Toshiba's Contribution to Advanced Carbon Capture Solutions

TOSHIBA

Toshiba Energy Systems & Solutions Corporation

September 2, 2024

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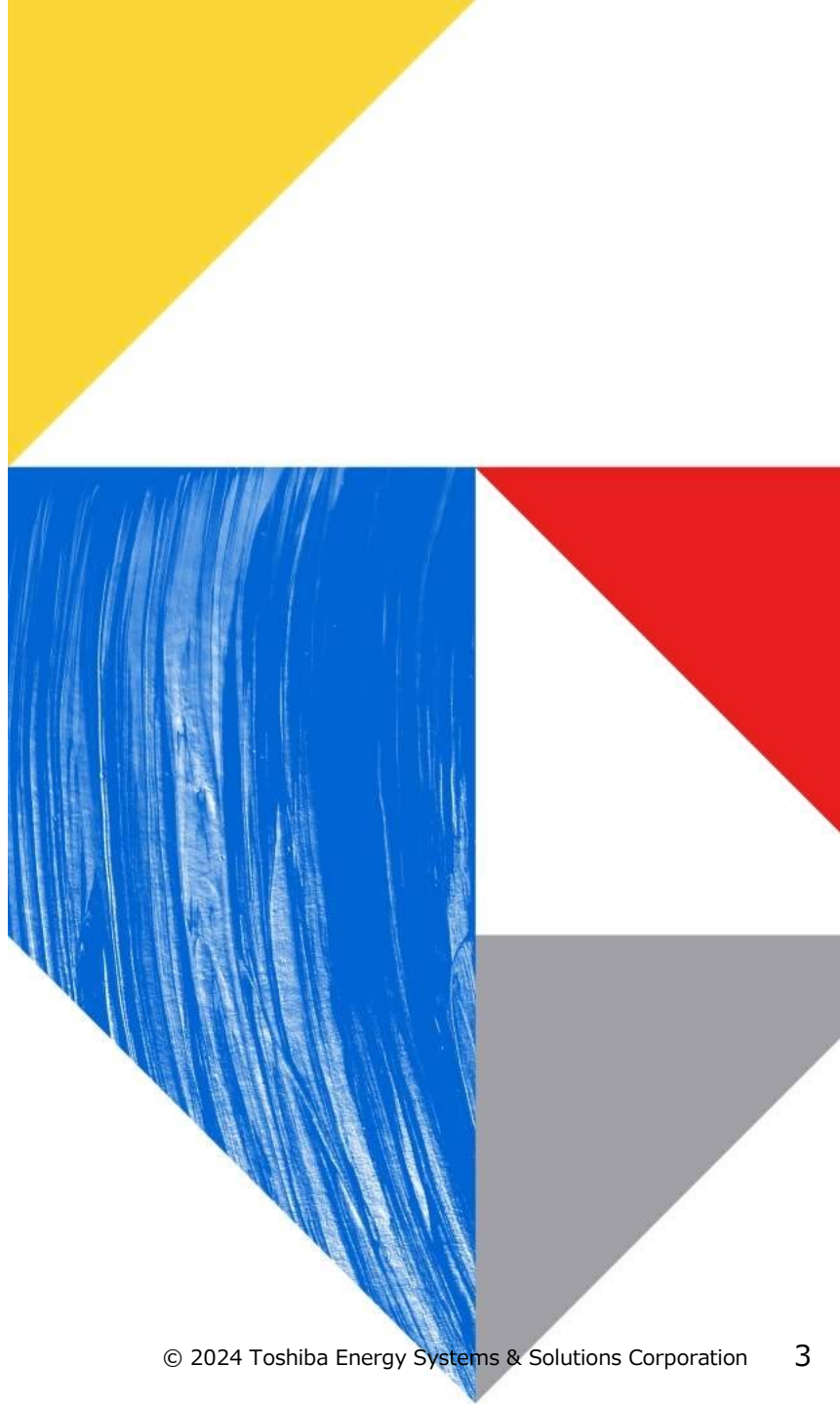
Company Overview



Organization

Toshiba Corporation

- Toshiba Infrastructure Systems & Solutions Corporation
- Toshiba Electronic Devices & Storage Corporation
- Toshiba Digital Solutions Corporation

Toshiba Energy Systems & Solutions Corporation

As of December 22nd, 2023

Taro Shimada
President and CEO
Toshiba Energy Systems & Solutions Corporation

- **Power Systems Div.**
  - Isogo Nuclear Engineering Center
  - Keihin Product Operations
- **Grid Solution Div.**
  - Hamakawasaki Operations
  - Fuchu Operations
- **Energy Aggregation Div.**
- **Digital Transformation Div.**
- **Domestic Marketing & Sales Div.**
- **Global Marketing & Sales Div.**
- **Energy Systems Research & Development Center**

Hokkaido Branch Office	Kansai Branch Office
Tohoku Branch Office	Chugoku Branch Office
Chubu Branch Office	Shikoku Branch Office
Hokuriku Branch Office	Kyushu Branch Office

