TNChE Asia 2025

Integration of Electricity, Sustainable Feedstock, Methanol, Ammonia Technologies into Ethylene Plants

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TOYO ENGINEERING

Your Success, Our Pride.

Company Overview

Company Name	TOYO Engineering Corporation
Established	May 1, 1961
Location	**Head Office / Engineering Center** Makuhari Technical Center 1-1, Nakase 1-chome, Mihama-ku, Chiba, 261-8601, Japan
	Tokyo Office 16F, Hibiya Fort Tower, 1-1-1 Nishi-Shimbashi, Minato-ku, Tokyo, 105-0003, Japan
Number of Employees	7,283 (including consolidated subsidiaries and companies applying equity method, as of March 31, 2024)
Business	Design, procurement, and construction (EPC) of oil & gas, chemical plants, and infrastructure facilities, along with various related services

EPC Services Provided by TOYO

Engineering

Plan and design the project.

Procurement

Source and deliver materials and equipment.

Construction

Integrate equipment and materials as a plant.

Agenda

0 Toyo’s Solution for Energy Transition in Ethylene Plant

1 Electrical Furnace

2 Motorization of 3 Main Compressors

3 Hydrogen Firing from Ammonia Cracking for Furnace

4 Methane Offgas to Methanol Synthesis

5 Waste Plastic Recycle

6 Summary

Toyo’s Solution for Energy Transition in Ethylene Plant

Toyo’s Competency

- ◆Vast Experiences of Ethylene EPC
- ◆Ethylene Plant OSBL Design Optimization

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Approaches to Ethylene Plant Decarbonization

- ◆ Energy Saving and CO_2 Reduction
- ◆ Energy Transition (Ammonia, Hydrogen, Electricity etc)
- ◆ Feedstock Transition (Biomass, Recycle etc)

Toyo’s Solutions for Ethylene Plant Decarbonization

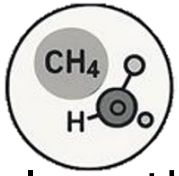
- Energy Transition Technology
  - Electrical Furnace
  - Motorization of 3 Main Compressors
  - Hydrogen Firing from Ammonia Cracking for Furnace
  - Methane Offgas to Methanol
  - Waste Plastic Recycle

Toyo's Solution for Energy Transition in Ethylene Plant

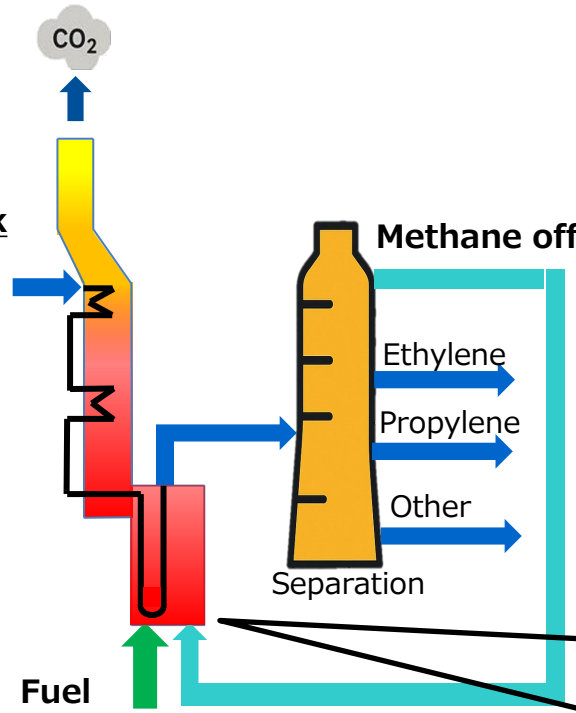
Sustainable feedstock for green plastics

Waste plastics recycle

Utilize excess Methane off gas



Methanol synthesis



Carbon Neutral Fuel/Power

- ✓ Electrical Furnace
- ✓ H_2 from Ammonia cracking

Reduce Boiler Steam

Motorization of 3 Main Compressors

Feature of Energy Transition for Furnace

Energy Transition	Production	Storage / Transportation	Consumption	Aptitude
Power (Renewable)	◆ Require large-scale renewable energy facilities	◆ Challenges: • Securing large-scale power • Stable supply • Power / energy storage • Supply system	◆ Development stage (based on conventional technology) ◆ Directly utilize renewable energy	Electrical heater in suitable location for renewable energy
NH_3	◆ Proven & commercial technology ◆ Prerequisite: Decarbonization at production	◆ Widespread infrastructure ◆ Easy storage / transportation as liquid	◆ Under development for 100% combustion burner	Naphtha Cracker (Ex. Japan & Asia, import Naphtha & Ammonia by ship)
H_2	◆ ~85% H2 off gas as by-product ◆ Only balance H_2 from water electrolysis etc.	◆ Challenges for liquefaction, long distance transportation and storage	◆ 85% co-fired burners commercialized in gas cracking furnaces ◆ Under development for 100% combustion burner	Gas Cracker (Ex. USA, import Shale gas and H2 through Pipeline)

