



Parameter Test Results of Large Scale BECCS ready CO2 Capture Demonstration Plant (MOEJ's Sustainable CCS Project)

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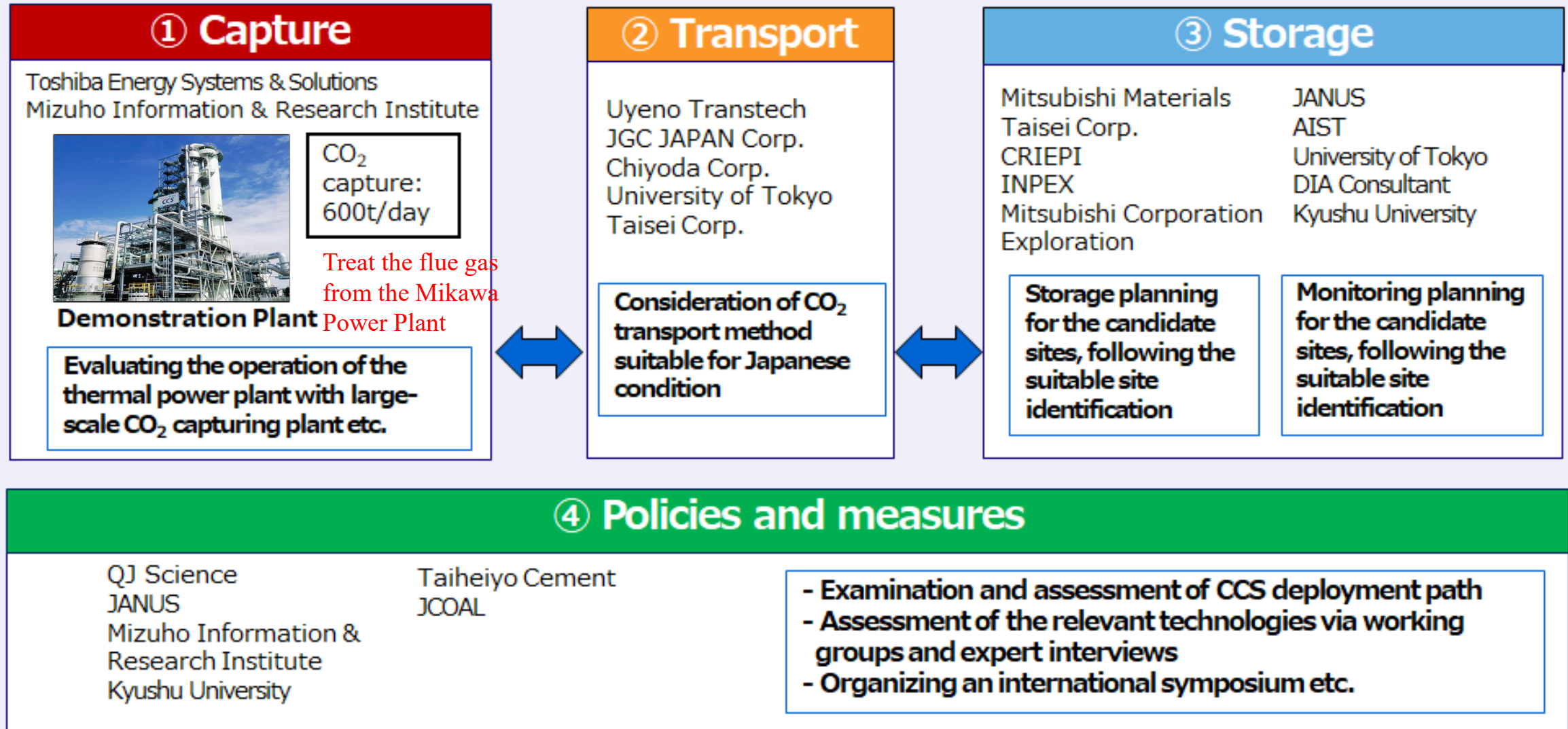
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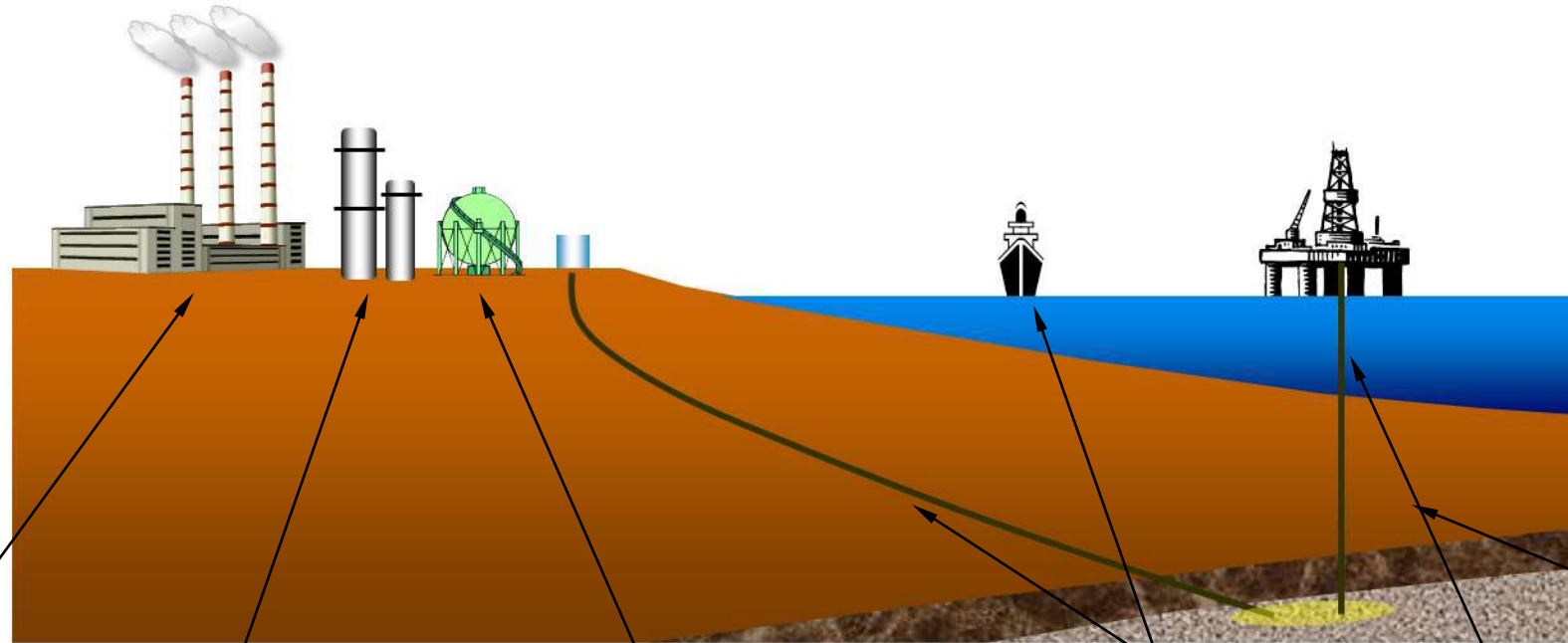
About this project and the Demonstration Plant

MOEJ's Sustainable CCS Project



*Commissioned by Ministry of the Environment, Government of Japan (MOEJ)

MOEJ's Sustainable CCS Project



Emission
Source

CO2 Capture

Compression &
liquefaction

Shipping

Storage

Surveillance

**2021 - 2025 : Capture& Shipping demonstration
(Phase2)**

**1. Demonstration and evaluation of large-scale
CO2 capture technologies**

2. Study of integration between CO2 compression and
liquefaction facility (transportation facility) and CO2 capture
demonstration facility

Future : Storage demonstration

- Site selection for storage
- Construct Storage facility
- CCS full-process demonstration
- Etc...