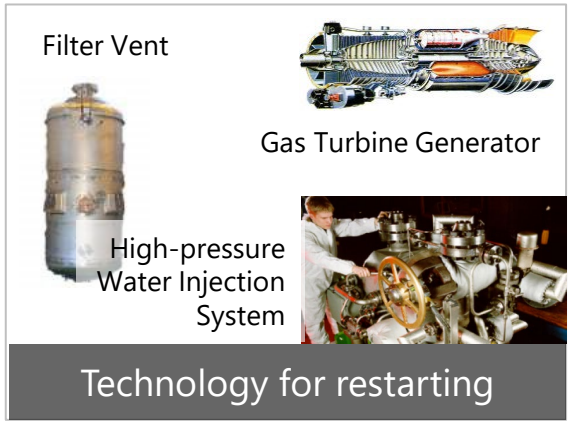
Business Domains

- Toward the realization of sustainable society

Thermal Power / Nuclear Power

Thermal Power

Nuclear Power

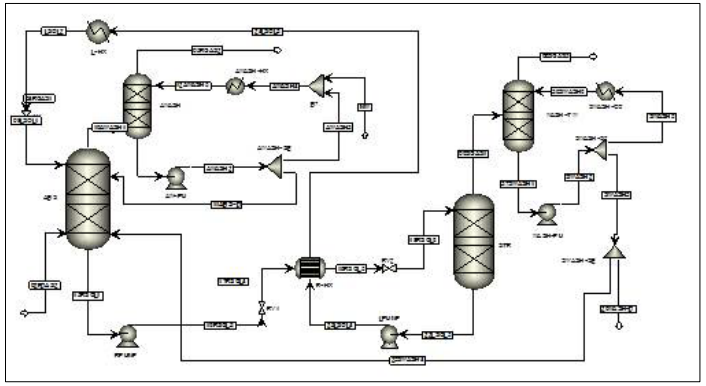


02

New technology development for Carbon Capture Solutions

CO2 Capture Technology Implementation Flow

① Development



Process Design & System Performance improvement evaluation by Simulation

Solvent Development

Performance / Degradation Evaluation by Small Loop

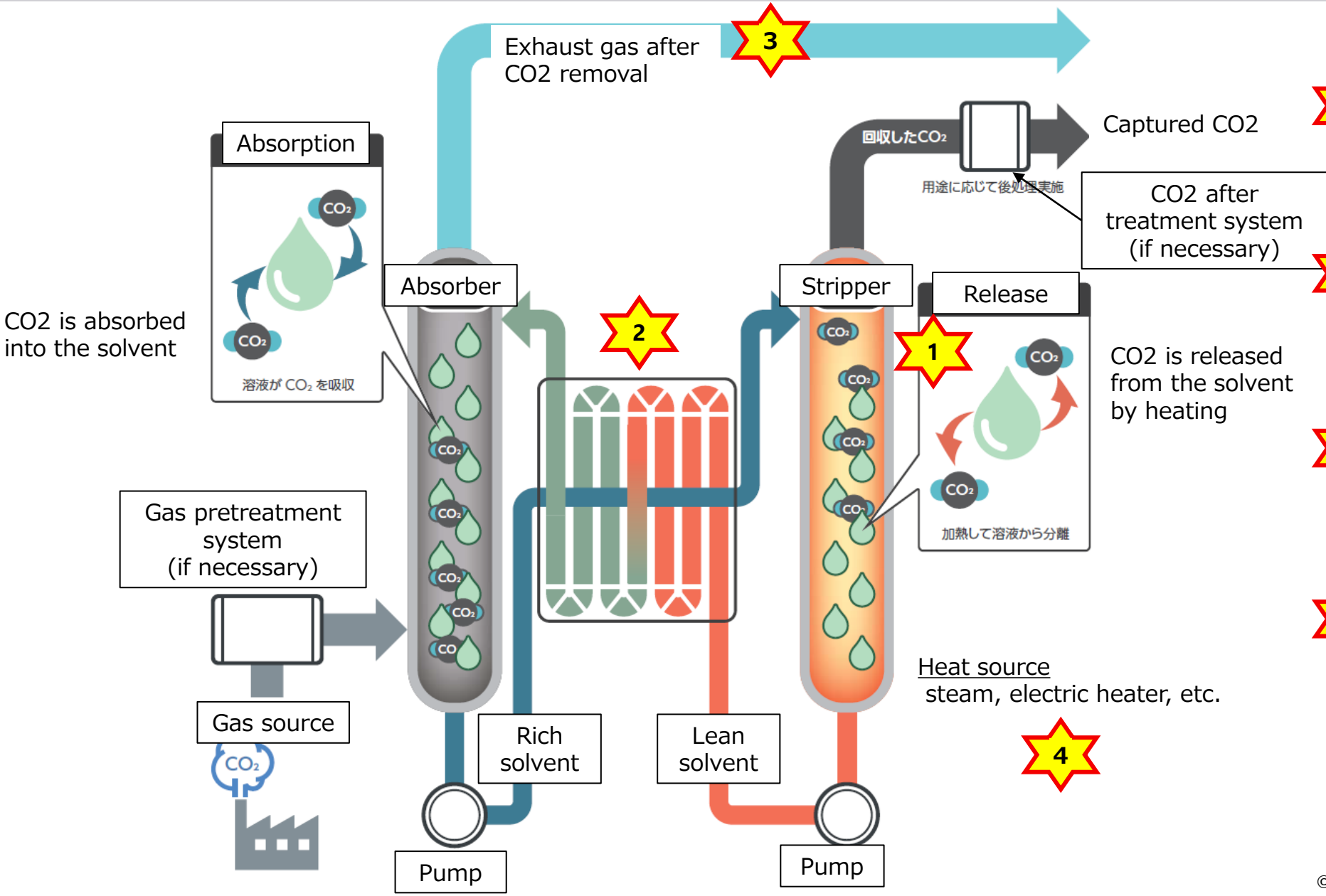
②Field Evaluation

Comprehensive evaluation based on actual exhaust gas

③ Commercial Scale

・Saga City Incineration（L）
・MOE Demonstration PJ（R）

Carbon dioxide capture system using chemical absorption method



Why Toshiba ?

1 Reliability/Quality of solvent

Owner and Operator of its own Pilot Plant

2 Less energy consumption

Licenser of amine solvent, 2.4GJ/ton, Tier 1 position in the world

3 Environmental

Testing of amine emissions and its control methods

4 Coordinating steam cycle

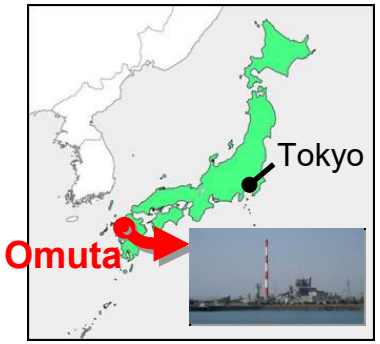
integrate CCUS system with existing steam cycle systems

