

6. rDME Business and LPG-rDME Market in Korea

(Wonjun Cho)

rDME Business and LPG-rDME Market in Korea



2022.10.27

Wonjun Cho

Contents

1 Carbon Neutral Business : rDME

2 Commercial Production of DME, rDME

3 DME Business : Applications

4 Summary & Cooperation



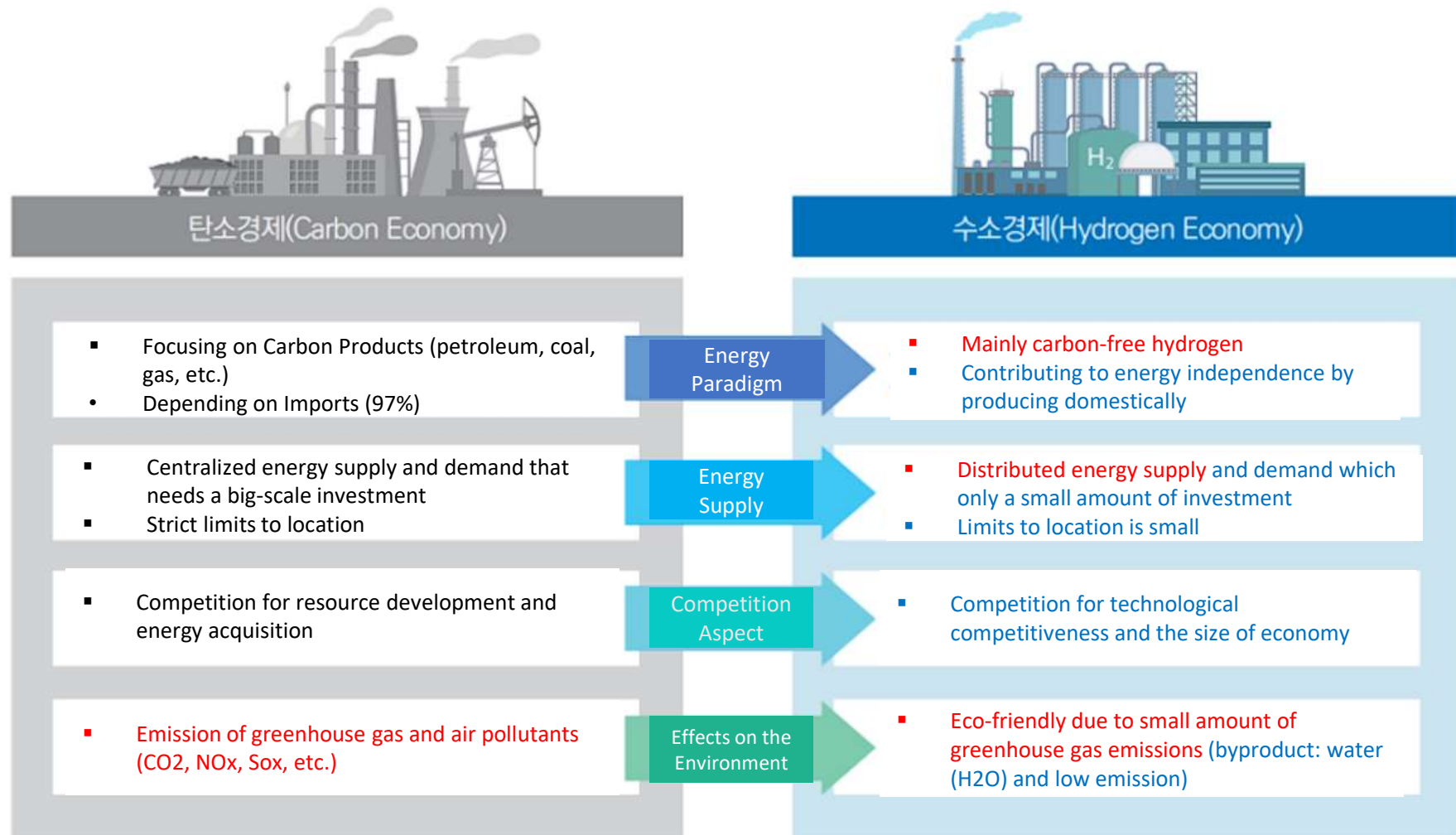
The background image shows an industrial facility under a clear blue sky. A prominent feature is a tall, cylindrical distillation column with a complex metal lattice structure. In the foreground, there are several large, horizontal, cylindrical storage tanks. The facility is surrounded by a fence, and there are some buildings and other industrial structures in the distance.

Carbon Neutral Business

Carbon-Neutral, Hydrogen Economy, CO₂, Hydrogen, DME, rDME

Comparison of Carbon Economy and Hydrogen Economy

- Hydrogen Economy: An economic system that creates new industries and markets by increasing the use of **cars, ships, trains, machinery, heat generated from electricity using hydrogen as an energy source** away from the existing fossil fuel and achieving stable production, storage, and transportation of hydrogen.