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Electrical Furnace Development Status

Technology Holders	Partner	Heating Method	Situation
Linde	BASF SABIC	Direct / External Residence	In Sep. 2022, announce the construction of demo plant (1 MTA, 6 MW) Start demo plant operation in 2024
Lummus	Braskem	External Residence	Announce Joint Study with Braskem in Apr. 2024 Start demo plant operation in 2025
Technip	LyondellBasell's CPChem	External Residence (assume)	MOU in Jun. 2023 Plan to construct demo plant at Texas, USA
TNO (Institute in Netherland)	Dow Shell	External Residence	Plan to start demo plant in 2025

- ✓ Development is proceeded all over the world by major Licensors.
- ✓ Demo Plant operation already started (Linde/Lummus).

Other system verification

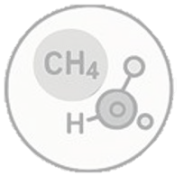
- ✓ Steam balance to be revisited due to less steam generation in electrical furnace
- ✓ Utilization of methane offgas to valuable chemical (Ex. Methane to methanol, etc.)

Motorization of 3 Main Compressors

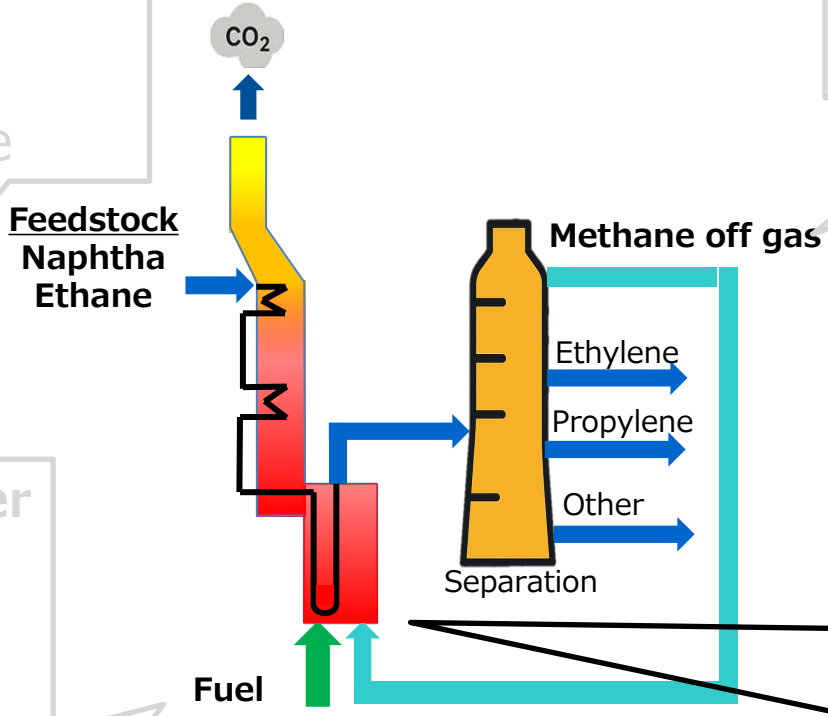
Sustainable feedstock for green plastics

