

Development of CO₂ Capture Technology Using Amine Adsorbents and Its Application to Direct Air Capture

Energy Solution & Marine Engineering Company
Carbon Neutral Business Strategy Office

Kawasaki Heavy Industries, Ltd.

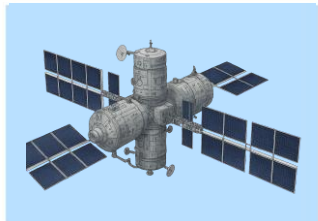
Kawasaki CO₂ Capture (KCC) Overview

Initial Development - 2008

Developed for use in
closed space applications



Submarine



Space station

Fundamental Technology Development Phase 2009 - 2014

Laboratory test



KCC Small Pilot Test



Fixed bed
(10 t/day)



Moving bed
(5 t/day)

Demonstration Test Phase 2015 - Present

Environmental impact Assessment



Large-scale moving-bed test※



Photo Shooting Cooperation:
Kansai Electric Power

※NEDO Project (JPNP16002)

Application Expansion Phase Starting 2025

Applicable to various CO₂ capture settings



Power Plant



Cement



Distributed Power
Generation



DAC



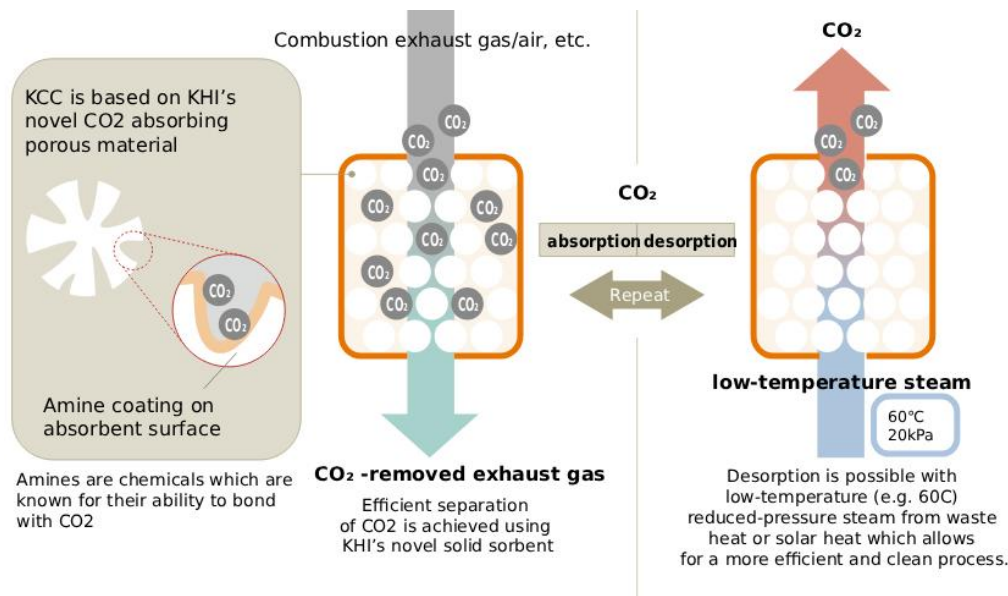
Waste
Treatment



Offshore
Facility

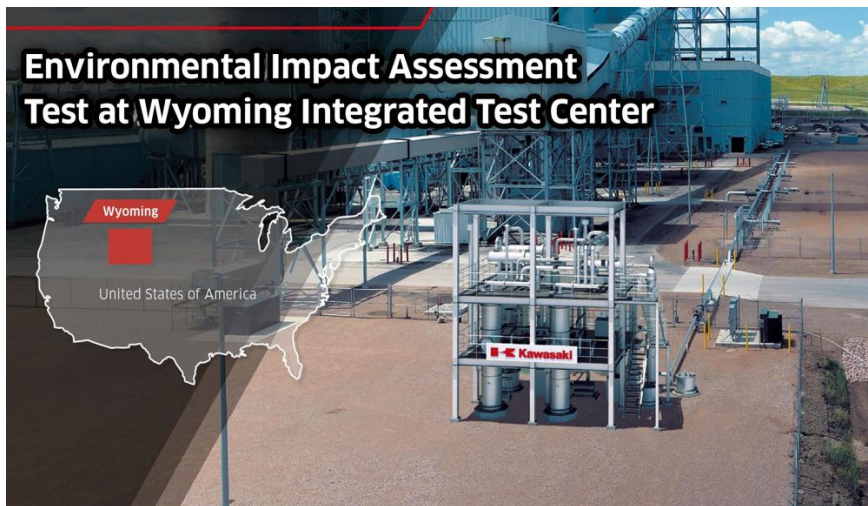
Energy-efficient KCC Amine Adsorbent

- Originally developed for use in submarines and aircraft air-conditioning systems.
- Kawasaki's proprietary **amine-impregnated adsorbent** (or amine adsorbent) enables CO₂ capture with significantly lower energy consumption than conventional liquid-based systems.
- Adsorbent regeneration is possible using **low-grade waste heat ($\leq 100^{\circ}\text{C}$)**, enhancing overall system efficiency and **compatibility with industrial heat sources**.



