1st Post Combustion Capture Conference

Development of Carbon Dioxide Removal System from the Flue Gas of Coal Fired Power Plant

May 19, 2011

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1. **Toshiba Power Systems Overview**
2. Decarbonizing Thermal Power
3. Development of Carbon Capture Technology
4. Pilot Plant Results
5. Future Solvent Screening
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Toshiba Corporation Organization

President & CEO

Norio Sasaki

Toshiba Corporation Headquarters, Tokyo

< Digital Products Group >

- Digital Products & Service Company
- Network & Solution Control Center
- Storage Products Company
- TOSHIBA TEC CORPORATION

< Electronic Devices & Components Group >

- Semiconductor Company
- Toshiba Mobile Display Co., Ltd.

< Infrastructure Systems Group >

- **Power Systems Company**
  - Thermal & Hydro Power Systems & Services Div.
- Social Infrastructure Systems Company
- TOSHIBA ELEVATOR AND BUILDING SYSTEMS CORPORATION
- Toshiba Solutions Corporation
- TOSHIBA MEDICAL SYSTEMS CORPORATION

As of April 1, 2011

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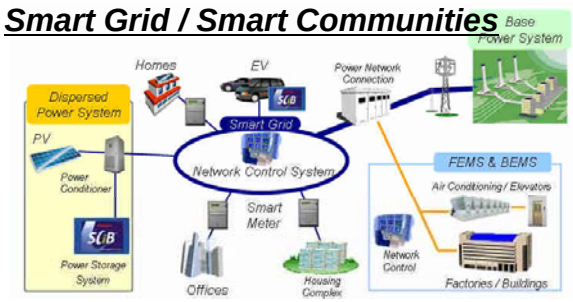
Toshiba's Energy Products & Services



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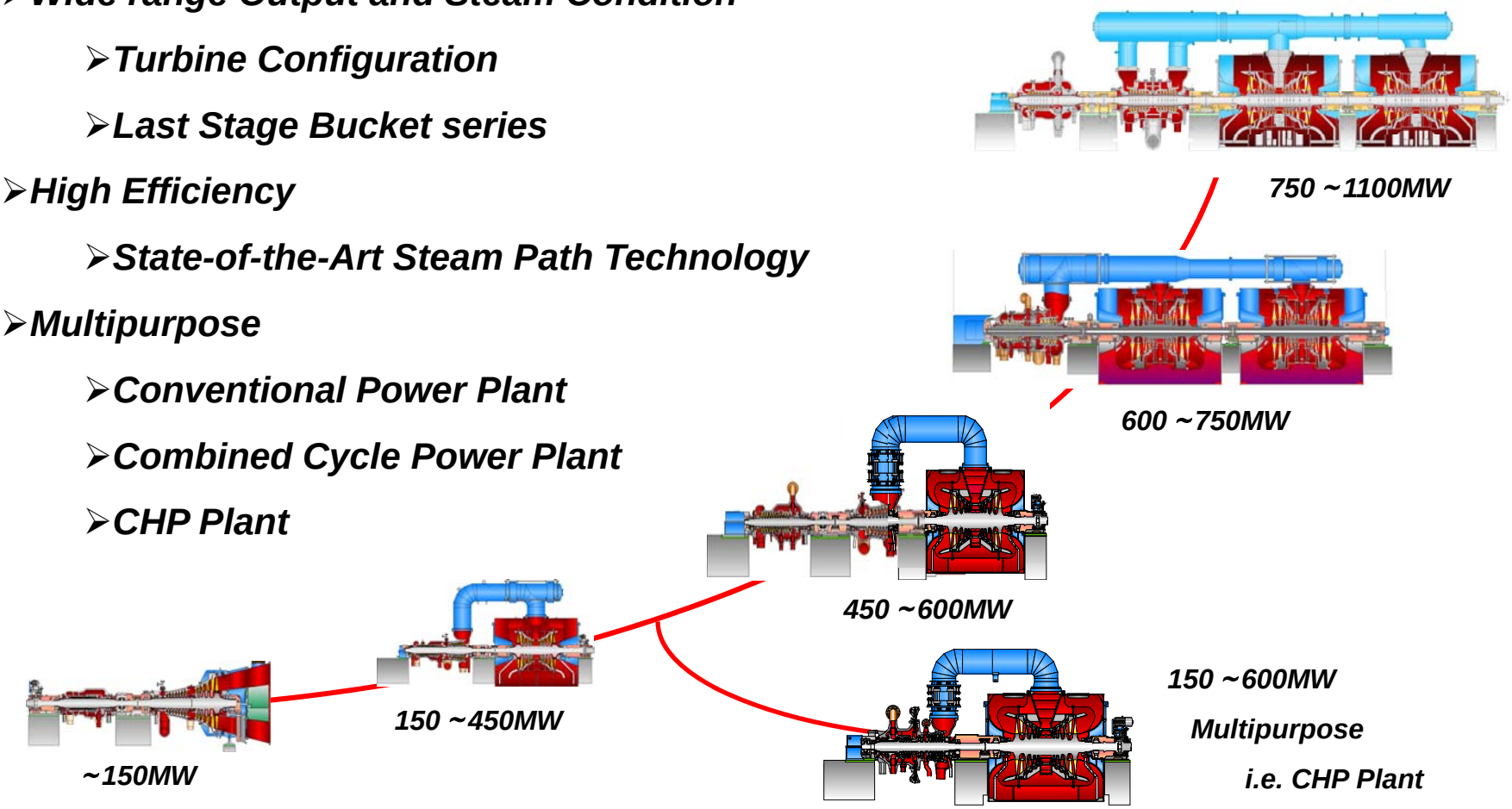
Toshiba's Thermal Power Plant Turbines

- ***Wide range Output and Steam Condition***
  - ***Turbine Configuration***
  - ***Last Stage Bucket series***
- ***High Efficiency***
  - ***State-of-the-Art Steam Path Technology***
- ***Multipurpose***
  - ***Conventional Power Plant***
  - ***Combined Cycle Power Plant***
  - ***CHP Plant***



Toshiba is the one of most experienced power system turbine providers in the world

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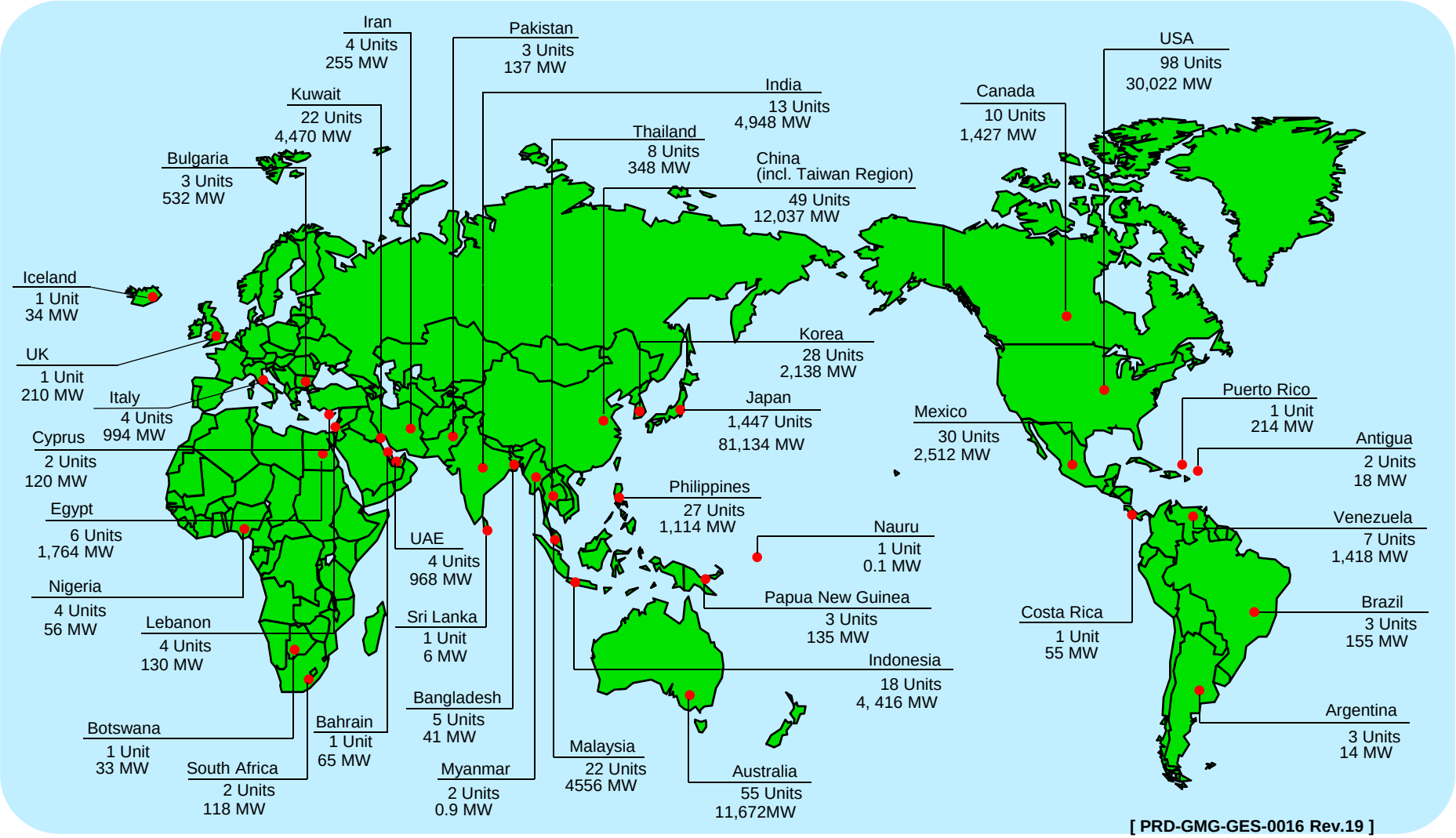
Toshiba Turbine Power Plants - Worldwide

