Cost Evaluation of Direct Air Capture (DAC) Process of Carbon Dioxide

Direct Air Capture (DAC) technologies, which capture low-concentration CO_2 directly from the atmosphere, are vital for the realization of a future zero-carbon society. The technologies used in Carbon Eng'g's KOH-$CaCO_3$-based DAC method [1] were evaluated and CO_2 capture costs were calculated.

- The case of 60,000 m^3/s and 900,000 t/year for the amount of air treated and CO_2 captured was evaluated. CO_2 capture costs were 35.4 JPY/kg-CO_2 (20.6 JPY fixed cost and 14.7 JPY variable cost). Air Contactor, a CO_2 absorption facility, accounted for 50% of the fixed costs, with natural gas, the energy source, accounting for 90% of variable costs.
- Reducing the cost of DAC requires the performance of Air Contactor, a low concentration CO_2 absorption facility that uses a KOH solution, be demonstrated at less than 400ppm. The cost of Air Contactor itself also needs to be reduced.
- The combination of an amine absorption method and DAC can be used to achieve zero-emission boiler exhaust gas, with significantly reduced costs for total CO_2 capture and storage (zero emission CCS) (Table 1). For example, if 98% of CO_2 is captured by the amine absorption process and the rest is captured by DAC, the cost would be 7.0 JPY/kg-CO_2.

Table 1: Cost of CO_2 zero emission measures for coal-fired power plants

Conditions: 958 MW of coal-fired power, 127 Mmol/h of combustion gas, 13.7% of CO_2, 766 t/h of emissions

Amine absorption process collection rate (%)	90	94	98	99	99.5
Exit CO_2 concentration	1.56%	0.94%	0.32%	0.16%	790 ppm
Amine absorption collection amount (%)	689.4	720.0	750.7	758.3	762.2
DAC collection rate (t/h)	76.6	46	15.3	7.66	3.83
Amine absorption and capture cost + storage cost (JPY/kg-CO_2)	5.4	5.8	6.4	7.0	8.1
DAC collection cost + storage cost (JPY/kg-CO_2)	36.7	36.7	36.7	36.7	36.7
Zero emission CCS cost (JPY/kg-CO_2)	**8.5**	**7.7**	**7.0**	**7.3**	**8.2**

Proposals for Policy Development

1) DAC technology is essential for the realization of a future zero carbon society.
2) DAC can be implemented anywhere, but overseas locations where natural gas is cheap and CO_2 reservoirs are nearby have an advantage. However, even if the CO_2 storage areas are abroad, given the size of these future implementations and the importance of these projects, it is vital for Japan to develop new DAC technologies.
3) It would be desirable to develop DAC-related technologies though national projects.

[1] D.W. Keith et al. "A Process for Capturing CO_2 from the Atmosphere", Joule 2, 1573-1594, 2018.