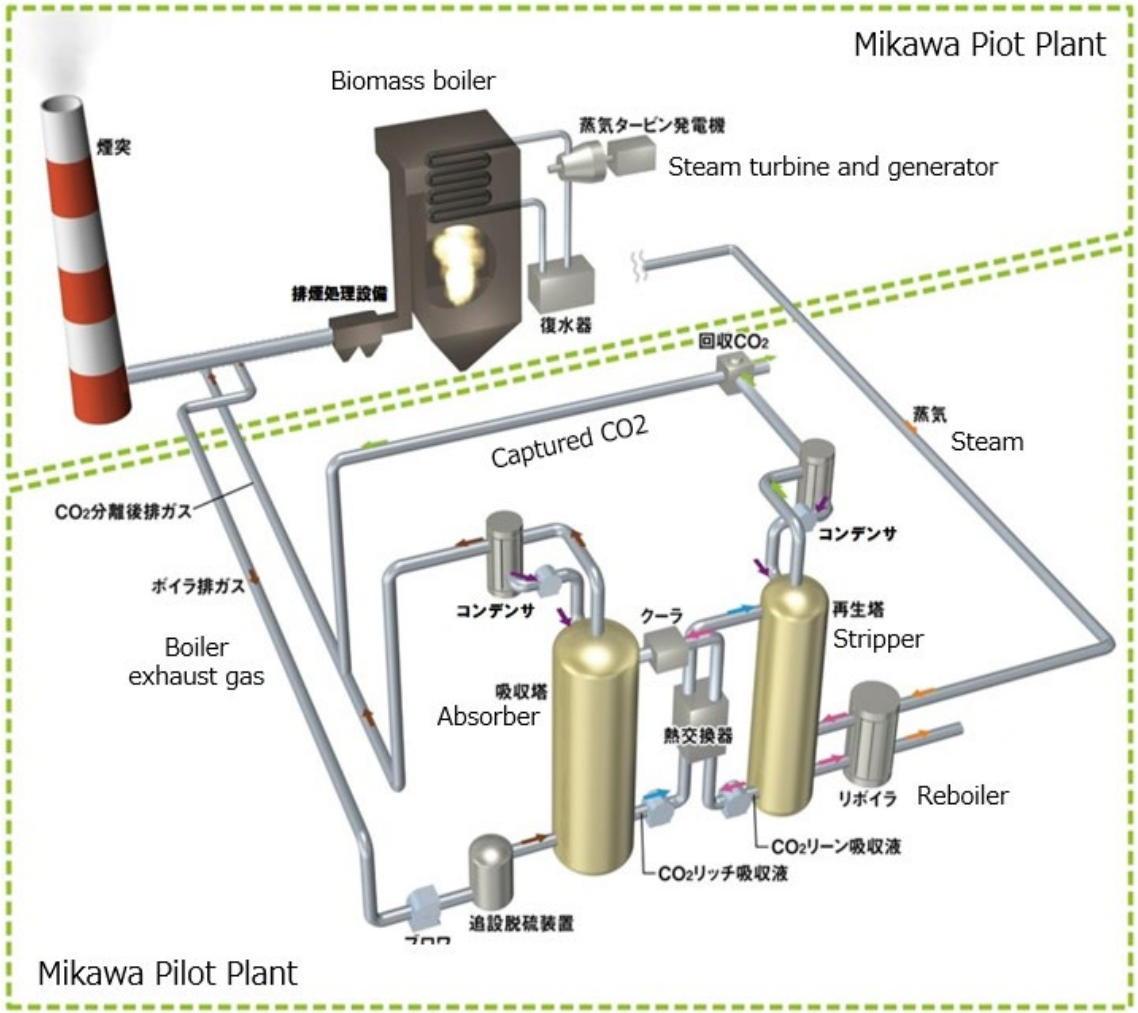
Pilot plant for CO2 Capture

1 Reliability/Quality of solvent

Plant Overview

- **Location**
  Omuta City, Fukuoka
- **Start of Operation**
  2009/9
- **Flue Flow Rate**
  2,100Nm3/h
- **CO2 Concentration**
  4~30%
- **Capacity**
  10ton-CO_2/day





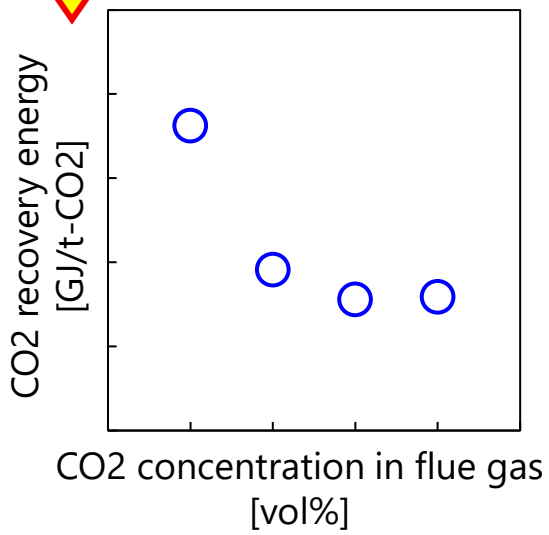
New technology development at commercial-scale facilities using actual flue gas

