2024 ADB ACEF
Practical Carbon Reduction Technology Using Green Ammonia and Hydrogen
“Doosan’s Decarbonization Technology”
Doosan Enerbility

1980~1962  
Business Establishment

2000~1981  
Growth and Development

2007~2001  
Successful Privatization and Leap

2019~2008  
The Path to Global Leadership

2020~  
Transition to Eco-Friendly Energy Company

Doosan Heavy Industries & Construction renamed as **Doosan Enerbility in 2022**

**Global Leader in Power and Water**

**4 Key growth drivers of Eco-friendly business**

- Hydrogen-ready Turbine
- Renewable Energy
- Hydrogen Energy Solutions
- Next Generation Nuclear Power

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National power generation are heavily dependent on coal-fired power, and despite the setting of NDC targets, power generation from coal continues to increase.
Asia’s Challenge to decarbonization

Problems of sudden phase out coal-fired power plants for practical reasons in many Asia Pacific countries

Problems with shutting down coal-fired power plants

- **No economic alternative**
  No power generation alternative as cheap as coal

- **No quick transition alternative to carbon-free energy**
  There are areas where carbon-free power generation such as wind power generation is impossible to replace existing power plant due to regional limitations.

- **No Electricity generation alternative from stopping large power plant**
  It takes a lot of time and money to build a new power plant. In particular, policy decisions are made more slowly in some Southeast Asian countries. No alternative to stopping power generation.

- **Threats on Energy security and Industry Ecosystem**
  Many parts of the industry depend on coal-fired power. Sudden changes pose a threat to energy security, can destroy related industrial and local ecosystems including massive job losses.
Introduction to Ammonia co-firing tech.

Affordable ‘Bridge Technology’ to reduce CO2 in Asia pacific countries

- Concept: Use NH₃ instead of Coal to Power plant
- Benefit: Reduce CO₂ emission immediately and affordably
- Challenge and What Doosan is capable of:
  - Maintain Same Power after modification and optimization
  - Maintain NOx emissions below standard levels
- Modification Work:

NH₃ Co-Firing
Introduction to Ammonia co-firing tech.

As ‘Bridge Technology’, ammonia co-firing is the realistic solution.

**Immediate CO₂ Reduction**
- Apply 20% Co-firing to 600MW Power plant for 25 years:
  
  \[
  \text{20 Million tons of CO}_2 \text{ will be reduced} = \text{Same as 5 years of early shut down}
  \]

- For 25 years, total 20 million tons of CO₂ reduction
- Same as 5 years of early shut down

**Maintaining Same Electricity Generation & Industry Ecosystem**
- Keeping stable electricity supply until transition to renewable energy
- No sudden change of existing ecosystem near coal fired power plant
- No Job losses and learning new skills

**Energy Security**
- for same power output and Revitalizing Industry Ecosystem for local area near power plant
First projects in progress

First projects confirmed for 4 operating power plants, and to be expanded to other 17 power plants in Korea

Expected Reduction of CO₂
(Availability 70%)

- 1 year
- 25 year

A. Shinboryeong #1 (1,000MW USC, 2017): 840,000 Ton/year
B. Dangjin #9 (1,000MW USC, 2017): 850,000 Ton/year
C. Yeosu CFB #1 (340MW CFB, 2016): 490,000 Ton/year
D. Samcheok Green #1 (500MW CFB, 2016): 340,000 Ton/year

+ 2.5 million Tons

150,000 ha
Metropolitan Manila X 2.3

16 units’ Emission
500MW(coal)

1 year

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Doosan Enerbility has been working on rearranging our business portfolio to achieve global carbon neutrality by focusing on our new growth driver and new eco-friendly businesses.

**Renewable energy**
- Korean standard wind power line up
  - Offshore: 5.5MW, 8MW
  - On & offshore: 3MW, 3.3MW

**Hydrogen Energy Solutions**
- Developing carbon-free fuel power generation technology to achieve carbon neutrality goal

**Next-generation nuclear power plant**
- World's largest nuclear power plant (1,400MW)
- Development of next-generation nuclear power plant SMRs model

**Hydrogen-ready Turbine**
- The world's Fifth largest GT OEM company
  - S1: 270MW, S2:380MW
Introduction to Renewable Energy (Wind Power)

Doosan Enerbility Business

- Nuclear
- Renewable
- Energy
- Electrolysis
- Hydrogen
- Ammonia
- Hydrogen
- Ammonia co-firing
- Hydrogen Turbine

**Renewable**
- Doosan, an **OEM** and **EPC player** in the wind power industry, is developing wind turbines for diverse and volatile environments.
- Doosan **designs, manufactures, and operates & maintains** wind turbine systems for on/off-shore wind farms, providing **end-to-end** services.

**Electrolysis**

- Green Hydrogen Production using Jeju's Haengwon Wind Farm
- Doosan carried out the integrated design and supervision of the plant and developed the lifecycle operation system to efficiently manage the hydrogen production, storage and utilization processes.
World’s 5th Original Engine Manufacturer (OEM)

- In 2020, R&D PJT of H-Class Gas Turbine development was finalized
- Successfully manufactured and running commercial operation in Gimpo CCPP, from 2023
- Remote digital O&M platform for Doosan gas turbine’s real-time operation status in the plant site (DooCare)
Doosan’s Hydrogen Gas Turbine Model Line up

Doosan Enerbility aims to complete the hydrogen turbine development of all GT models within 2027.