Total: 1,896 Units, 168,267 MW (As of March 2011)



[PRD-GMG-GES-0016 Rev.19]

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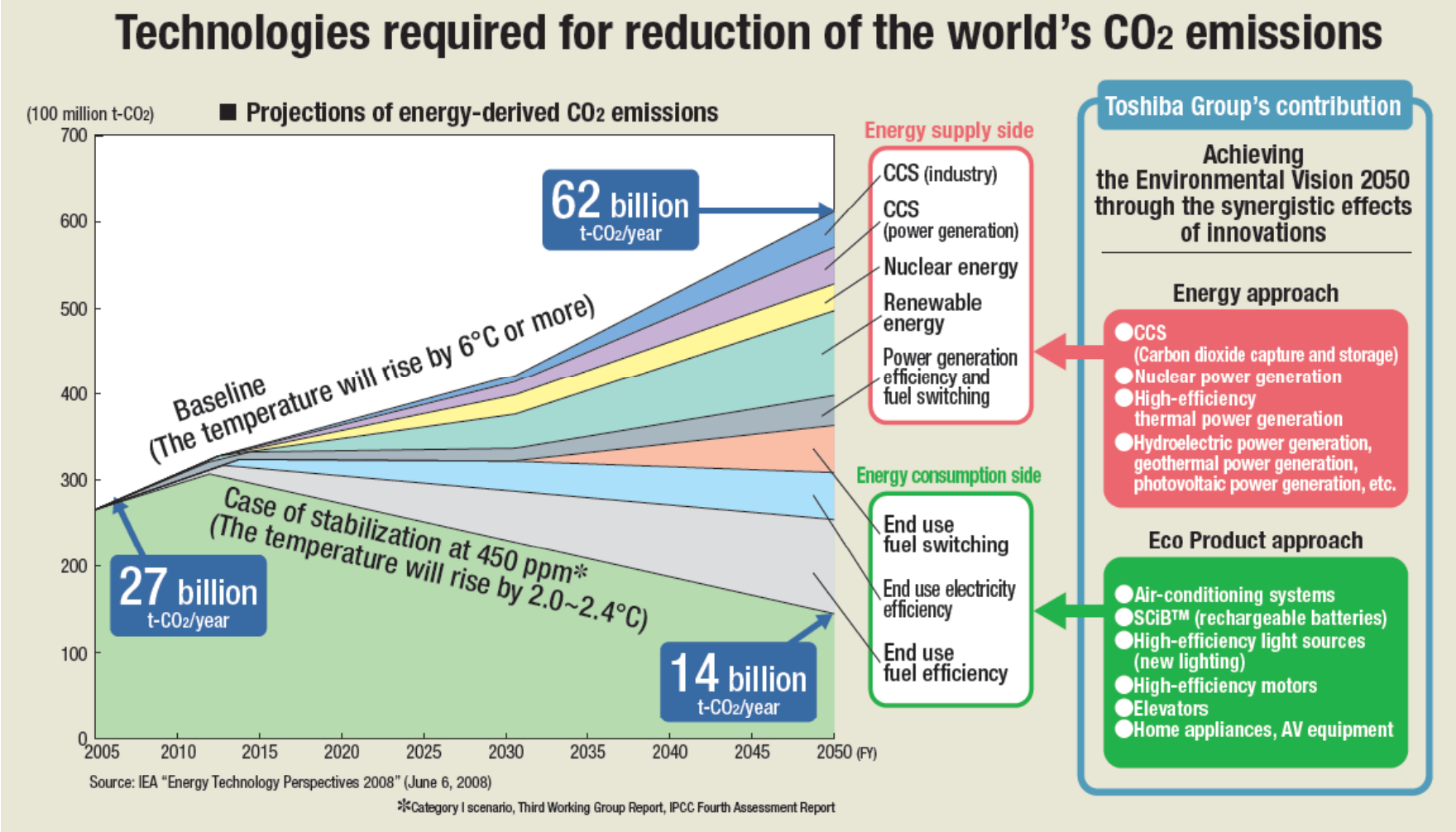
Toshiba Group Environmental Vision 2050



(Toshiba Group Environmental Report 2009)

Advanced High Efficiency Cycles and CCS technology play vital role in reduction of CO_2 in the Thermal Power Plant arena

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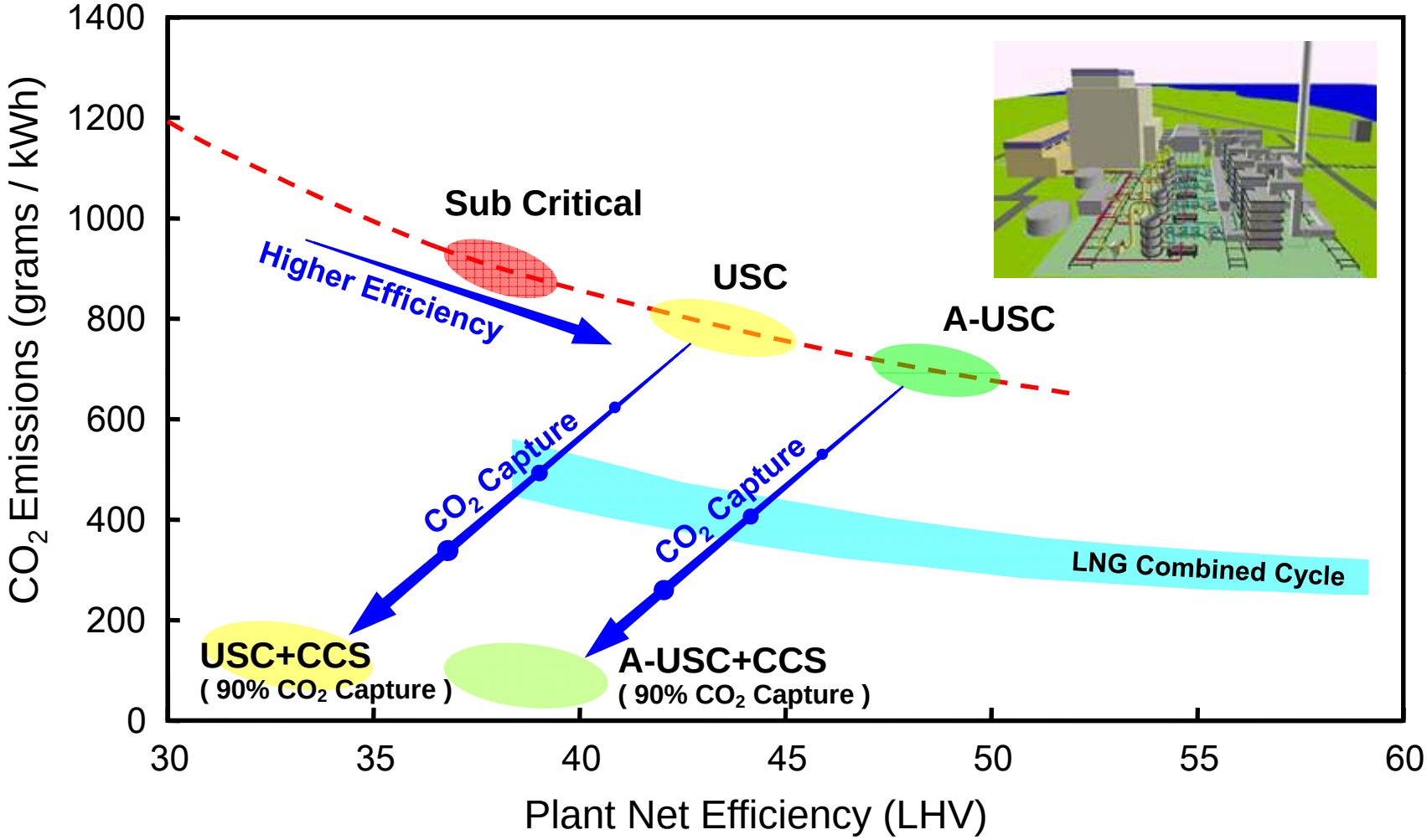
CO_2 Reduction in Thermal Power Plants