Pilot plant for CO2 Capture

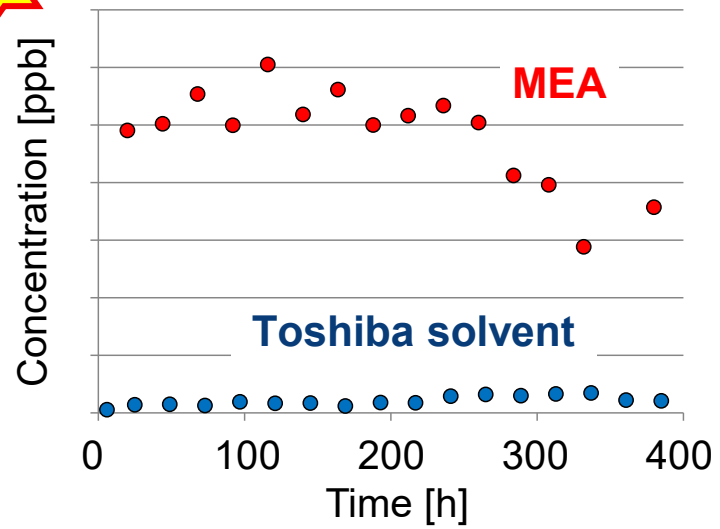
2 Less energy consumption

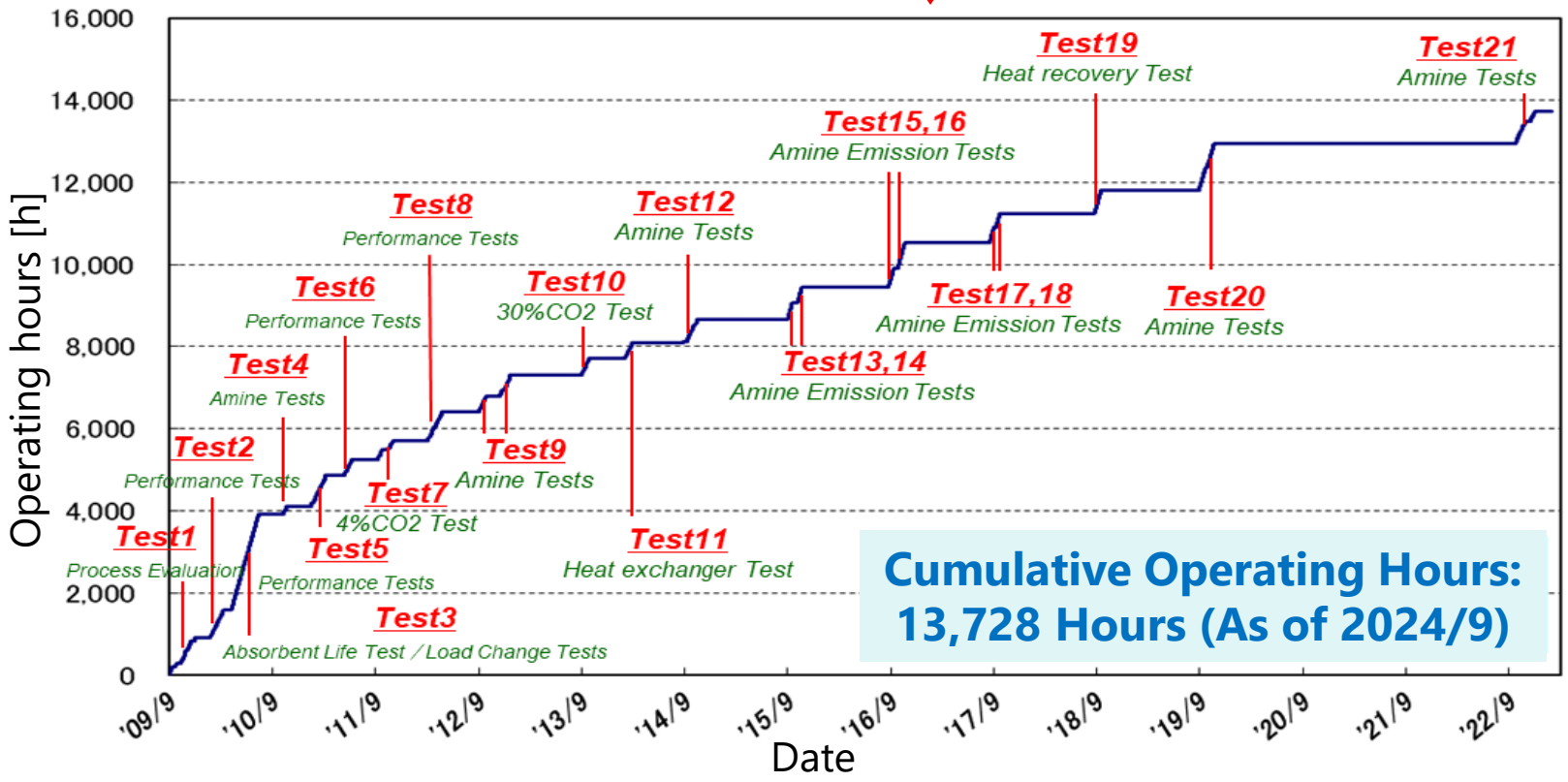
3 Environmental

2 Example of test result



3 Amine concentration at absorber outlet





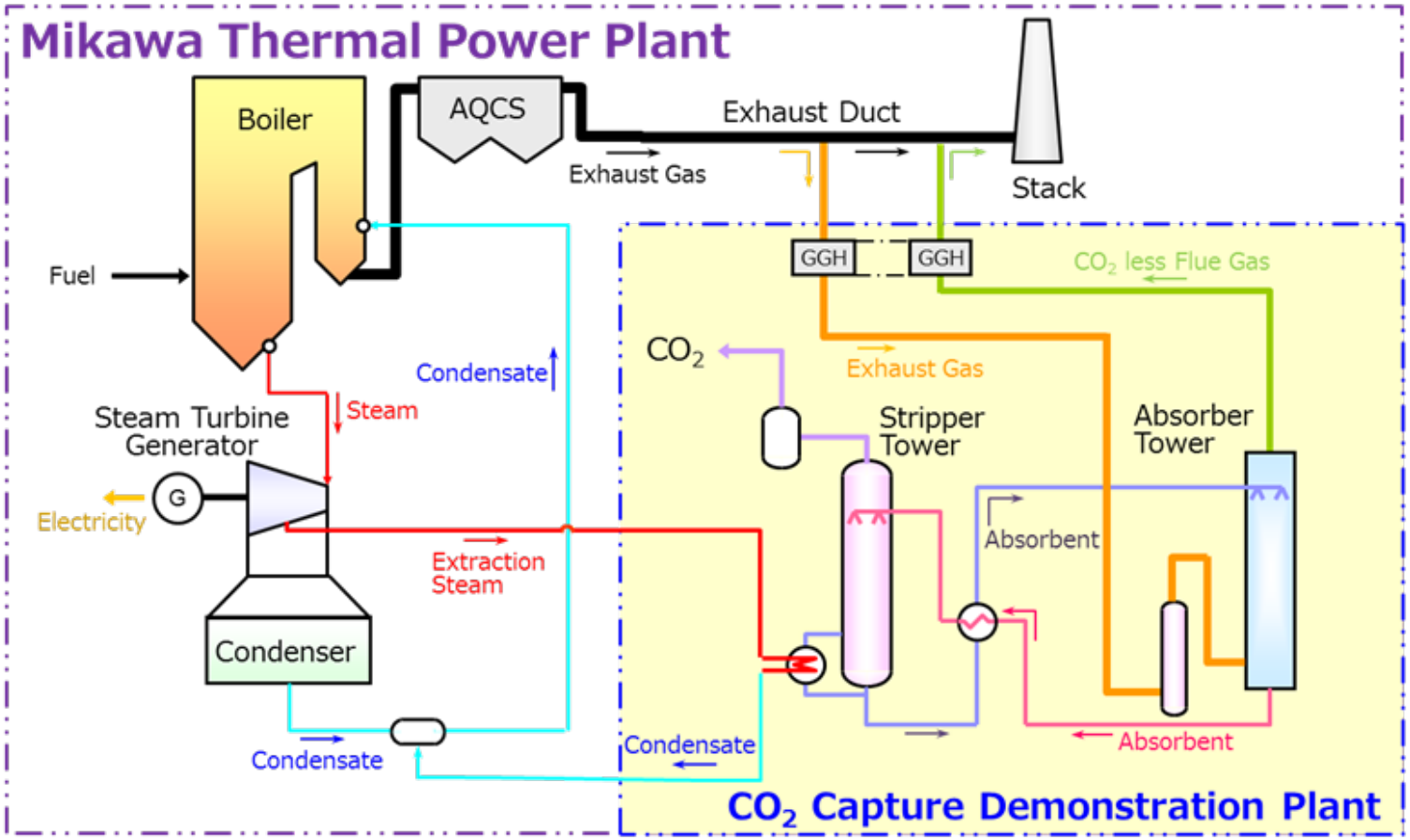
Cumulative Operating Hours: 13,728 Hours (As of 2024/9)