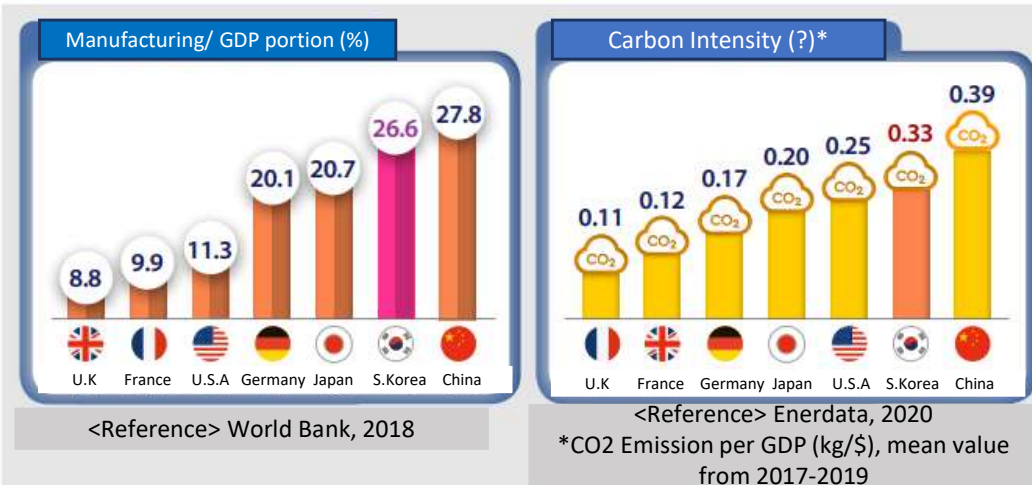


<2050 Long-Term Low Greenhouse Gas Emission Development Strategy (LEDS), Motie, Korea, 2020>

Current Status of South Korea's Carbon-Neutral

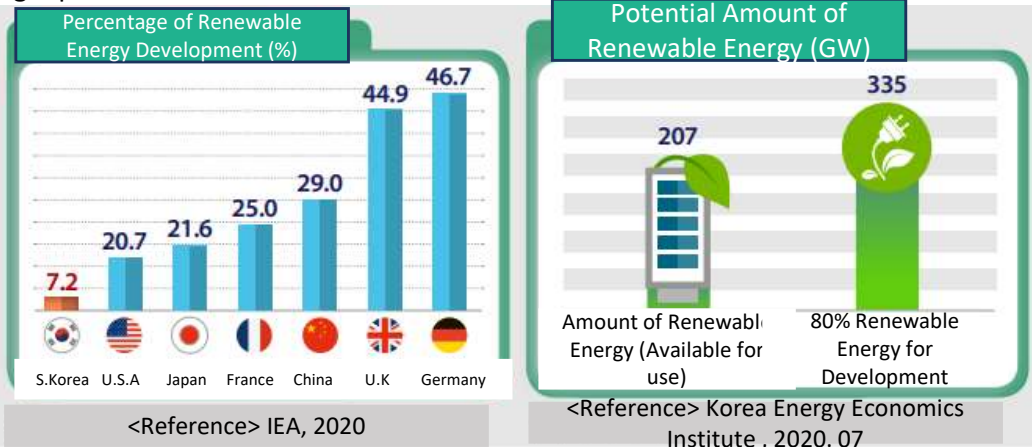
High Energy Consuming Industrial Structure

- High energy consuming industrial structure based on manufacturing
- High CO2 emissions compared to GDP



Limitations to Expansions of Renewable Energy

- Development of renewable energy is low compared to other developed countries
- Limits to expansion because of land areas, natural environment (weather), and geopolitical locations.



Failure to Utilize Nuclear Power Plants for Carbon-Neutral

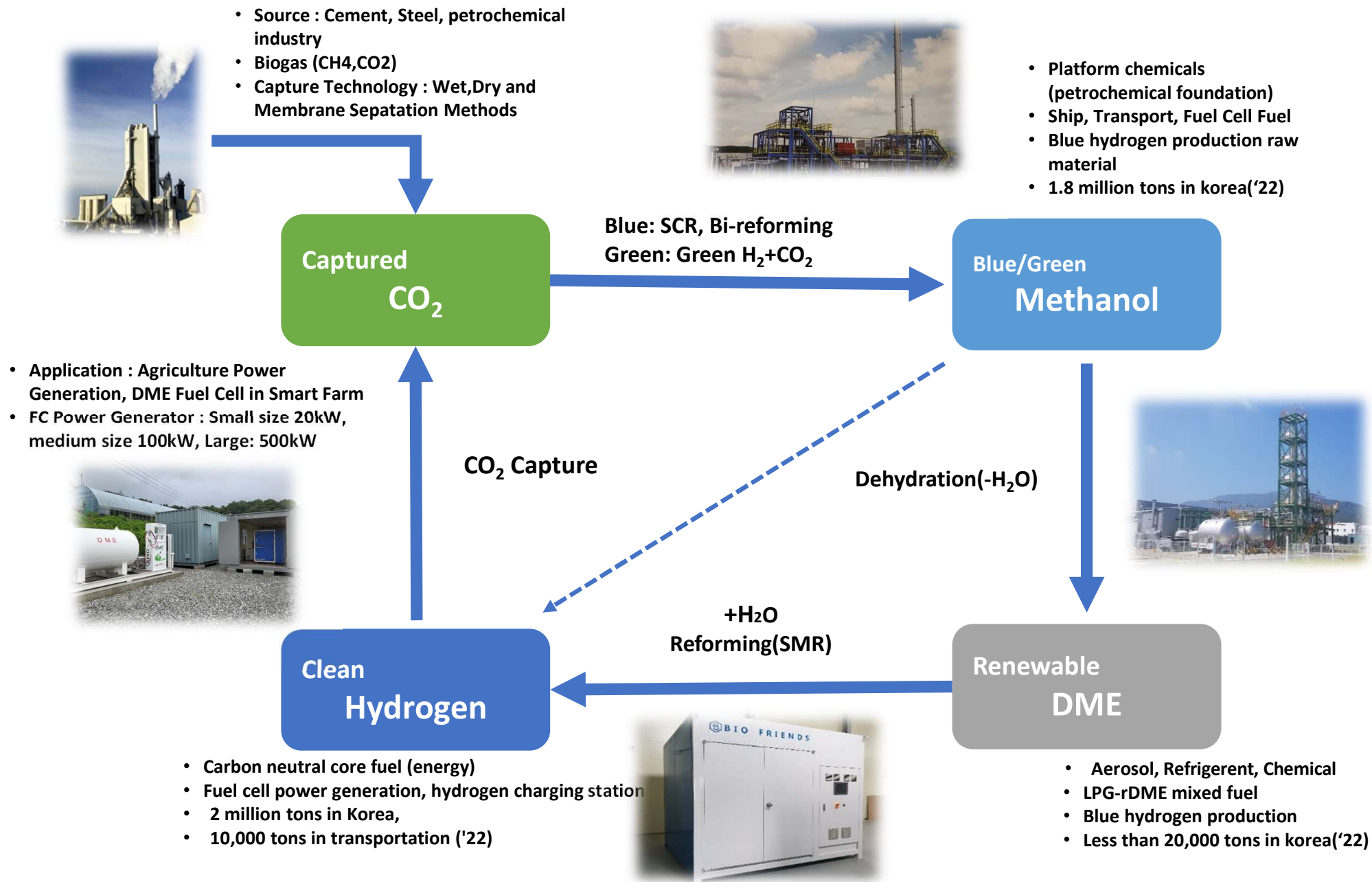
- U.S.A and France have extended the life expectancy of existing nuclear power plants. They have utilized nuclear power plant as an important policy method for Carbon-Neutral.

