# The Progress of Osaki CoolGen Project

Fourth International Conference on Carbon Recycling

September 26, 2022

Osaki Coolgen Corporation

https://www.osaki-coolgen.jp/en/

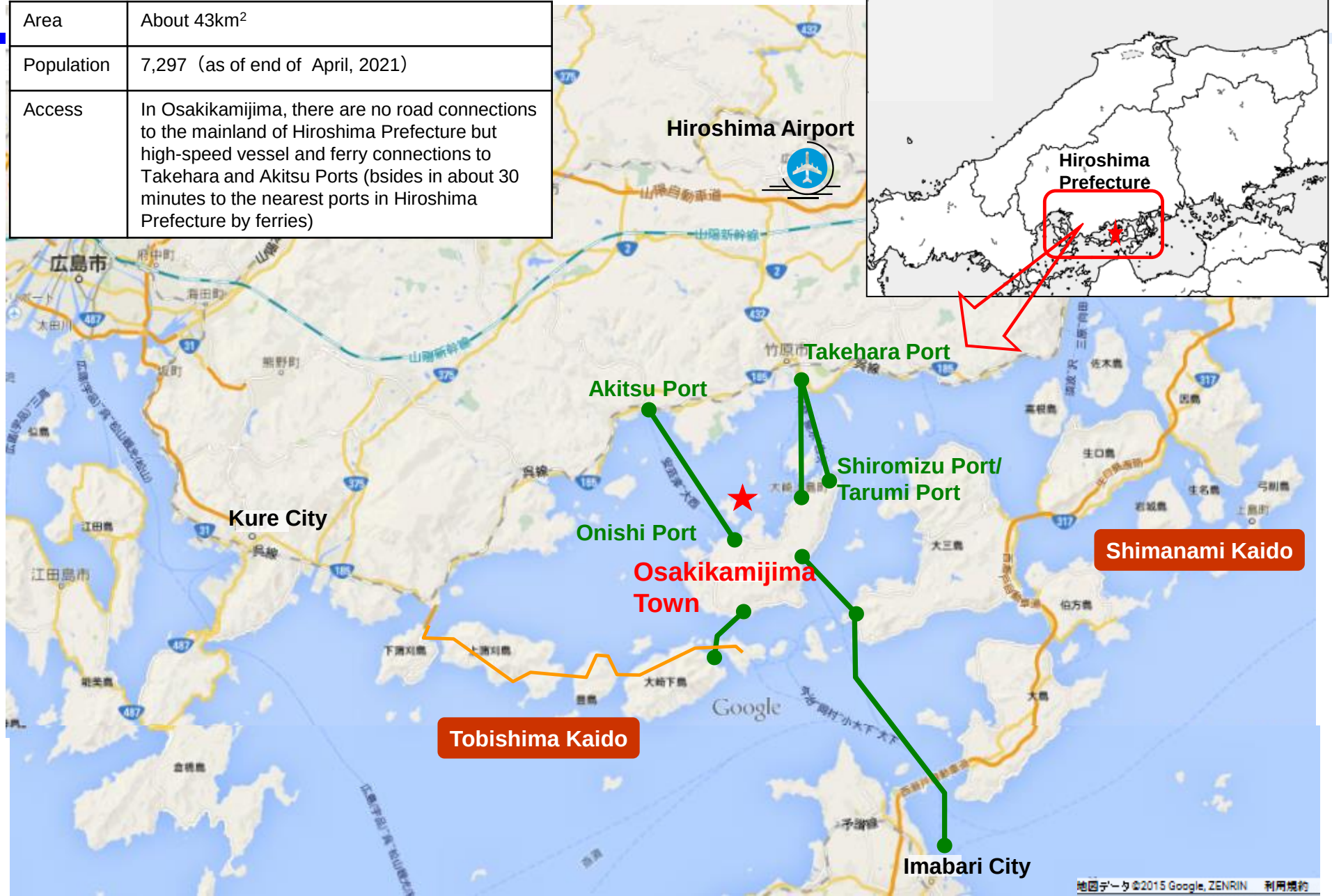
# Company Profile



| | |
|---|---|
| Company Name | Osaki CoolGen Corporation |
| Founded | July 29, 2009 |
| Location | Hiroshima Prefecture, Japan |
| Investing enterprises | The Chugoku Electric Power Co., Inc. (Energia)<br>Electric Power Development Co., Ltd (J-POWER) |
| Line of business | Construction of large-scale demonstration facilities and implementation of demonstration tests for oxygen-blown IGCC and CCS which are the essential technologies to realize IGFC, the ultimate high-efficiency coal-fired thermal power |

