TOSHIBA

Japan CCS Forum 2025

Toshiba's activity in CCUS
~Integration with gas turbine combined cycle~

4th December 2025

Toshiba Energy Systems & Solutions Corporation

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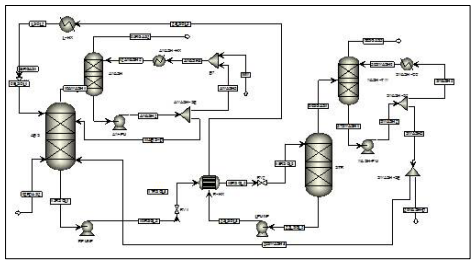
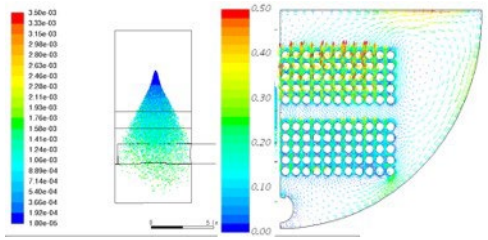
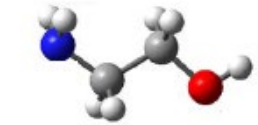
Implementation flow of Toshiba's CO2 capture technology



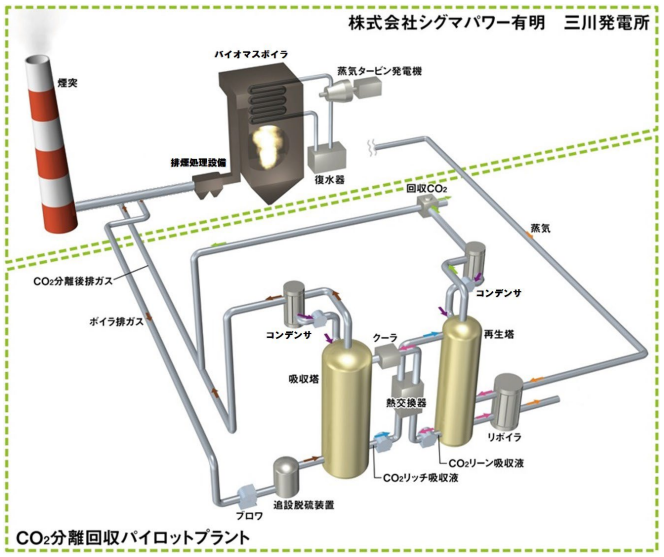


Process design / Evaluation of System Performance Improvement by Simulation and laboratory test



