Owner: Electric Power Development Co.
Power Station: Isogo Unit No.2
Rated Output: 600 MW
Turbine Type: TCDF
Revolution: 3,000 rpm
Main Steam Press.: 25.0 MPa.a
Main & Reheat Steam Temp.: 600 / 620°
Initial Operation: 2009.7
Date of Photography: 2009
3.8 Design Features of 400-600MW Steam Turbine

- 1-LP Casing (2 Flow) with various size of last stage blade
- HP/IP Combined Casing
- Advanced Vortex Nozzle to improve the stage efficiency
- Continuous Covered Blade to improve the seal performance

Tandem Compound Type 400 ~ 600 MW Class Steam Turbine
Owner: GDF SUEZ Energie Nederland N.V.
Power Station: Rotterdam
Rated Output: 790.1 MW
Turbine Type: TC4F
Revolution: 3,000 rpm
Main Steam Press.: 26.3 MPa
Main & Reheat Steam Temp.: 600 / 620°C
Initial Operation: 2013
Date of Photography: February 2012
3.10 Design Features of 600-800MW Steam Turbine

- 2-LP Casings (4 Flow) with various size of last stage blade
- Continuous Cover Blade to improve the seal performance
- HP/IP Combined Casing
- Advanced Vortex Nozzle to improve the stage efficiency

Tandem Compound Type 600~800 MW Class Steam Turbine
3.11 Supercritical Coal Fired Power Plant (EPC)

- First sliding pressure supercritical power plant in Canada
- Awarded best coal-fired project at Power-Gen International 2005

**<Leading Specification>**

- **Owner:** EPCOR
- **Site:** Genesee Phase3
- **Type:** Supercritical
- **Fuel:** Sub-bituminous Coal
- **Output:** 450MW (NET)
- **Steam Condition:** 24.1MPa / 566°C / 566°C
- **Commercial Operation:** 2005
3.12 Supercritical Coal Fired Power Plant (EPC)

- Awarded 2007 Plant of the Year by Power Magazine
  (1) First US supercritical plants in 16 years
  (2) High efficiency and low emission
  (3) On time delivery and start-up

<Leading Specification>
- Owner: Mid-American Energy
- Site: Walter Scott Jr. Energy Center 4
- Type: Supercritical
- Fuel: Sub-bituminous Coal (PRB)
- Output: 790MW (NET)
- Steam Condition: 25.3MPa / 566°C / 593°C
- Commercial Operation: 2007
### Leading Specification

- **Owner:** Evonik/EVN
- **Site:** Walsum Unit 10 (Germany)
- **Type:** Ultra Supercritical
- **Fuel:** Hard Coal
- **Output:** 790MW (Gross)
- **Steam Condition:**
  - 26.4MPa / 600°C / 620°C
- **Turbine:** Hitachi
- **Boiler:** HPE
4. IGCC & CCS Technologies
4.1 IGCC (EAGLE Pilot Plant in Japan)

- **Gasifier**: O₂-blown entrained flow gasifier (2-stage spiral flow type)
- **Coal Feed Rate**: 150 t/day
- **Gasification Pressure**: 2.5 MPa
- **Syngas Volume**: 14,800 m³/h
- **Gas Clean-up**: Absorption with MDEA
- **Sulfur Recovery**: Limestone-gypsum
- **CO₂ Capture Unit Capacity**: 1,000 m³/h
- **GT Output**: 8,000 kW
4.2 Features of EAGLE* Gasifier

EAGLE gasifier is oxygen blown two stage spiral flow type entrained bed gasifier. Two stage spiral flow enables high efficiency for various type of coal.

Two stage concept enables optimum $O_2$/coal ratio operation. Increasing residence time by spiral down flow, particle scattering is prevented. Oxygen feed flow quantity of upper burners of the gasifier is selected as little as possible in the range that does not let carbon losses increase.