# Osakikamijima

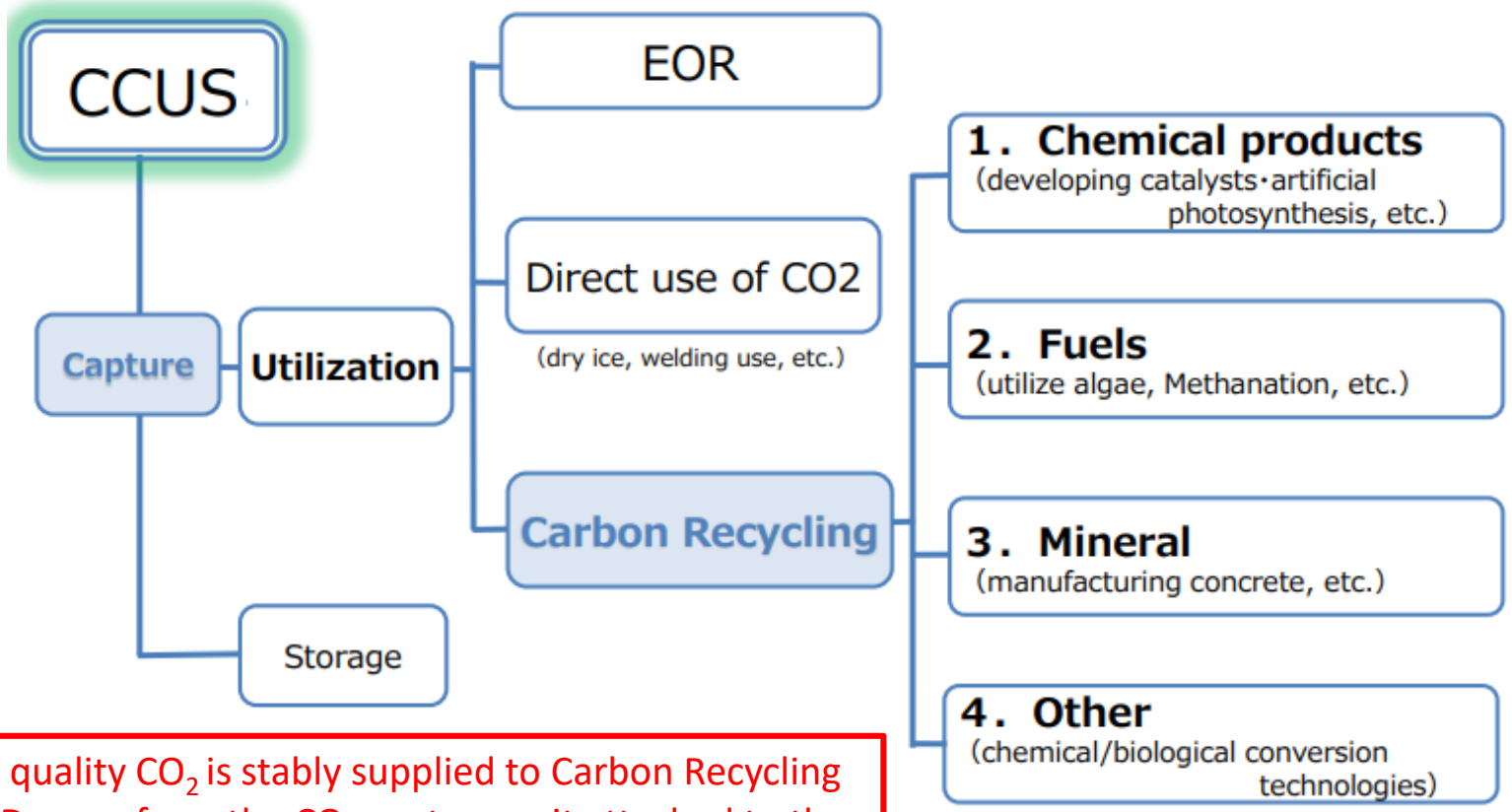
| | |
|---|---|
| Area | About 43km$^2$ |
| Population | 7,297（as of end of April, 2021） |
| Access | In Osakikamijima, there are no road connections to the mainland of Hiroshima Prefecture but high-speed vessel and ferry connections to Takehara and Akitsu Ports (bsides in about 30 minutes to the nearest ports in Hiroshima Prefecture by ferries) |



# Carbon Recycling in CCUS



- Carbon Recycling: Focusing on utilization of CO2, in order to contribute to the energy security issues as well as climate change problems by innovative R&D with industries, academia and public from all over the world.




High quality $CO_2$ is stably supplied to Carbon Recycling RD&D users from the $CO_2$ capture unit attached to the oxygen blown IGCC demonstration test facility of Osaki Coolgen Project.

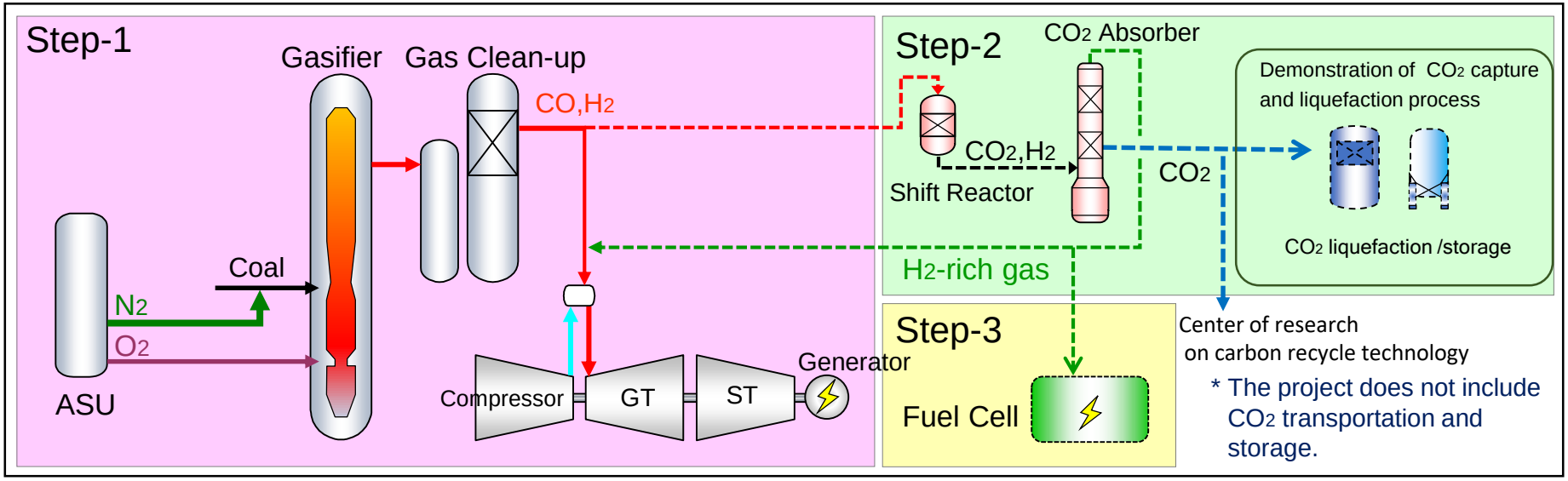
Reference: Roadmap for Carbon Recycling Technologies（Ministry of Economy, Trade and Industry）