Environmental Impact Assessment Test in Wyoming

- Location: Integrated Test Center in Wyoming, USA
- CO₂ Source: Dry Fork Coal-Fired Power Plant in Gillette, Wyoming
- CO₂ Concentration: approximately 13 vol%
- Size of Pilot: 2 tons of CO₂ per day



The project is commissioned by the Ministry of the Environment, Government of Japan.
Project Leader : Japan Carbon Frontier Organization (JCOAL)
Joint Implementation Partner : Kawasaki Heavy Industries, Ltd.

Oct. 2023

Environmental Impact Assessment Test in Wyoming

Method: Two units constructed - one with DEA-based adsorbent, one with Kawasaki's proprietary amine. Atmospheric composition monitored at multiple sites before, during, and after the KCC run.

Potential hazards

- Amines
- Amine degradation products



- Candidate sites (air and flux)
- Candidate sites (water quality)



Demonstration Plant

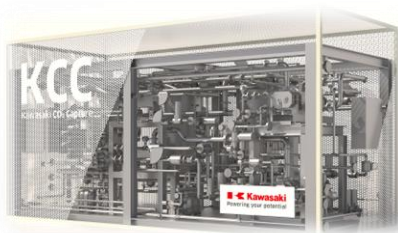
Results: **KCC technology shows low environmental risk.**
Kawasaki's amine adsorbents showed reduced environmental impact compared to DEA.

Demonstration Project at a Waste-to-Energy Facility

- Small-size KCC unit designed for flexible deployment across various emission sources.
- Joint demonstration of CO₂ capture, methanation, and transportation with local partners.

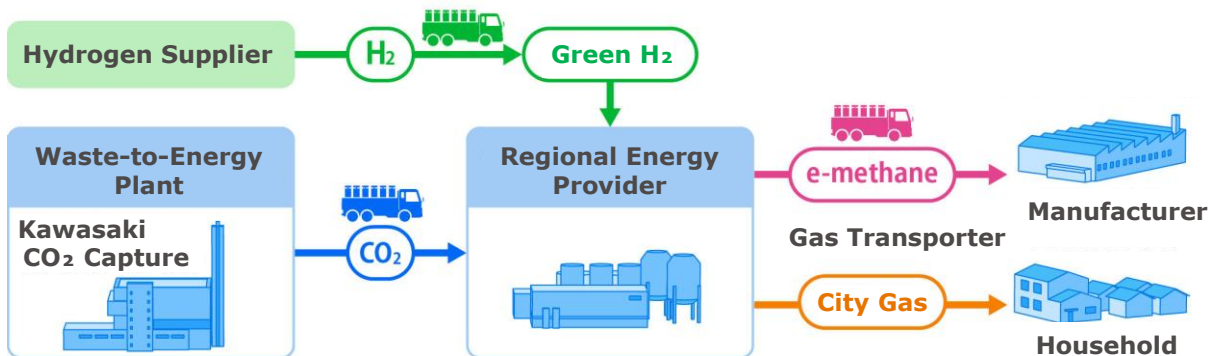
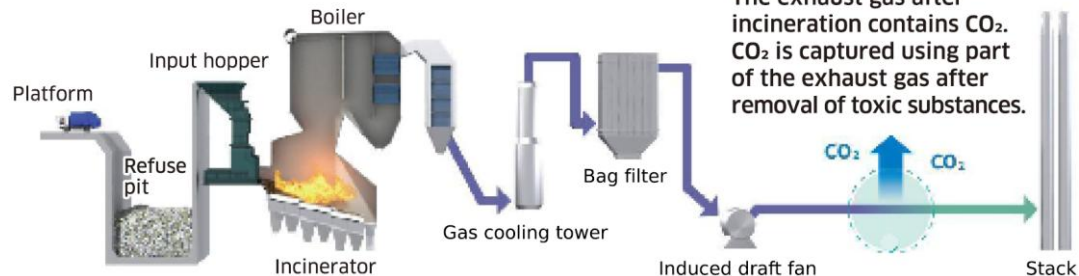