Solvent development

System development by small loop test



Overall demonstration at Mikawa Pilot Plant

Application for actual plant design

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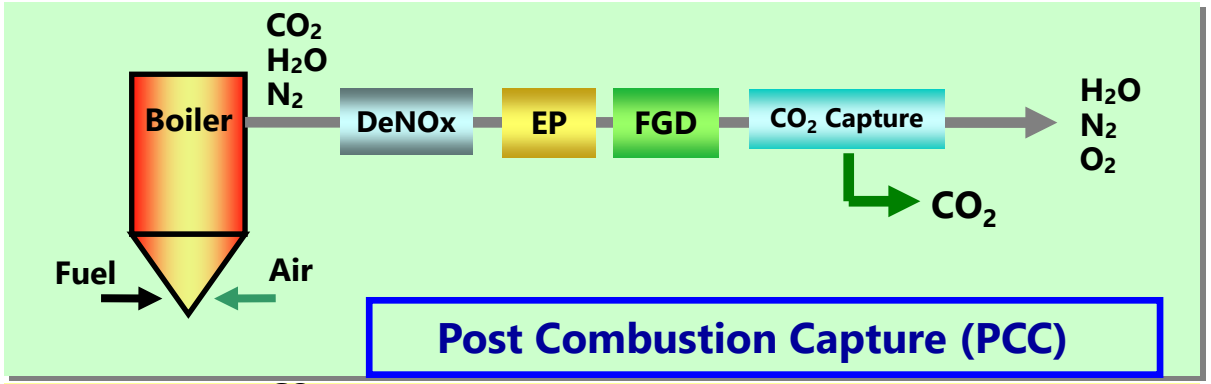
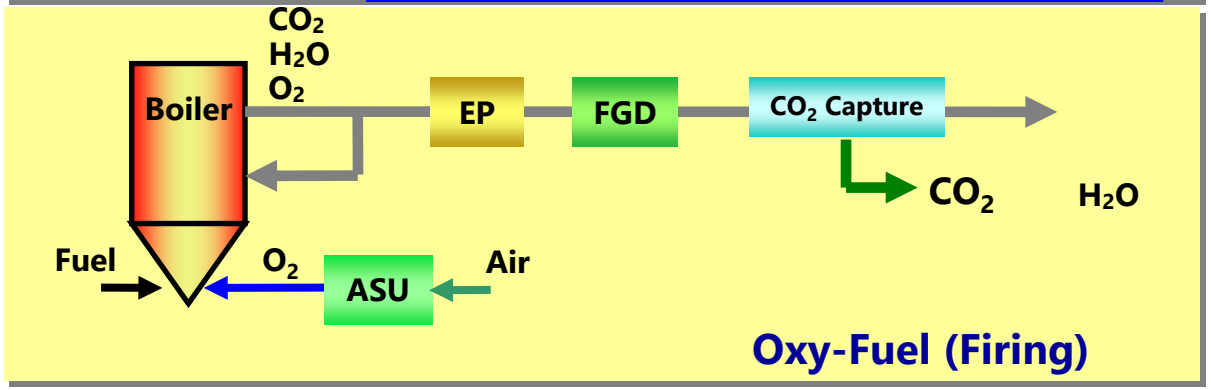
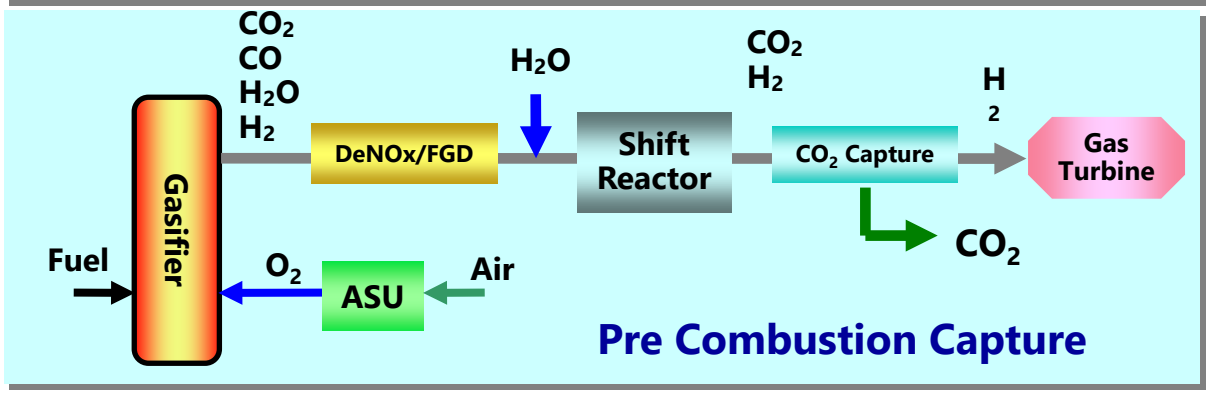
CO2 capture technology for thermal power plants







ASU: Air Separation Unit FGD: Fuel Gas Desulphurization EP: Electrostatic Precipitator

PROS:
- Process proven in chemical industry
- Adaptable to new plant, add-on to existing plant
- Adaptable to other emitters (steel, cement)
- Partial capture configuration possible

CONS:
- Energy loss for capture
- Larger equipment than other techs

PROS:
- Capture process after boiler simplified
- Little penalty associated with capture itself

CONS:
- Energy penalty and cost required for ASU
- Plant operational flexibility
- Additional equip required for CO2 purity
- No partial capture configuration possible