# Outline of Osaki CoolGen Project



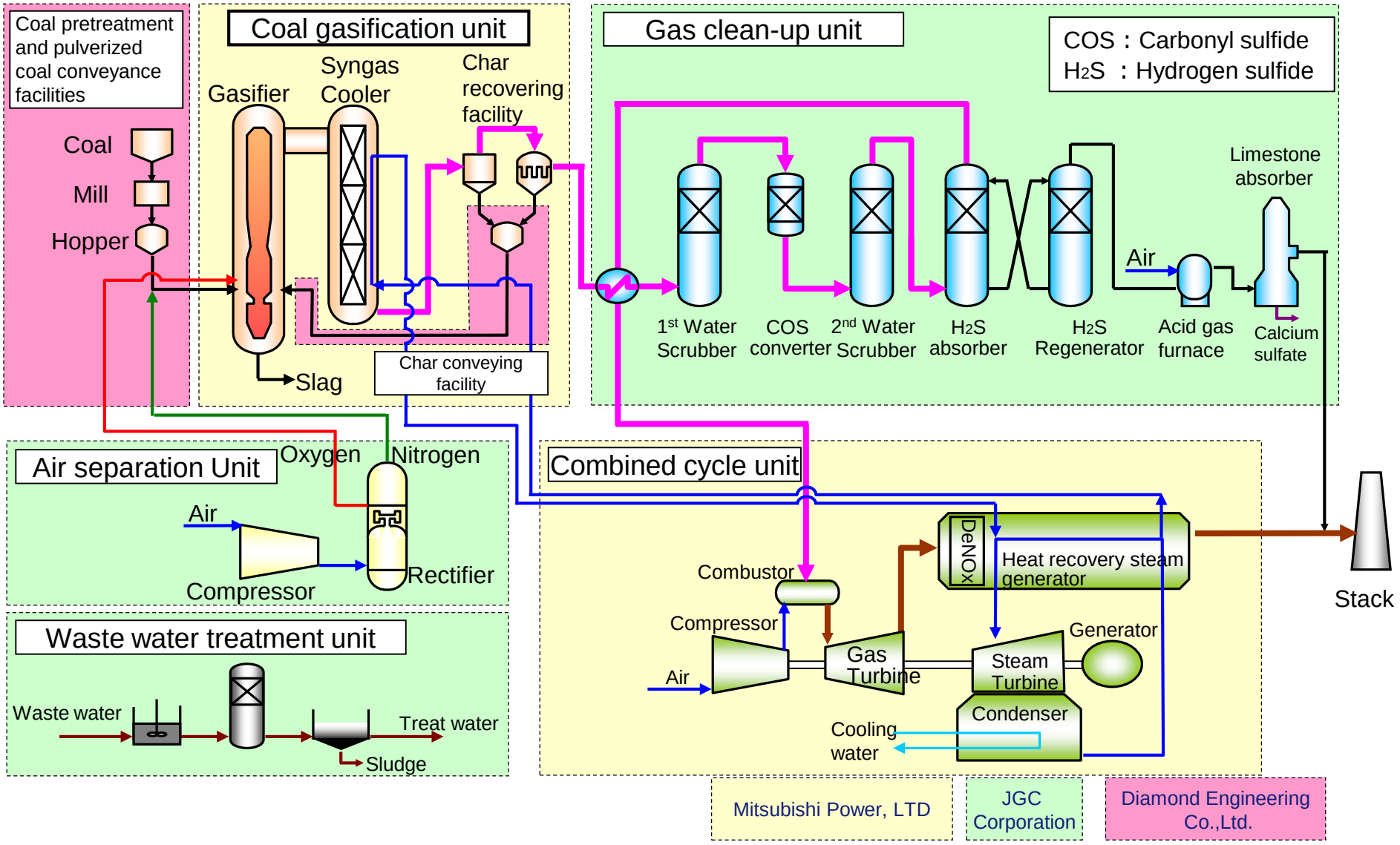
- For the realization of innovative low carbon coal-fired power generation in which IGFC, an ultimate high-efficiency power generation technology, is combined with $CO_2$ capture in order to significantly reduce $CO_2$ emission from coal-fired power generation.
- The project is to be implemented in three steps. Step 1 was implemented from FY2012 as a subsidized project of the Ministry of Economy, Trade and Industry and Step 2 has been implemented since FY2016 as a NEDO subsidized project .

| FY | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Step 1: Demonstration of oxygen-blown IGCC | Design, manufacturing and installation | | | | | | Demonstration | | | Construction, Installation | Demonstration |
| Step 2: Demonstration of IGCC with $CO_2$ capture (including $CO_2$ capture and liquefaction process) | | | | | Design, manufacturing and installation | | Demonstration | | | | Demonstration |
| Step 3: Demonstration of IGFC with $CO_2$ capture | | | | | | | | Design, manufacturing and installation | | | |