Fukuyama Waste Management Center
(Koriyama city)



Small-size KCC unit
(300 kg-CO₂/d)

Flow of exhaust gas treatment



Outline of the Planned Demonstration Project

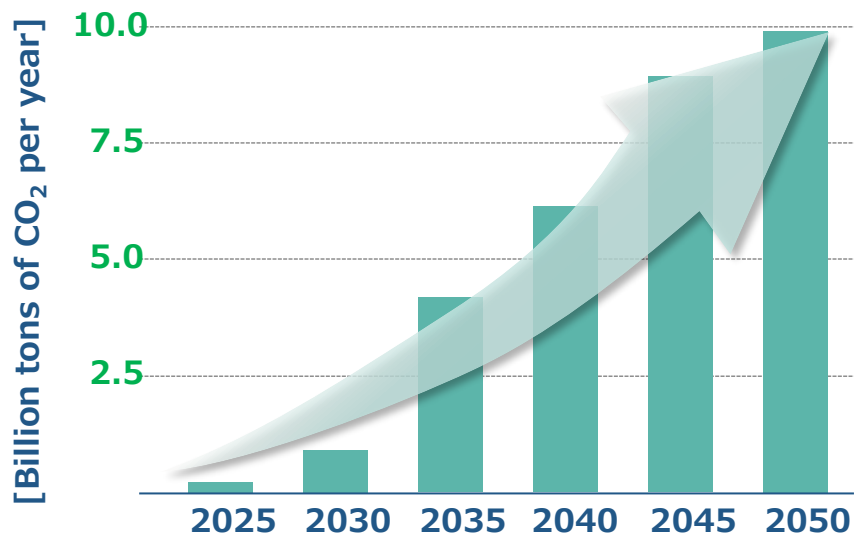
Our Vision toward Large-Scale DAC



- A 1 km² deployment of DAC units with a capacity of 0.5–1 million tons of CO₂ per year.
- We aim to establish the necessary framework for commercialization around 2030.

Growing Demand for Direct Air Capture

- Carbon removal through DAC is expected to become increasingly important toward 2050.
- Kawasaki is developing **amine adsorbent-based CO₂ capture systems** for both emission sources and direct air capture.

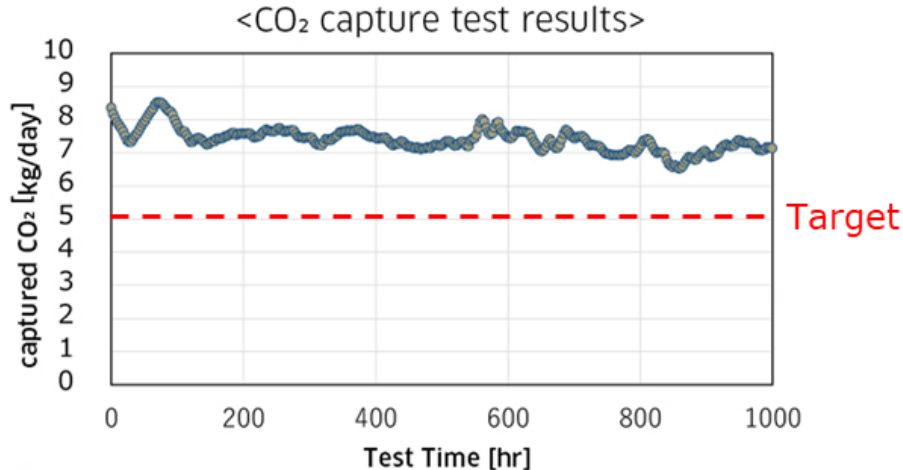


Source: Kawasaki, based on IEA Net Zero by 2050.