Waste plastics recycle

Utilize excess Methane off gas



Methanol synthesis



Carbon Neutral Fuel/Power

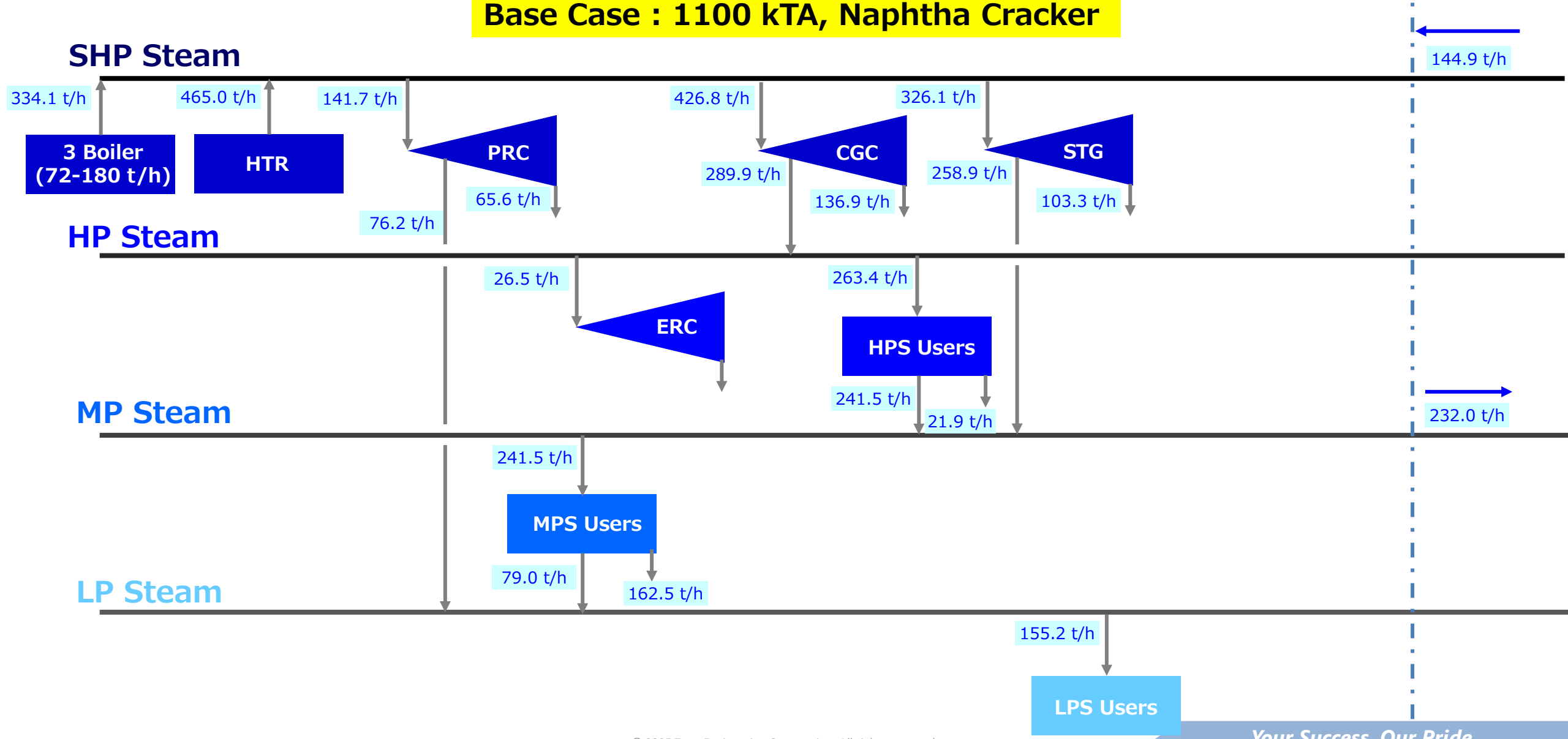
- ✓ Electrical Furnace
- ✓ H_2 from Ammonia cracking