PROS:
- Capture equipments smaller (high pressure)
- Capture energy penalty smaller

CONS:
- **Energy penalty** and cost required for ASU
- IGCC lacks operational flexibility of CC
- Only new build application
- No partial capture configuration possible

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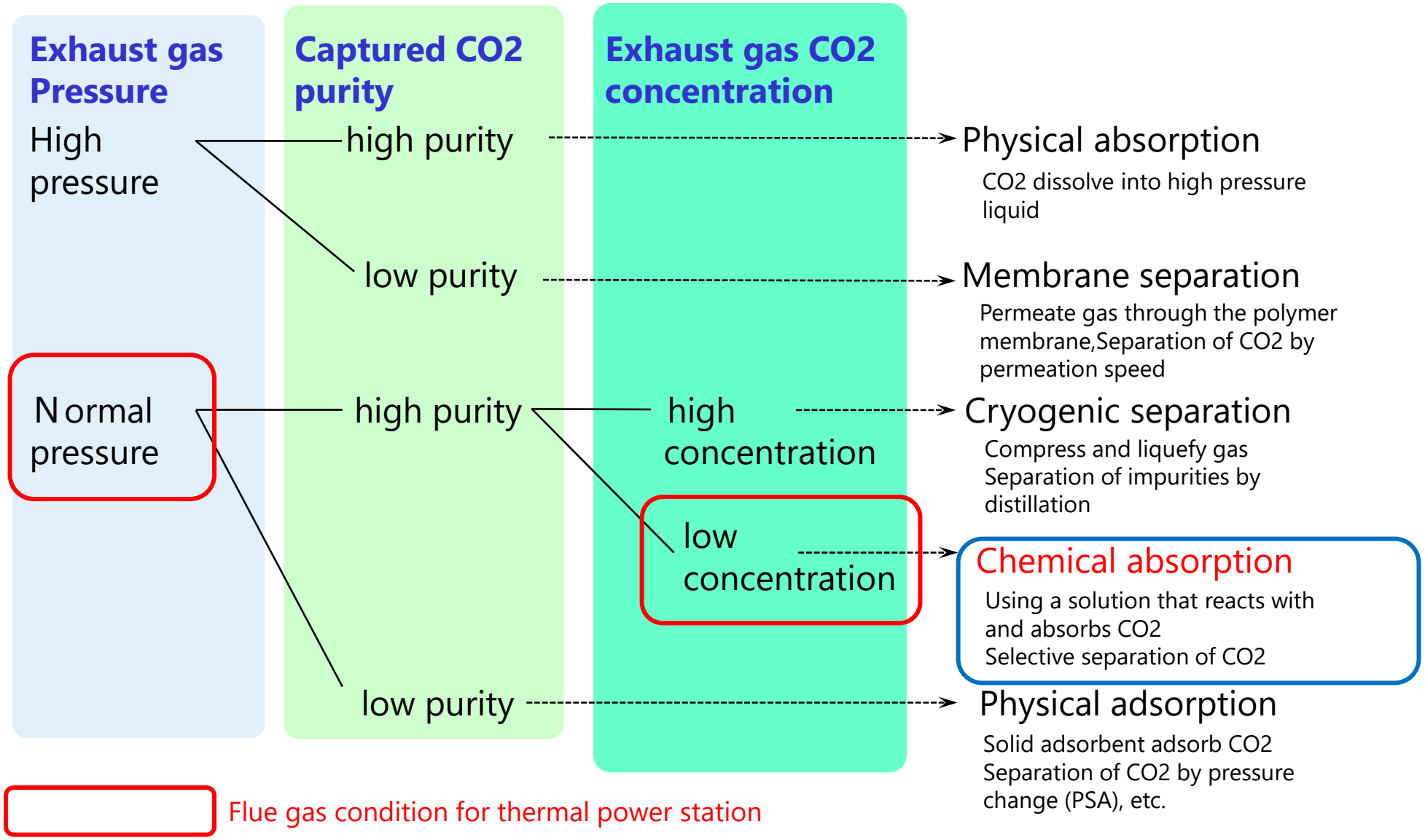
Introduction of CO2 capture method



