Current status and challenges of direct air capture (DAC) technology development at RITE

Katsunori Yogo

Research Institute of Innovative Technology for the Earth(RITE),
Kyoto, Japan

Research and development of CO_2 capture technology in RITE

Research Institute of Innovative Technology for the Earth

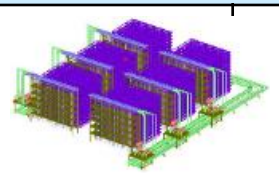
2005 2010 2015 2020 2025 2030

High-pressure gas(1~3 Mpa)

Membrane







Polyimide membrane (for normal pressure)

Membrane material development → Membrane manufacturing → Elementalization actual gas testing → scale-up systemization → scale-up Industrial use (hydrogen production plant) CO_2-H_2 separation

Blast furnace gas/Combustion exhaust gas (13~22%-CO2)

(Amine) Chemical Absorption


1 ton-CO_2/day


30 ton-CO_2/day


ESCAP® (Muroran)

(Steel making)


ESCAP® (Niihama)

Coal fired power plant

Material development Bench-scale testing

COURSE50 Project

Phase I STEP1 → Phase I STEP2 → Phase II → GI foundation

scale-up Target: (advanced CCS project)

Performance improvement

Combustion exhaust gas (3~13%-CO2)

Thermal Power Plant

Solid sorbent


~3 kg-CO_2/day


5 t-CO_2/day


40 ton-CO_2/day

Laboratory Testing @RITE → Bench scale testing @KHI Nishiakashi → Pilot scale testing @Maizuru Power Station → Pscale-up Practical application

Laboratory Testing for Natural Gas power Station → Bench scale testing

Air(DAC) (400ppm)

Solid sorbent


laboratory testing


pilot-scale

Moonshot-type R&D Project → Pscale-up Practical application

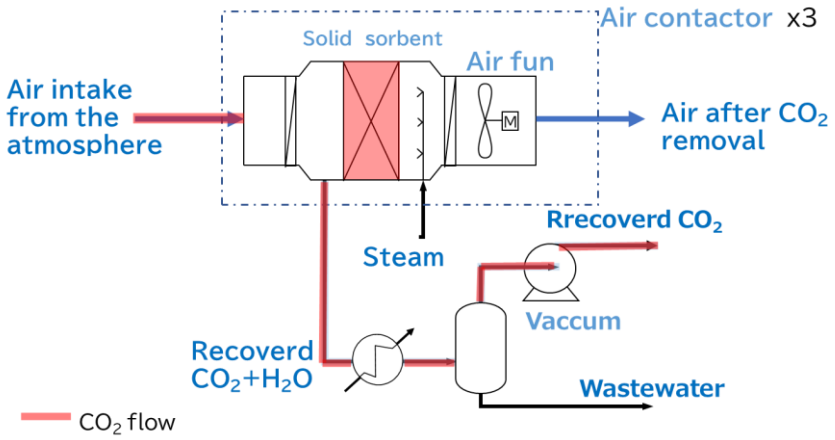
DAC pilot-scale demonstration plant at Osaka-Kansai Expo*

RITE Research Institute of Innovative Technology for the Earth

*The DAC demonstration tests are being carried out as part of NEDO 's Moonshot-type R&D project.

"RITE Future Forest"

Air contactor(2F)



CO_2 recovery unit(1F)

CO_2 Storage tank

RITE-DAC:

- Steam-aided Vacuum Swing Adsorption(low-temperature steam at 60℃)
- The recovered CO_2 is stored in tanks for utilization
- Evaluation: impact of ambient temperature and humidity
- Comparison: performance of multiple structural support types

Achievements to date:

- Largest DAC test facility in Japan(300 kg/day equivalent)
- CO_2 captured by DAC is supplied for various uses. (Purity>95%)

Supply destination [Supply method]	Purpose
Osaka Gas Co., Ltd. (Expo Venue) [Pipe Connection]	● Methane Production ● ⇒ Used for cooking at the State Guest House
Air Water Inc. (Expo Venue) [Pipe Connection]	● Dry Ice Production
Mitsubishi Gas Chemical Company, Inc. (Niigata Plant) [Transport Tank]	● Methanol production ● Geological storage (future feasibility under consideration)

Challenges for Scaling Up and Societal Implementation

RITE
Research Institute of Innovative Technology for the Earth

Advantages of RITE-DAC:

- Low-temperature regenerable(60℃), High oxidation degradation resistance RITE-amine solid sorbent system
- High reliability of equipment and system (manufactured by Mitsubishi Heavy Industries Group)

We are currently experiencing “Learning by Doing” through large-scale demonstration. Several challenges have become apparent through this trial. Specifically, these are reducing cycle time by improving absorption and desorption rates, and mitigating the impact of humidity. We plan to continue improving the materials and system.

To achieve widespread adoption of DAC:

① Further reductions in both cost and energy consumption are essential:

- Technological innovation aimed at achieving half the current cost is necessary.
- Modularisation and standardisation of equipment is also indispensable.
- Complex systems are unsuitable for scaling up; the system must be simple.
  The DAC system using amine absorbents is simple and scalable.

② Not only technological progress but also raising public awareness and progress in international cooperation are necessary.

③ DACCS(DAC with geological storage) as CDR is promising from the perspective of MRV, as it does not have the risk of uncertainty or reversal. However, we must keep in mind that DACCS is a backstop technology.