# Step 1：Schematic operation flow of oxygen-blown IGCC demonstration units and facilities

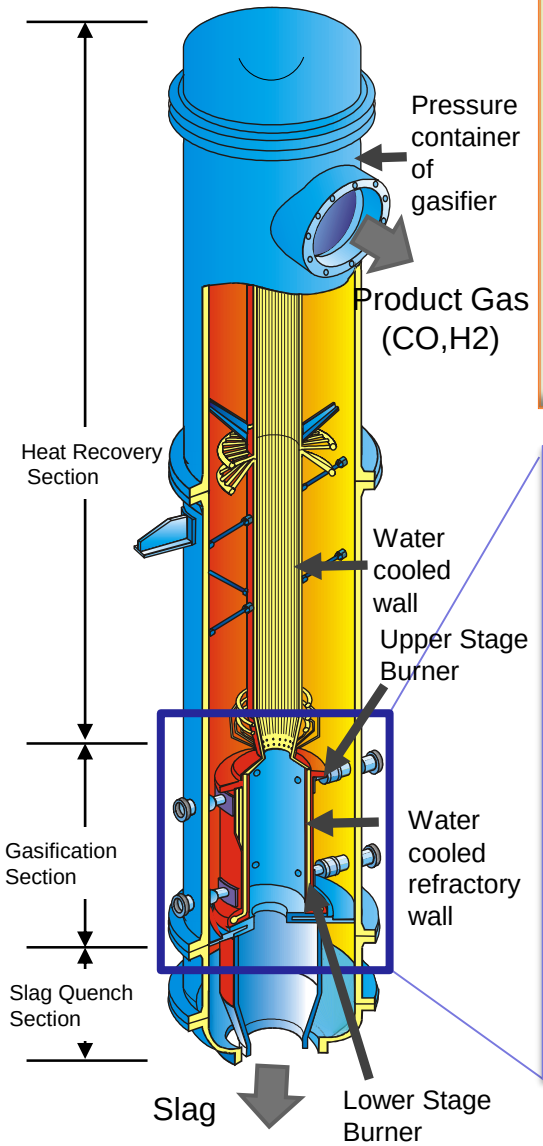




# Characteristics of Gasifier : High Gasification Efficiency

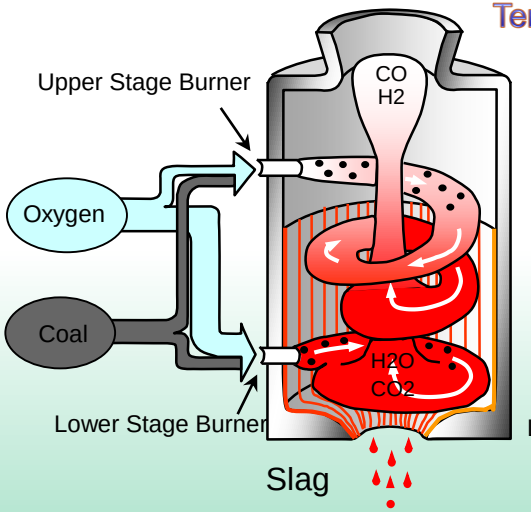


## Structure of Gasifier

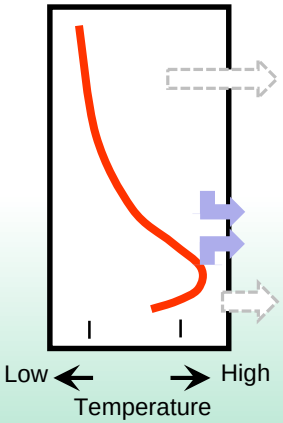



- The furnace achieves two-stage spiral flow in one chamber style gasification with upper and lower coal burners arranged in a gasification section.
- The furnace realizes high gasification efficiency and stable discharge of slag through appropriately controlling the amounts of oxygen supplied to the upper and lower sections of the chamber regardless of whether feedstock is coal with low ash melting point or high ash melting point.
- Being an oxygen-blown gasifier, the furnace has lower $N_2$ and higher fuel component rates (CO and $H_2$) in syngas (or higher calorific power) than air blown gasifiers.

### Schematic Gasifier Flow




### Temperature distribution




**Upper Stage : Lean Oxygen**

Realization of high-efficiency gasification

Ensuring of sufficiently long retention time required for coal gasification with two-stage swirl flow

**Lower Stage : Rich Oxygen**

Achievement of a high temperature higher than ash melting point for stable discharge of coal ash (slag)

# Demonstration Targets and Results (Step1)



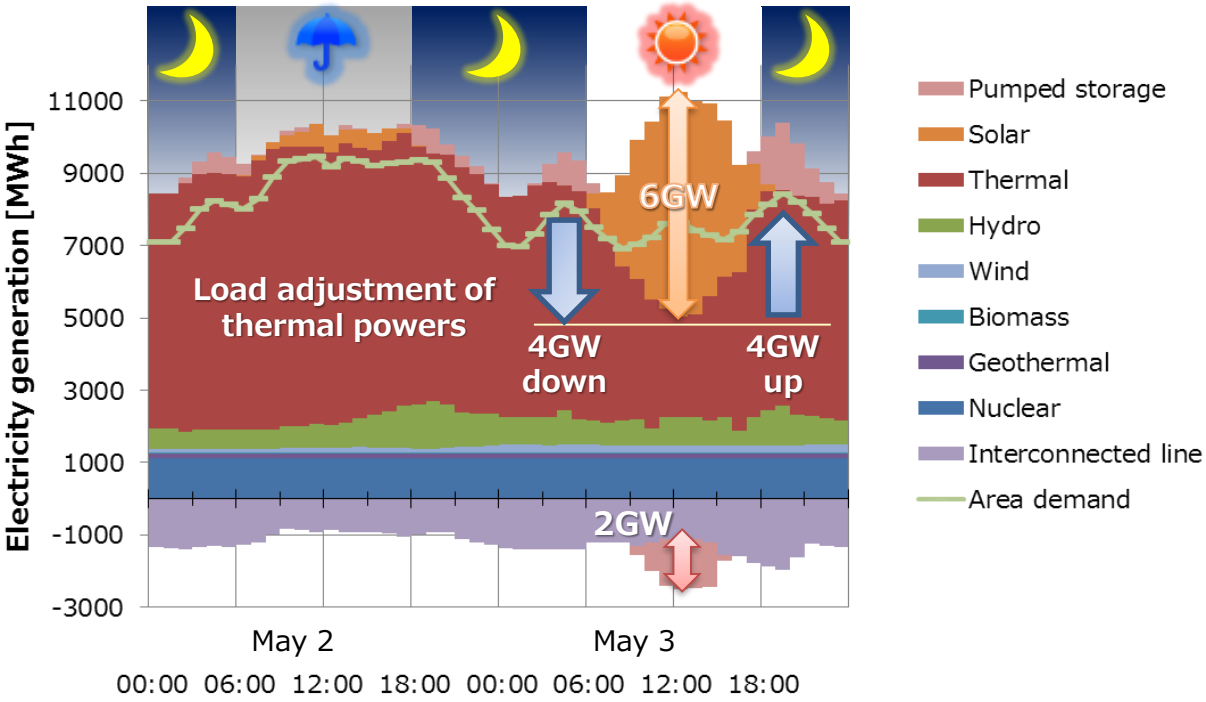
| Items | Targets | Results |
|---|---|---|
| Plant efficiency | ➢ Net efficiency 40.5% (HHV) | ➢ Net efficiency 40.8% (HHV) **Achieved** |
| Emission level | ➢ SOx : 8ppm<br>➢ NOx : 5ppm<br>➢ Particulate : 3mg/m$^3$N ($O_2$ equivalent 16 %) | ➢ SOx : <8ppm<br>➢ NOx : <5ppm<br>➢ Particulate : <3mg/m$^3$N ($O_2$ equivalent 16 %) **Achieved** |
| Coal variety compatibility | ➢ Applicable to various types of coal | ➢ Verified with four kinds of coal (including design coal) **Achieved** |
| Reliability | ➢ Commercial-level annual plant availability of 70% or higher (5,000 hours endurance test) | ➢ Endurance test 5,119h (accumulated)<br>➢ Continuous operation 2,168h **Achieved** |
| Flexibility | ➢ Commercial-level (Load change rate of 1-3%/min) | ➢ Load change rate ~16 %/min<br>➢ Minimum load 0MW(net) **Achieved** |
| Economy | ➢ To obtain a prospect of the equivalent or less generating cost with commercial PCF plant | ➢ Obtained a prospect of equivalent generating cost with commercial PCF plant **Achieved** |