Reduce Boiler Steam

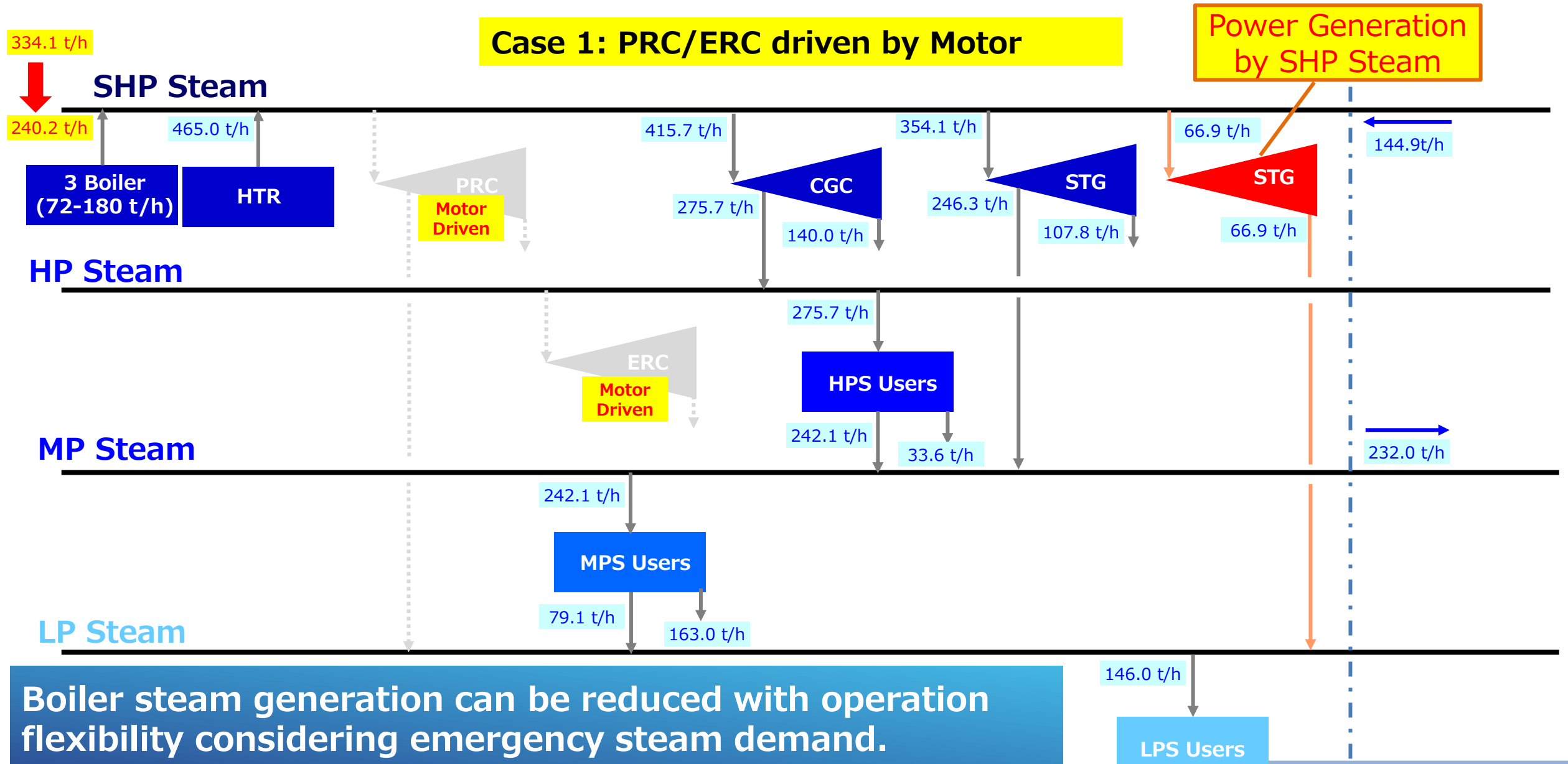
Motorization of 3 Main Compressors

Motorization of 3 Main Compressors

Base Case : 1100 kTA, Naphtha Cracker

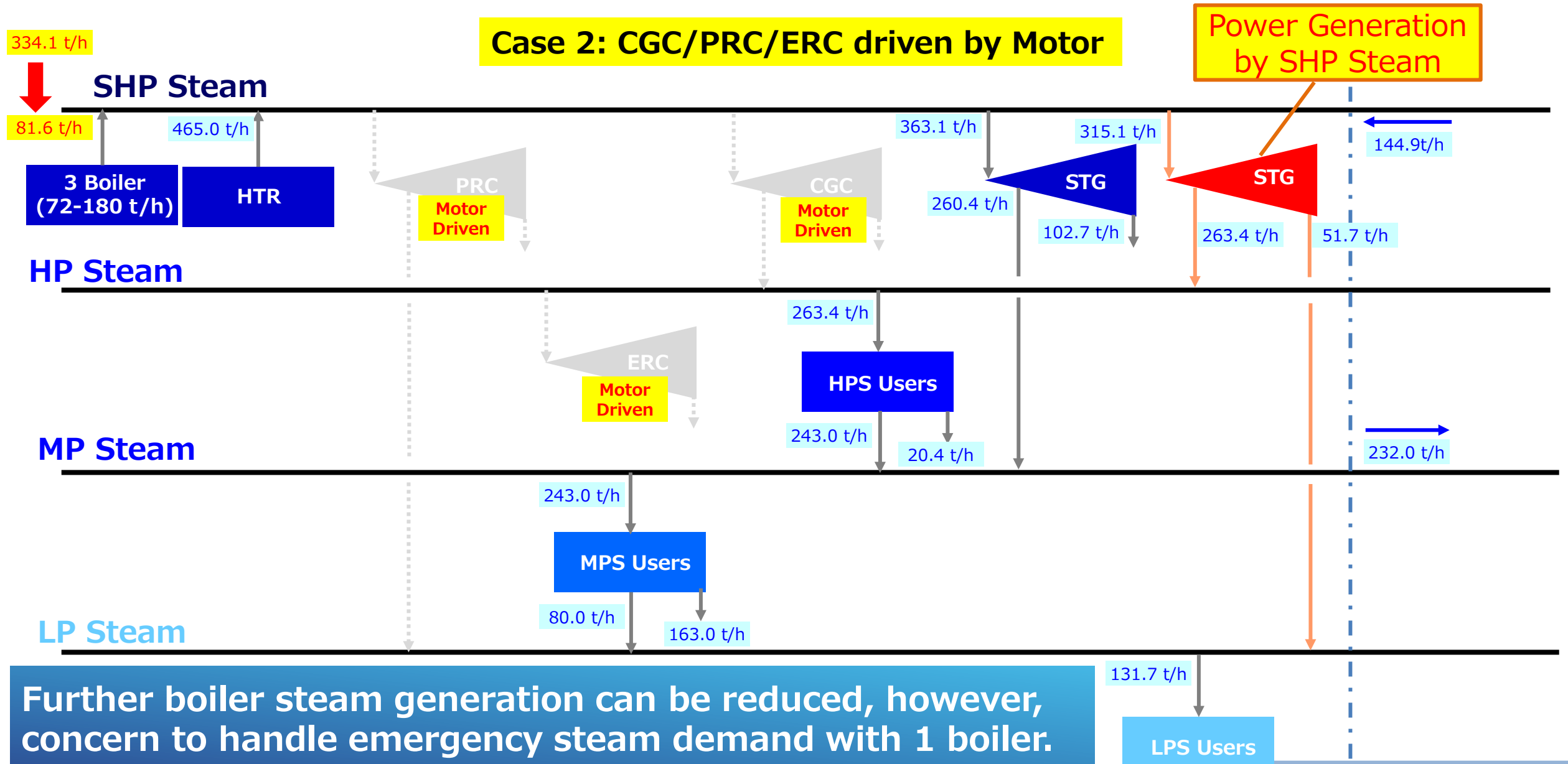


Motorization of 3 Main Compressors



Boiler steam generation can be reduced with operation flexibility considering emergency steam demand.