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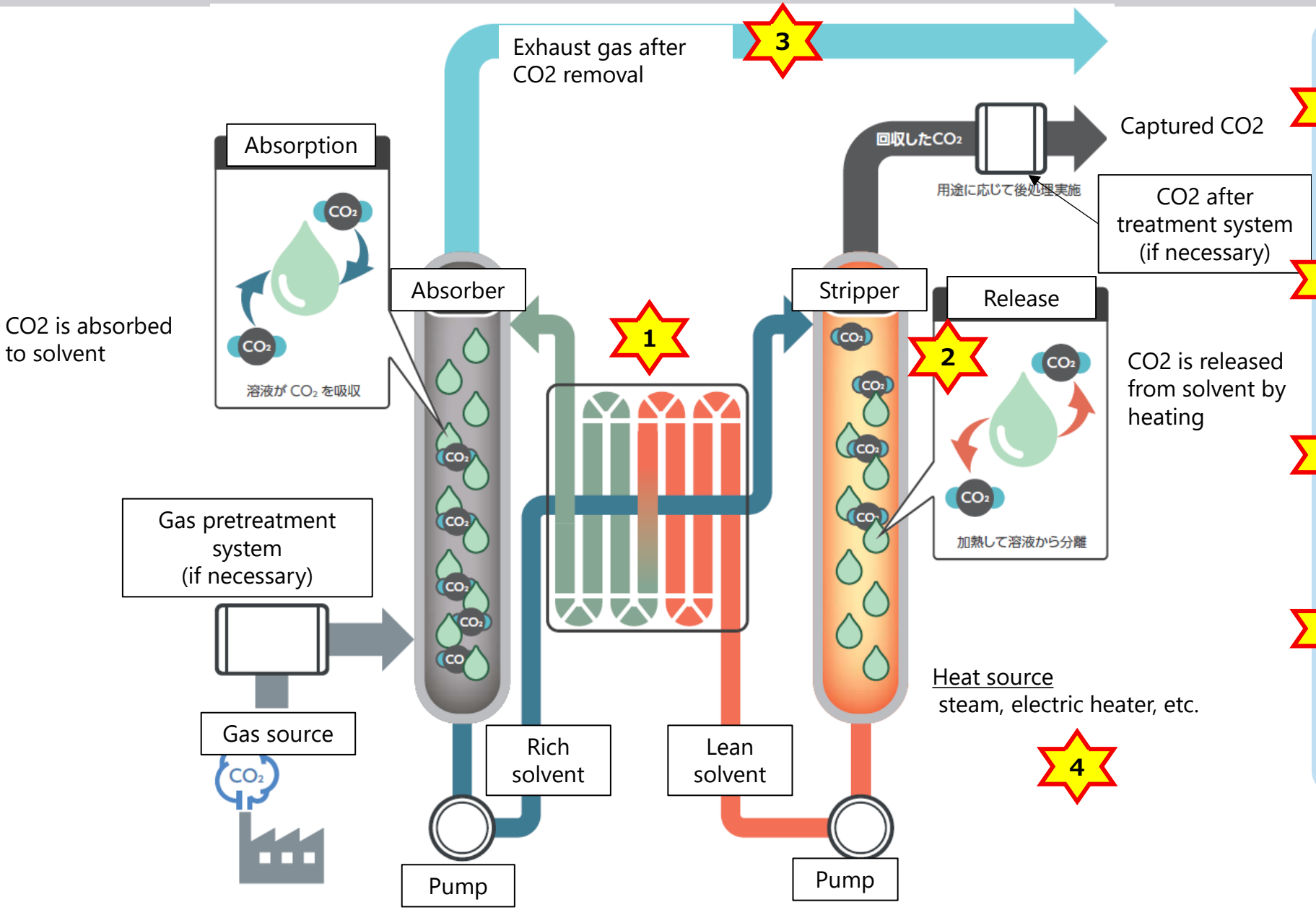
Carbon dioxide capture system using chemical absorption method



Why Toshiba ?