- Competitive entry into small modular reactor market
- Utilization as a source for hydrogen production as well
 - nuclear power plants(SMR), blue hydrogen, methane pyrolysis etc.

| | |
|--|---|
| | <p>Emphasis on nuclear power plant development as a core method to achieve Carbon-Neutral (Prime Minister Lie Keqiang)</p> <p>*New construction of 20 nuclear power plants by 2025 (14.5 plan, 2021. 04)</p> |
| | <p>Using nuclear power plant for the conversion into clean energy (President Joe Biden)</p> <p>*Announcement of an investment plan of Small Modular Reactor (SMR) about \$2.8billion (Department of Energy, 2020. 10)</p> <p>*Expansion of life expectancy of 1st and 2nd nuclear power plants in Surry, Virginia: 60 years -> 80years (Nuclear Regulatory Commission, 2021. 05)</p> |
| | <p>Inclusion of safety-assured nuclear power plant to methods for Carbon-Neutral policy. (Chief Cabinet Secretary Katō Katsunobu, 2020. 10)</p> <p>*JGC Corporation has participated in SMR business</p> |
| | <p>Agreed that nuclear power plant is crucial in national electricity supply in the future (President Emmanuel Macron, 2020. 12)</p> <p>*Expansion of life expectancy of existing nuclear power plant (40 years -> 50 years), Nuclear power plant development will increase to 50% after achieving Carbon-Neutral in 2050</p> |
| | <p>Agreed that Nuclear power development contributes to Carbon-Neutral (Prime Minister Boris Johnson, 2020. 07)</p> <p>*Announcement of construction plan of 16 SMR by 2050 (2020, 11)</p> |
| | <p>Delay for operation permission of Shin Hanul 1 and 2 (nuclear power plant), Delay for construction permission of Shin Hanul 3 and 4, Passive utilization of nuclear power for the "2050 Carbon-Neutral Promotion Strategy</p> |

Net Zero Business Model (1)

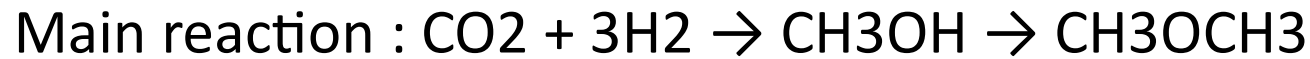
Carbon-Neutral, Net Zero Business Model of Bio Friends Inc: rDME



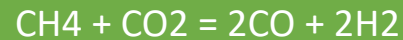
Net Zero Business Model (2)

Securing carbon-neutral resource for production of rDME

- For carbon neutrality, securing resources is very important.
- In particular, it is important to economically secure CO₂ and hydrogen in the technology for manufacturing rDME.
 - When manufacture or utilizing DME, CO₂ emission should be minimized.



Biogas



CO₂ dry reforming
- coking resistance catalyst

Mass production from wastewater, livestock manure, landfill (>5,000Nm³/hr biogas)

High plant cost : Waste gathering + Biogas upgrading + Reforming & DME process + Power plant + Utility

Biomass



Add the more hydrogen
- from clean hydrogen

Mass production from biomass and syngas(>7,500Nm³/hr of syngas)

High plant cost : Biomass gathering + Gasification + Treatment + MeOH & DME process + Power plant + Utility



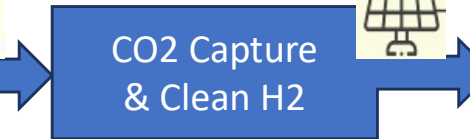
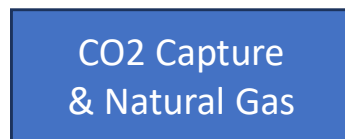
Bi-reforming(SCR)



CO₂ Dry+Steam reforming
- Bridge stage before clean H₂

CO₂ Capture and Utilization Project, Not economic business, Need clean H₂(blue+green H₂)

High plant cost : CO₂ capture + (Reforming) + MeOH & DME process + Power plant + Utility



rDME

Business of Bio Friends: DME Production

DME Production from Methanol Produced from CO2 Generating Source in Korea(Carbon-Neutralization)

- ◆ Bio Friends is set to produce 6,500 tons of DME from 10,000 tons of methanol produced from CO2
- ◆ Planning to supply DME to Korean DME Market (aerosol, refrigerant, fuel, and hydrogen market), and aim to achieve Carbon-Neutral as a Blue Chemical
- ◆ A Preemptive Business by system stabilization and expansion of demand both domestically and internationally at 2nd plant, which is set to be completed on March 2023.