2014 - 2016 : Pre-FEED (Done) (Phase 0)
2016 - 2020 : Construction &
Commissioning (Done) (Phase 1)

Achievement

Completion of the construction of CO2 Demo Plant
Completion of the commissioning of CO2 Demo Plant
world-class performance of mitigation of Amine emission

Layout of the Mikawa Power Plant and CO2 Capture Plant

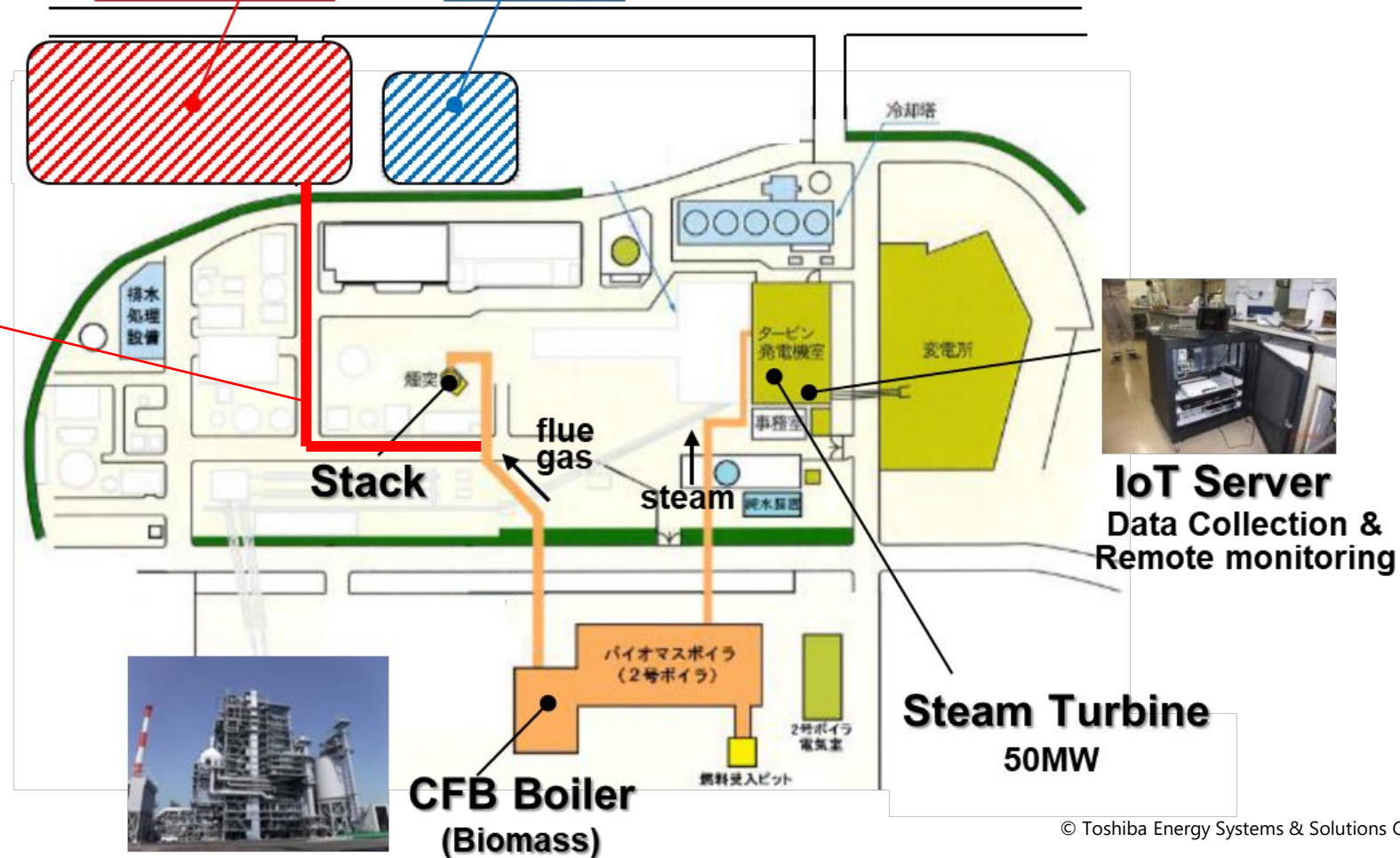
CO₂ Capture Demonstration Plant

Constructed under
the Ministry of the
Environment Project



PCC Pilot Plant

Toshiba owned



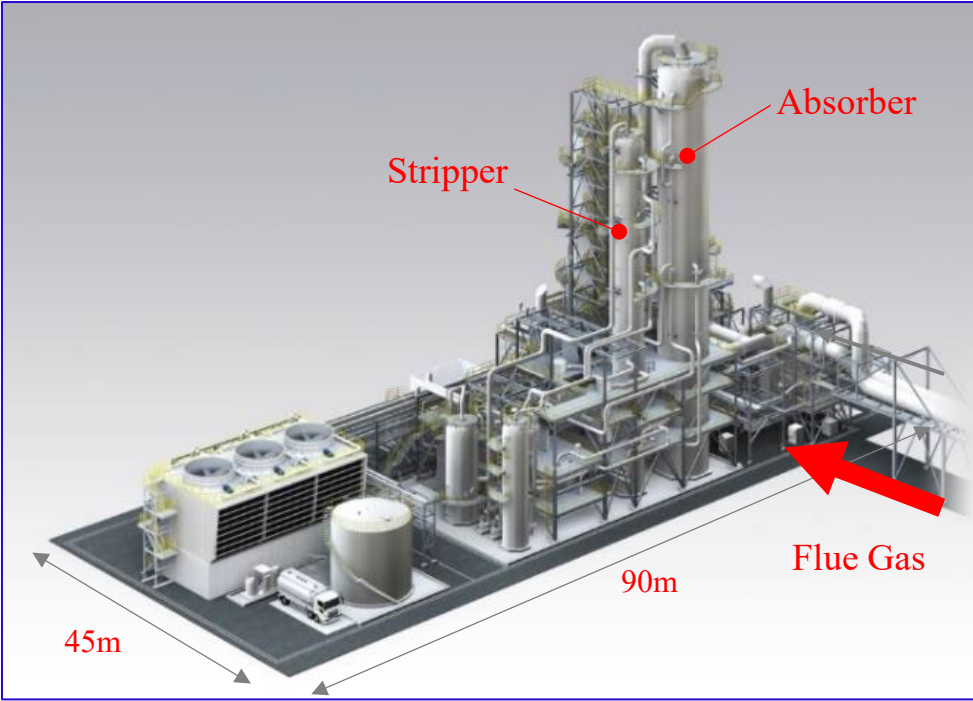
Plant Overview - CO2 Capture Plant Specifications-