KCC DAC Bench-Scale Demonstration

- Leveraging 40 years of experience in CO₂ removal technologies originally developed for enclosed environments such as submarines — the technological foundation of our DAC system.
- Japan's first initiative to deploy DAC technology optimized for the country's climate conditions.
- Demonstrated stable performance, consistently achieving CO₂ recovery volumes well above target over more than 1,000 hours of continuous operation.



CO₂ Capture and Utilization for Concrete Material

- Kawasaki and Kajima Corporation have launched a joint study to capture **CO₂ in concrete**.
- CO₂ captured from the atmosphere using Kawasaki's DAC technology is fixed into Kajima's environmentally-friendly concrete "**CO₂-SUICOM**".
- This concrete is used to pave the entrance of the **Sustaina-Dome at EXPO 2025**.



Carbon-Negative Hydrogen Mobility: TOYOTA × KCC DAC Technology

- TOYOTA launched a new technology challenge titled "**Capture CO₂ as You Drive**" during the *Super Taikyu Series 2023* at Fuji Speedway.
- This initiative is supported by **Kawasaki's proprietary amine adsorbent**.

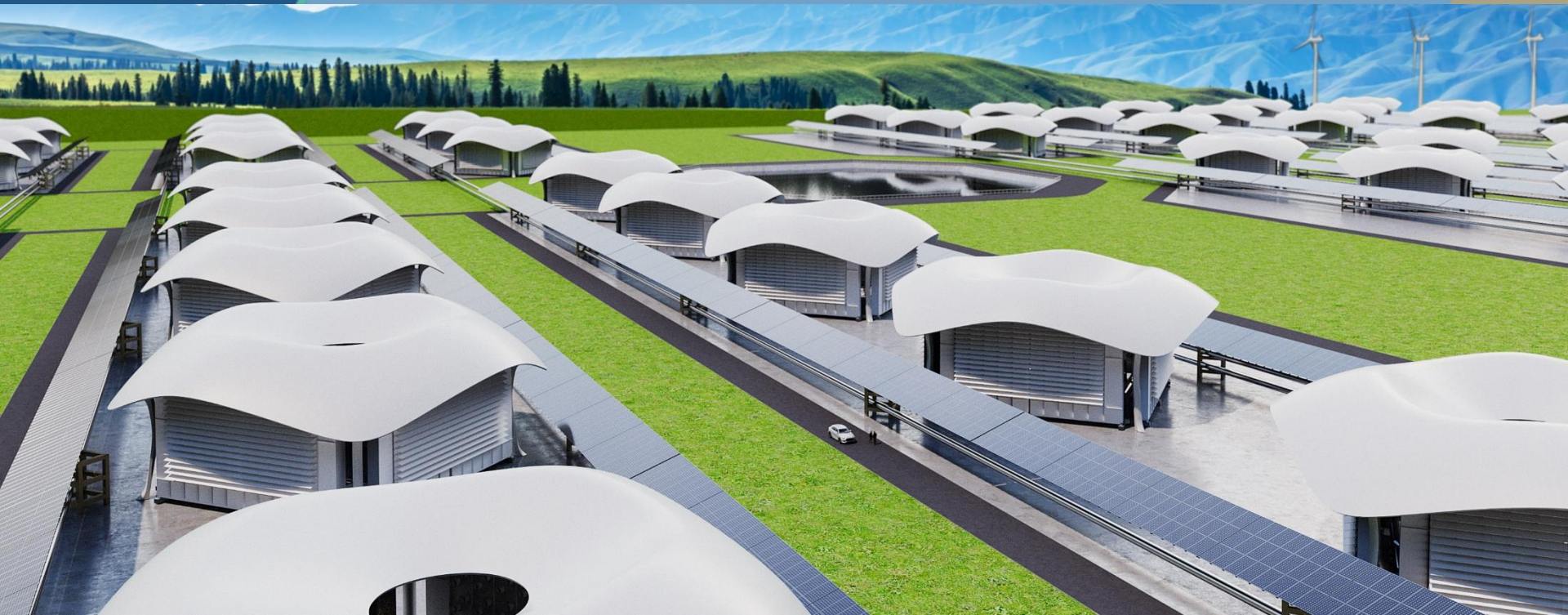


Photo courtesy of Toyota Motor Corporation



Photo courtesy of Toyota Motor Corporation

Large-Scale DAC Ready

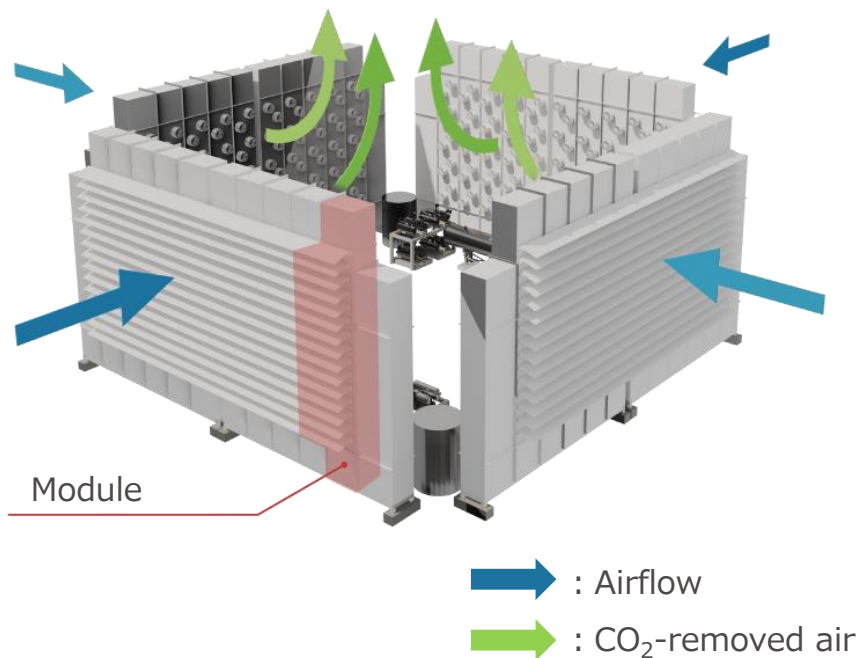


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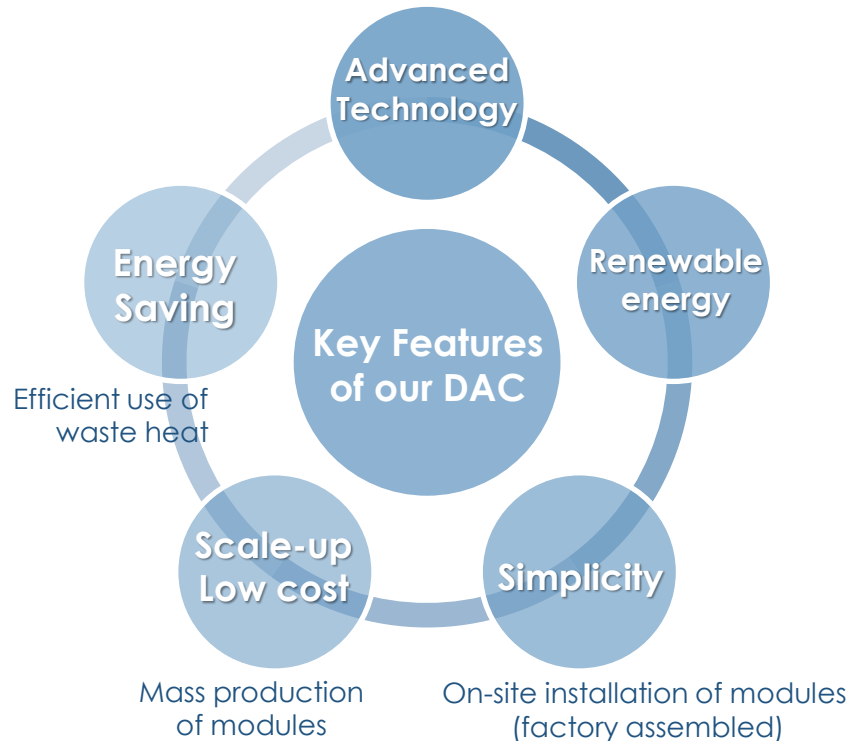
Model Diagram of a DAC System

From the Group Vision 2030
Progress Report (2023)