- Boeun 1st plant (October 2018 ~ August 2020 construction complete)
- 5,000 tons of DME production
- Sales to Korean aerosol, refrigerant, and fuel market



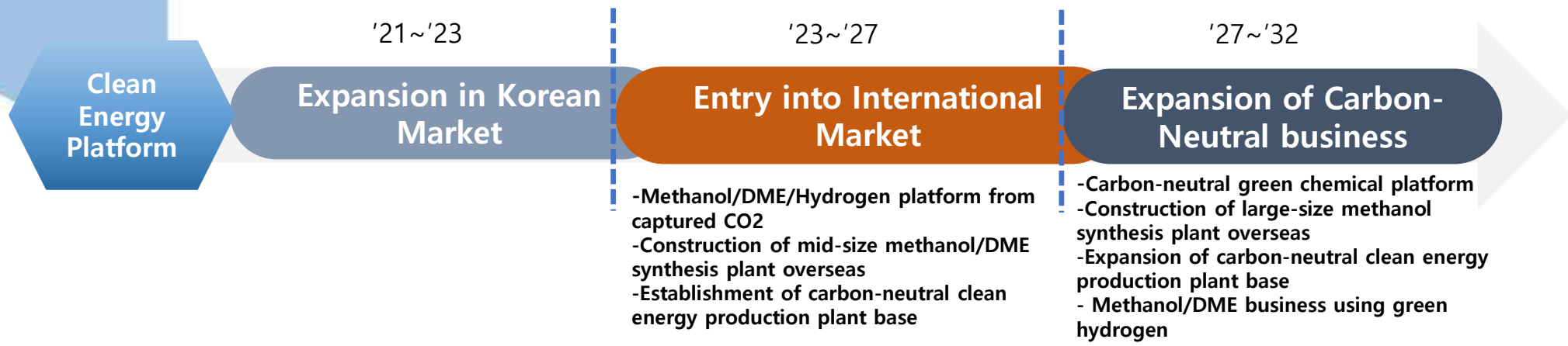
(주)바이오프렌즈
BIO FRIENDS Inc.

Boeun 2nd factory Preview

SCALE : NONE 제작자: 황성환 사원

- Boeun 2nd plant(July 2021 ~ March 2023 construction set to be completed)
- 10,000 tons of DME production(Utilization of methanol produced by CO2)
- Promotion of linkage business with hydrogen production base in Cheongju, Chungju, and Boeun

Master Plan and Vision of the DME, rDME, H2



Renewable Methanol and DME Supply




- Acquisition of Korean market for 40,000 ~100,000 tons/yr (2030)
- Export of plants for 1,000,000 tons/yr (2030)
- Export of rDME plant and Green Hydrogen Production

Carbon-Neutral Business Linked with Cement/Petroleum Industry



- Renewable energy business from CO₂ captured from cement and steel industry
- Entry into the International Green New Deal business

Carbon-Neutral Global business



신재생에너지+대중에너지=신재생에너지

- Carbon-Neutral eFuel (Methanol,DME) business
- Global Carbon-Neutral market expansion

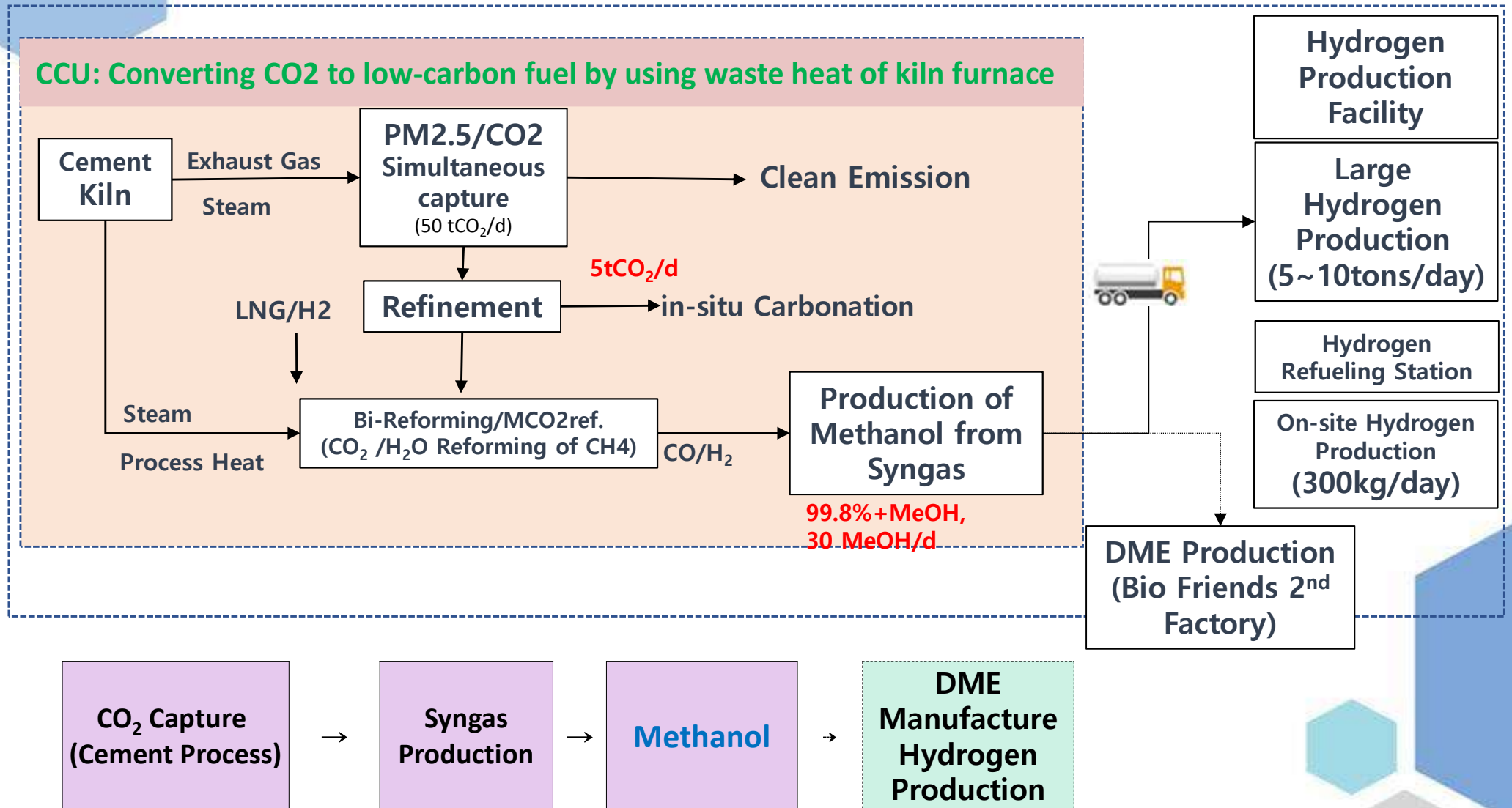
A photograph of an industrial facility, likely a chemical plant, featuring a tall, dark, lattice-structured distillation column in the foreground. In the background, there are several large, silver, spherical storage tanks and other industrial structures. The sky is clear and blue. A dark horizontal band is overlaid across the middle of the image, containing white text.