Plant Specifications

CO2 capture	Over 600 t/day
CO2 capture rate	Over 90%
Steam Conditions	
- Pressure	0.35 MPaG
- Temperature	180 °C
- Flow	29 t/h

Exhaust Source Overview

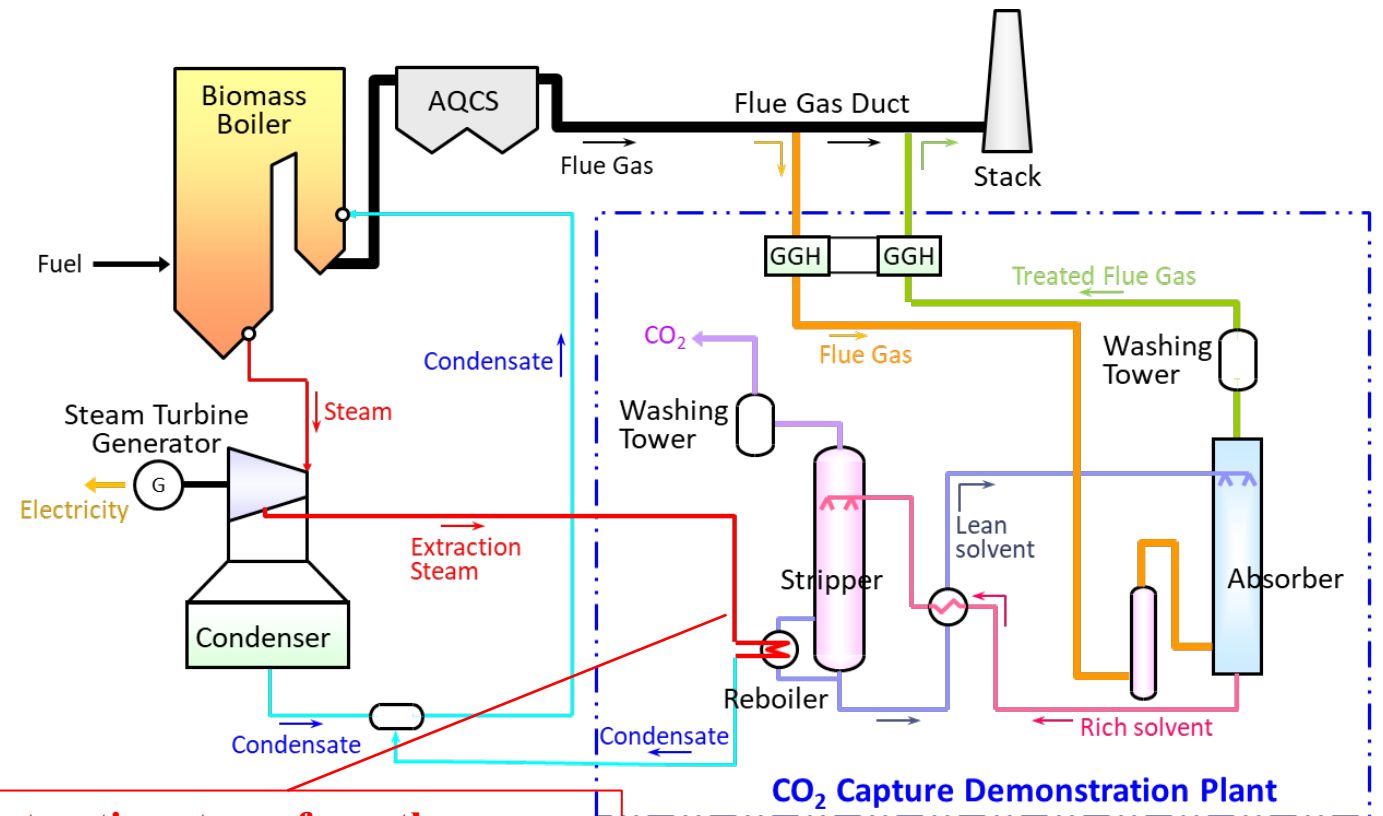
Location	Omuta City, Fukuoka Prefecture
Power Generation	100% Biomass Power Generation
Fuel	PKS (Palm Kernel Shell)
Power Output	50,000 kW
CO2 emissions	About 1,100 t/day



- Solvent : Toshiba solvent-1 (TS-1)
- CO2 in flue gas : 15 vol.% in dry base

CO2 Capture Demonstration Plant –Features-

- ◆ Since the Mikawa Power Plant has a boiler burning 100% biomass, this CO2 Capture Demonstration Plant can be a part of total BECCS system(World's first BECCS project), once captured CO2 is transported and stored.
- ◆ This plant captures 600 tons-CO2/day from the flue gas of the Mikawa Power Plant (more than 50% of its total emissions) and is fully integrated with this power plant with turbine extraction steam feeding the energy for desorbing CO2 at the stripper.