- **DGT6-300H S1** (270MW)
  - 5th H class GT in the world
  - 50% Hydrogen Co-Firing Development by 2024

- **DGT6-300H S2** (380MW)
  - Most Advanced Large GT
  - 100% Hydrogen Combustion technology Development by 2026

- **DGT-100** (90MW)
  - High performance medium GT
  - 100% Hydrogen Combustion technology Development by 2026

- **DGT-5** (5MW)
  - Small GT for Distributed Power
  - Demonstration by using Green Hydrogen produced by wind power

- **Other OEM (120~180MW)**
  - H₂ Co-firing for installed GT
  - 50% Hydrogen Co-Firing technology Development by 2024

**Demonstration Plan**

- [PJ] EWP Ulsan CCPP by 2027
- As Hydrogen Ready GT for the repowering of old coal fired power plants
- [PJ] Boryeong CCPP by 2026
- As Hydrogen Ready GT especially for balancing power
- Demonstration by using Green Hydrogen produced by wind power
- [PJ] KOSPO Shin-Incheon CCPP by 2027
The climate crisis is more urgent than ever and requires rapid action. For successful decarbonization of Asia Pacific countries, cross-national cooperation and support including governments, financial sector, research institutes and private companies is needed.

Climate crisis is more urgent than ever.

It's time to act for future generations

Current policies
2.7°C warming in 2100 if emissions continue on current trajectory

2030 NDC targets (2.4°C warming in 2100)

Paris Agreement upper limit (2.0°C warming in 2100)

Paris Agreement goal (1.5°C warming in 2100)

We are here
1.2°C warming in 2022

Pre-industrial average (0°C baseline from 1850-1900)

Global average temperature increase

Decision-makers have no choice but to consider action for the climate.

※ Source: CFR Education <The Paris Agreement>

Cooperation and support for clean power generation technology

Governments

“...Ammonia co-firing technology cooperation for coal-fired power plants...”

G2G MOU (Dec,'22)

The summit discussion at APEC 2023 (Nov,'23)

Company / Institute

“Joint cooperation in research on application of ammonia co-firing technology in Vietnam”

MOU (Jun,'23)

“...partnership to Create Decarbonization Roadmap in Coal-Fired Power Stations in Malaysia...”

MOU, F/S (Feb,'23)
[Back-Up] Ammonia Co-Firing Technology Development

- **Low Nox Burners** (MkIII & MkV)
- **Two-stage Combustion**
- **D-NOx Burner**
- **ADV. D-NOx NH₃ Co-Firing Burner**

**NOx Performance**

<table>
<thead>
<tr>
<th>Co-Firing Ratio</th>
<th>NOx Emission</th>
</tr>
</thead>
<tbody>
<tr>
<td>~ 30%</td>
<td>&lt; 110 ppmv</td>
</tr>
</tbody>
</table>
[Back-Up] Boiler New/Retrofit Area

New/Retrofit Area

<table>
<thead>
<tr>
<th>Items</th>
<th>Retrofit</th>
<th>New</th>
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<tbody>
<tr>
<td>NH₃ Facility</td>
<td></td>
<td></td>
</tr>
<tr>
<td>NH₃ supply system</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>NH₃ co-firing burner</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>NH₃ piping and Valves</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>Boiler</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pressure part</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>Duct</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>I&amp;C</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>Steel structure</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>Treatment /Safety System</td>
<td></td>
<td></td>
</tr>
<tr>
<td>NH₃ treatment system</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>NH₃ Safety system</td>
<td>✓</td>
<td></td>
</tr>
</tbody>
</table>

NH₃ Tank  ➔ Vaporizer
Clean Hydrogen Portfolio Standard (CHPS)

**Bidding volume:** 3,000 GWh (combined of H₂ and NH₃ Fuel)
- Power plant construction and preparation period (3 years)
- Consideration of 15-years transaction period after the commencement of commercial operation

**Bidding volume:** 3,500 GWh (combined of H₂ and NH₃ Fuel)
- Power plant construction and preparation period (3 years)
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<table>
<thead>
<tr>
<th>Year</th>
<th>Bidding Volume</th>
<th>Description</th>
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<tbody>
<tr>
<td>'24</td>
<td>3,000 GWh</td>
<td>Power plant construction and preparation period (3 years)</td>
</tr>
<tr>
<td>'24</td>
<td>3,500 GWh</td>
<td>Consideration of 15-years transaction period after the commencement of commercial operation</td>
</tr>
</tbody>
</table>

**Evaluation**

- **Price (60%)**
  - \( \text{Bid Price}^* = \text{Fixed Cost} + \text{Fuel Cost} \) (* LCOE of Clean Hydrogen Power Generation)
  - \( \text{Bid Price}^* = \left(\frac{\text{Min. Bid Price on Market}}{\text{Bid Price}}\right) \times 60 \)

- **Non-Price (40%)**
  - Environmental Contribution
  - Industrial & Economic Contribution
  - Business Reliability
  - Etc.
  - \( \text{Total Score} \times 0.4 \)

**Grades of Clean H₂**

<table>
<thead>
<tr>
<th>Grade</th>
<th>Emission (kgCO₂/kgH₂)</th>
<th>Environmental Contribution (CHPS)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grade 1</td>
<td>0 ~ 0.1</td>
<td>100%</td>
</tr>
<tr>
<td>Grade 2</td>
<td>0.1 ~ 1</td>
<td>100%~50%</td>
</tr>
<tr>
<td>Grade 3</td>
<td>1 ~ 2</td>
<td>&gt; 50%</td>
</tr>
<tr>
<td>Grade 4</td>
<td>2 ~ 4</td>
<td></td>
</tr>
</tbody>
</table>

Clean Hydrogen Certification System

**Definition**

\[ \text{CO}_2 \leq 4\text{kgCO}_2/\text{kgH}_2 \]

**Range**

- Extraction of Feedstock
- \( \text{H}_2 \) Production
- Transport & Storage
- Use \( \text{H}_2 \)

**Well-to-Gate**

- Environmental Contribution
- Industrial & Economic Contribution
- Business Reliability
- Etc.