Commercial Production of DME, rDME

Low-Carbon Fuel (Methanol, DME) from CO₂ in the Cement/Petroleum Industry

Project Overview

Construction and Demonstration of a Semi-Commercial scale Low Carbon Fuel(rMethanol/rDME)Production
 - Budget : \$30 Millions (National Project), Project Period : '21.12 ~ '25.12(48 Months)

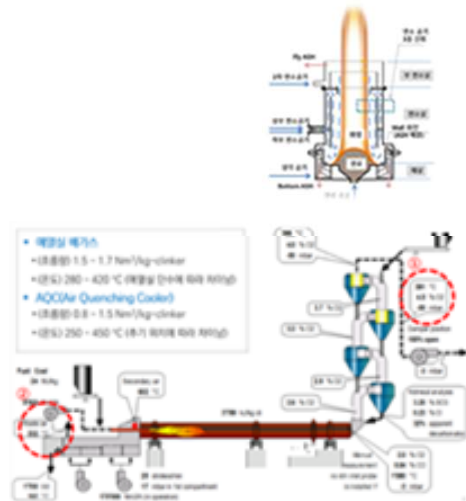


Target Technology (Product) Overview

Core Elements of the Target Technology

1 Application of Process Heat Utilizing Waste Heat and Construction of Such an Infrastructure

- CO2 capture of 50 tons/day and supply and utilization of process heat for chemical conversion.
- Construction of Infrastructure for a smooth process from captured CO2 to methanol synthesis



2 Simultaneous Capture of CO2 and Fine Dust

- 50 tons/day of CO2 capture from 50 tons/day of cement kiln combustion gas
- 90% success rate of CO2 capture, system demonstration, and process optimization.



3 Demonstration of Conversion into Syngas and Production of Methanol

- Stable syngas conversion based on a complex reformation system from capture CO2 (achieving over 80% success rate)
- High purity methanol synthesis from a manufactured syngas (over 99.8% purity, 30~47t MeOH/d)