Extraction steam from the power plant is utilized as the heat source

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Demonstration Test Overview

Motivation and Brief PFD

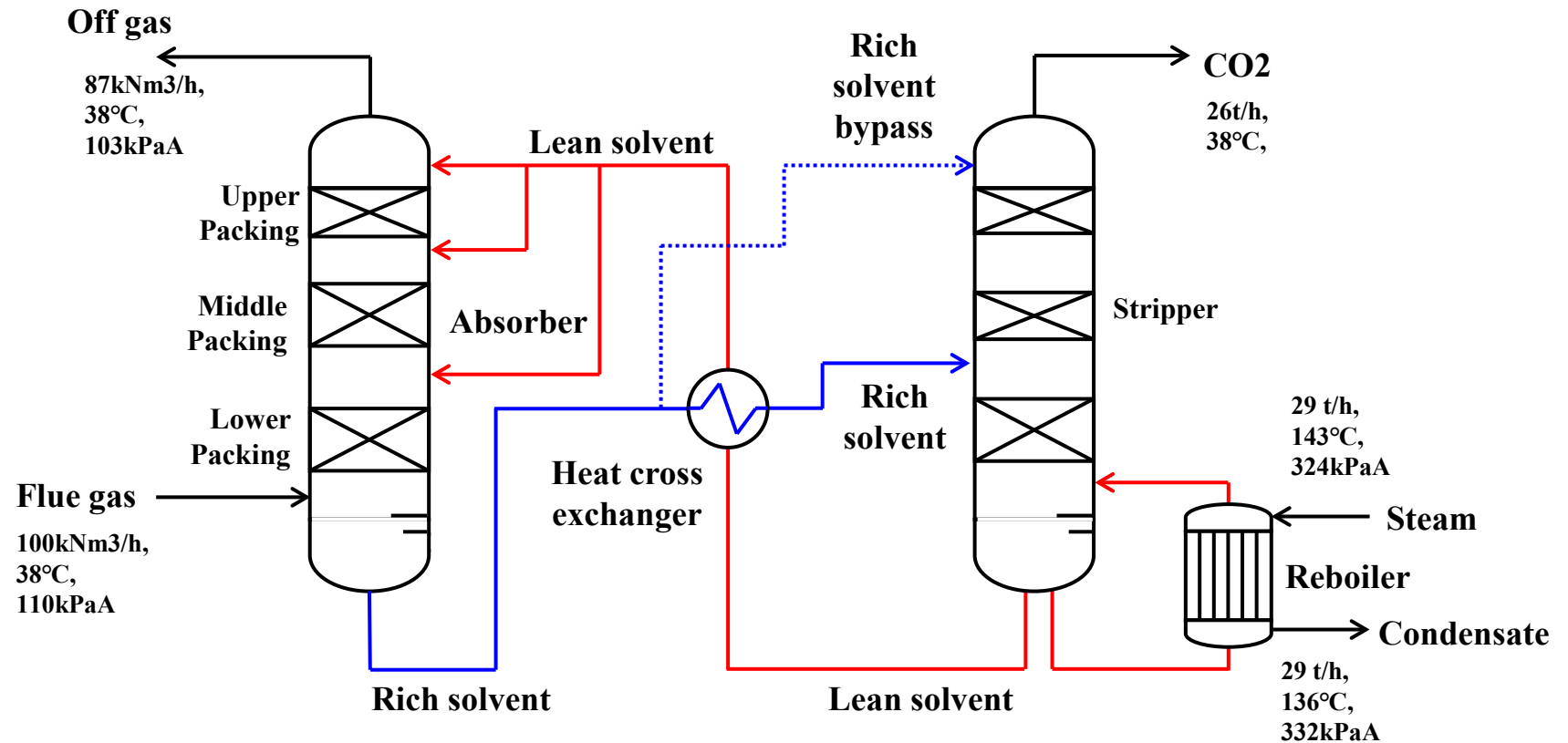
Motivation :

Evaluation CO₂ capture amount, CO₂ capture rate and CO₂ capture energy upon meeting the design performance criteria, changing the parameters (Solvent flow rate, Steam flow rate), the Absorber supply stage is also modified

Design Criteria :

CO₂ capture amount: 600[tpd]

CO₂ capture rate: 90[%]



Evaluation the performance changing various parameters

Test Result - In the rated load (100% load) -

CO2 capture amount [tpd]			CO2 capture rate [%] (=C/B*100)
Gas side		Solvent side (=E-F)	
Absorber side (=B-C)	Stripper side (=D)		
656.8	640.2		
			93.9

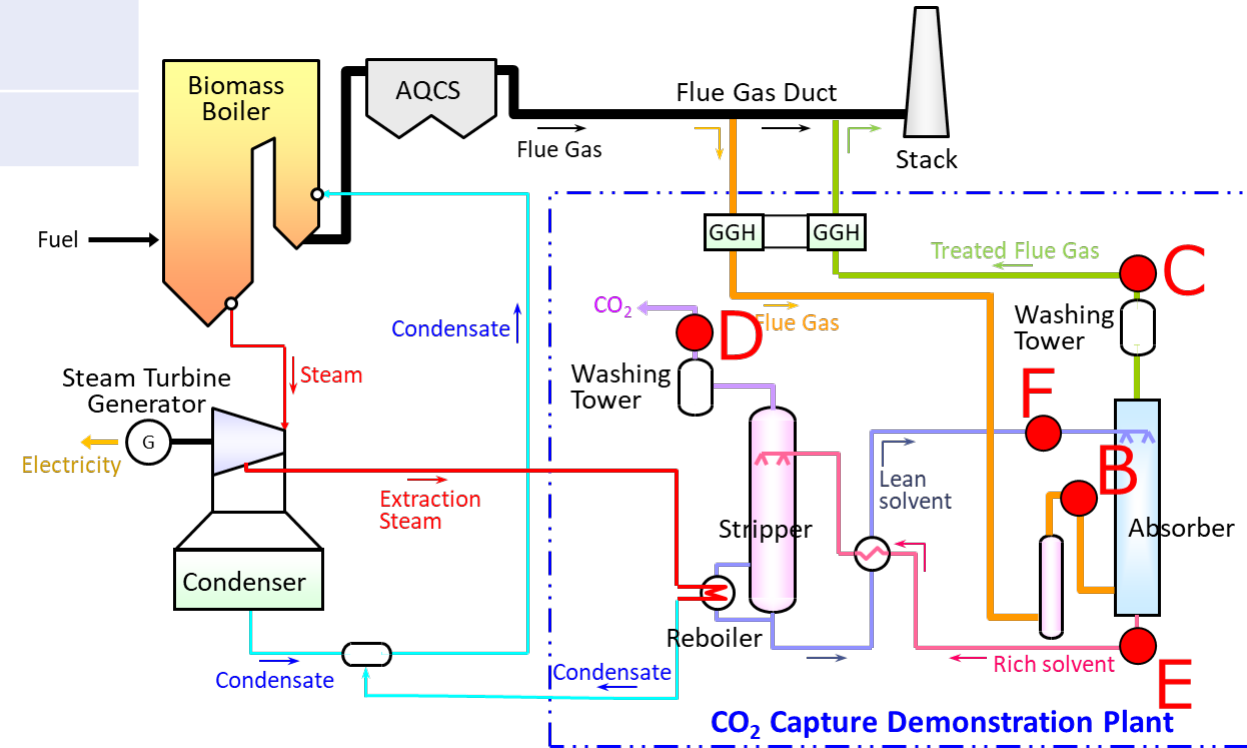
Performance

- ✓ CO2 capture amount (=D) : 640.2 ton/day[tpd]
- ✓ CO2 capture rate (=C/B*100) : 93.9%
- ✓ CO2 capture energy: 2.51 GJ/ton-CO2

note:

For example, “B-C” means CO₂ flowrate in point B subtracted by that in point C

In this context, 100% represents the design value based on our MBHB



CO2 capture amount assessed via Stripper side based on ISO basis

Test Result - Minimum/Maximum Flow Rate -

Motivation:

Verify that the system operates properly and performs as expected when steam, exhaust gas, and solvent circulation rates are run at their design minimum and maximum flow rates.