Motorization of 3 Main Compressors



Further boiler steam generation can be reduced, however, concern to handle emergency steam demand with 1 boiler.

Motorization of 3 Main Compressors

In addition to steam balance verification, TOYO can support other system's verification like Electrical system, Layout and Flare adequacy.

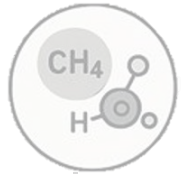
Verification System	Verification Points
Electrical	✓ Type of Motor selection ✓ Variable speed drive (VSD) type selection ✓ Study of new substation and impact on existing electrical system
Layout	✓ Larger motor length than turbine ✓ Gear feasibility for huge capacity motor ✓ Foundation Modification ✓ Maintenance Space
Flare	✓ Impact of motorization of CGC, PRC and ERC trip during total power failure scenario

Ammonia Cracking

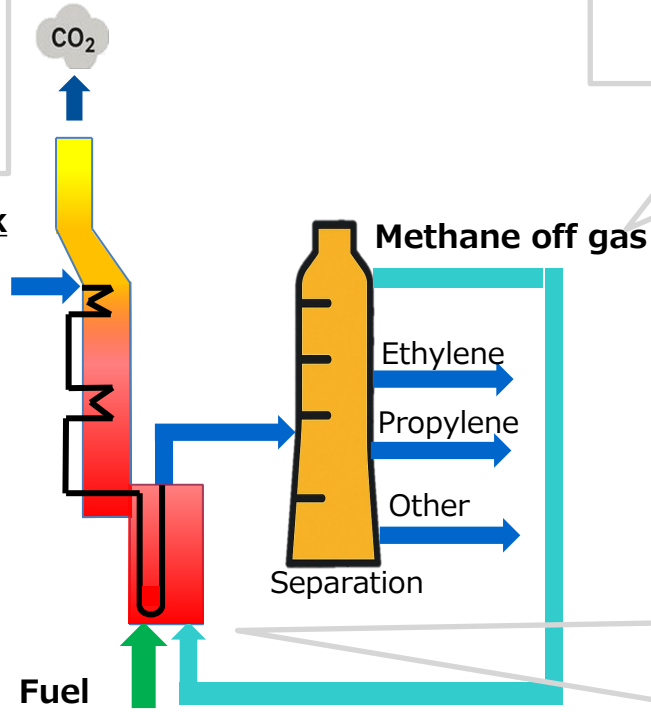
Sustainable feedstock for green plastics

Waste plastics recycle

Utilize excess Methane off gas



Methanol synthesis



Carbon Neutral Fuel /Power

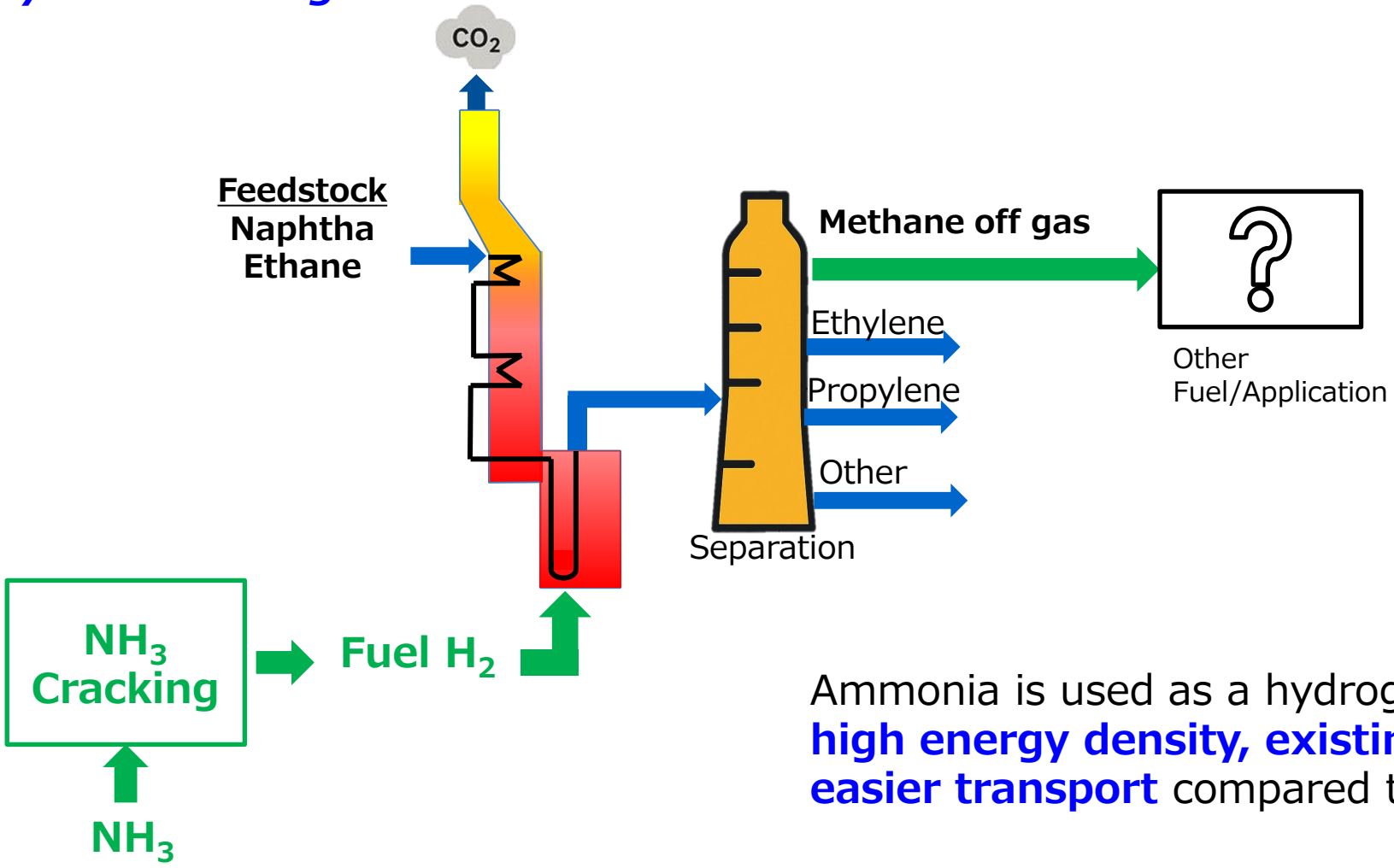
- ✓ Furnace electrification
- ✓ H_2 from Ammonia cracking

