Toshiba’s Activity in Ministry of the Environment Sustainable CCS Project
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01

Background
Business Domain of Toshiba Energy Systems & Solutions

Power Generation Systems
- Thermal Power
- Nuclear Power

Transmission and Distribution / Energy Storage
- Transformer
- Supervisory Control And Data Acquisition Systems (SCADA)
- Hydrogen-based Autonomous Energy Supply System
- Stationary Battery Energy Storage Systems

Renewable Energy
- Hydro Power
- Geothermal Power
- Solar Power
What is CCS?

CCS: Carbon (Dioxide) Capture and Storage

- CO₂ Emission Source
  - Thermal power
  - Industry (Steel, Cement, etc.)
- CO₂ Capture
- CO₂ Compression
- CO₂ Transportation
- CO₂ Storage
- Monitoring
As a method to mitigate global warming, the necessity of CCS is recognized as a countermeasure against emission of CO$_2$. 


Source: The Global Status of CCS 2017 – P.20
02

Application of CO₂ Capture to Thermal Power Plants
CO₂ Capture Technology from Thermal Power Plants

**Post Combustion Capture (PCC)**

- **PROS:**
  - Process proven in chemical industry
  - Adaptable to new build, existing retros
  - Adaptable to other emitters (steel, cement)
  - Partial capture configuration possible

- **CONS:**
  - Energy penalty for capture
  - Equipments tend to be larger than other techs

**Oxy-Fuel (Firing)**

- **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

**Pre Combustion Capture**

- **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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*ASU: Air Separation Unit  FGD: Fuel Gas Desulphurization  EP: Electrostatic Precipitator*
To capture CO₂ in the flue gas continuously, amine solvent is used which absorbs CO₂ at low temperature and discharges at high temperature.
Reducing CO₂ Emission from Thermal Power Plants

Substantial CO₂ reduction is realized by Integration and Optimization of both High efficiency Turbine Cycles and CCS technology.
Integrating CO₂ Capture to Thermal Power Plants

1. Integration to Flue Gas System

2. Integration to Power System & Cycle

3. Integration with Plant Utility Systems

4. Integration with Power Plant Operation and Maintenance

Utility Facilities
- Auxiliary power
- Water Supply System
- Control and Service Air
- Cooling Water
- Cooling Tower
- Waste Water Treatment
CO₂ Capture to Technology Implementation Flow

【Toshiba’s Activity】

1. Process Design / Evaluation of System Performance Improvement by Simulation
2. Overall Demonstration at Mikawa PCC Pilot Plant
3. Design of Solvent / Evaluation of Basic Properties and Absorption Performance
4. Performance / Degradation Evaluation by Small Loop
5. Large Scale Demonstration / Commercial Plant

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【Toshiba’s Activity】
Mikawa Thermal Power Plant

**CO₂ Capture Demonstration Plant**
Constructed under the Ministry of the Environment Project

Sigma Power Ariake Co., Ltd.
Mikawa Power Plant
Omuta City, Fukuoka, Japan

**PCC Pilot Plant**
Toshiba owned

**Turbine No.1**
50MW Commercial

**Turbine No.2**
Full Size Steam Turbine Test Facility

**IoT Server**
Data Collection & Remote monitoring

**PC Boiler**
(Not Used)

**Stack**

**CFB Boiler**
(Biomass/Coal)

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Mikawa PCC Pilot Plant - Overview and Summary

Plant Outline
Location: Omuta City, Fukuoka
Inside Mikawa Thermal Power Plant
(Property of SIGMA POWER Ariake Co.Ltd.)
Plant Commenced: September 29, 2009

Carbon Capture Technology: Post Combustion Capture (PCC)
Amine-based Chemical Absorption (Toshiba’s Solvent System)
Capture Capacity: 10 ton-CO₂ / day
Flue Gas Flow: 2100 Nm³ / hour (from Mikawa Biomass/Coal Fired Power Plant)
* Test flue gas CO₂ concentration adjustable from 4%(NGCC) to 30%(Steel works)
  utilizing absorber and stripper exit gas recirculation and air bypass intake line.

Summary of Results (as of May, 2019)
- Cumulative 11794 hours of operation on a live flue gas of biomass / coal fired thermal power plant
- CO₂ Recovery Energy: less than 2.4 GJ/ t-CO₂
  (@90% CO₂ Capture, CO₂ Conc. approx. 12%)
- Verified system stability over 2800 hours of continuous operation.

Reference Website
03

Ministry of the Environment Sustainable CCS Project (CO₂ Capture)
Outline of the Project

1. CO₂ Capture from the Mikawa Power Plant
   - CO₂ capture facility to be designed and constructed to capture more than 500 tons of CO₂ per day. (500 tons of CO₂ per day is about 50% of the daily emissions from the 50 MW Mikawa Power Plant)
   - The plant will be used to evaluate performance of technology under various operating conditions, cost and environmental aspects of the amine-based post-combustion chemical absorption technology.

2. Establishing a Socio-political Environment for the Introduction of CCS in Japan
   - Research on aspects including socio-economics and policies to establish an enabling environment necessary for the smooth introduction of CCS in Japan.
   - Develop basic concepts toward an integrated CCS system, with aims to achieve practical applications of the capture technology by 2020.

Project Consortium (as of Mar 2019)

- Ministry of the Environment
- Toshiba
- Mizuho (Administrator)
- Mitsubishi Materials
- JGC Corporation
- Chiyoda Corporation
- Central Research Institute of Electric Power Industry
- JCOAL
- JG Corporation
- AIST
- JNC
- JCOAL
- The University of Tokyo
- Taiheiyo Cement
- JCOAL
- DIA Consultants
- Kyushu University
As part of the MoE’s Sustainable CCS Project, Toshiba has designed and now constructing the CO₂ Capture Demonstration Plant, which will capture more than 500 tons-CO₂/day from Mikawa Power Plant (more than 50% of its total emissions). The Capture Plant will be built and fully integrated with the Power Plant, with turbine extraction steam feeding the energy for regeneration of CO₂ at the stripper tower. The Mikawa Power Plant now has a new boiler capable of burning 100% biomass. Consequently, the project has the potential to be one of the first BECCS project in the world.
## Schedule of 5-year Project

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Status of Construction Site

Present Status
The following are presently considered as items to be demonstrated/verified at the CO₂ Capture Demo Plant*:

◆ Performance Issues
  • CO₂ Capture mass flow
  • CO₂ Capture rate
  • Energy required to capture CO₂
  • Overall effect on performance of the power plant equipped with CO₂ capture facility

◆ Operability Issues
  • Effects of flue gas property (fuel)
  • Effects of CO₂ capture rate setting
  • Effects of heat inputs to CO₂ capture
  • Start-up, shut-down, transient operations
  • Part load, part capture operability

◆ Environmental Issues
  • Emissions for CO₂ capture facility
  • Control methods of emissions
  • Degradation and its effects

Note: Depth and extent of evaluation is subject to limitation of available time, schedule, and budget
Thank you for your attention!

Next:
Ministry of the Environment Sustainable CCS Project (Transport)