Test conditions	Flue gas flow rate [%]	Solvent flow rate [%]	Steam flow rate [%]
Maximum Flow Rate	100	110	130
Minimum Flow Rate	50	50	50

Performance

Maximum Flow Rate Test

- ✓ Captured CO₂: 697[tpd]
- ✓ CO₂ capture rate : 99.7[%]
- ✓ CO₂ capture energy: 2.58[GJ/ton-CO₂]

Minimum Flow Rate Test

- ✓ Captured CO₂: 321[tpd]
- ✓ CO₂ capture rate : 93.1[%]
- ✓ CO₂ capture energy: 2.48[GJ/ton-CO₂]

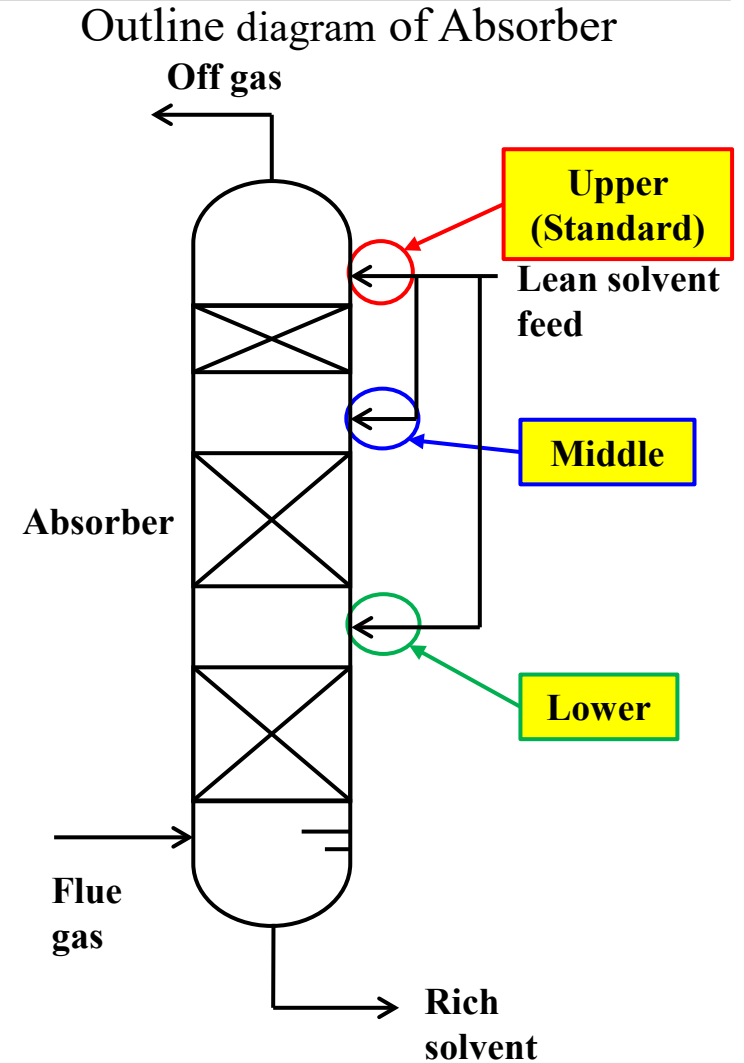
Performance were verified at the design maximum/minimum operating conditions

Demonstration Test Condition

Test No	Supply stage	Solvent flow rate [%]	Steam flow rate[%]
1	Upper (Standard)	100	100→90→80→70
2	Upper (Standard)	110	110→120→130
3	Upper (Standard)	100→90→80→70	100
4	Middle	100	100→110→120
5	Middle	110	100→110→120
6	Middle	90	100→110→120
7	Lower	100	100→110→120
8	Lower	110	100→110→120

note: Flue gas flow rate is 100%

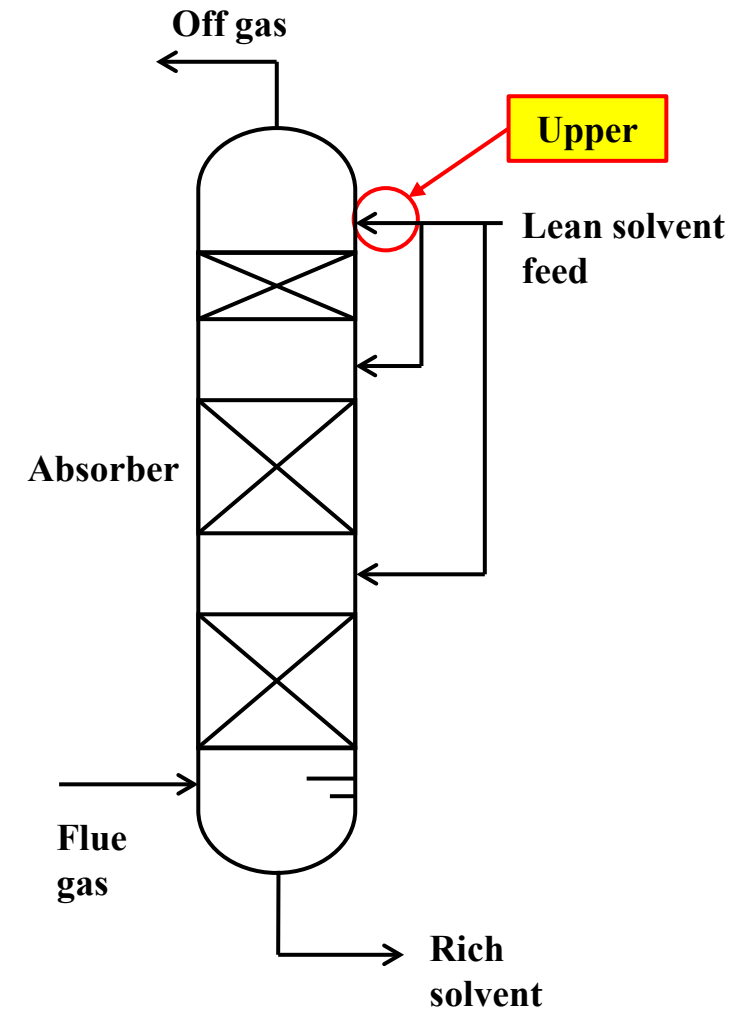
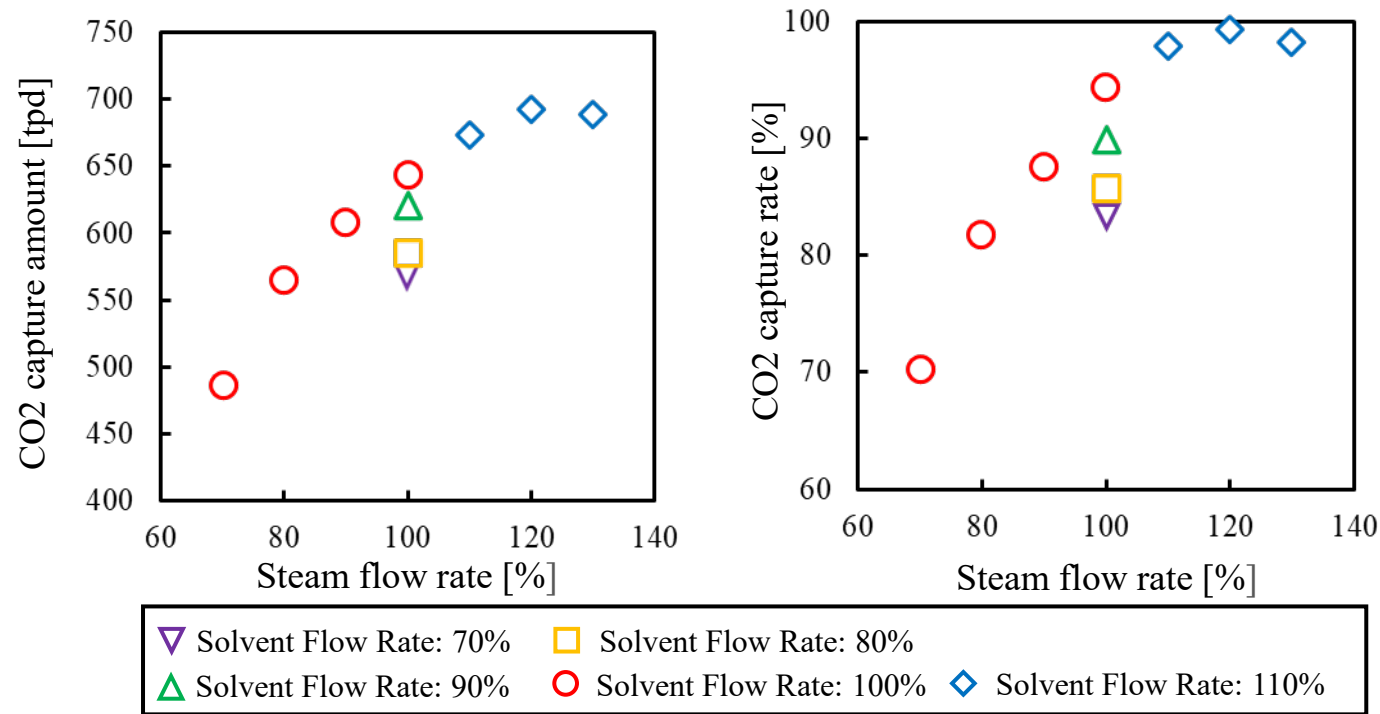
100% represents the design value based on our MBHB