Prevention of particle scattering by Spiral down flow

High efficiency gasification with less Oxygen

Optimized $O_2$ ratio for various coals

*Coal Energy Application for Gas, Liquid & Electricity
### 4.3 Development of IGCC with CO₂ Capture

<table>
<thead>
<tr>
<th>Year</th>
<th>’00</th>
<th>’05</th>
<th>’10</th>
<th>’15</th>
<th>’20</th>
<th>’25</th>
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<tr>
<td><strong>EAGLE</strong></td>
<td>Design, Manufacturing, Installation</td>
<td>Operation</td>
<td></td>
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<tr>
<td><strong>EAGLE Step2</strong></td>
<td>Design, Manufacturing, Installation</td>
<td>Operation</td>
<td>Reliability Improvement</td>
<td>1000m³/h CO₂ Capture Pilot Plant/Sweet Shift + Chemical Absorption</td>
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<tr>
<td><strong>EAGLE Step3</strong></td>
<td>Feasibility Study, Design, Manufacturing, Installation</td>
<td>Operation</td>
<td>1000m³/h CO₂ Capture Pilot Plant/Sour Shift + Physical Absorption</td>
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<tr>
<td><strong>Osaki Cool Gen Project (Demonstration)</strong> Supported by METI</td>
<td>Design, Manufacturing, Installation</td>
<td>Demonstration Operation of Oxygen blown IGCC</td>
<td>CO₂ Capture Unit Design, Manufacturing, Installation</td>
<td>Demonstration Operation of IGCC with CO₂ Capture</td>
<td>Demonstration Operation of IGCC/IGFC with CO₂ Capture</td>
<td></td>
</tr>
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**METI**: Ministry of Economy, Trade and Industry

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Note: The diagram shows the development timeline for IGCC with CO₂ capture technology, including various stages such as design, manufacturing, installation, and operation. The timeline is color-coded to represent different phases and milestones, with specific technologies and improvements highlighted. The information is supported by the Ministry of Economy, Trade and Industry (METI).
4.4 Process Flow of OSAKI Cool Gen Project

IGCC: 170MW class (Coal feed rate: 1,100t/d)
Gasifier: Oxygen-Blown Entrained-flow
Gas Turbine: Demo Class

Fuel Gas (H₂, CO etc.)

Air Separation Unit

Gasifier

O₂

Coal

Air

IGCC/IGFC with CO₂ Capture

CO₂ Capture

Shift Reaction: Shift catalyst is under consideration.

CO₂ Capture Unit: Capture process is under consideration.

H₂

CO₂, H₂

CO₂ Capture Unit

CO₂ Transport and Storage

GT

Stack

Generator

ST

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Absorb CO\textsubscript{2} in Flue Gas by Amine, CO\textsubscript{2} Release by Heat and Storage

**Principle**

Absorption

40~50°C

\[ \text{R-NH}_2 + \text{CO}_2 + \text{H}_2\text{O} \rightleftharpoons \text{R-NH}_3^+ + \text{HCO}_3^- \]

Heated, Regenerate

100~120°C

R: Alkyl

**Process**

1) CO\textsubscript{2} in flue gas absorbed by Amine
2) Regenerate CO\textsubscript{2} in regenerator by heat
3) Amine re-circulate to absorber
## 4.5 Development Road Map

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<td><strong>Absorption</strong></td>
<td><strong>Basic</strong></td>
<td><strong>Bench Test</strong></td>
<td><strong>Scale-Up Technology/Improve Efficiency</strong></td>
<td><strong>CO₂ Capture for 1000MWₑₑ</strong></td>
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<td><strong>System</strong></td>
<td><strong>1MWt Pilot</strong></td>
<td><strong>FS</strong></td>
<td><strong>5MWt pilot (HPE)</strong></td>
<td><strong>20MWt pilot</strong></td>
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<tr>
<td></td>
<td><strong>1MWt Pilot</strong></td>
<td><strong>5MWt pilot</strong></td>
<td><strong>5MWt pilot</strong></td>
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4.6 CO₂ Scubber Testing Plant (Gelderland/Netherlands)

- up to 5000 Nm³/h flue gas, equals to 5 MWth
- CO₂ removal > 90 %, Purity of CO₂: 95%
- Removal capacity up to 1 ton CO₂ / hour
- Two trains arrangement
- Ready for operation by end of 2011
4.7 Example of CO$_2$ Capture for 1000MW$_{el}$

<table>
<thead>
<tr>
<th>Item</th>
<th>Unit</th>
<th>Value</th>
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<tbody>
<tr>
<td>Flue Gas</td>
<td>m$^3$/h</td>
<td>3,000,000</td>
</tr>
<tr>
<td>CO$_2$ Rec.</td>
<td>%</td>
<td>90</td>
</tr>
<tr>
<td>Coal</td>
<td>t/h</td>
<td>300</td>
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</table>