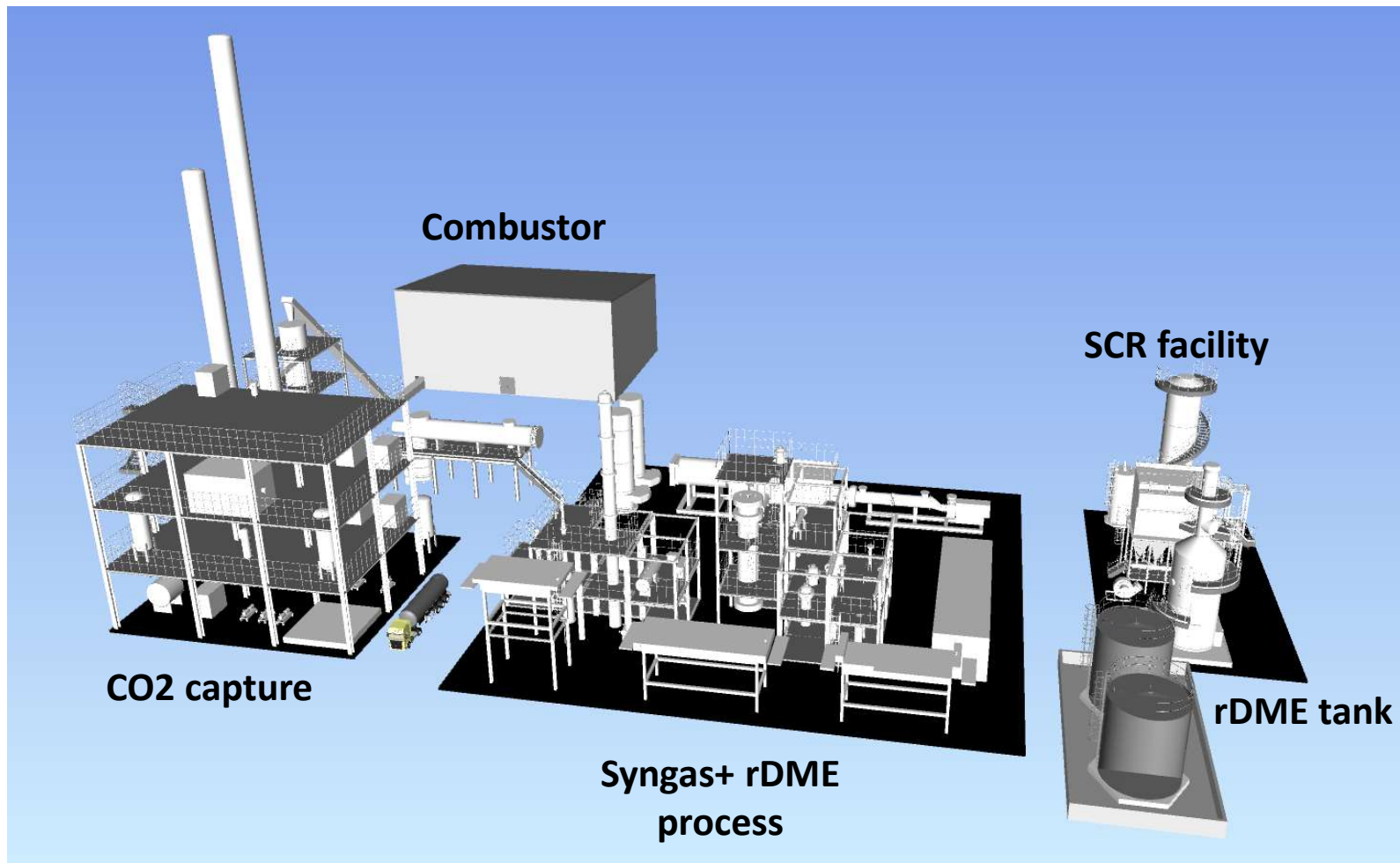
4 Domestication of Technology Based on Demonstration of a Combined Linkage Process and Export of the Technology

- A completion of domestication of technology by demonstration of methanol production combined process utilizing captured CO2
- Establishment of unique plant technology for CO2 conversion by utilization of waste heat energy, syngas manufacture based on an original catalyst technology, and production of low-carbon fuel (methanol, DME, etc)



rDME Project in Korea_Net Zero Project

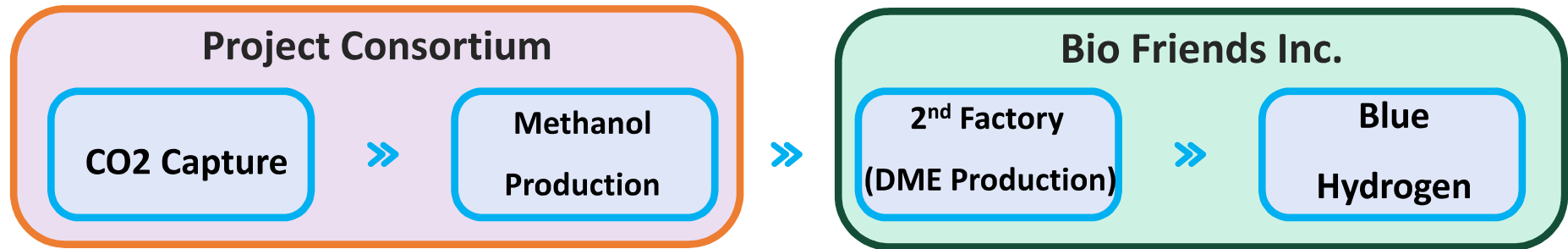
- rDME production from CO2 utilization process of CO2 source (cement, steel, refinery industry)
- This process is expected as a business model for carbon neutrality.
 - 1st stage (' 21 ~ ' 25) : 10,000ton/year capacity of rDME (Demonstration Plant in Cement Industry)
 - 2nd stage(' 25 ~ ' 28) : 140,000ton/year capacity of rDME (Commercial Plant in Cement and Refinery Industry)



Project Consortium with Bio Friends

Methanol/DME Production from CO2 Source in Korea, Carbon-Neutral through CCU Technology

- ◆ Bio Friends owns the DME plant, a clean energy platform, and a hydrogen production facility. Currently promoting CO2 carbon-neutral business
- ◆ Purchase of methanol manufactured from captured CO2 and utilization of Bio Friends' sales network to obtain economic feasibility(DME, Small-Scale Hydrogen Production Base)
- ◆ In the future, by electrification of the entire process, Bio Friends plans to realize the chemical conversion of CO2 into eMethanol or eDME, a CCU business.



■ Methanol Production Plant (Danyang)

-Methanol production from captured CO2 (Predicted to produce 9,000~15,000t/yr)
 -5,000~10,000 t/yr for DME production
 -1,200 t/yr for Blue Hydrogen production

■ DME Bio Friends 2nd Plant

-Agreement with Boeun-gun(June 2021)
 -Completion of DME plant scheduled in the first half of 2023 (DME Product: 15,000 t/yr)
 -Usage: Aerosol, Refrigerant, H2 and gricultural fuel (LPG-rDME blending)

■ Small-Scale Hydrogen Production Base (~4 Tons/day)

-Production of hydrogen production base in Boeun-gun in the first half of 2025 (~1,200 t/yr of Blue Hydrogen)
 -Supply to hydrogen refueling stations in mid area of Korea



DME Business : Applications

DME Truck, DME Distributed Power Generator, H₂FC for Smart Farm

DME Chemical Market

- The fourth-generation refrigerant as Europe and the United States Market (Ammonia mixed)
- Used as foaming agent and spraying for greenhouse gas reduction and CO2 reduction
- Use of **LPG-rDME mixed raw materials** for eco-friendly products

Other Application Benefits of DME

Coolant for refrigerating stations

Dimethyl ether mixed with ammonia (mass ratio 40%/60%) can be readily used in refrigeration equipment. The coolant designation is then R723.