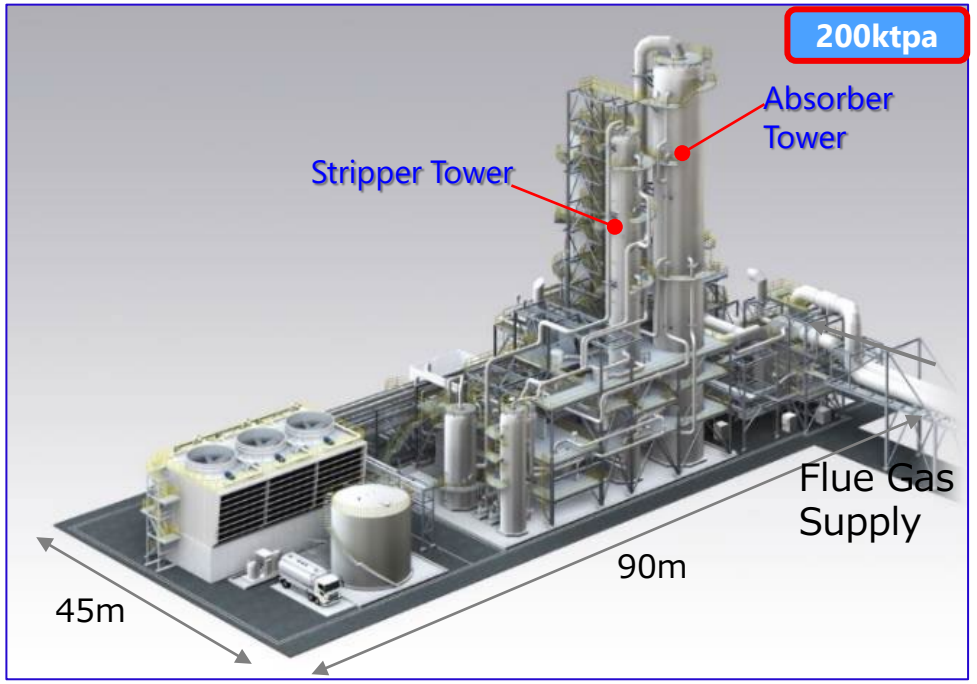
Tests conducted

- ✓ Seeking high performance amine solvents
- ✓ System improvements with various components
- ✓ Effect of CO_2 gas concentration on CO_2 recovery energy
- ✓ New amine emission control system

Deployment to Power Plants (MoE's Sustainable CCS Project)

The world's first large-scale BECCS* ready demonstration facility added to a biomass power plant. One of the largest in Japan, capturing over 50% of emitted CO2 (over 600t/day)

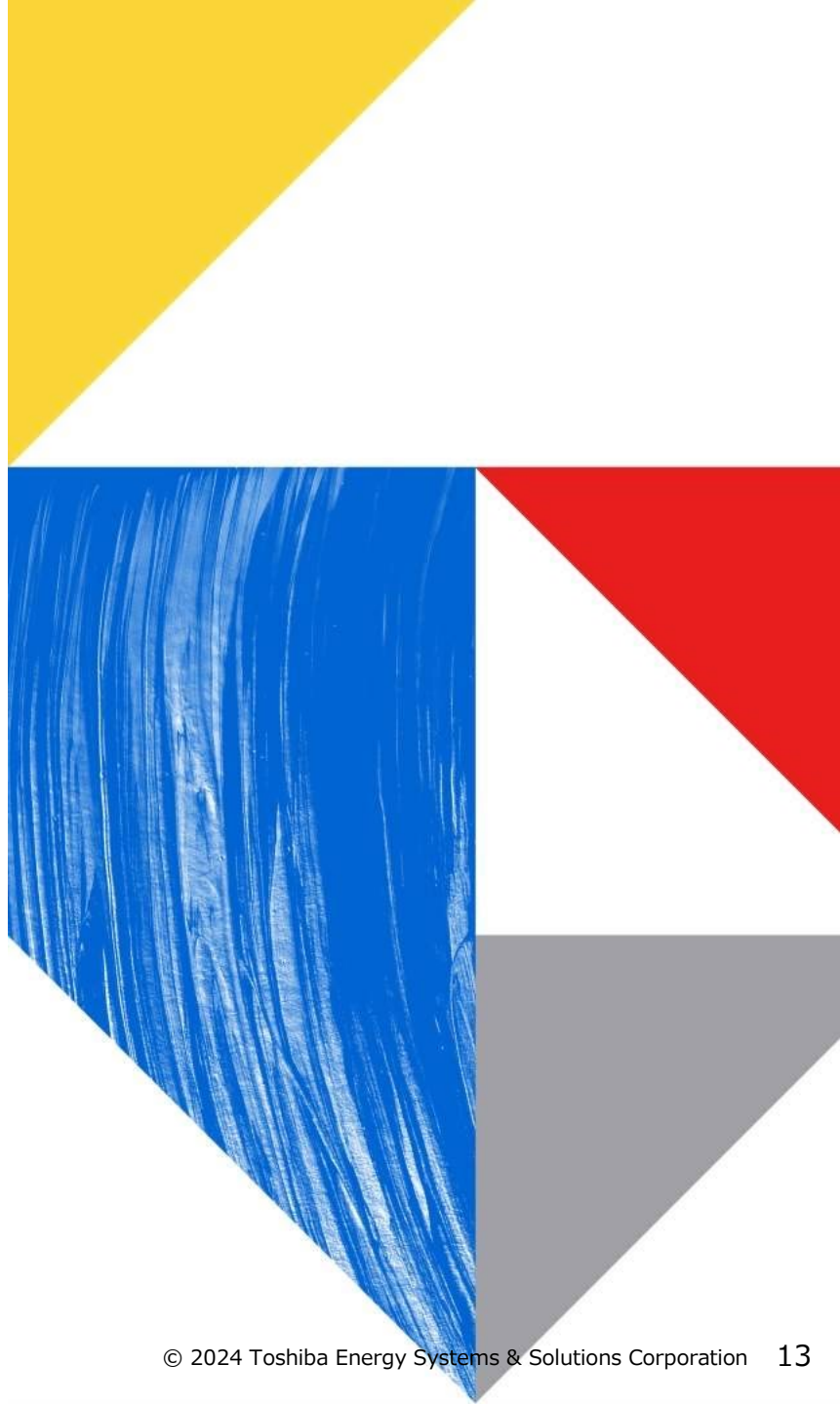




* BECCS：Bio-Energy with Carbon Capture and Storage

03

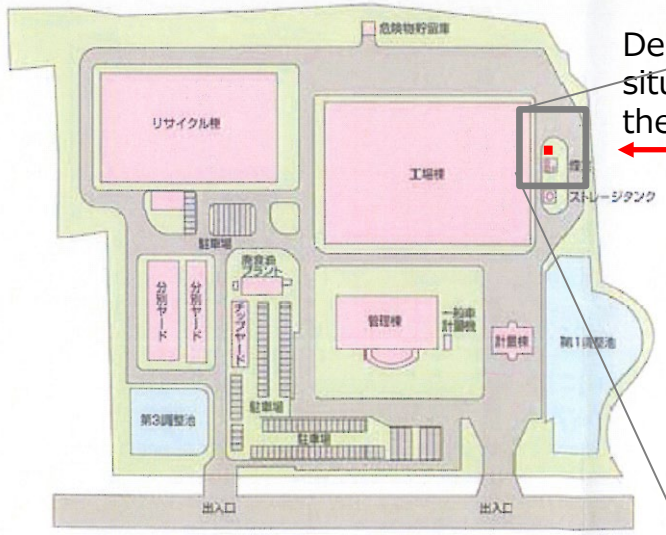
Advanced Carbon Capture Solutions



Waste Incineration Plant at Saga City : Phase 1: CO2 utilization in agriculture（deployment in small scale）

- Project promoted by Saga city as part of its Biomass Industrial City Vision. CO_2 is captured from exhaust gas of existing Saga city municipal waste incineration (WtE; Waste to Energy) plant.
- First phase of the project started in 2013 until 2015. Using the small scale demo skid, the concept of capturing high purity CO_2 from WtE was proven through cumulative 8000 hours of operation.