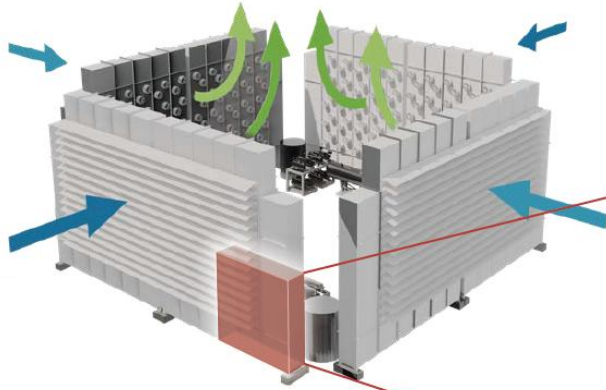
DAC facility with a CO₂ capture capacity of
approx. 20,000 t-CO₂/year



Proprietary adsorbents and technologies
established by demonstration projects



Direct Air Capture (DAC) Facility at Kobe Works



Large-scale DAC facility
20,000 t-CO₂/year



Overview of KCC Demonstration Facility at Kobe Works



DAC

PCC

PCC

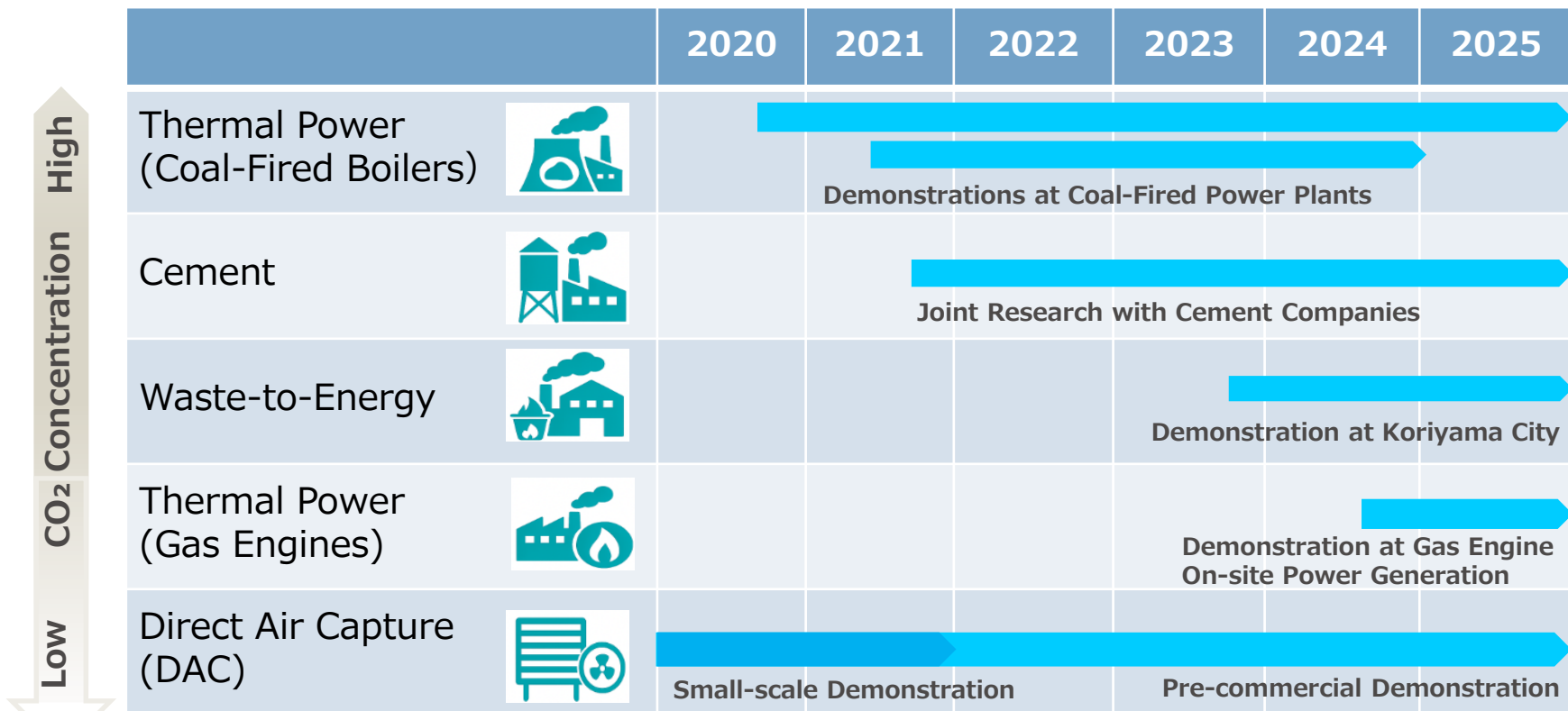
Capture of low-concentration CO₂ in the exhaust gas from an in-house gas engine power generation system