1 Less energy consumption

Licenser of amine solvent, with lower steam energy consumption

2 Reliability/Quality of solvent

Owner and Operator of its own Pilot Plant

3 Environmental

Testing of amine emissions and its control methods

4 Coordinating steam cycle

integrate CCUS system with existing steam cycle systems

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Delivery records in the development of the 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)

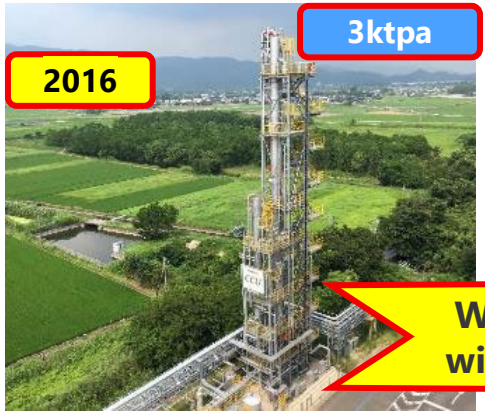
Ⅱ WtE Plant （CCU）

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 ready plant

★BECCS： Bio-Energy with CCS

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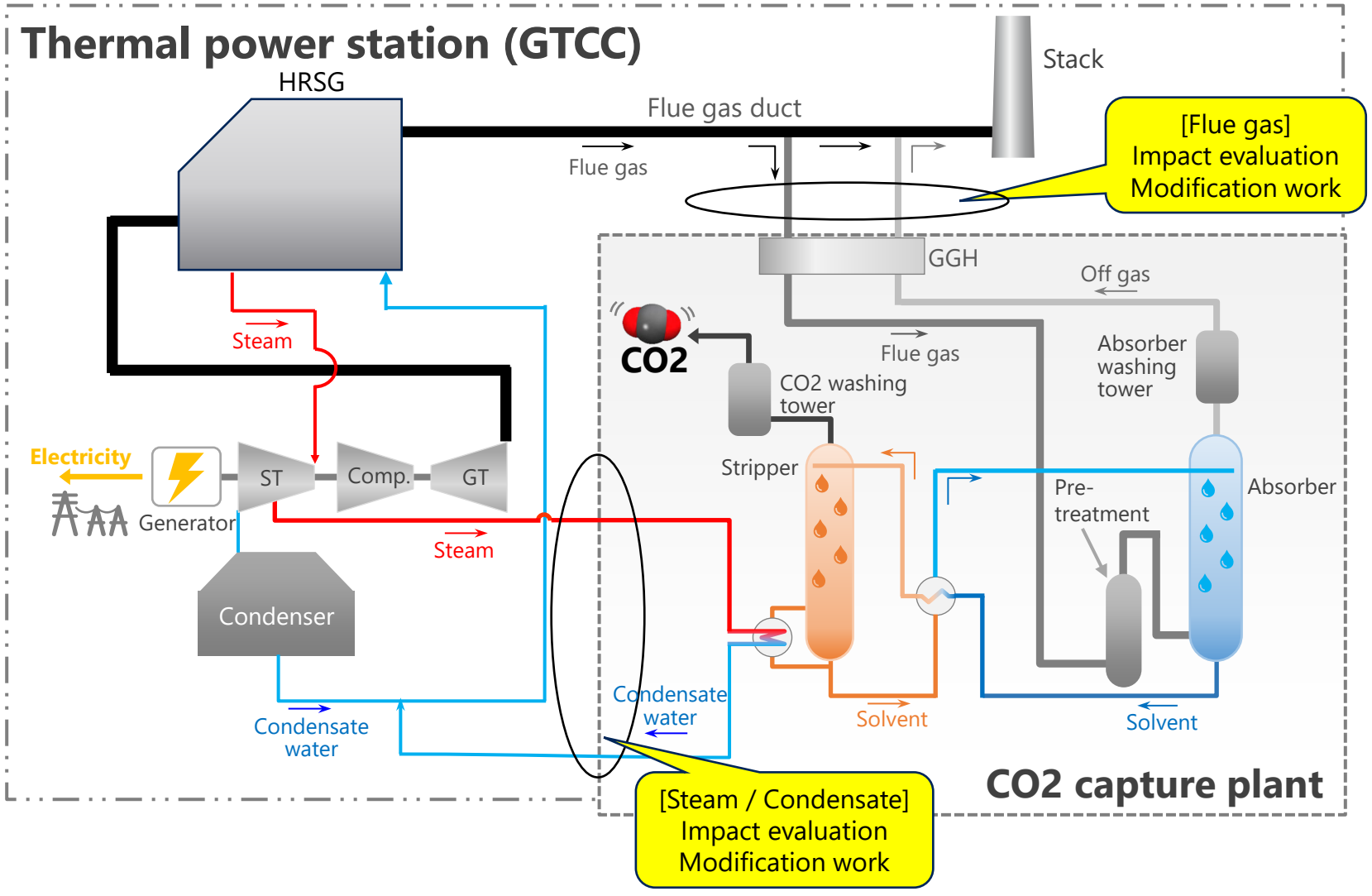
Integration between CO2 capture plant and thermal power station