Verify the conditions that satisfy the design criteria

Test Result -at Upper Stage feed-

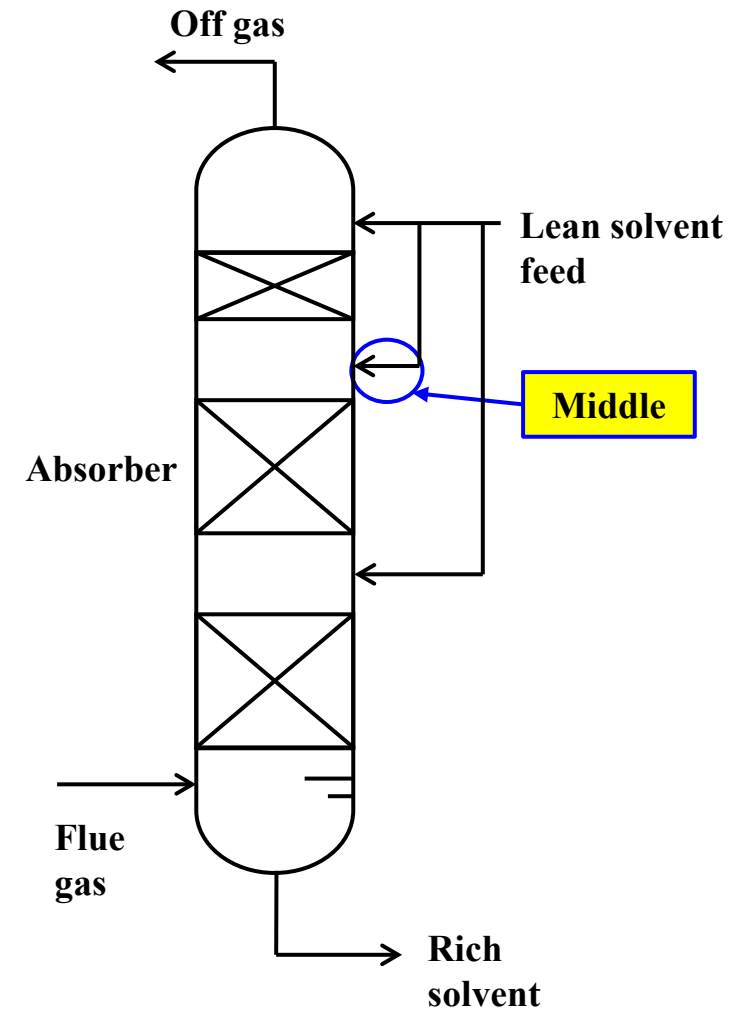
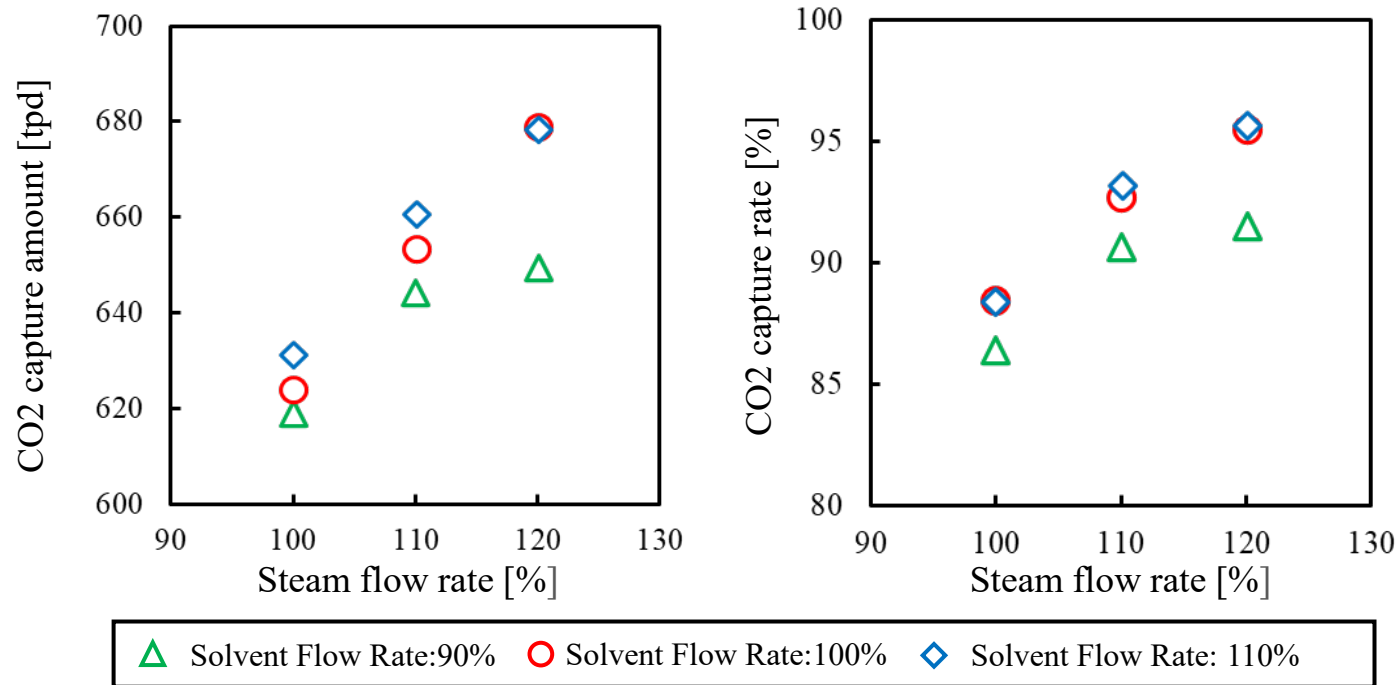
Test No	Supply stage	Solvent flow rate [%]	Steam flow rate[%]
1	Upper (Standard)	100	100→90→80→70
2	Upper (Standard)	110	110→120→130
3	Upper (Standard)	100→90→80→70	100