Substantial CO_2 reduction is realized by Integration and Optimization of Both High efficiency Turbine Cycles and CCS technology

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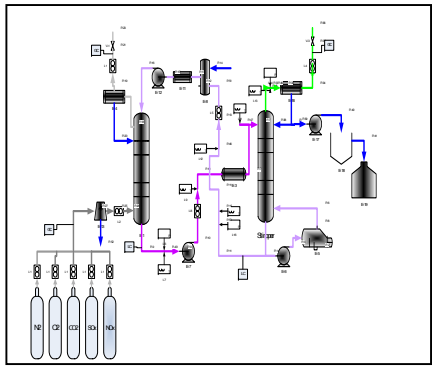
System Verification and Implementation



Screening of Absorbents and Evaluation of System Performance Improvement by Simulation

Overall Demonstration at Mikawa - PCC Pilot Plant

Evaluation of Basic Properties and Absorption Performance

Performance / Degradation Evaluation by Small Loop

Design of Full Scale Demonstration Plant

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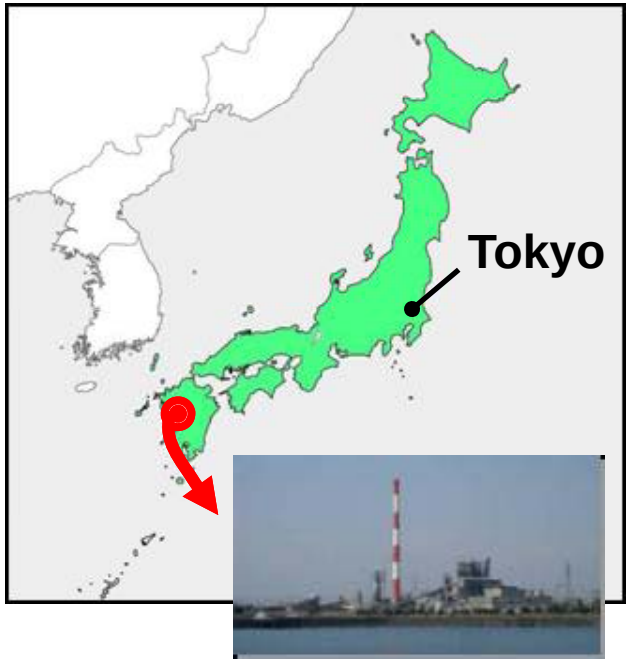
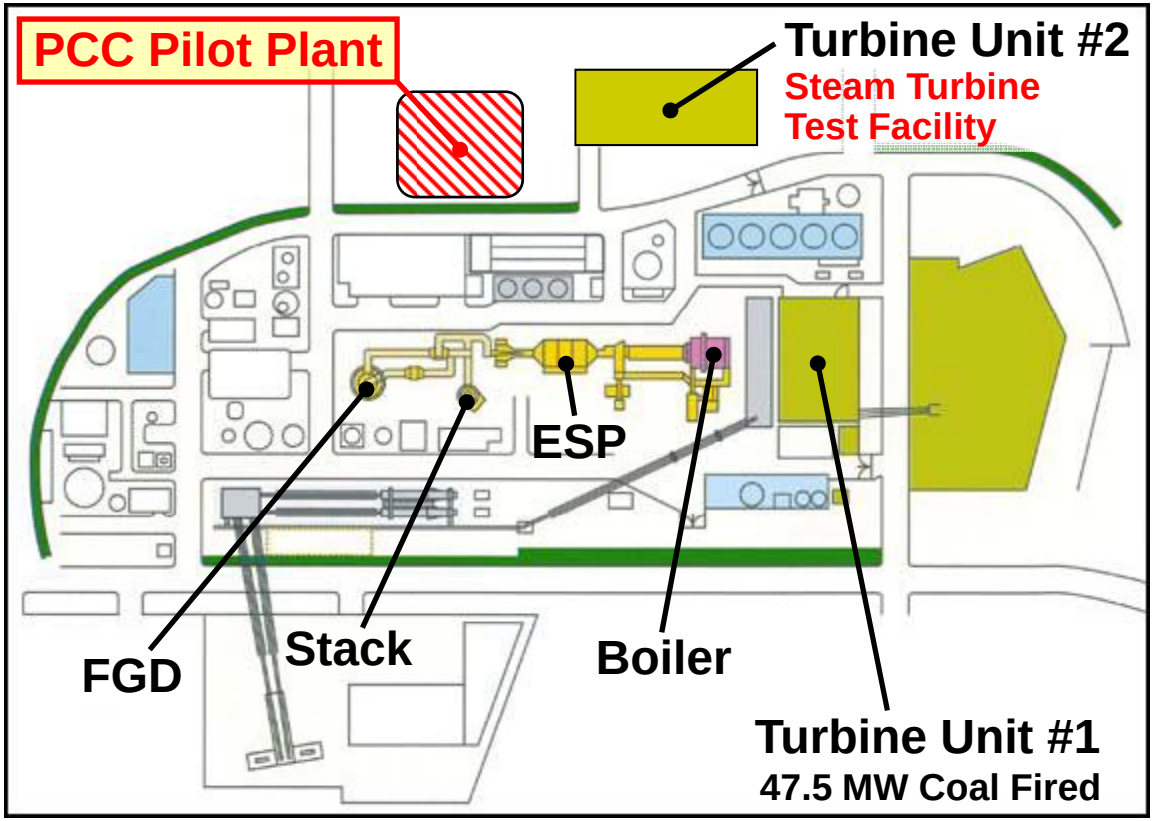
Toshiba PCC Pilot Plant at Mikawa

Location:



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

Plot Plan:



Mikawa: Toshiba's Showcase of Low Emission Thermal Power Technology

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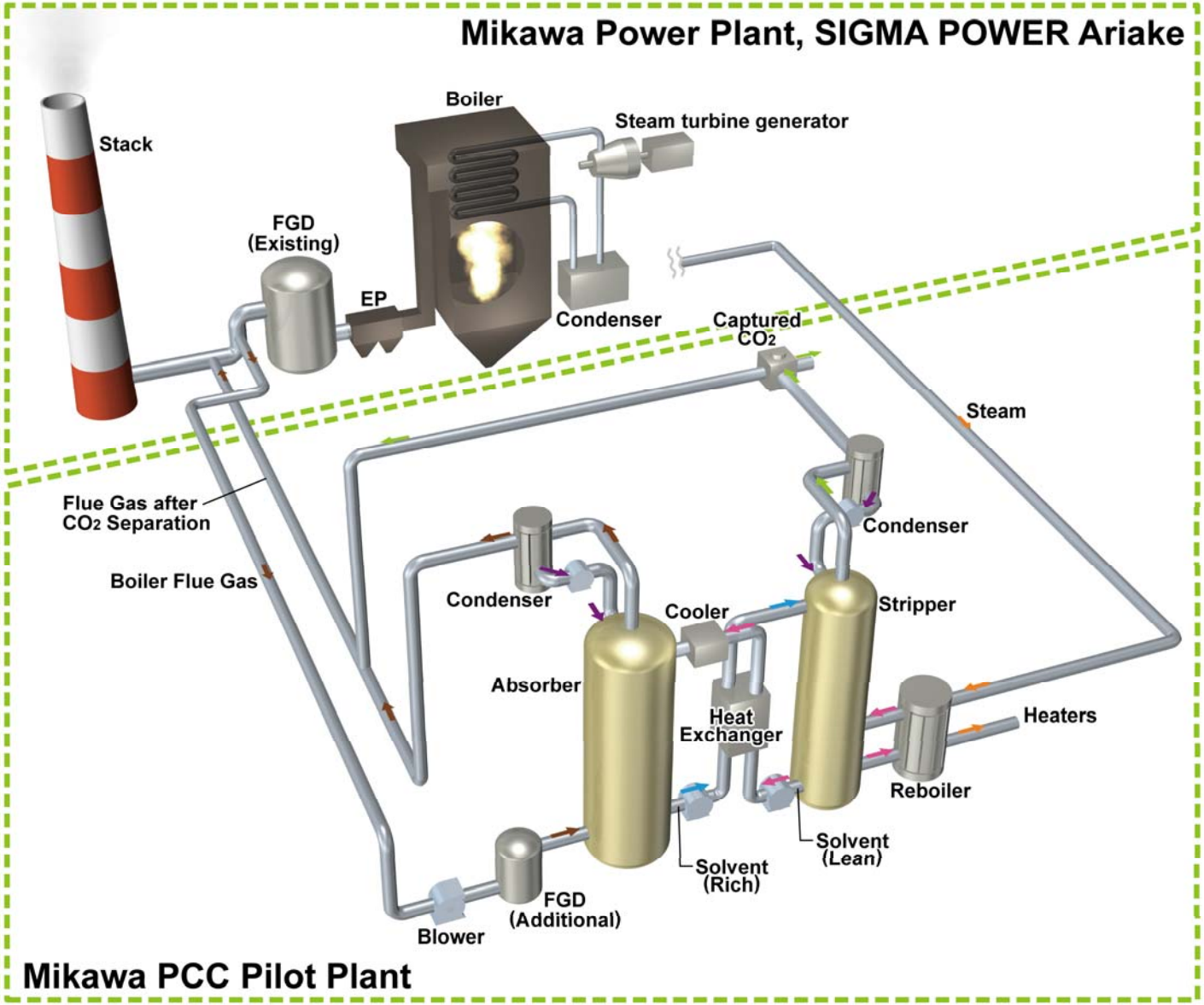
PCC Pilot Plant - Schematic