Material balance / Heat balance

- ✓ Matching of CCS and bottoming cycle
- ✓ Plant overall (CCS+GTCC) design optimization

Flue gas system

- ✓ Flue gas supply/return line impact evaluation
- ✓ Flue gas system integration with GTCC
- ✓ Study of additional flue gas pretreatment for CCS

Steam cycle system

- ✓ Steam supply and condensate water line impact evaluation
- ✓ Steam system integration with GTCC
- ✓ Study of steam turbine modification and auxiliary equipment

CO2 capture plant

- ✓ Integration with bottoming cycle and utility
- ✓ Plan overall (CCS+GTCC) layout optimization

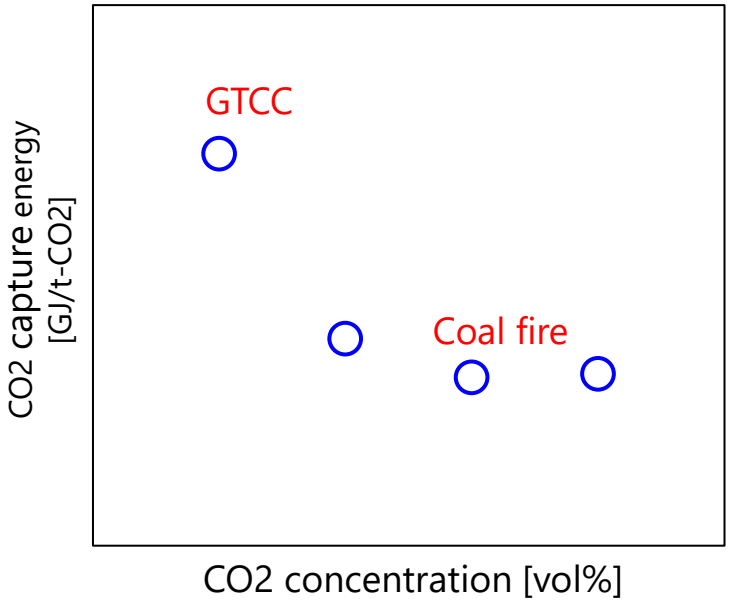
Optimal integration between CO2 capture plant and Thermal power station is important

CO2 capture from gas turbine combined cycle

- Cabinet Decision on the 7th Strategic Energy Plan on 18th February 2025 in Japan.
- In this Plan, new construction of Gas Turbine Combined Cycle (GTCC) power plants with decarbonization countermeasures are promoted as follows.