DAC

Direct capture of CO₂ from ambient air

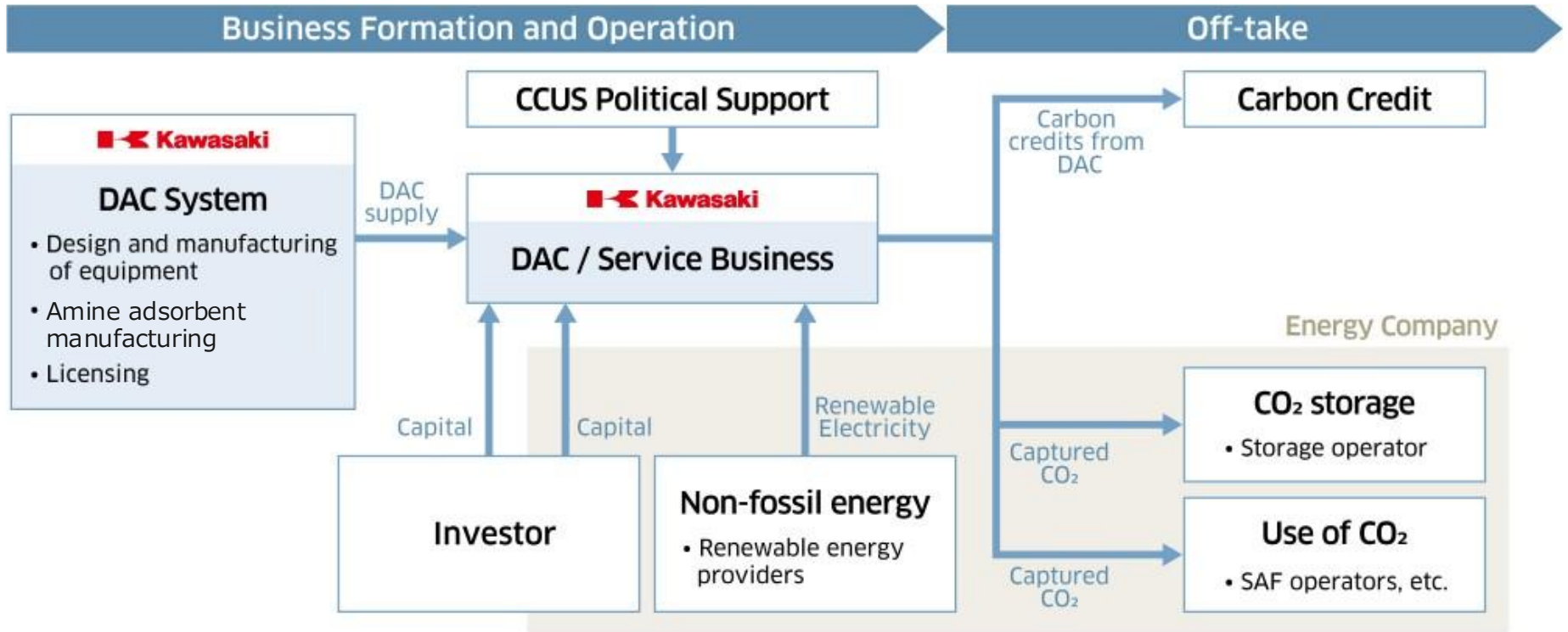
Specification	DAC	PCC
CO ₂ Source	Ambient Air	Gas Engine
Capacity (t-CO ₂ /year)	100~200	360
Regeneration Temperature	60 °C	
Configuration	Moving-Bed System	

Application of KCC Technology to Various Sectors



Meeting Societal Needs: CO₂ Capture from Diverse Emission Sources

Kawasaki's DAC Business Model Overview



New Values

A Safe and Secure
Remotely-Connected Society

Trustworthy
Solutions
for the Future

"Near-Future" Mobility

Energy and Environmental Solutions

Cross Over

Frontier