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PCC Pilot Plant - Specification

Mikawa PCC Pilot Plant

Table 1 Pilot Plant Specification

Location	Mikawa Thermal Power Plant SIGMA POWER Ariake Corp.
Source Gas	Flue Gas of Coal-Fired Boiler
Treated Gas Flow Rate	2100Nm^3/h
CO_2 Concentration	Approx. 12%
CO_2 Capture Ratio	90%
Captured CO_2	10t-CO_2/day
Impurities	SOx, NOx, Dust, etc
Solvent	TS-1 Solvent

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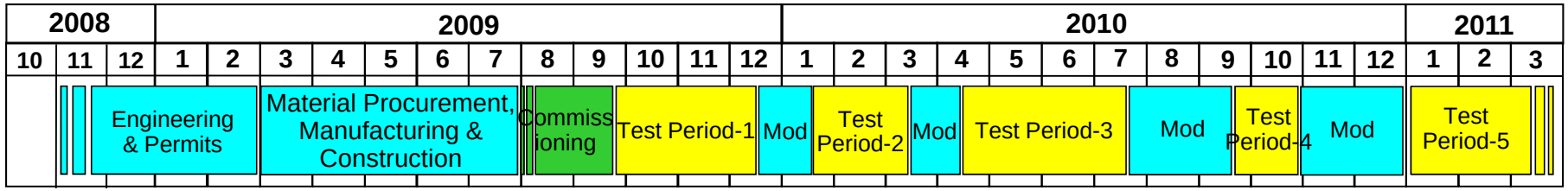
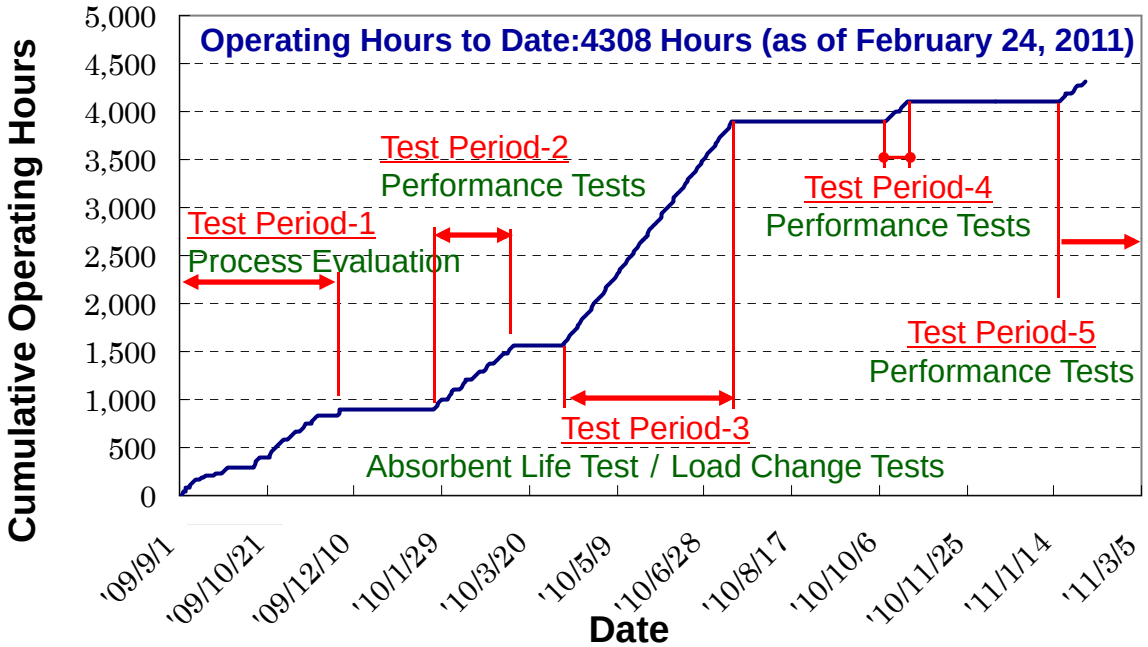
PCC Pilot Plant - Schedule and Tests





Process Evaluation : Ensure Stable Operation and Good Measurement Accuracy
Performance Tests : Seek Higher CO_2 Capture Efficiency and Lower Capture Energy
Absorbent Life Test : Assess Absorbent Degradation by Live Flue Gas
Load Change Tests : Evaluate Response at Transient Operations

Operating Hours to Date: 4308 Hours (as of February 24, 2011)

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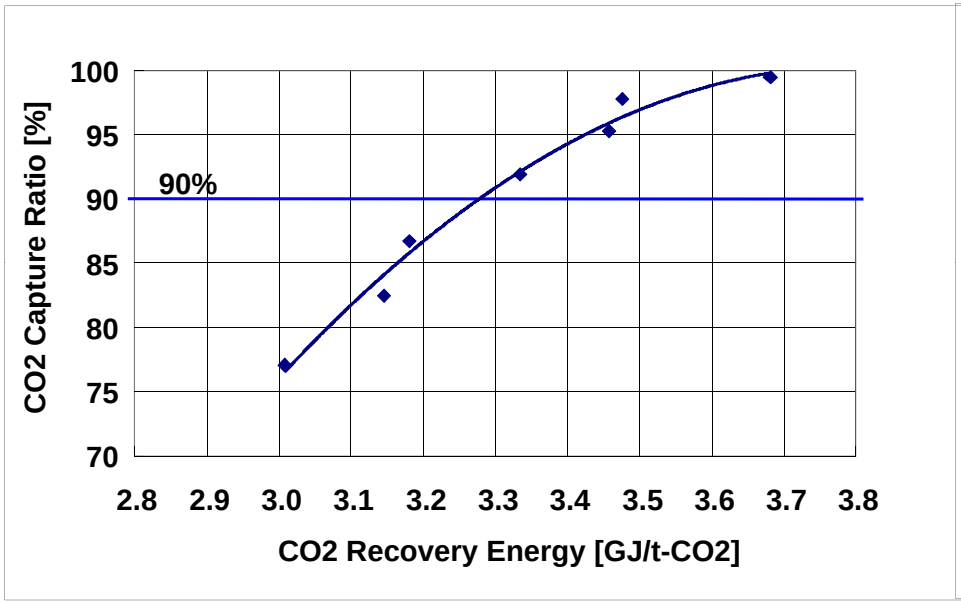
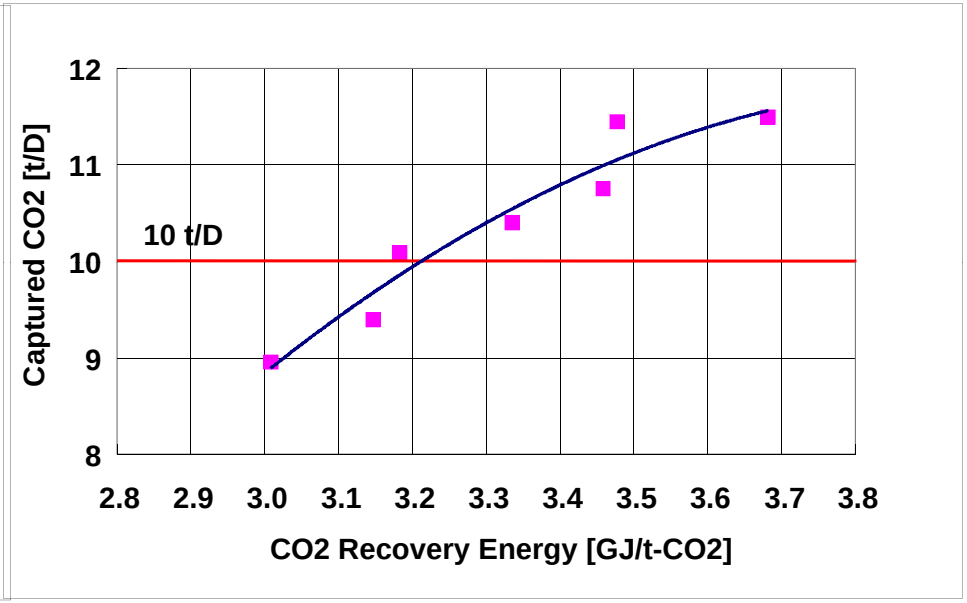
Results - CO_2 Recovery Energy (2010)