Saga Waste Incineration (WtE) Plant



Demo Skid situated near the stack

Small Scale Demo Skid (10~20 kg/day)

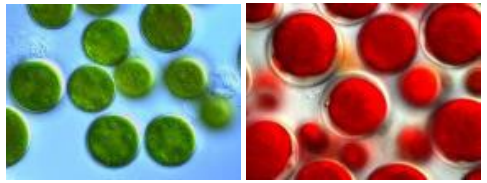
(Salad crop cultivation)
Verification of impurities in CO2 gas

Waste Incineration Plant at Saga City :
Phase 2: CO2 utilization in agriculture（deployment in commercial scale）

■ Promotion of Environment-friendly Agriculture & Algae Industry

◆ World's first commercial-use CCU system constructed in a municipal waste incineration plant.

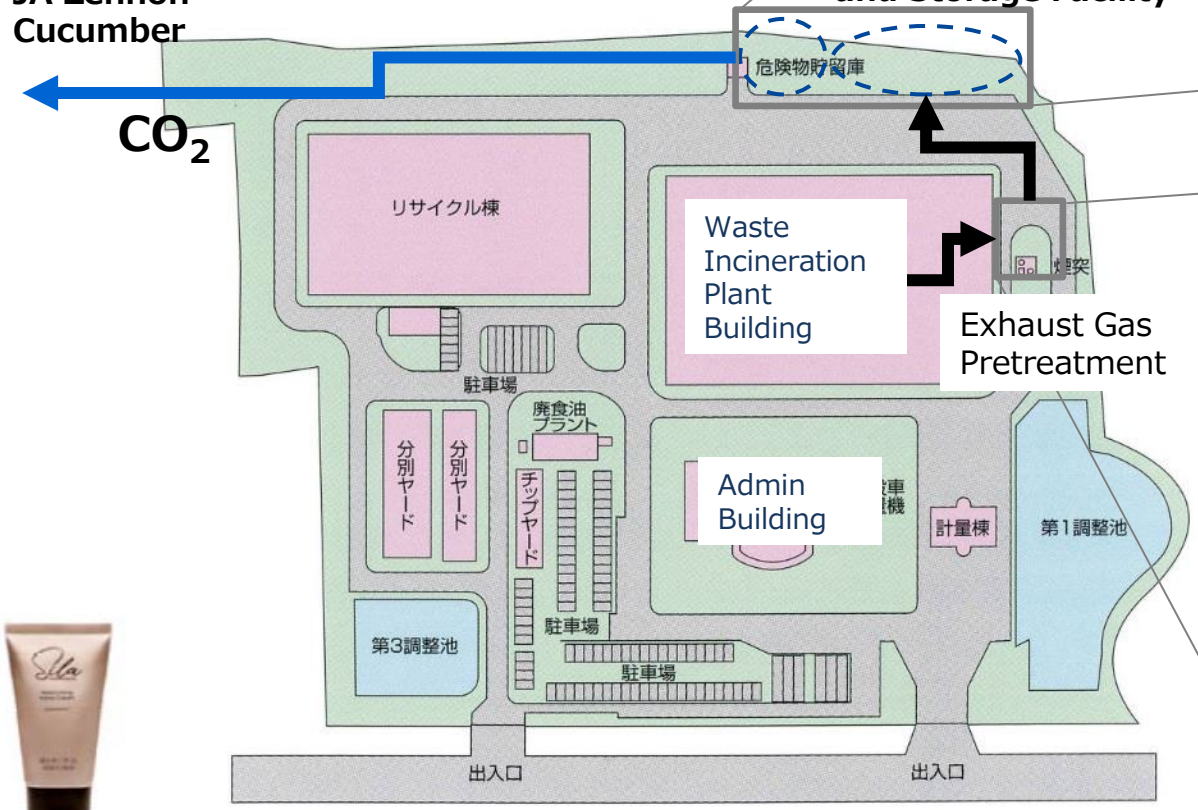
JA Zennoh Cucumber



Albita Algae

10 ton/day
Operational since 2016

Carbon Capture and Storage Facility



CO2 Transfer piping to the Algae Cultivation area

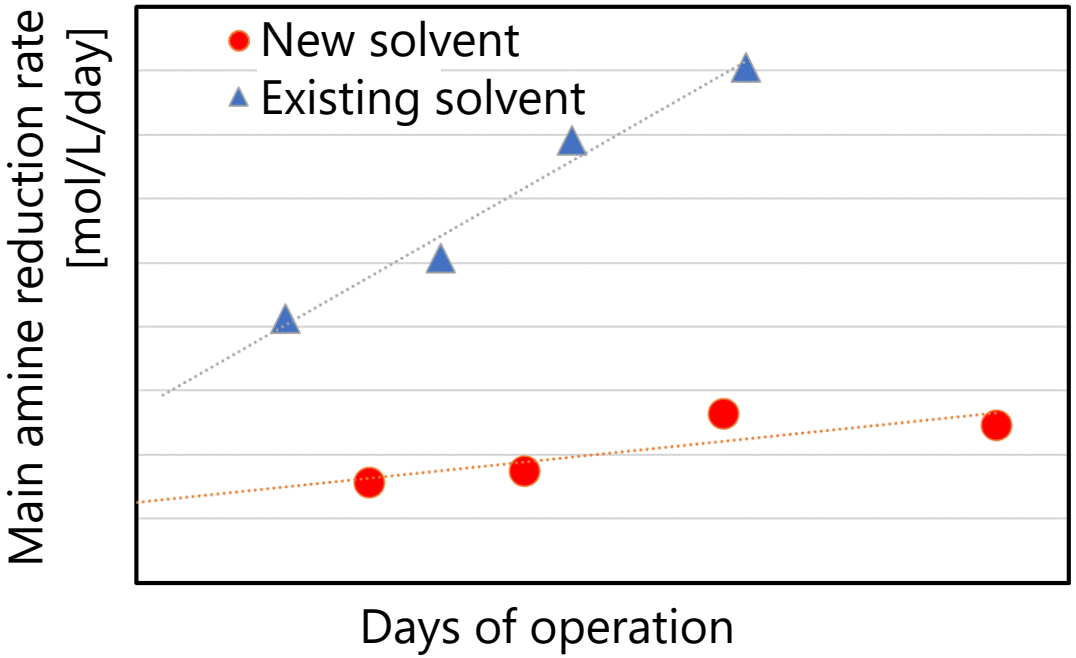
Haematococcus is cultivated and astaxanthin is extracted. It affects an antioxidant action.
(Use : cosmetics etc.)