Reduce Boiler Steam

Motorization of 3 Main Compressor

Ammonia Cracking

*TOYO aim to shift energy use from **fossil fuels to hydrogen** by utilizing ammonia as a **hydrogen carrier**. Among several hydrogen-related technologies—such as ammonia combustion and cracking—TOYO propose **ammonia cracking** for this case in order to **minimize the modification on Ethylene Cracking furnace .***



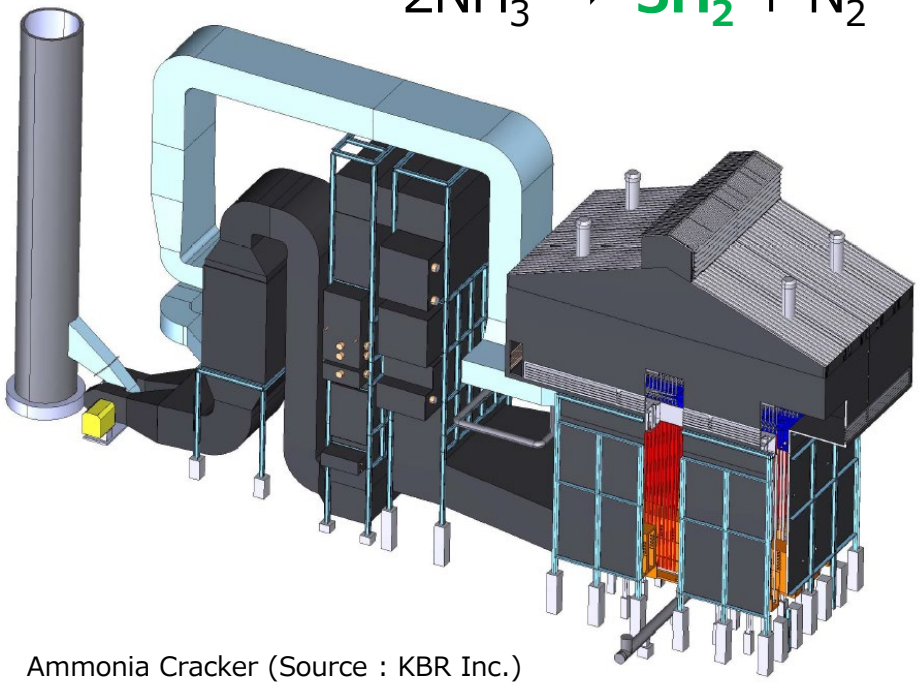
Ammonia is used as a hydrogen carrier due to its **high energy density, existing infrastructure, and easier transport** compared to pure hydrogen.

Ammonia Cracking

TOYO will provide Ammonia Cracking Technology with KBR

“Hydrogen from Ammonia Cracking Technology”
H2ACT®
Licensed from KBR

$$2NH_3 \rightarrow 3H_2 + N_2$$



Ammonia Cracker (Source : KBR Inc.)