(Quoted from 7th Strategic Energy Plan)

- ✓ *To further secure thermal power supply capacity, Japan will accelerate new construction and replacement of LNG-fired power plants on the premise of further decarbonization, while keeping an eye on future trends in the electricity supply-demand balance.*
- ✓ *In addition, decarbonization of LNG-fired power generation using hydrogen and CCUS and other technologies will be promoted through the Long-Term Decarbonized Capacity Auction and other means.*



- CO2 concentration of GTCC flue gas (4~5%) is lower than that of coal fire flue gas (12~14%).
- Lower CO2 concentration leads to higher CO2 capture energy.

Larger amount of steam energy from steam turbine is necessary for GTCC plant compared with coal fire power plants.

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Toshiba and GE Vernova MoU summary

Toshiba and GE Vernova (GEV) have signed MoU to advance carbon reduction and efficiency for GTCC plants in Japan and other parts of Asia (press released on 6th November).

Front row from left: Mr. Jeremee Wetherby of GE Vernova, Mr. Kensuke Suzuki, Head of New Technology of Toshiba's Power Systems Division
Back row: Mr. Shinichi Kihara of METI's Director-General for Energy and Environmental Policy

- Objective of the MoU is to reduce CO2 emissions combining GEV's Exhaust Gas Recirculation (EGR) system and Toshiba's CO2 capture technologies in GTCC plants in Japan and other parts of Asia.
- The MoU strengthens a strategic collaboration that has spanned 40 years between the two companies.
- This initiative is related to the focus group introduced June 2025 by Japan's Ministry of Economy, Trade and Industry (METI) and GEV.