A hand cream, body cream, and the supplement "Sila*" are on sale.
*Saga Incubates Local Algae

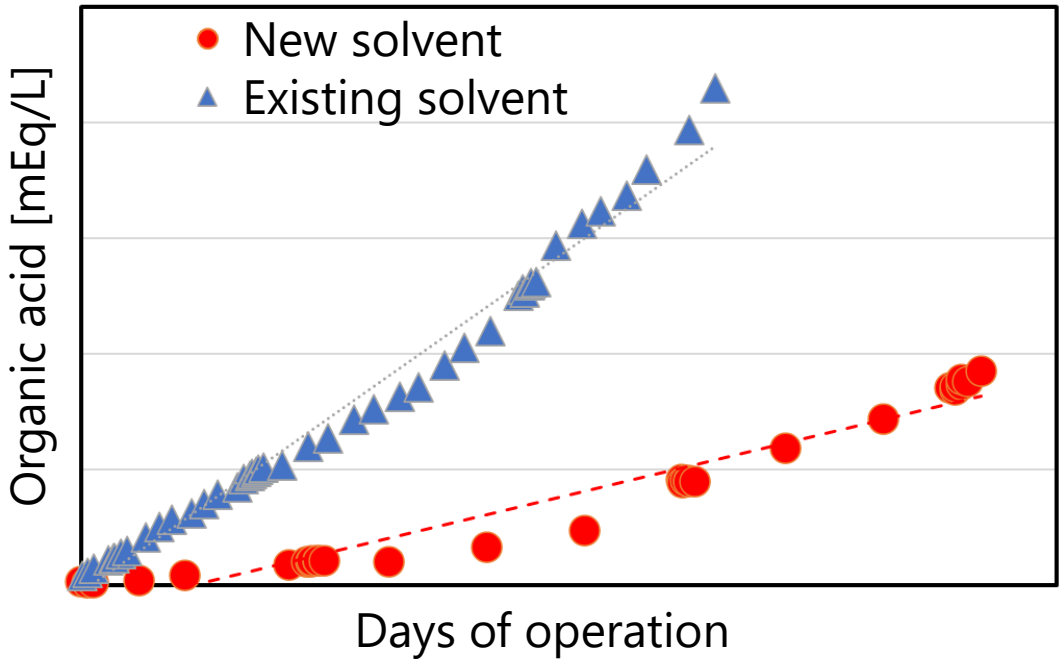
Exhaust gas pretreatment plant (desalination treatment)

Waste Incineration Plant at Saga City : Phase 3: CO2 utilization in agriculture（collaborative research Part Ⅰ）

■ Toshiba conducted collaborative research with Saga City beginning in March 2023.
■ Toshiba supplied the new solvent and verified the performance at Saga city's commercial plant for a year.



Comparison of decrease in main amine concentration in new and existing CO2 solvents



Comparison of organic acid accumulation speed in new and existing CO2 solvents

Compared to our existing solvent, it enables higher performance operation.

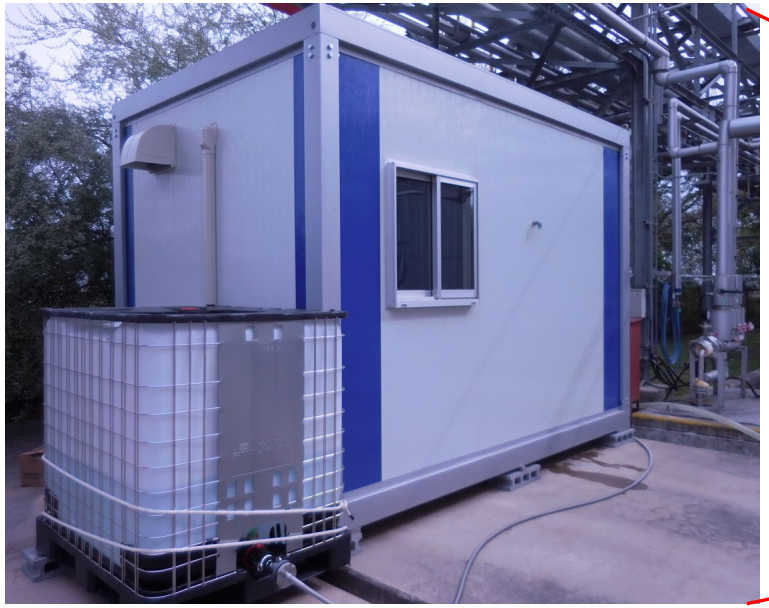
Waste Incineration Plant at Saga City : Phase 4: CO2 utilization in agriculture（collaborative research Part Ⅱ）

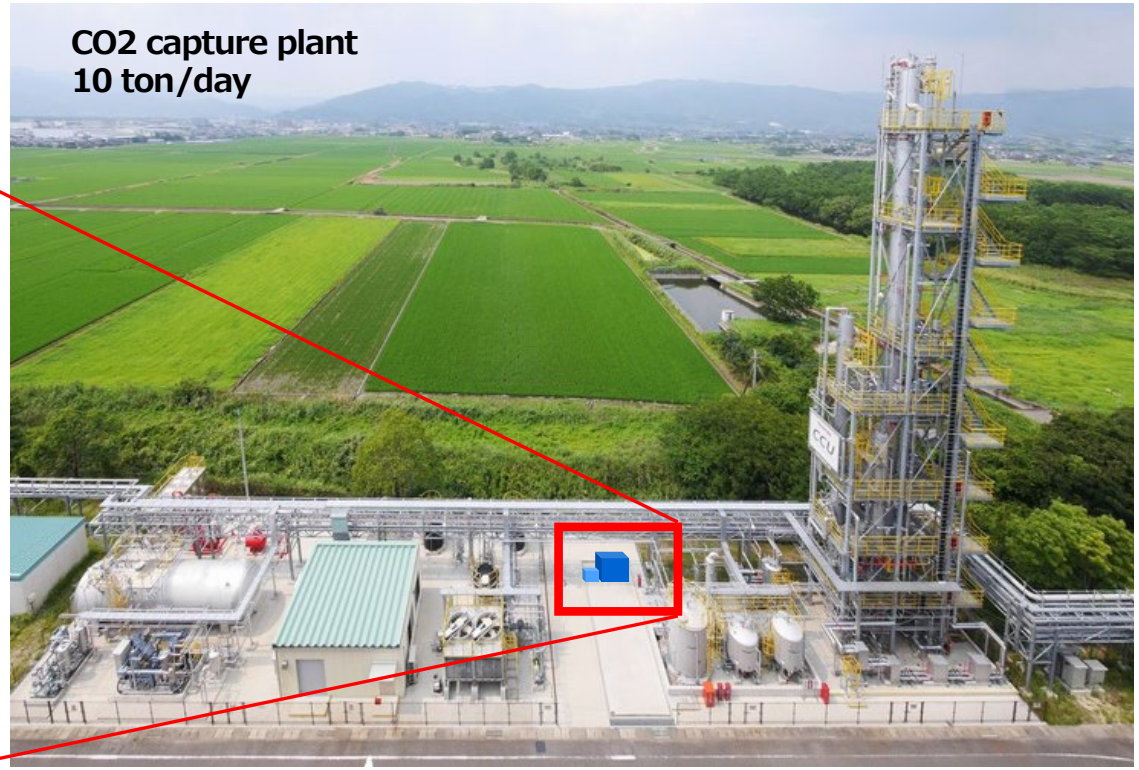
■ As for the development of solvent reclaiming technology, Toshiba has been conducting collaborative research with Saga City since April 2024.