CO_2 Recovery Energy : 3.2 ~ 3.3GJ/t-CO2 @ 90% Capture

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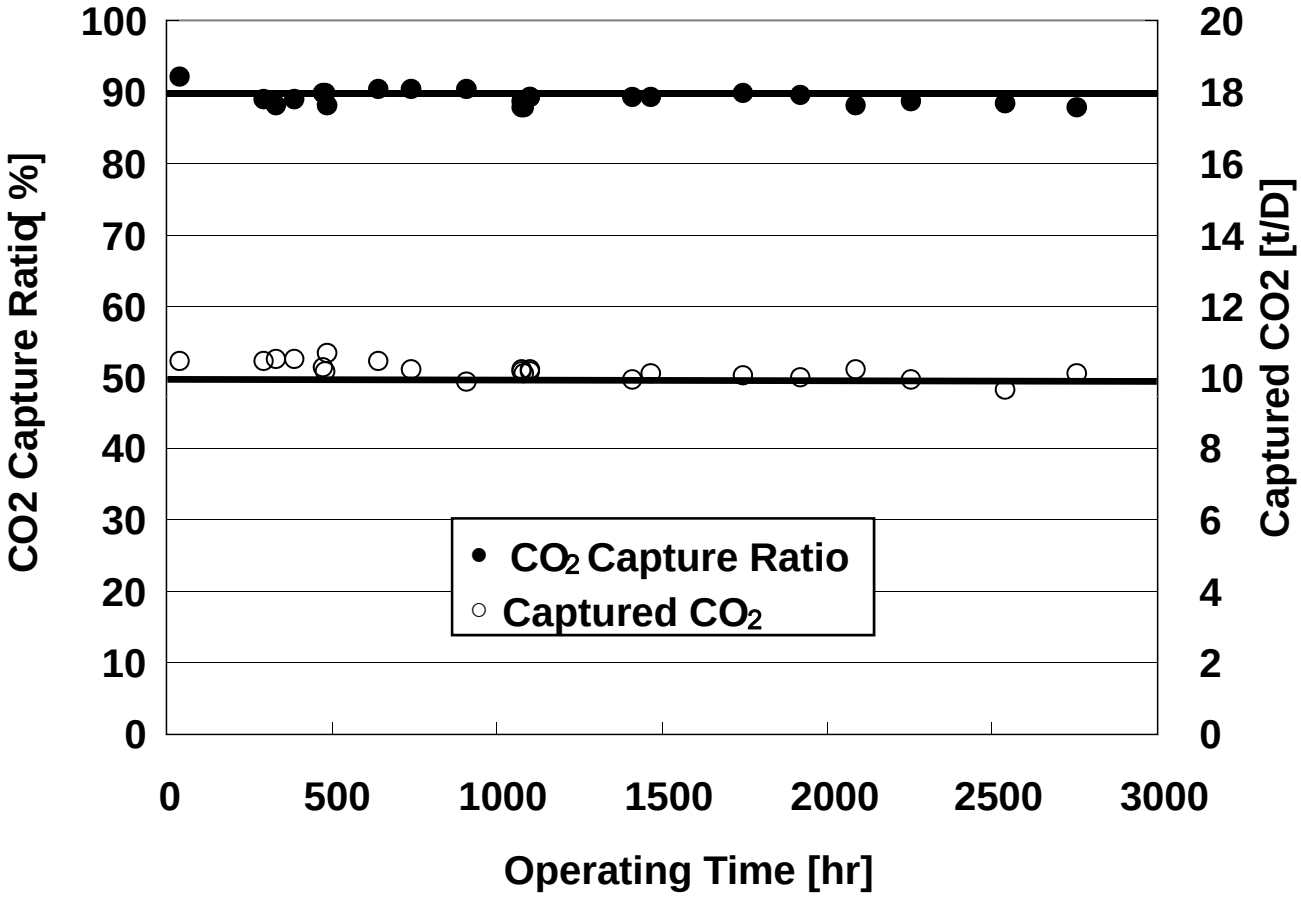
Results - Performance Degradation (2010)



Performance Stable over 2800 Hours of Continuous Operation

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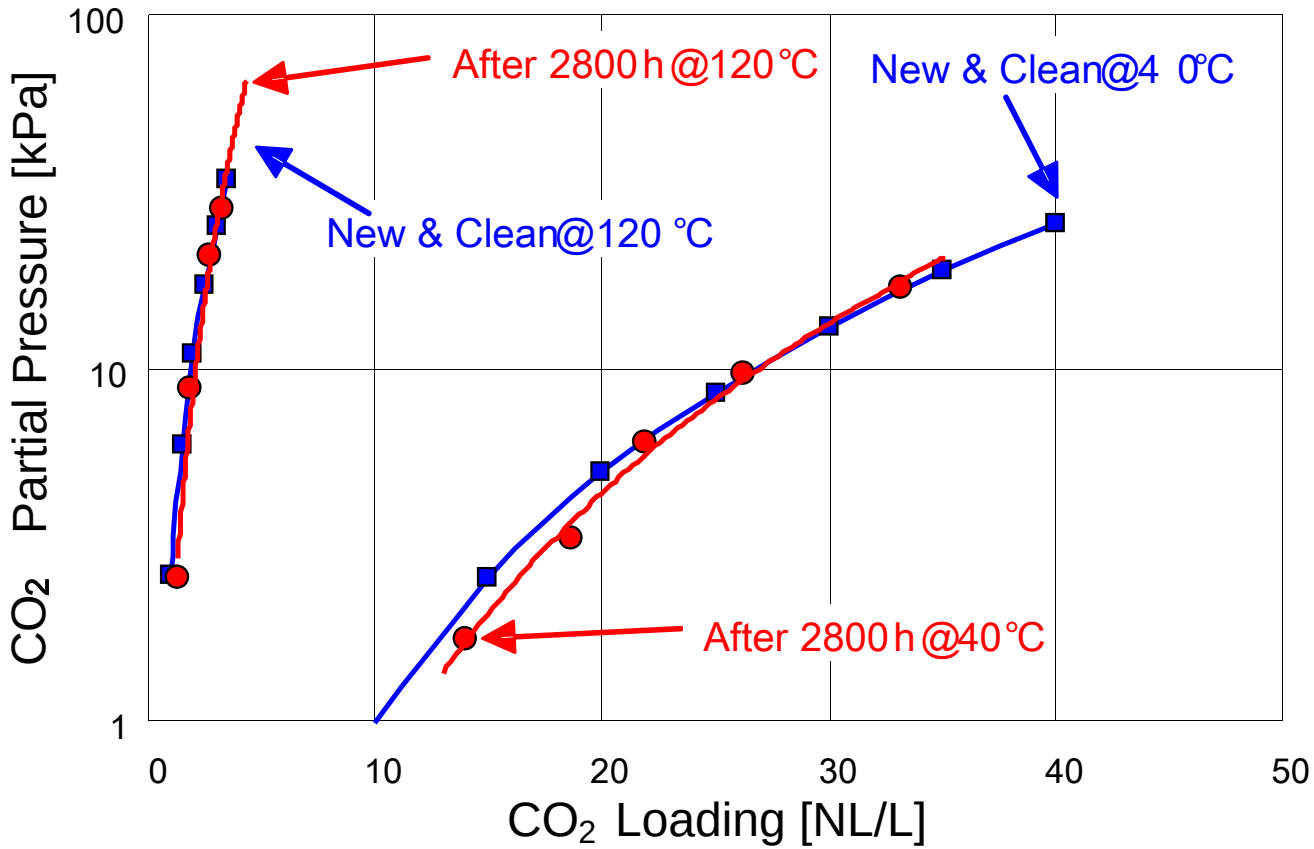
Results - Solvent Degradation (2010)