More than 100% Solvent flow rate and Steam flow rate are needed

Test Result -at Middle Stage feed-

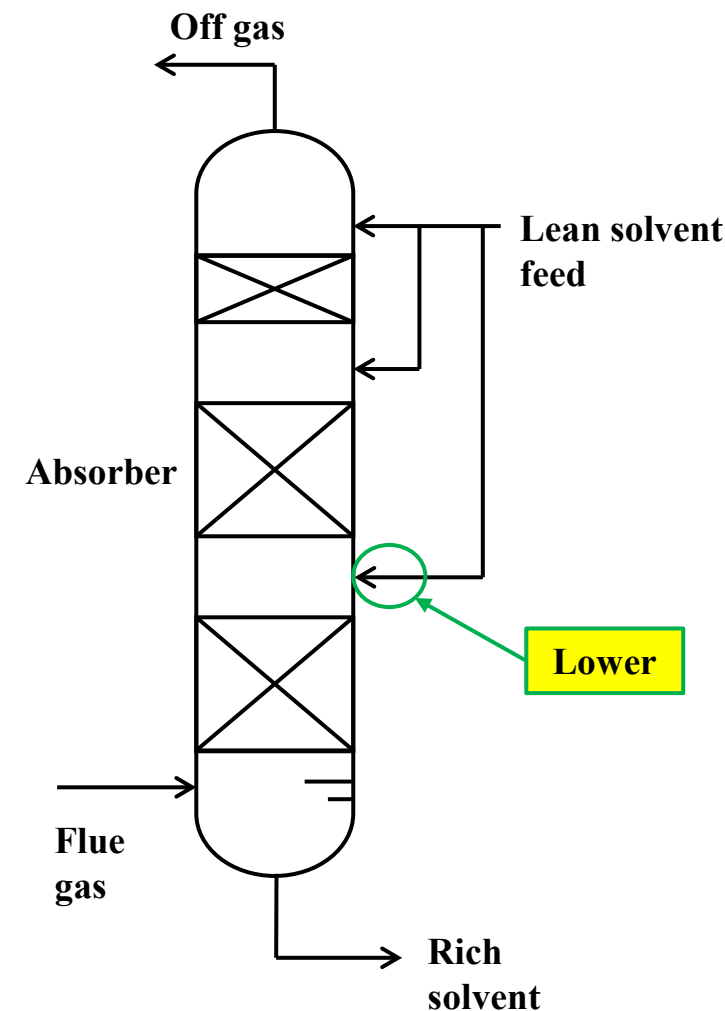
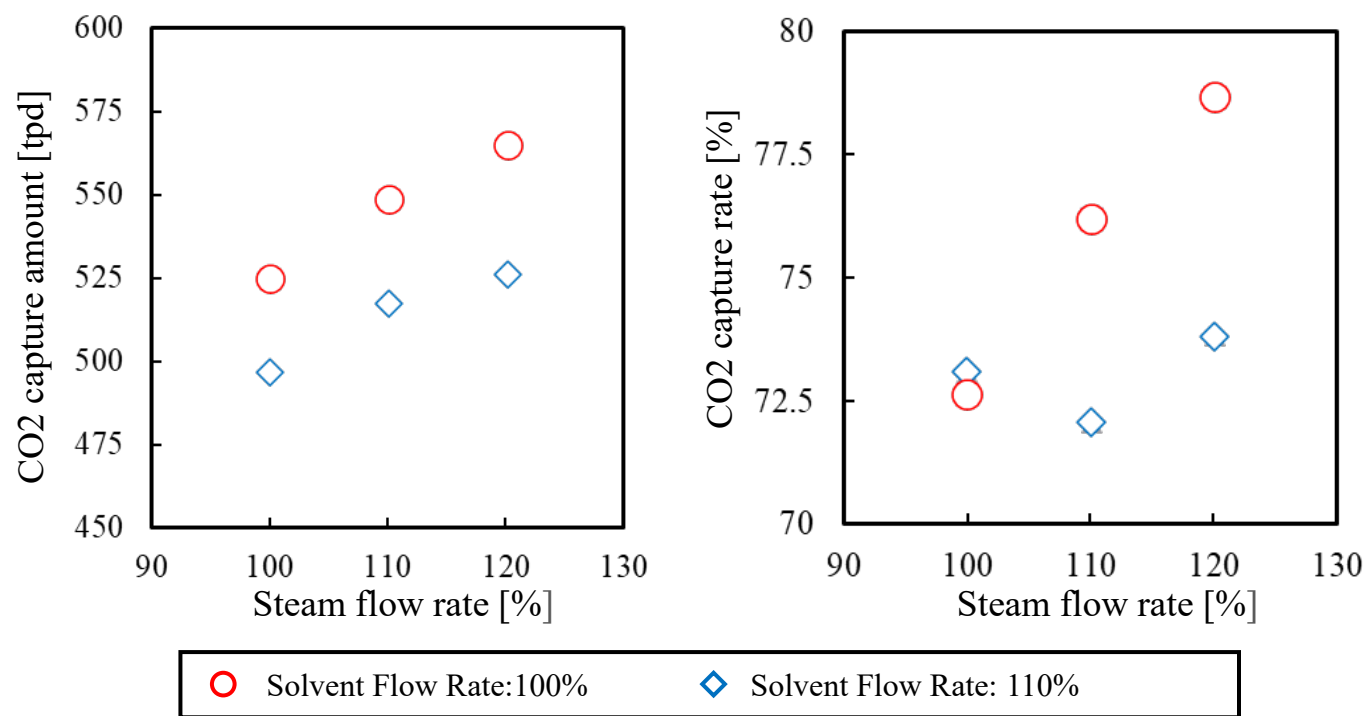
Test No	Supply stage	Solvent flow rate [%]	Steam flow rate[%]
4	Middle	100	100→110→120
5	Middle	110	100→110→120
6	Middle	90	100→110→120