# The role of thermal power in the introduction of a large amount of renewables

## The impact in the introduction of a large amount of renewables

During period of low demand, there is a big difference of status of power demand and supply between May 2 (weekday) and May 3 (holiday).

**Status of power demand and supply in Kyushu**




Source: KYUSHU ELECTRIC POWER TRANSMISSION AND DISTRIBUTION CO.,INC., Power usage in Kyushu (from April 2018 to June 2018)

For introduce of a large amount of unstable renewables

- For stable of power system, there are thermal powers, pumped storage powers, and interconnect lines.
- Especially, thermal powers takes an important role of load adjustment.

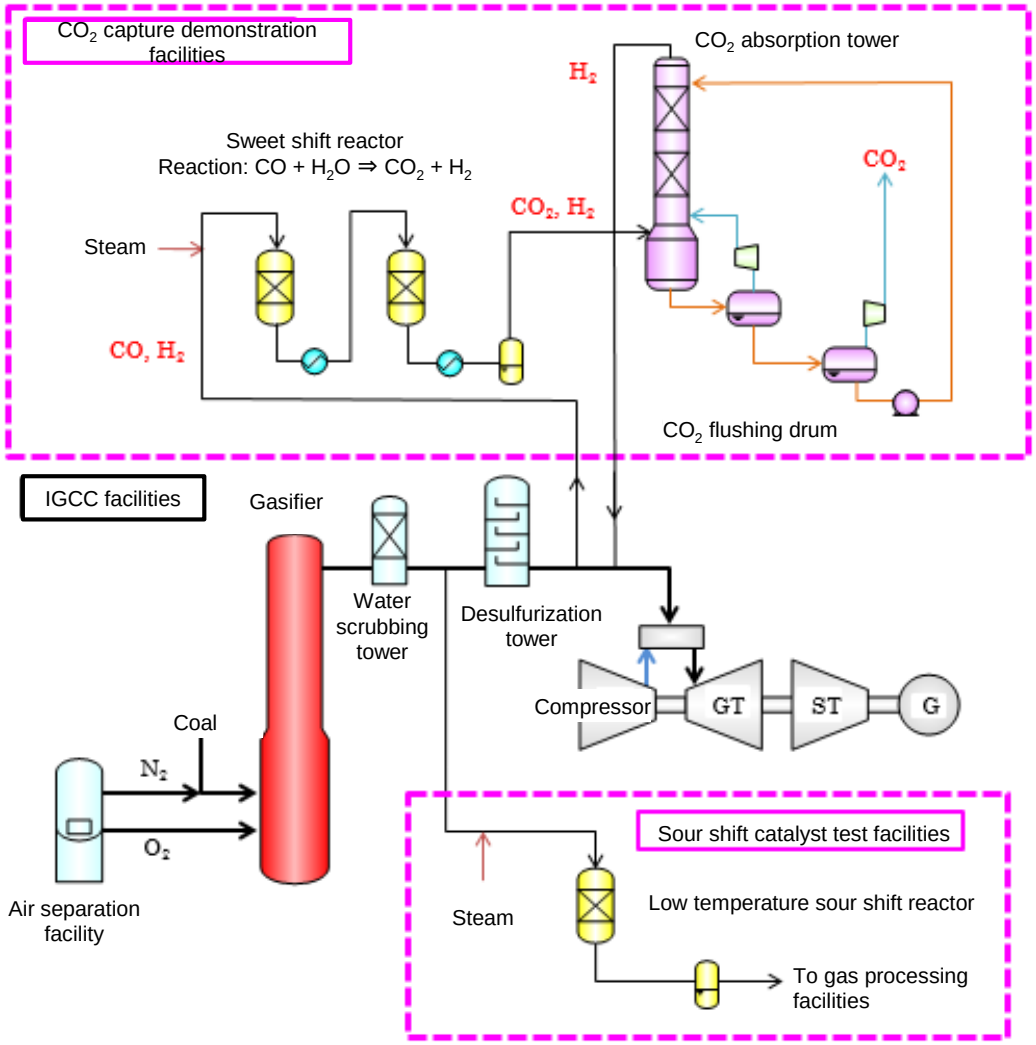
Thermal powers are required not only high efficiency, but flexible operation.

- Improvement of load change rate
- Lower minimum load
- Shortening of startup time

# Step 2: Outline of Demonstration Test Plan



To verify technical capability of the IGCC plant to stably maintain high power generation efficiency and stably separate $CO_2$ even when the IGCC plant is combined with $CO_2$ capture demonstration facilities.