No Detrimental Degradation after 2800 Hours of Continuous Operation

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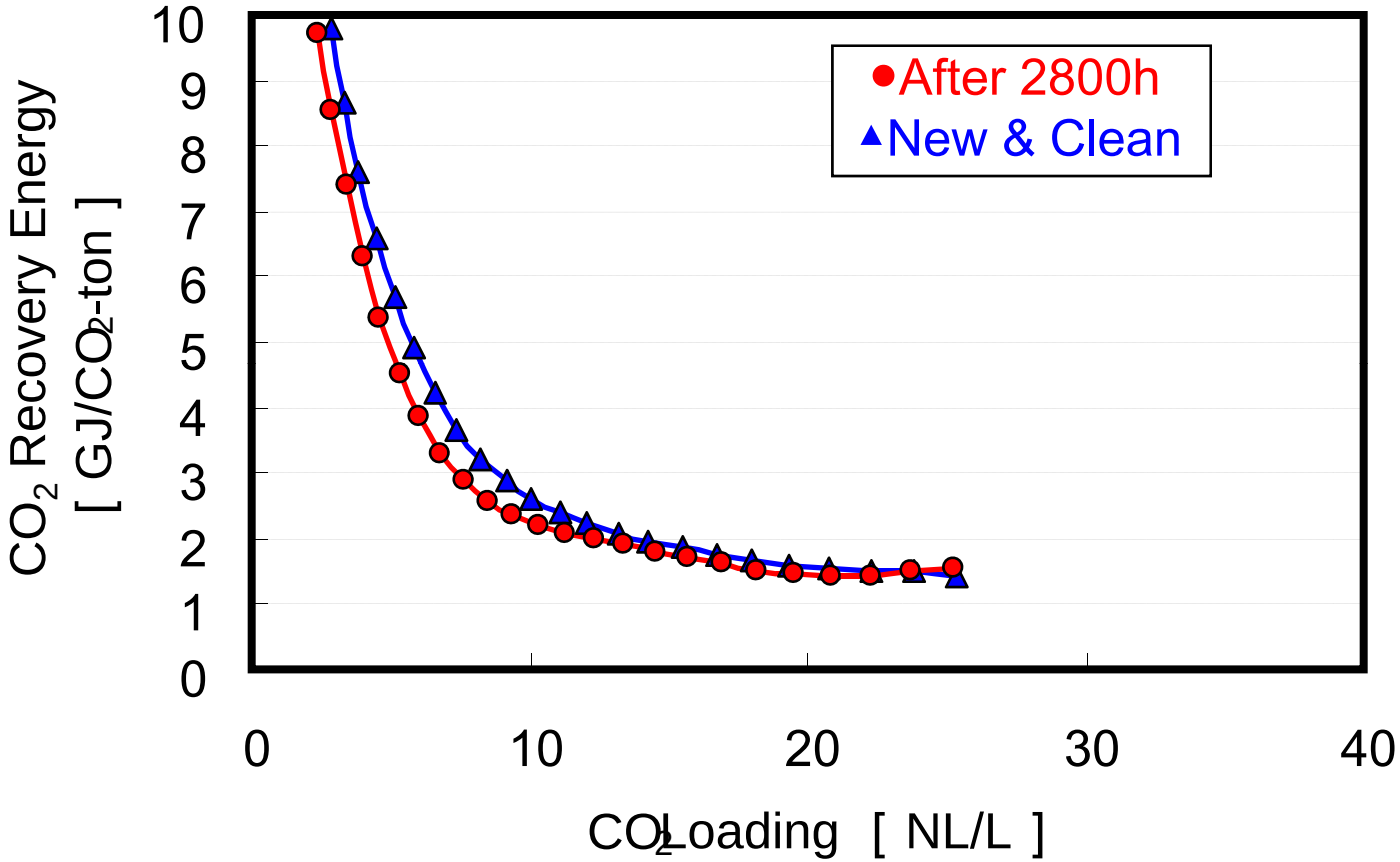
Results - Solvent Degradation (2010)



No Detrimental Degradation after 2800 Hours of Continuous Operation

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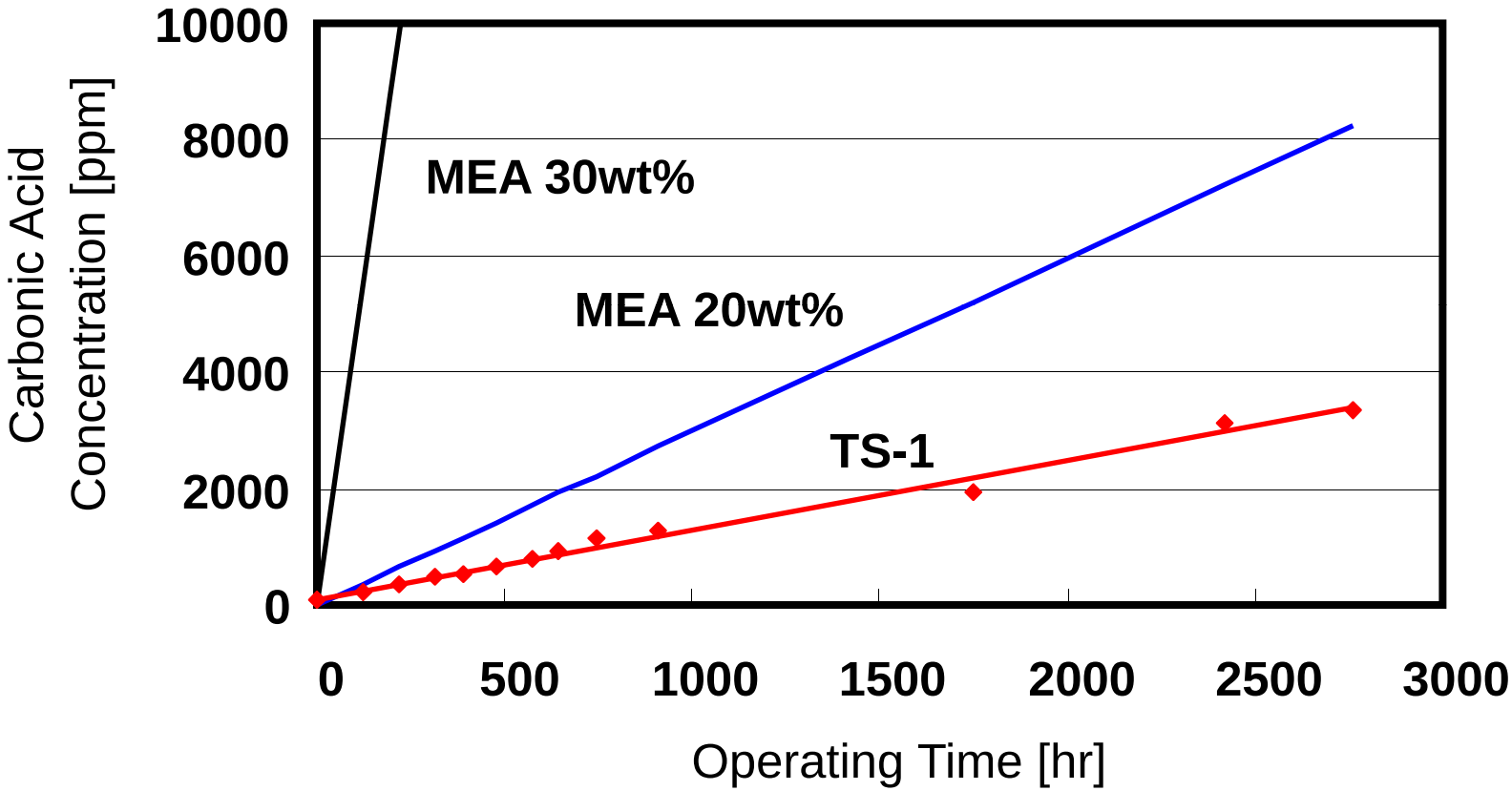
Results - Solvent Degradation (2010)