1. **Proven Technology**
   Use well-proven KBR reactor, with decades of successful design and reliable operation
2. **Flexible Capacity**
   Hydrogen Production : 10 - 1,200 MTPD
3. **Reduces Greenhouse Gas**
   Zero emission flow scheme

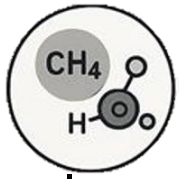
Ready for Sales!

Methanol Synthesis

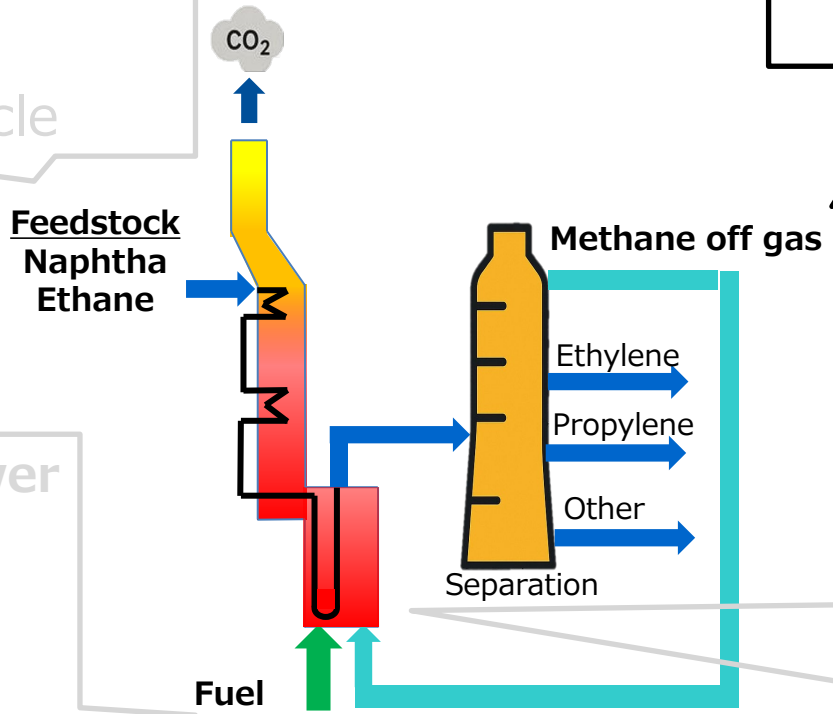
Sustainable feedstock for green plastics

Waste plastics recycle

Utilize excess Methane off-gas



Methanol synthesis



Carbon Neutral Fuel/Power

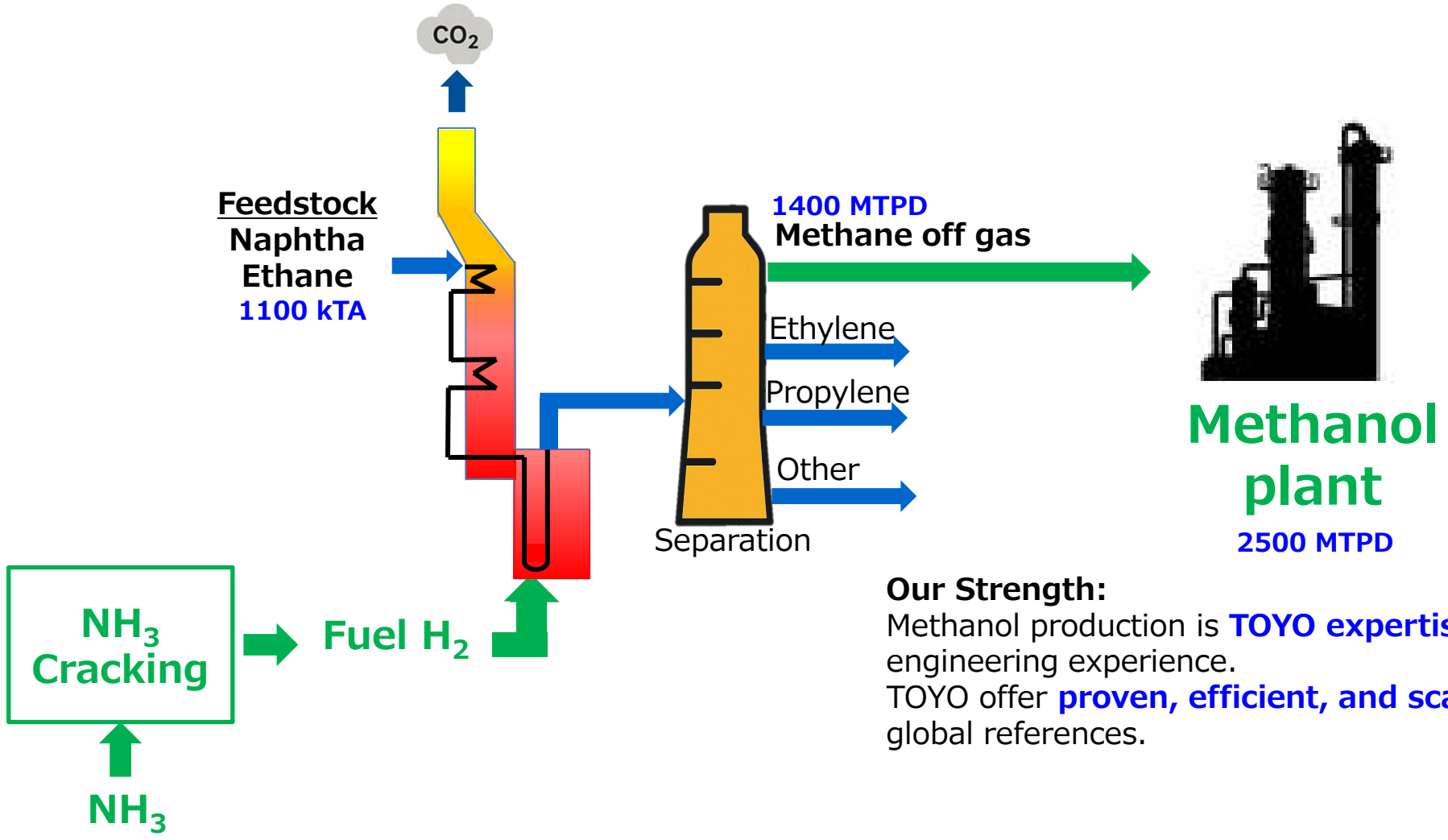
- ✓ Furnace electrification
- ✓ H_2 from Ammonia cracking