Schematic operation flow of the Step 2 demonstration system

| Outline of the $CO_2$ capture demonstration facilities | |
|---|---|
| Demonstration scale | $CO_2$ recovery from IGCC gas with a recovery rate of 15% |
| $CO_2$ absorption and regeneration method | Physical absorption method |
| CO shift method | Sweet shift method (gas extraction after desulfurization) |
| Basic performance | $CO_2$ recovery rate: 90% or more<br>Purity of recovered $CO_2$: 99% or more |

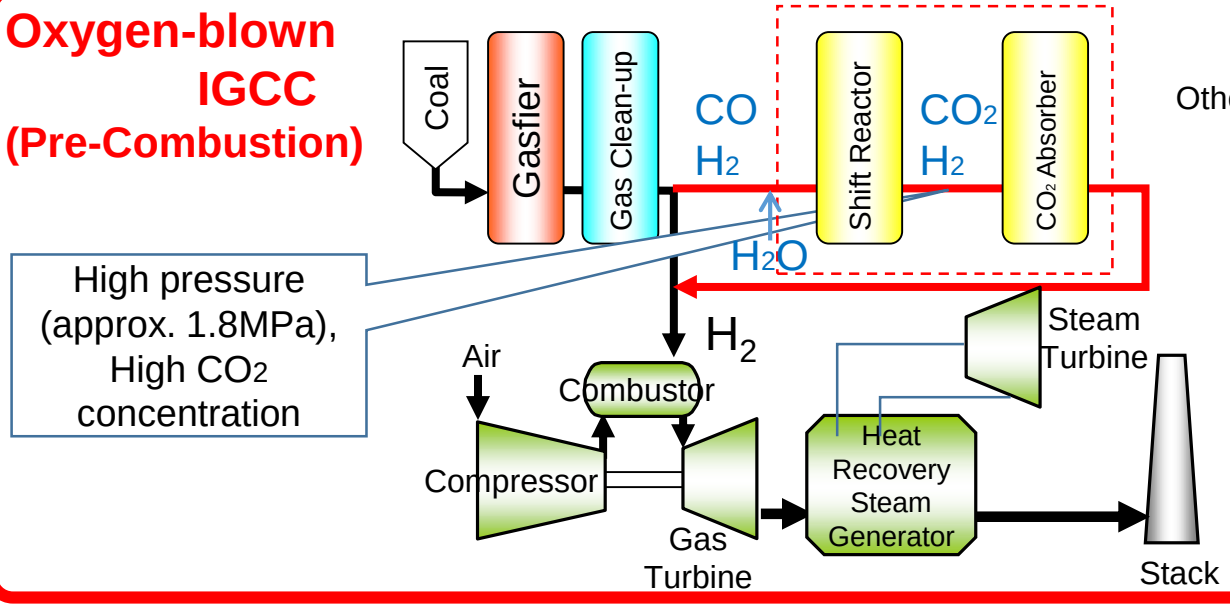
| Sour shift catalyst test facilities | |
|---|---|
| CO shift method | Low temperature sour shift method (gas extraction before desulfurization) |

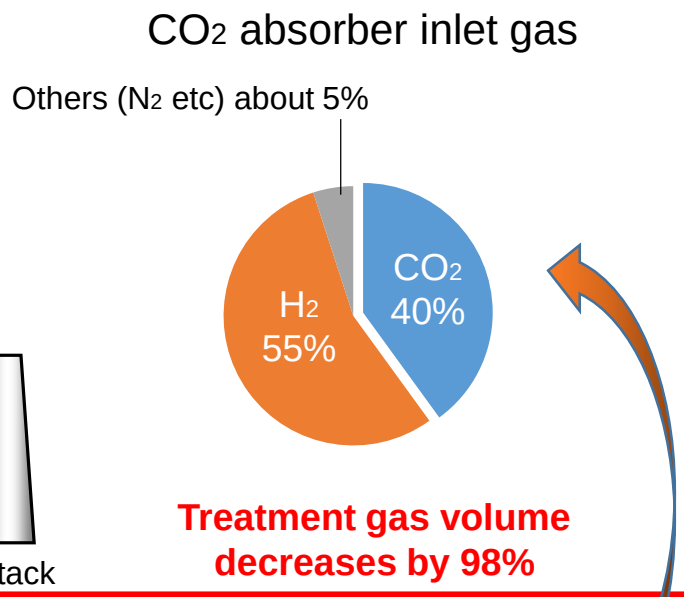
# Oxygen-blown IGCC with $CO_2$ capture : Pre-combustion $CO_2$ capture



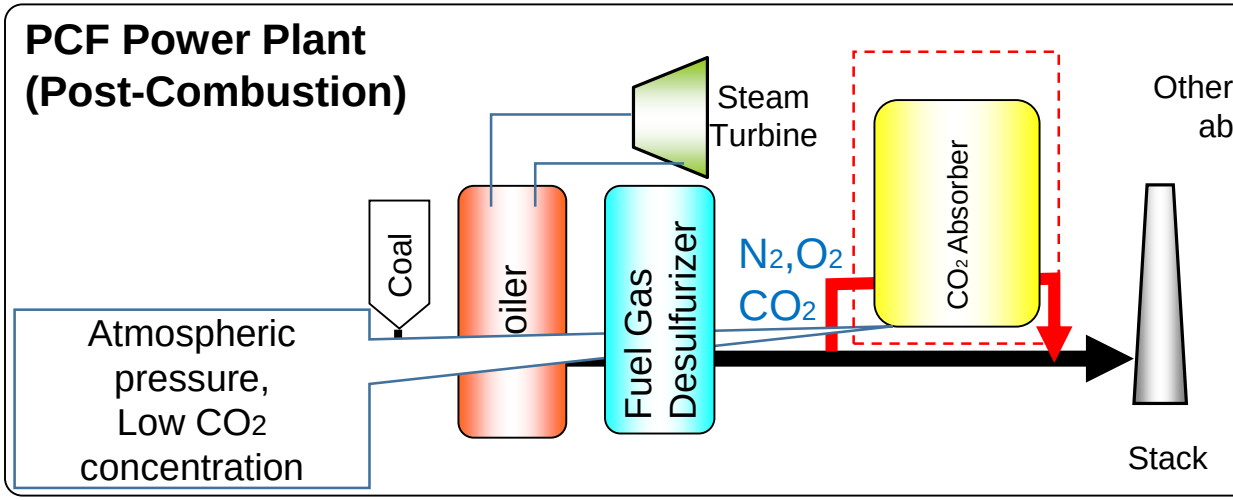
- Compared to captured $CO_2$ from the emitted gas by Post-combustion method, Pre-combustion method can efficiently capture $CO_2$ with little energy losses because syngas before combustion has high $CO_2$ concentration and high pressure with less processing gas.