■ Toshiba has installed an electrodialysis test facility, which is currently under demonstration at Saga city's commercial plant.

Interior of electrodialysis test facility

Exterior of electrodialysis test facility





The demonstration is scheduled to continue until the end of FY 25.

04

Delivery records and Business expansion into Global market

Delivery records for the development of CCUS

Ⅰ Industrial Sector （demonstration ）

Beverage supplier （10kg/day-CO_2）

2019 | 3tpa

Gas supplier （10kg/day-CO_2）

2024 | 3tpa

[Toshiba Successfully Delivers Carbon Capture System to Tokyo Gas | News Release | Toshiba Energy Systems & Solutions (global.toshiba)]

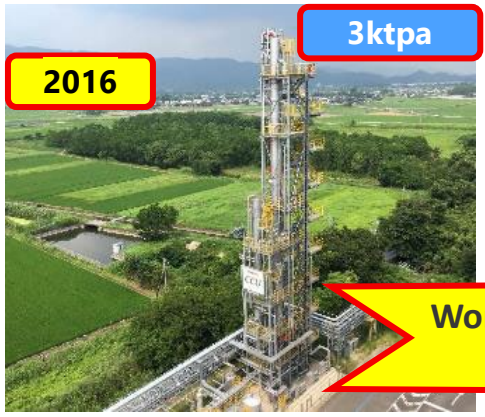
Ⅱ WtE Plant （CCU）

Pilot plant (PoC)（10kg/day-CO_2）

2013 | 3tpa

Commercial plant （10 t /day-CO_2）

2016 | 3ktpa



World 1st CCU with WtE plant

Ⅲ Coal／Biomass power plant （CCS）

Pilot plant （10 t /day-CO_2）

2009 | 3ktpa

MoE's Sustainable CCS Project （600 t /day-CO_2）

2020 | 200ktpa

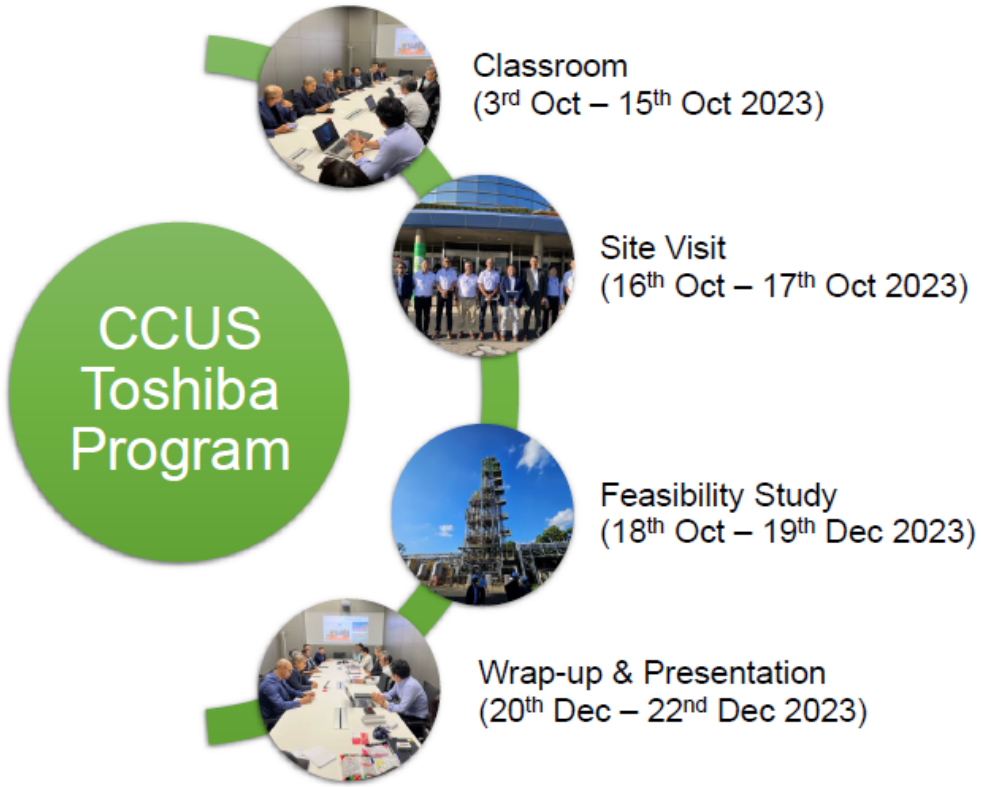
World 1st large size BECCS

★BECCS： Bio-Energy with CCS

Business expansion into global market ~Application of CO_2 Capture Technology to Large Thermal Power Plants(1)~

Toshiba has agreed with national utility company in Malaysia to further collaborate on CO_2 capture technology implementation, and begun full-scale introduction of CCS technology to thermal power plants in **Malaysia**, including the acceptance of national utility company 's engineers to Toshiba ESS facilities.

Overall Activities (82days)



[Toshiba and Tenaga Nasional Berhad, to Accelerate the Application of CO_2 Capture Technology to Thermal Power Plants | News Release | Toshiba Energy Systems & Solutions (global.toshiba)]

Business expansion into global market
~Application of CO_2 Capture Technology to Large Thermal Power Plants(2)~

Toshiba has established a framework of a strategic technology partnership with PLN-Nusantara Power for the future introduction of carbon capture technology.
Both parties will conduct a Feasibility Study under the MOU, including the implementation of a pilot plant at existing PLN power generation assets in **Indonesia**.

Idea of candidate plant (Toshiba OEM)

Paiton Power Station

Carbon Capture
Pilot Plant

AZEC Jakarta, Aug.21,2024

Exploring opportunities to introduce CCS Add-ons for Thermal Power Plants in Southeast Asian Countries.

Thank you for your attention !

The information and statements made in this document and during the presentation represent solely the personal views of the individual, and do not represent the views of the organization to which the speaker belongs.

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