Amine Degradation lower than Conventional Amine Technologies

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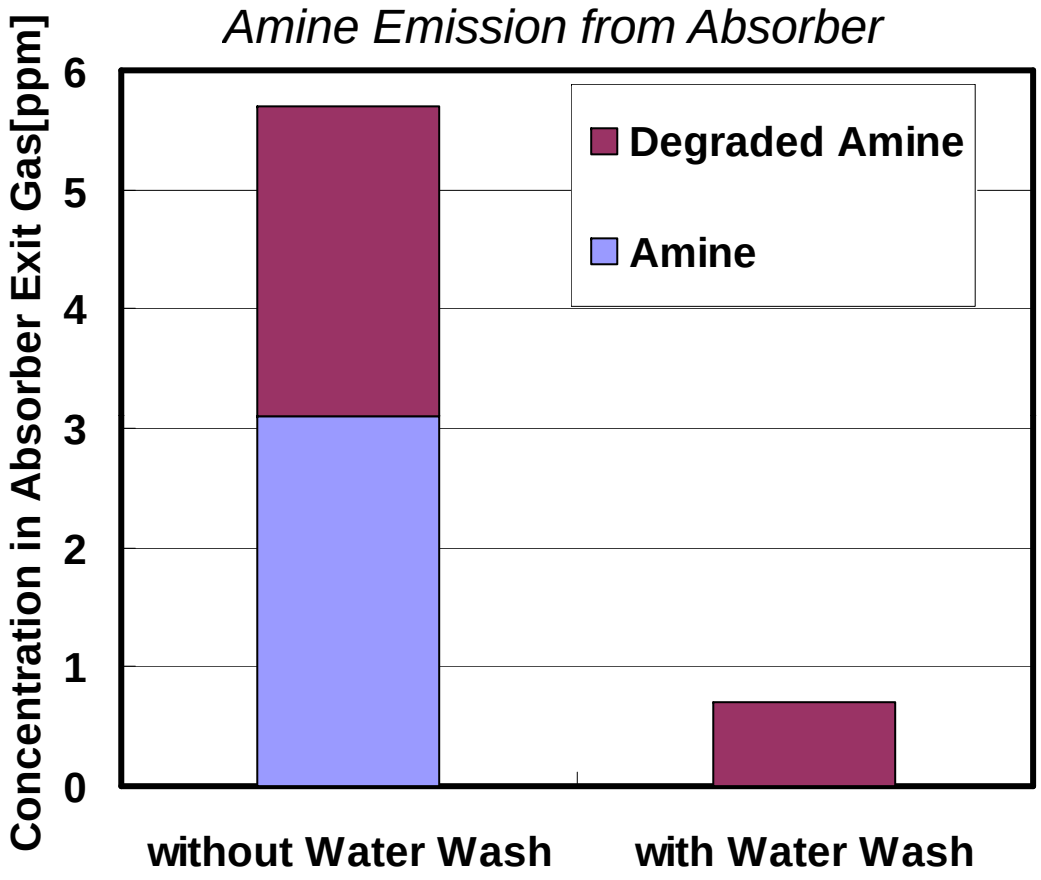
Results - Amine Emissions (2010)



Amine Emissions are Controlled, Evaluated and Monitored

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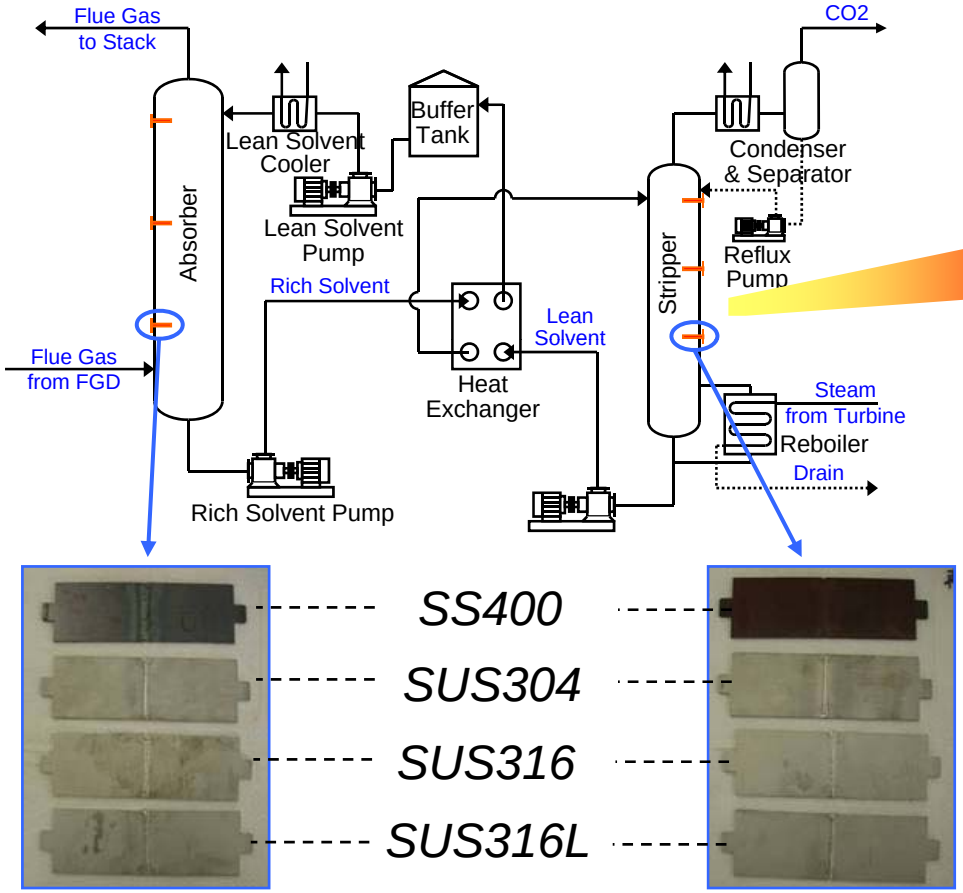
Results – Material Test Piece (2010)

Corrosion Coupon Tests



Test Pieces

No Substantial Degradation is found to Present

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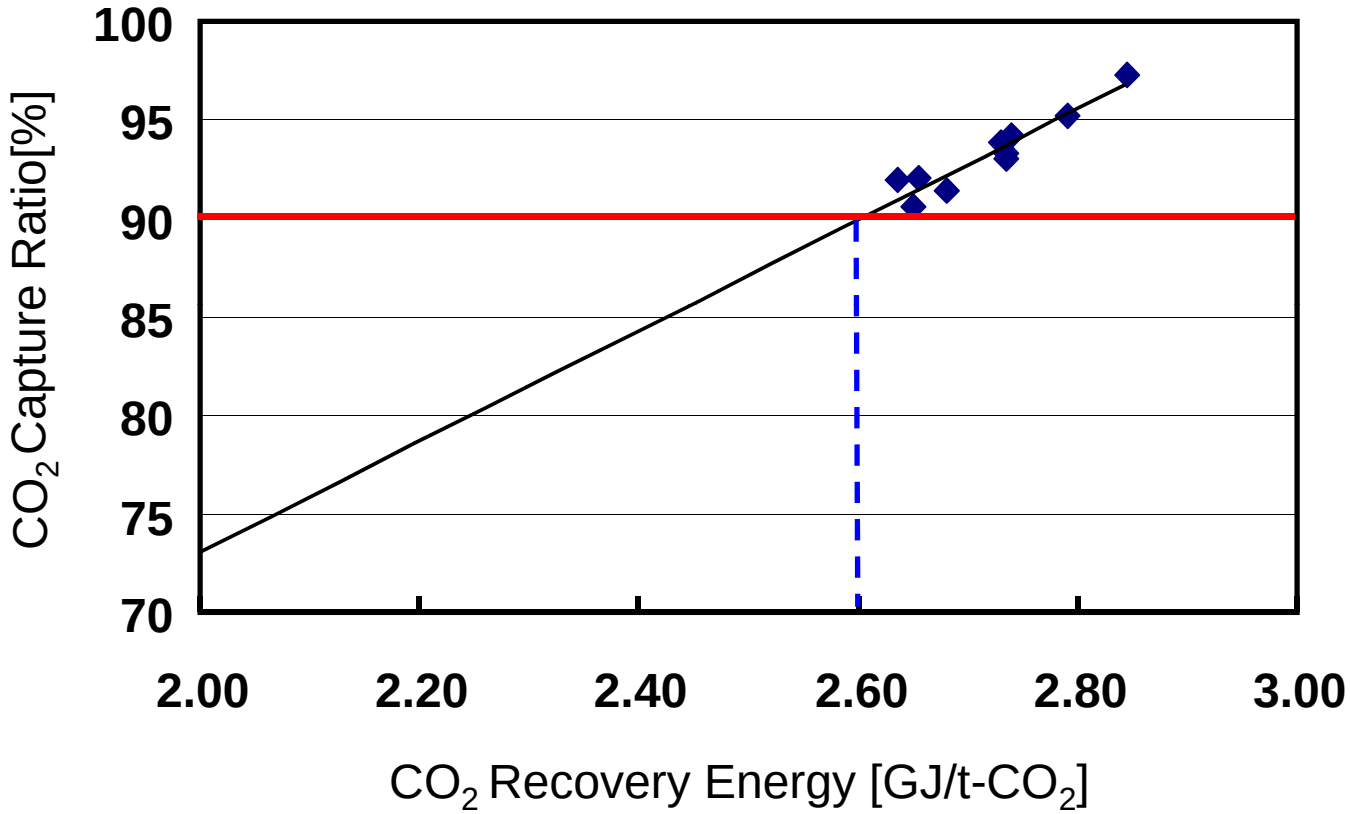
Results - CO_2 Recovery Energy (2011)