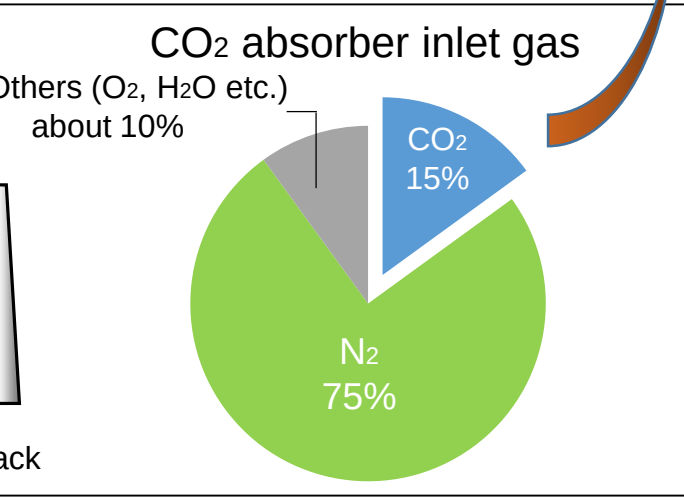
## Oxygen-blown IGCC (Pre-Combustion)




## PCF Power Plant (Post-Combustion)



# $CO_2$ Capture Technology Roadmap

$CO_2$ separation and capture cost

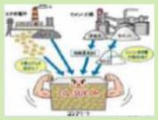
High

Low

## Chemical absorption method

use a solvent, such as amine.
Separation and capture cost: 4200 yen/t-$CO_2$

## Utilization of $CO_2$

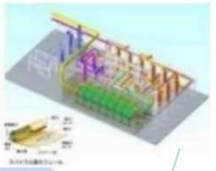


This technology utilizes captured $CO_2$ to produce valuables such as alternatives to oil and chemical raw material

## Solid absorbent method

reduces energy requirement and separate $CO_2$ by combining amine, etc.

## Membrane separation method



separates by using a membrane which penetrates $CO_2$ selectively.

## Storage of $CO_2$



To store separated and captured $CO_2$ under ground. practical realization of CCS technology by around 2020.

The plant for this business is under construction, and the storage will be initiated in 2016.

**Development Target**

## Physical absorption method

$CO_2$ absorbed into a physical absorption solution under high pressure.
Separation and capture cost: Approximately 2000 yen level/t-$CO_2$
Around 2020

## Closed IGCC

the oxygen fuel technology to the IGCC technology.

* The cost prospect in the Figure was estimated based on various assumptions at present.

Present — Around 2020 — Around 2030

Source : Technology road map for next generation thermal power generation (METI)

# $CO_2$ Capture Unit



# Demonstration Targets and Progress

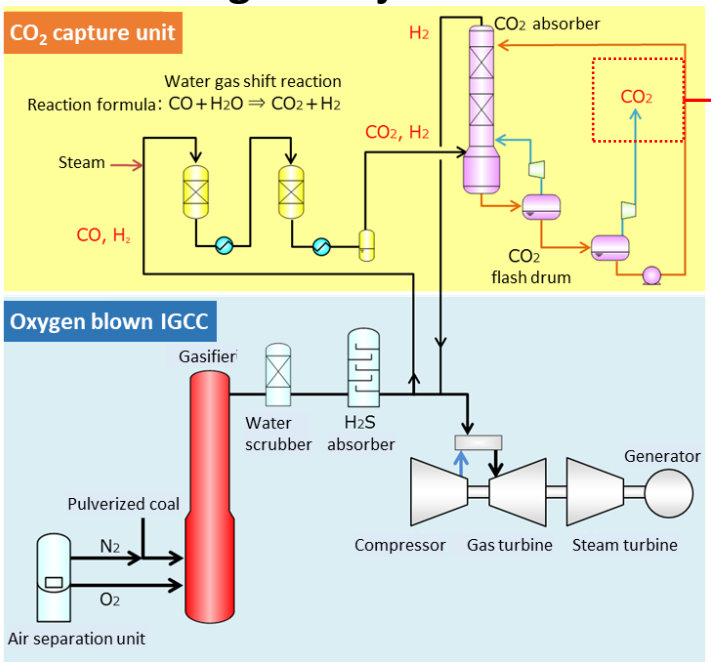
Practical realization of a commercial scale plant through the demonstration of the system using the large-scale demonstration facilities with oxygen-blown IGCC combined with $CO_2$ capture facilities

| Items | Targets | Results |
|---|---|---|
| Basic performance | ➢ $CO_2$ recovery rate : 90% or more<br>➢ Purity of recovered $CO_2$: 99% or more | ➢ $CO_2$ recovery rate : 90% or more<br>➢ Purity of recovered $CO_2$: 99% or more<br>**Achieved** |
| | The prospect of net efficiency 40% with capturing 90% of $CO_2$ in a commercial-scale plant (1500℃ class IGCC) | Conduct the additional demonstration test on various operating conditions to optimize process<br>**During verification** |
| operability and reliability | Establishment of the operation method of IGCC with $CO_2$ capture and verification the reliability | ➢ Established the method of start-up and stop of IGCC with $CO_2$ capture<br>➢ Verified with two different coals<br>**During verification** |
| economic efficiency | Evaluation of the cost per amount of recovered $CO_2$ in the commercial-scale IGCC plant using cost target data shown in the technology roadmap*2 as a benchmark. | Evaluate after the demonstration test<br>**During verification** |