Application of this mixture as a coolant increases the cooling capacity of the refrigerating station.

Limited solubility of mineral oil in R723 and the possibility of use in conjunction with copper (corrosion mitigation) will make a small-capacity station more effective than units operating with conventional coolants.

Plus, replacement of 40% of the ammonia in existing refrigeration facilities with DME reduces ammonia consumption with no loss of efficiency.



Industry Chemical (locker) for CO2 reduction

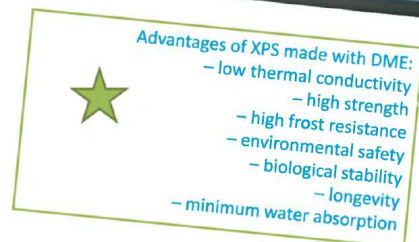
For Greenhouse gas reduction : applied R723 (NH4 60%:DME 40%) used in Building coolant, refrigerating station

DME for Extruded Polystyrene (XPS)

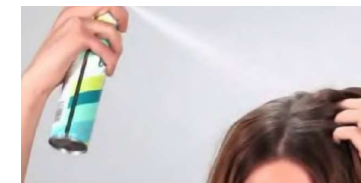
Due to its high propagation factor, dimethyl ether used in the production of XPS enables the production of boards to specified parameters at lower prime cost.

The advantages of DME use:

- no need for other solvents (ethanol, acetone);
- possibility of replacing freon to reduce prime cost;
- high propagation factor enables the production of boards with lower density to reduce prime cost;
- possibility to produce boards of higher thickness (up to 100 mm and higher) with improved compressive strength;
- enhancement of heat insulation properties;
- increase of final product output;
- reduction of CO₂ emissions into the atmosphere.



Applied DME as a foaming/blowing agent for CO₂ reduction



Hair spray for CO2 reduction



Foaming/blowing agent for CO2 reduction

DME Engine Development and Application: Transportation

DME Engine Development & Connecting with ICT Technology

- DME engine will be applied to vehicles and distributed power generation
- Large farmhouse facilities or smart farms (application to more than 10a)
- Operation of optimized smart farms linking with cooling/heat pump (CHP)



DME Tri-GenSet

- Establishment of a transport business base linking with DME vehicle, driving information, and smart farm ICT



Transportation Vehicle Using DME Fuel

- Delivery of crops by low-emissions DME Fuel Transport Vehicle
- Transport business throughout Daejeon, Chungbuk-Do, and Gangwon-Do (establishment of 4th industrial revolution in distribution)



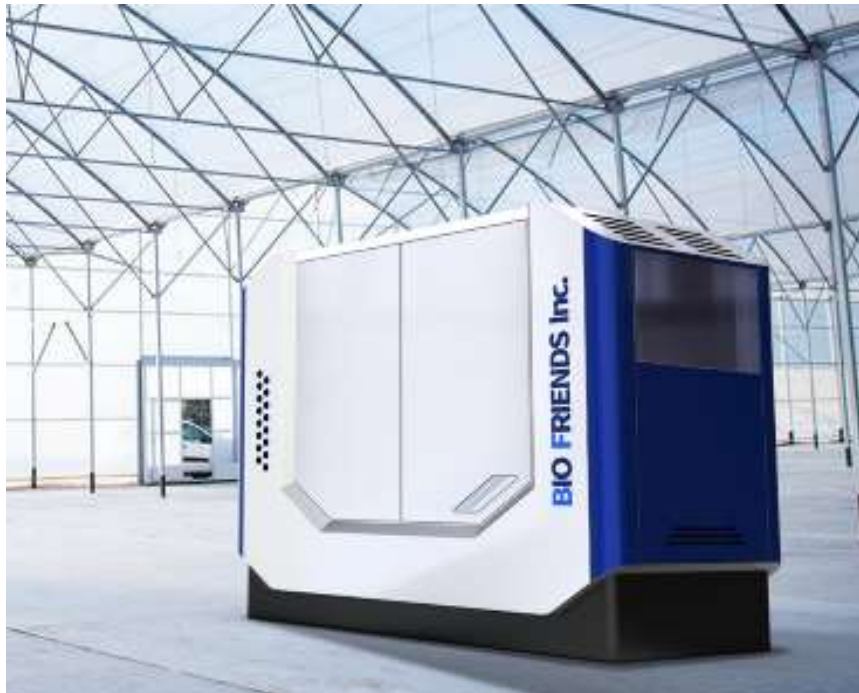
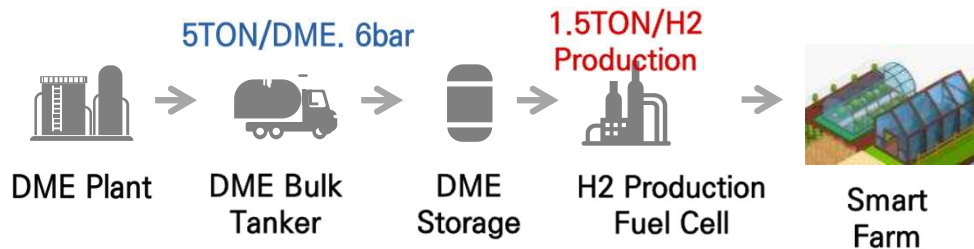
Engine for DME (3.3L)



Hydrogen Production from DME and Connecting with Fuel Cell Business

Eco-friendly DME Fuel Accounts for 30% of Energy Source in Smart Farms and Smart Barns as an Agricultural Fuel

- By distributing eco-friendly energy (DME) to agricultural areas where natural gas is not supplied, clean fuel is used for plants where 30% of crop cultivation is energy
- As a government project, a DME fuel cell is installed at a smart farm to provide energy solutions through electricity, cooling/heating, and CO₂ farming
- It is a CCS Technology as CO₂ is stored in plants, and DME fuel cell will be utilized as fuel cell power plant after the conversion of DME into hydrogen.



