# MHI’s Diversified Products Focusing on Gasification

## MHI’s Diversified Products are Contributing to Every Area of Society;

<table>
<thead>
<tr>
<th>Category</th>
<th>Products</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>ENERGY &amp; ENVIRONMENT:</strong></td>
<td>Power Systems, Pollution Control Equipment</td>
</tr>
<tr>
<td><strong>INFRASTRUCTURE:</strong></td>
<td>Bridges, Gates, Desalination Plants</td>
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<tr>
<td><strong>TRANSPORTATION:</strong></td>
<td>Aircraft, Ships, Land Transportation Systems</td>
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<tr>
<td><strong>INDUSTRIAL &amp; CHEMICAL:</strong></td>
<td>Pulp &amp; Paper Machinery, Chemical Plants, Industrial Robots, Machine Tools</td>
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<tr>
<td><strong>LIFE STYLE AND LEISURE:</strong></td>
<td>Air-Conditioners, Refrigeration Units, District Heating, Pleasure Boats, Leisure Facilities</td>
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<tr>
<td><strong>OCEAN AND SPACE DEVELOPMENT:</strong></td>
<td>Ocean Research Ships, Deep Submergence Research Vehicles, Rockets, Space Planes</td>
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<tr>
<td><strong>DEFENSE:</strong></td>
<td>Submarines, Naval Vessels, Jet Fighters, Missiles, Tanks</td>
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</table>
Origin of MHI IGCC & Gasification Technologies

Boiler
625,778t/h (2,976 units)
Developed to Gasifier

Gas Turbine
62,478MW (486 units)
Optimized for IGCC

Steam Turbine
182,939MW (1,987 units)
Developed to Gas C/U for IGCC

Gas Purification System
Scenario of Mitsubishi’s Clean Coal Technology

1. Improvement of Thermal Efficiency

- Ultra High temp. GT (1,700°C)
- 1,700°C GT
- J type GT
- IGCC
- NGCC (Natural Gas)
- USC (coal)

2. CO2 Capture and Storage

- Fuel
  - Low CO2 Generation
  - CO2 Capture
  - CO2 Transportation
  - CO2 Storage

- Hot gas Clean-up System
- MHI High Efficiency IGCC Power Plant
- MHI CO2 Capture technology
- MHI High Pressure CO2 Compressor for CCS Plant

IGCC: Integrated Gasification Combined Cycle
Contribute to Both of the Power Generation and the Chemical Industries

- **Air-Blown Gasifier with High Temp. GT for IGCC (i.e. for the Power) at the Highest Plant Efficiency and Economical Merits**

- **Oxygen-Blown Gasifier for Chemical Products (i.e. SNG, CTL, NH3, etc.) at the Minimum Utility Consumption Including Aux. Power**
Mitsubishi IGCC / Gasification Technology Development

- **Air-Blown Gasifier for IGCC**
  - 200t/d Pilot Plant (Nakoso)
  - 2t/d PDU (CRIEPI)

- **1,700t/d / 250MW Demo. Plant**
  - Clean Coal Power R&D, Ltd.

- **Pilot Test Plant (MHI Nagasaki)**

- **Oxygen-Blown Gasifier for Chemical Products**
  - 3,600t/d Commercial Plant
  - 500MW or More Commercial Plant

- **1,700t/d / 250MW**
  - 2020
  - 2015

- **500MW or More**
  - 2025

**Abbreviations**

- PDU: Process Development Unit
- CRIEPI: Central Research Institute of Electric Power Industry
Recent IGCC and Gasification Projects
MHI has been undertaking

• Air blown IGCC
  – Australian ZeroGen Project
  – CCS Demonstration in Nakosso

• Oxygen blown gasification
  – A project (SNG)
  – B project (CTL)
  – C project (Polygeneration-Combined Air blown / Oxygen blown)
## Australian ZeroGen Project - Principal Specification

<table>
<thead>
<tr>
<th>Principal Specification</th>
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<tbody>
<tr>
<td>Coal</td>
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<tr>
<td>Output</td>
</tr>
<tr>
<td>Gasifier</td>
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<tr>
<td>Gas Turbine</td>
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<tr>
<td>Bottoming Cycle</td>
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<td>Gas Clean-up</td>
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<tr>
<td>Carbon Capture</td>
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<td>CO2 Storage</td>
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</table>
**Australian ZeroGen Project**
- **MHI’s Scope of Supply**