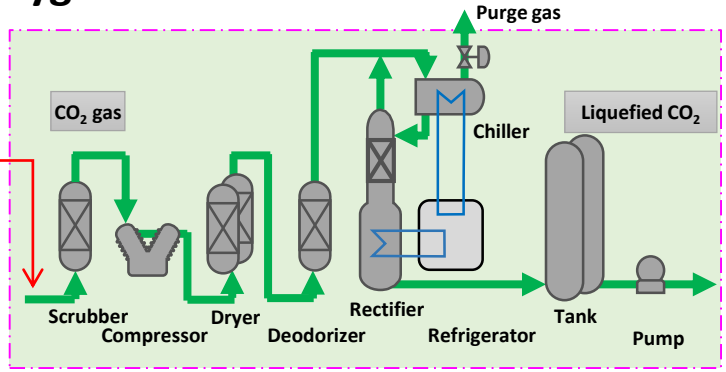
*1 The power generation efficiency includes $CO_2$ capture process (except power for $CO_2$ storage)
*2 Technology roadmap for next-generation thermal power generation (METI, June 2015)

# $CO_2$ supply from $CO_2$ capture unit

**High quality $CO_2$ is supplied to tomato cultivation. and Carbon recycling RD&D users from the $CO_2$ capture unit attached to the oxygen blown IGCC demonstration test facility of Osaki Coolgen Project.**




**Schematic diagram of the Oxygen blown IGCC with $CO_2$ capture**




Partly to Tomato Cultiuation

5t/day

**Schematic diagram of $CO_2$ liquefaction unit**

Carbon recycling RD&D users

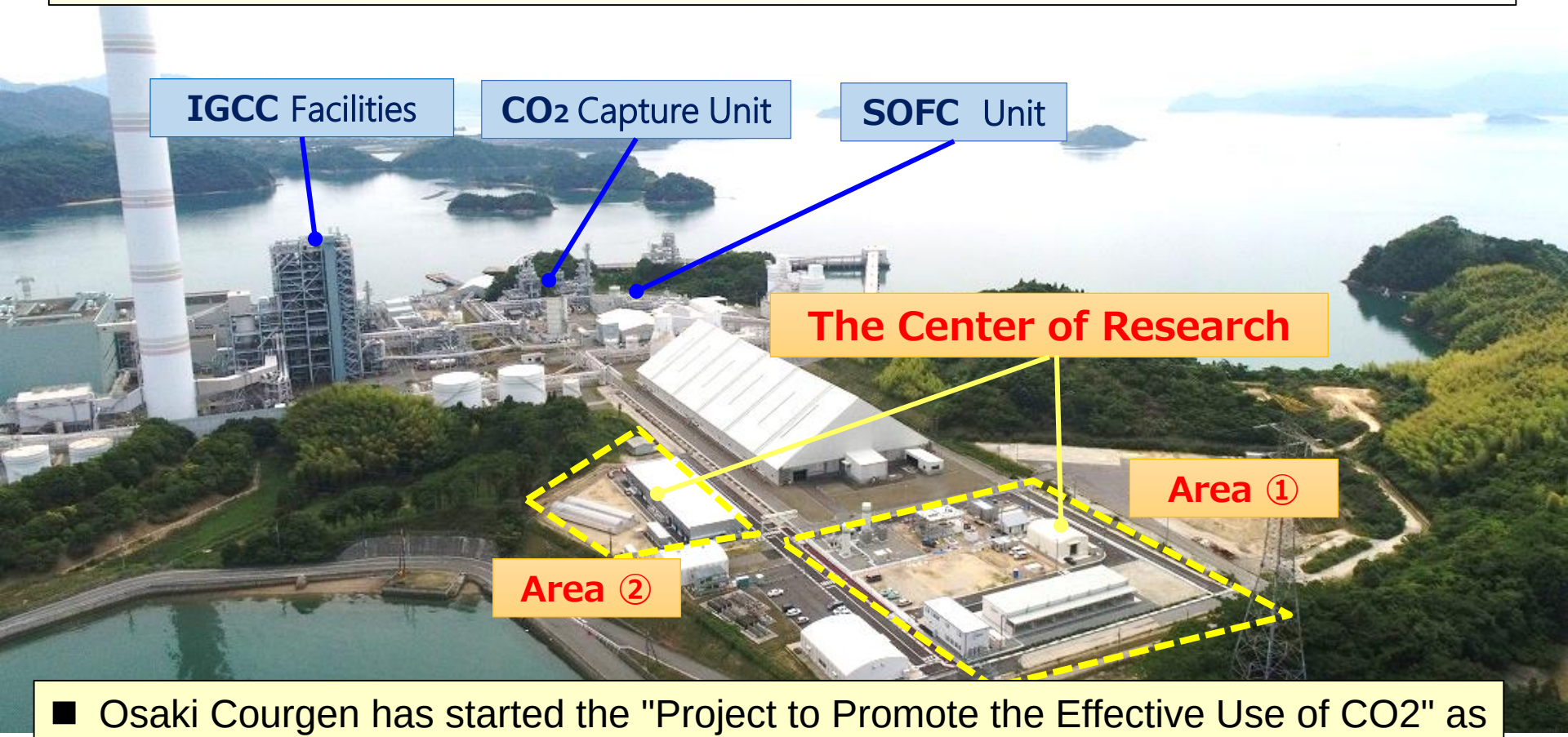
10t/day

CG provided : JCOAL

**Carbon recycling demonstration base**

# Promotion project on establishment of the Center

- Carbon Recycling 3C initiative, as a Japan policy, is decided to establish the Center of Research at Osakikamijima town, Hiroshima prefecture where $CO_2$ can be captured now.




- Osaki Courgen has started the "Project to Promote the Effective Use of CO2" as a NEDO commissioned project, and has completed the development of its R&D base, and has been supplying CO2 since June 2022.

# Thank you for your reading



We would like to express our gratitude to the Ministry of Economy, Trade and Industry (METI), and the New Energy and Industrial Technology Development Organization (NEDO) for continuous support to the Osaki CoolGen Project.

We will carry on design, construction and demonstration steadily and safely, and make our best effort to achieve successful completion of the Osaki CoolGen Project.