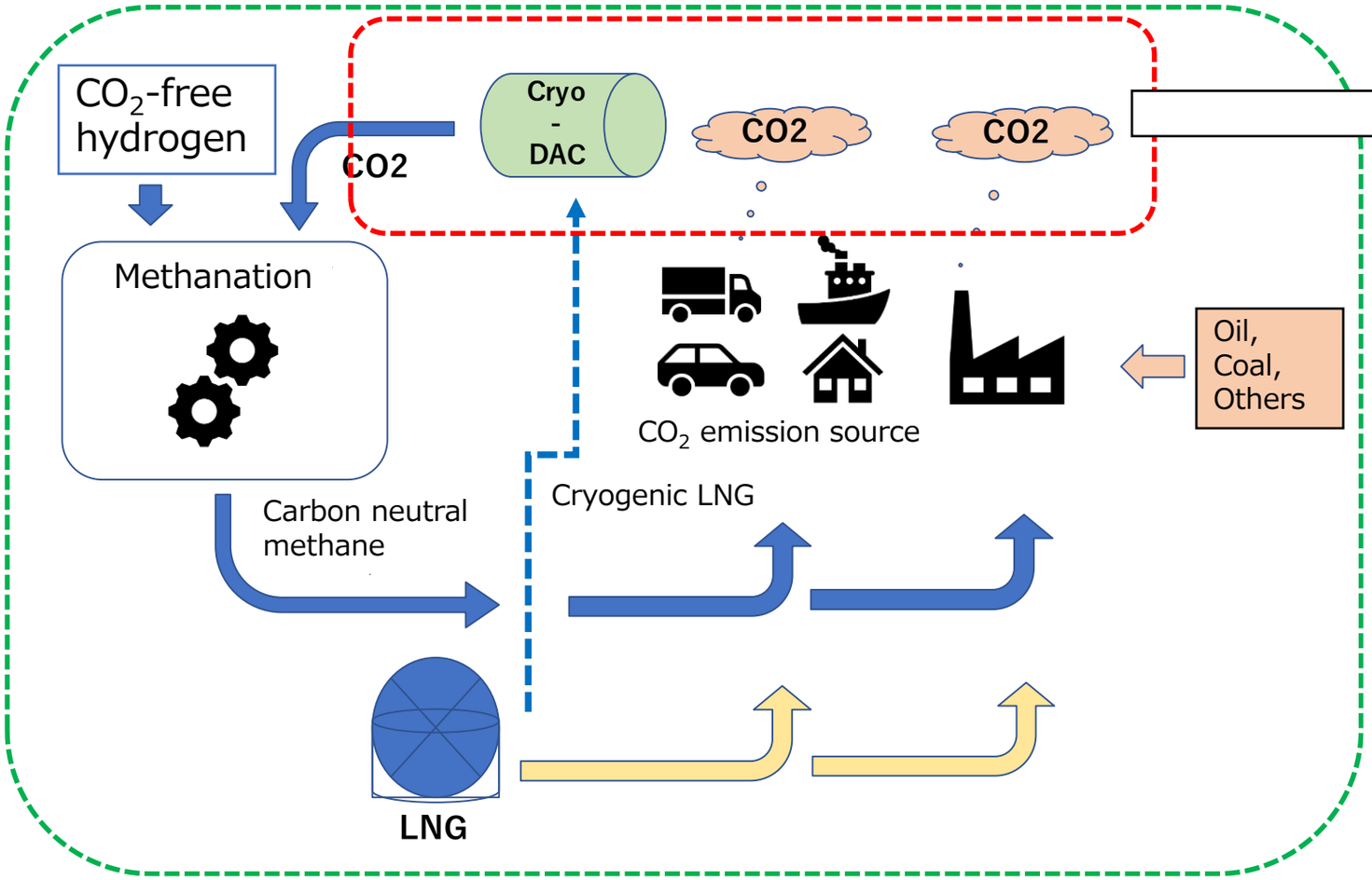
- Cryo-DAC has a potential to surpass overseas manufacturer's DAC.
- **Cryo-DAC can regenerate at room temperature** and do not need input of heat.



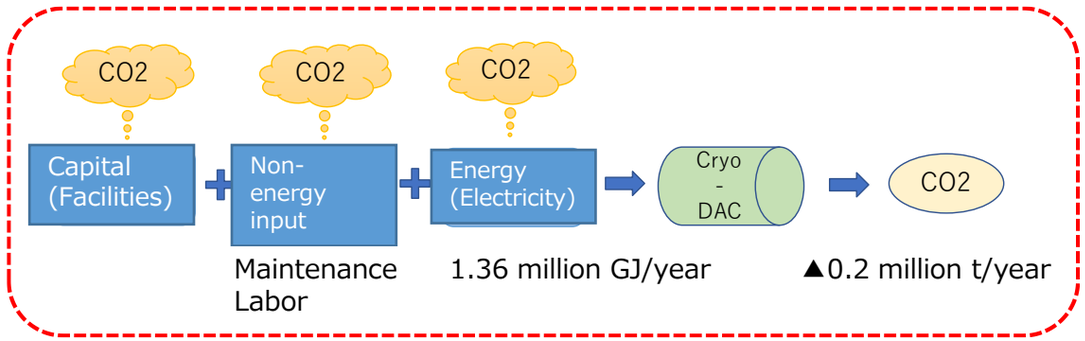
※Techno-Economic Assessment for CO2 Capture From Air Using a Conventional Liquid-Based Absorption Process
https://www.frontiersin.org/articles/10.3389/fenrg.2020.00092/full

Life cycle assessment on carbon cycle with Cryo-DAC

- As a form of carbon cycle, **CO_2 recovered by Cryo-DAC could be use for methanation**.
- Environmental friendliness on Cryo-DAC has been assessed.
  - **Net CO_2 of about 20% could be recovered** when CO_2 emitted due to power input for CO_2 recovery is subtracted.
  - Net CO_2 of about 98% could be achieved if renewable energy increases and **a low-pressure-drop absorber, under development, is realized**.



The image of carbon cycle with Cryo-DAC and methanation



The image of life cycle assessment on Cryo-DAC

Conclusions

<R &D outlines>

- Technology to monitor the soundness of the sublimation tank is developing, economic and environmental friendliness is assessing and life cycle assessment of carbon cycle on Cryo-DAC are evaluating.

<Main achievements>

- ①The system that evaluates sensors to monitor the soundness of the sublimation tank at low-temperature has been developed, and ②Cryo-DAC process has been modeled with a process simulation. In addition, energy needed for Cryo-DAC and the environmental friendliness has been assessed.
- When compared with preceding DAC, Cryo-DAC has a potential to surpass overseas manufacturer's DAC.

<Future outlook>

- Strain sensors will be evaluated to optimize circuit and consider structures and the sensor prototype will be made.
- Process parameters will be evaluated to optimize the process.

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