More than 90% Solvent flow rate and 110% Steam flow rate are needed

Test Result -at Lower Stage feed-

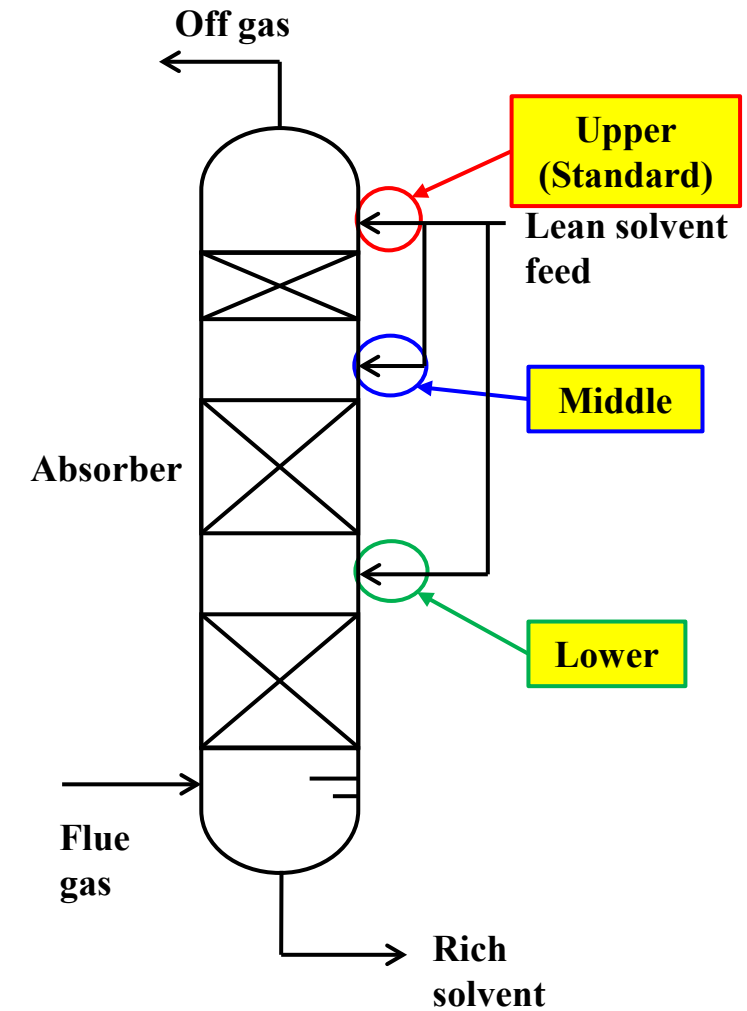
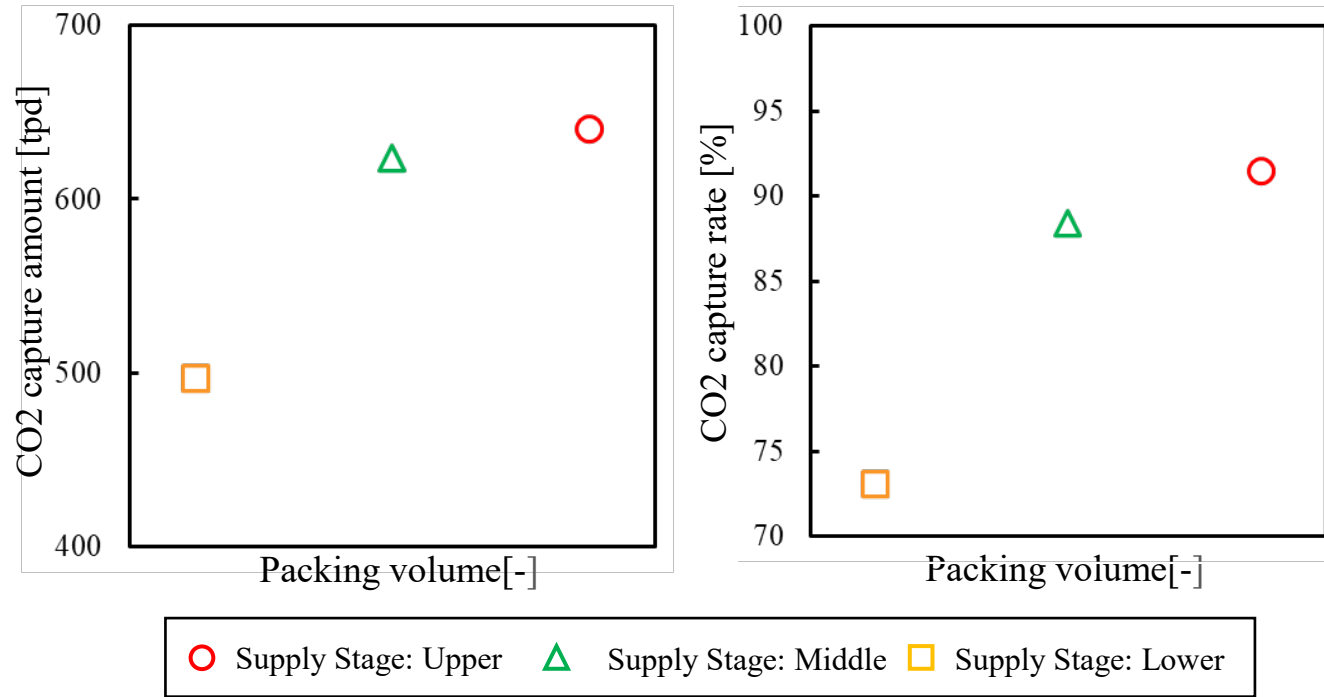
Test No	Supply stage	Solvent flow rate [%]	Steam flow rate[%]
7	Lower	100	100→110→120
8	Lower	110	100→110→120



Unable to achieve the design criteria at Lower stage feed

Test Result -depending on Packing stage-

Supply Stage	Flue Gas Flow Rate[%]	Solvent Flow Rate [%]	Steam Flow Rate [%]
Upper	100	100	100
Middle	100	100	100
Lower	100	100	100



Confirmed 600tpd was achieved under the condition of middle packing feed

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Summary

Summary

Conclusion

- ✓ The Demonstration Plant accomplished stable operation at the average capture rate of 640 tons per day, which corresponds to more than 50% of emitted CO₂ from the Mikawa Power Plant. This Demonstration Plant also showed the adequate integration with the power plant without any problem.
- ✓ In the maximum flow test (Solvent flow rate 110%, Steam flow rate 130%), the CO₂ capture amount record 697 tons-CO₂/day.
- ✓ We, Toshiba ESS, conducted a parameter variation test and evaluated operating conditions that meet the design criteria at scale.
- ✓ It was confirmed that the performance criteria were met even under middle stage supply under certain conditions, indicating the possibility of downsizing Absorber (Lower CAPEX).

Summary

Future Work

- ✓ More performance tests will be conducted using solvent temperature and flue gas temperature as parameters.
- ✓ The replacement of type of Absorber packing will be carried out, and performance evaluations will be conducted before and after the replacement.



Thank you for your attention !

Acknowledgements

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TOSHIBA