**MHI’s Scope of Supply**

- **Coal**
  - **Air-Blown Gasifier**
    - **N2**
    - **O2**
    - **Air for Gasifier**
    - **SRU**
      - **Steem**
      - **CO2 Comp**
        - **CO2 Pipe Line**
          - **CO2 Underground Storage**
            - **Other Company’s Scope**

- **Air Booster**
  - **CO Shift**
    - **AGR**
      - **Combustor**
        - **GT Comp**
          - **HRSG**
**Australian ZeroGen Project - Project Schedule**

**Project Schedule**

- 2008/10 ~ 12: Scoping Study
- 2009/1 ~ 3: Pre-Study
- 2009/6: Feasibility Study Awarded
- 2010/9: FEED Study Contract (Scheduled)
- 2012/1: EPC Contract (Scheduled)
- 2015/9: Operation Start (Scheduled)

<table>
<thead>
<tr>
<th>Year</th>
<th>Award Pre-Study</th>
<th>Award FS</th>
<th>Commencing FEED</th>
<th>Contract EPC</th>
<th>Start Commissioning</th>
<th>COD</th>
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<tbody>
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<td>2016</td>
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**Key Milestones**

- Scoping Study
- Pre-Study
- Feasibility Study Awarded
- FEED Study Contract (Scheduled)
- EPC Contract (Scheduled)
- Operation Start (Scheduled)
**CCS Demonstration in Nakoso**


- **TEPCO** has been charged to perform a study for CCS demonstration system at Nakoso IGCC site.

  ✓ **Japan CCS** Co., Ltd., founded in May 2008 with investment from 29 companies, including electric utility companies and oil companies.

  ✓ **NEDO** (New Energy and industrial technology Development Organization)

  ✓ **TEPCO** (Tokyo Electric Power Company)

**CCS Demonstration in Nakoso**

Major activities of the FS in 2008:
- Study on methods for CO2 capture and separation
- Study on the amount of the CO2 captured for both 100% of syngas and 10% of syngas treatment cases
- Preliminary specification of the CCS system

Source: Japan CCS CO., Ltd. RITE CCS Workshop 2008
Standard Design Parameters of MHI Oxygen-Blown Gasifier

MHI Can Design and Supply Gasifiers Both for Air-Blown and Oxygen-Blown

- Same “MHI 2-Stage Entrained Flow Gasifier” as Air-Blown Demo. Project Applied
  - Important factors duly considered
    (ex. increased heat flux, change in burner, change of carrier gas, impact to SGC)
- Minimized Oxygen Consumption by 2-Stage Gasification
- SGC, as Monolithic Structure with Gasifier, Producing Steam and Supplying Aux. Power Needed in Plants

<table>
<thead>
<tr>
<th>Type</th>
<th>MHI Oxygen-Blown Gasifier for Chemical Process</th>
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<tbody>
<tr>
<td>Coal Capacity</td>
<td>3,500t/d~4,000t/d</td>
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<tr>
<td>Operation Press.</td>
<td>2.8MPa ~4.0MPa (Subject to process requirement)</td>
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<tr>
<td>Gasifier Dimension</td>
<td>Standard Size within Experience</td>
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<tr>
<td>Gasification Agent</td>
<td>Oxygen</td>
</tr>
<tr>
<td>Syngas Flow Rate</td>
<td>270 ton/h~330 ton/h</td>
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<tr>
<td>HHV of Syngas</td>
<td>2,500kcal/Nm3-dry</td>
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<tr>
<td>HP Steam Conditions from the Gasifier SGC</td>
<td>Typically 160~190t/h, 13MPa x 430deg-C</td>
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**O₂-blow Gasification “A” Project for SNG Plant**

- **Bit. Coal**
  - O₂-blow Gasifier System
  - O₂-blow Gasifier System
  - O₂-blow Gasifier System

- **Air Separation Unit**
  - N₂ (*Purge*)
  - O₂

- **Water**
- **Steam for Process and Power**
- **Slag**

- **Syngas**

- **Acid Gas Removal System**

- **Methanation**

- **SNG**

*Nitrogen is used to purge or inert equipment for safety*
O₂-blown Gasification “B” Project for CTL Plant

Bit. Coal → MHI’s scope

- O₂-blown Gasifier System
- Air Separation Unit
- O₂
- N₂ (Purge*)

Steam for Process and Power → Acid Gas Removal System

Syngas → Liquid Fuel Synthesis

Slag

CTL

*Nitrogen is used to purge or inert equipment for safety
*Nitrogen is used to purge or inert equipment for safety*
“Mitsubishi’s Contribution for Energy and Environment Solutions”