Smart Farm Business using rDME



Installation of “DME-H2 FC System” and “DME Power Gen.”

A Smart-farm is being built for demonstration of “DME-to-H₂ Reforming & Fuel Cell system”
- Installation : ~End of June 2022. Test for cultivation, DME-FC operation : ~ End of Dec. 2023

(1) Total system demonstration(4 seasons)

- DME Tank, DME-FC, DME Power Gen., Solar System



(2) DME Heating (Winter season)

- DME Combustor, Small scale DME FC



Application of DME Fueled Facilities in Smart Farm

Fuel Cell Power



- 1.Capacity : 30kW
- 2.H₂(99.99%)
- 14Nm³/hr
- 3.380V, 3 phase
- 4.For Heat pump power

DME Power Gen.



- 1.Capacity : 40kW
- 2.Emission
- NO_x
- CO₂
- 3.Need the CO₂ filtering by membrane

H₂ Production



PSA



- 1.Capacity : 14Nm³/hr
- 2.Separation : PSA
H₂(99.99%)
- 3.CO₂(99%)
- 3~5Nm³/hr
- Adjust for CO₂ Fertilization



Cultivation



LPG-rDME Blending Fuel Supply Business

LPG-rDME (DME 20%) blending fuel supply project in the Chungchung region Korea
 : Linking the LPG supply business in rural villages and the industrial boiler fuel conversion business



Boeun 1st DME Plant (BioFriends)

DME 20%



LPG Companies



Propane 80%



LPG-rDME Blending Fuels in the rural area
 And for Industrial boiler fuel



기존 LPG 탱크로리



친환경 rDME플랜트



LPG 90%/rDME 10%(안)



LPG 소형탱크

LPG-rDME Blending fuel supply chain

LPG-rDME Blending Fuel Supply Business

The LPG-rDME fuel supply project is scheduled to start from '23, the blending fuel sales of more than 500 tons are expected. It is predicted that 24,000 tons of LPG-rDME blending fuel will be supplied in '28. During this period, we plan to reorganize the legal system for refueling.

○ Estimation of low carbon fuel (annual LPG-rDME fuel)

(unit : ton)

| | Application | '24 | '25 | '26 | '27 | '28 |
|------------------------|---------------------------------|-------|-------|-------|--------|--------|
| rDME (with 80% LPG) | Industrial | 1,000 | 2,000 | 4,000 | 6,000 | 10,000 |
| | Agriculture | 500 | 1,000 | 2,000 | 4,000 | 7,000 |
| | Blending fuel (heat/cooking) | 500 | 1,000 | 2,000 | 4,000 | 7,000 |
| | total | 2000 | 4,000 | 8,000 | 14,000 | 24,000 |



[sources : '22.9, BioFriends Boeun DME plant]

Global rDME business of BioFriends Inc.

Indonesia
(MeOH to DME)

- 5,000 tons/year DME Production MOU, Joint Investment Agreement('20.11~'22) → Project Execution Agreement('22.4)
 - Completion Basic Design for DME plant, Feasibility study
 - Uncertainty of the sales pathway
 - Increasing the DME capacity(min. 30,000 TPY) and potential market

Indonesia
(Coal, MSW to rDME)

- DME plant construction and operation of 100K~300K TPY Coal to DME Plant : 1 MOU contract ('20.7) and 1 Discussion ('22.9)
 - rDME production plant using coal or MSW, Application:LPG-rDME mixed fuel business

Norway
rDME

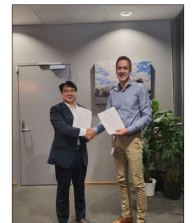
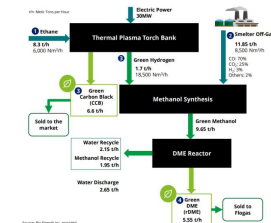
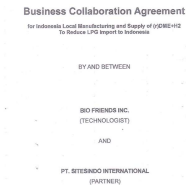
- MOU for Norway rDME ('20.11), Joint Study Agreement('21.3) →Implementation of Feasibility Study ('22.4), HOA start('22.6~)
 - * Recently, Bio Friends signed an HOA with Flogas, as an offtaker company, and is preparing for HOA with Eramet(CO2 sources) and Orions(Offtaker).

USA

- Technical agreement for rDME and hydrogen project in the world('21. 6) → Engineering and Business Implementation
 - * Bio Friends plans to promote the rDME project in California, USA with HnH Worldwide and Oberon Fuels, and the main business is to promote the rDME and hydrogen business using biogas/natural gas.

Others

- Collaboration with Dimeta('22.6 ~)
 - We plan to target overseas rDME business by participating in the 300,000-ton rDME project, mainly in Europe and the United States.
- Collaboration with Indian Company(rDME Application)





Clean DME , Hydrogen Business

Thank you !

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(주)모던 Company Introduction
(Moonsoo Dong)