PCC Pilot Plant System Modified in 2011 to Improve CO_2 Rich Loading



CO_2 Recovery Energy : ~ 2.6 GJ/t-CO2 @ 90% Capture

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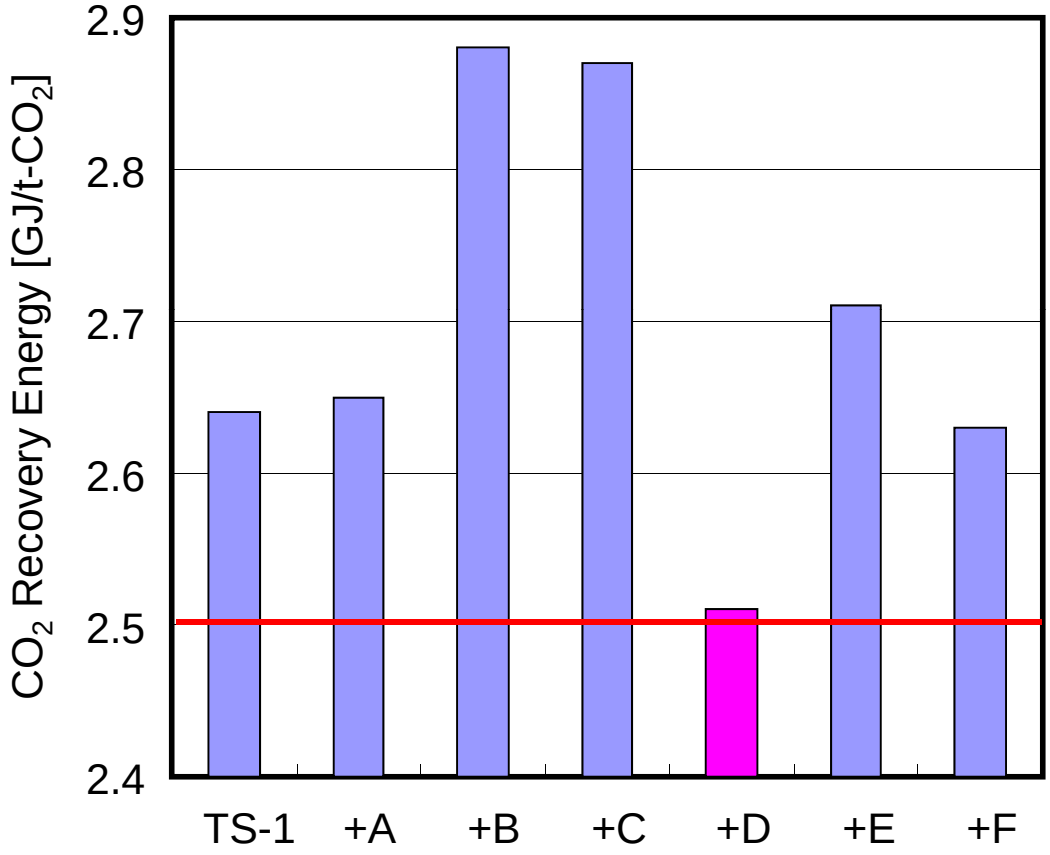
Solvent Screening - Simulation

Thermodynamic Simulation Conducted to Search for Improved Performance



Future Solvent Candidates are Screened through Simulation

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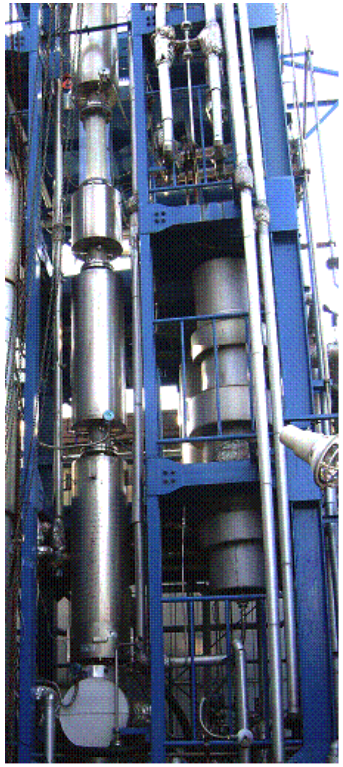
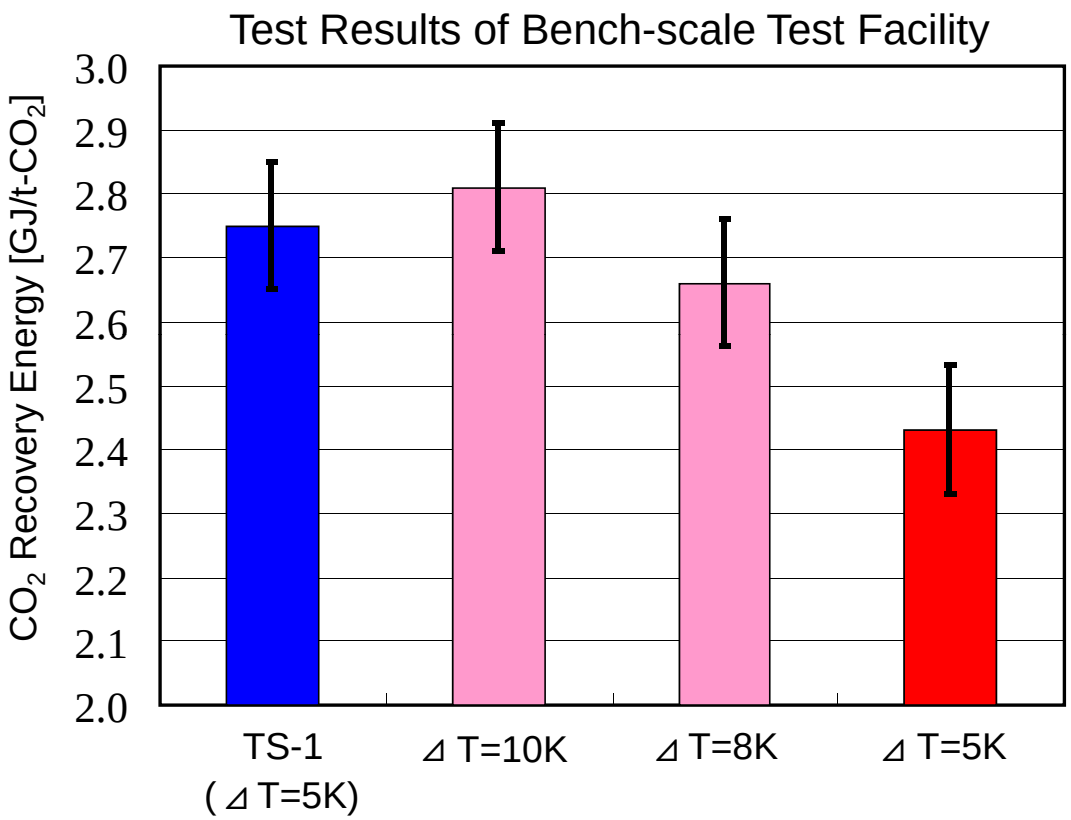
Solvent Screening – Bench Scale Test



Bench Scale Test



Evaluation of Promising Solvents are Conducted at Bench Scale

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Summary

- ***Toshiba Corporation holds a well respected history as leading and reliable thermal power plant technology supplier in the global market.***

- ***Toshiba has positioned Carbon Capture as one of the key technologies to decarbonize thermal power plant.***

- ***In view of actual application to power plants, Toshiba constructed its PCC Pilot Plant in Mikawa (Japan), which works to actual live flue gas of a coal fired thermal power plant. The plant has accumulated more than 4300 hours of operation to date.***

- ***High performance of Toshiba solvent system was proven in 2010 tests, and was improved further by system modification made in 2011.***

- ***Toshiba's search for improved performance solvents and system application continues through its comprehensive system verification and implementation program.***

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Thank You !

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