https://www.global.toshiba/ww/news/energy/2025/11/news-20251106-01.html

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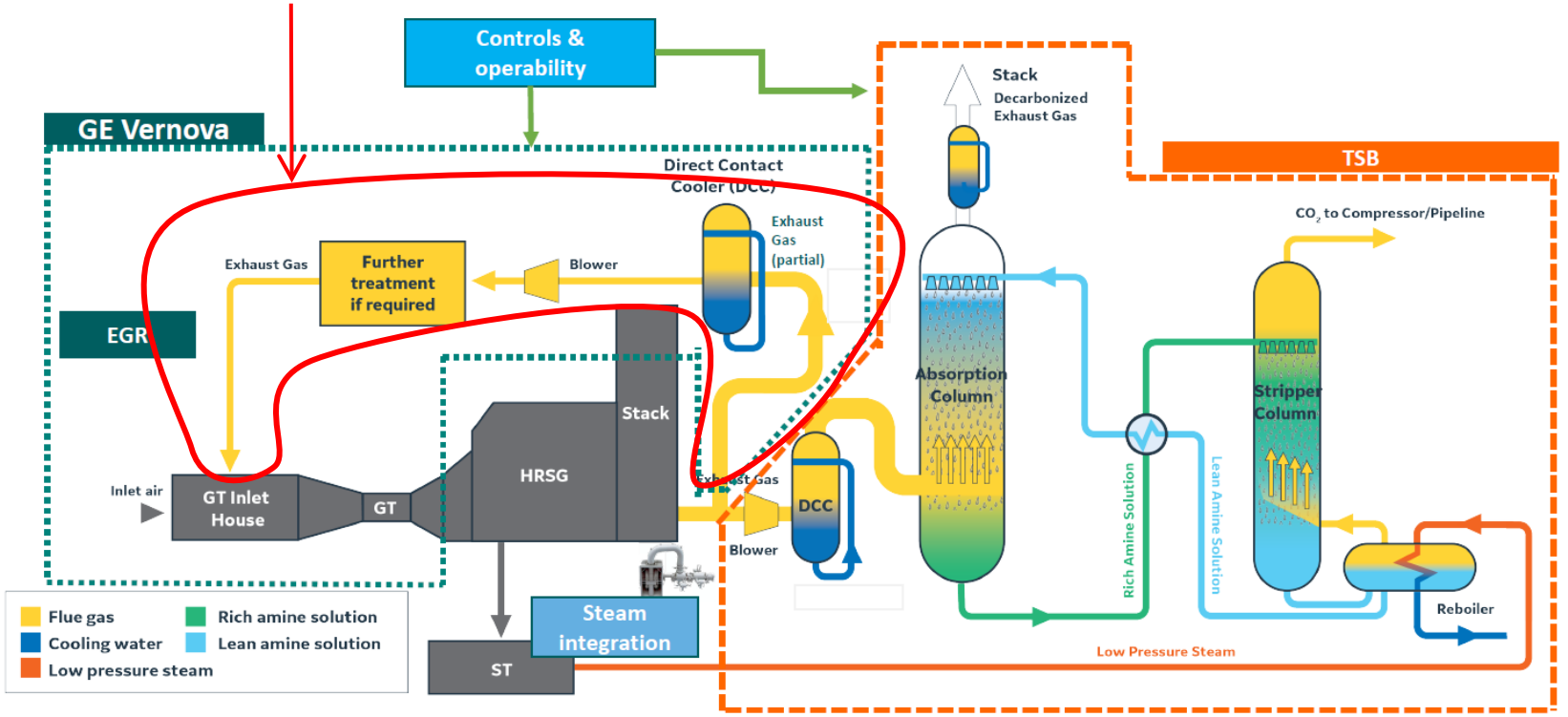
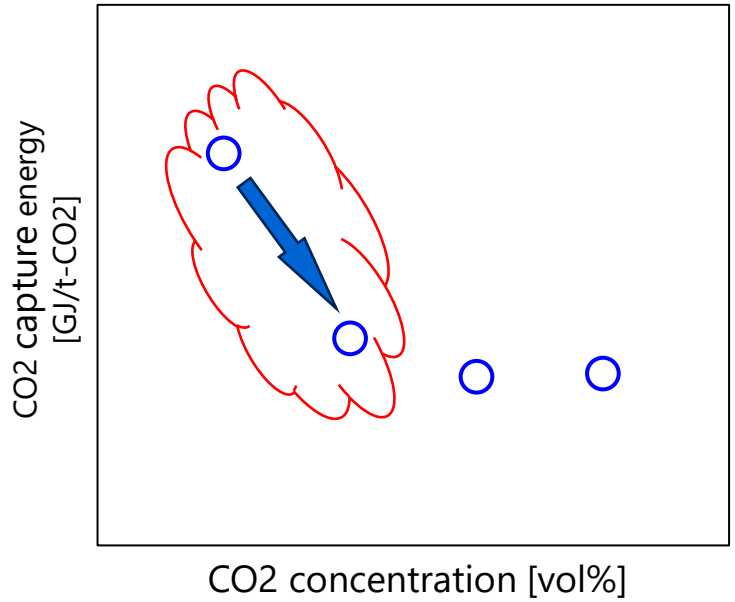
Application of EGR system to CO2 capture from GTCC plant

EGR system (supplied by GEV)





- CO2 concentration in the flue gas will be increased by applying GEV's EGR technology.
- CO2 capture energy will be decreased, therefore steam energy from steam turbine can be decreased.
- As a result, smaller GTCC power output decreasing can be achieved compared with no EGR condition.
- Further benefits of applying EGR are shown on the next page.

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Benefits for applying EGR system

Below benefits are expected by applying EGR technology to CO2 capture from EGR system.

Item	Effect	Detail
CO2 capture energy	Lower	Higher CO2 concentration in the flue gas reduces the CO2 capture energy. This suppresses the decrease of electrical power outlet of GTCC plant when steam integration is considered.
Main equipment size and footprint	Smaller	The flue gas flow rate decreases by applying EGR system, resulting in a reduced amount of flue gas entering the CCS system. This makes major equipment such as the absorber more compact, allowing for a smaller installation footprint.
Auxiliary power	Lower	Compact CCS equipment such as lower flue gas flow rate leads to a reduction in auxiliary power consumption.
Solvent make-up	Smaller	A smaller absorber reduces the solvent inventory, and lower oxygen concentration in the flue gas suppresses oxidative degradation of solvent, resulting in reduced makeup solvent requirements during operation.

As a result of the above benefits, a reduction of CAPEX and OPEX of CO2 capture system should be expected.

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