Reduce Boiler Steam

Motorization of 3 Main Compressor

Methanol Synthesis

Instead of flaring or burning **methane off-gas**, TOYO propose converting it into **methanol**, a valuable chemical and fuel.



Our Strength:
Methanol production is **TOYO expertise**, built on decades of engineering experience.
TOYO offer **proven, efficient, and scalable technology** with global references.

Methanol Synthesis

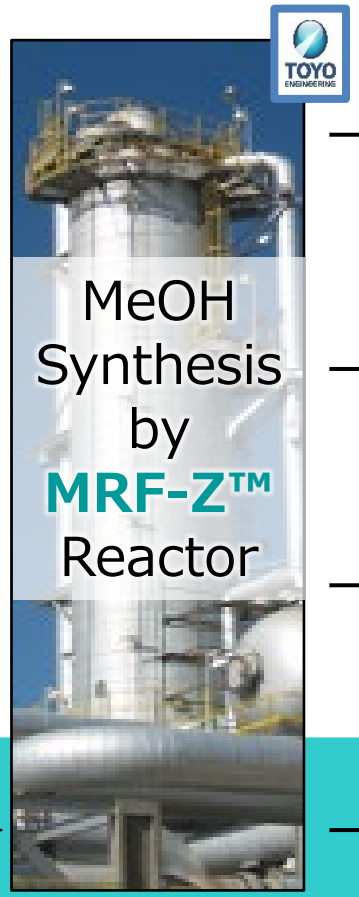
Lineup of TOYO's Methanol Synthesis Applications

: Proprietary Technology

Natural Gas → Reforming → CO, CO_2, H_2

Bio Methane → Reforming → CO, CO_2, H_2

Biomass → Gasification → CO, CO_2, H_2



Conventional Methanol

Bio Methanol

Bio Methanol

Sustainable Methanol

"g-Methanol™"
TOYO's e-MeOH process

$CO_2 + H_2$ → **e-Methanol**

Methanol Synthesis

Utilizing Established Technology for Sustainable Methanol Production

Pilot Plant, Japan (1985)

50 t/d

Trinidad & Tobago Methanol Co. (1990)

300 t/d

(For Acetylene Off Gas)

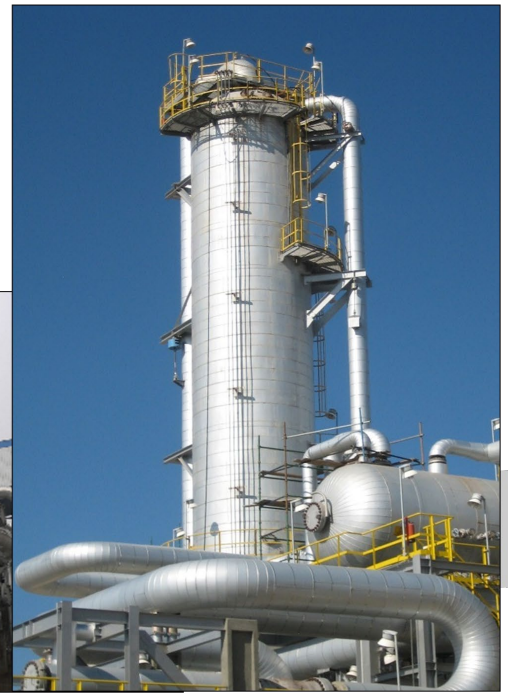
Sichuan Vinylon Works, China (1998)

420 t/d

Lu Tian Hua, China (2006)

1,350 t/d

Oman Methanol Co. (2007)



3,000 t/d

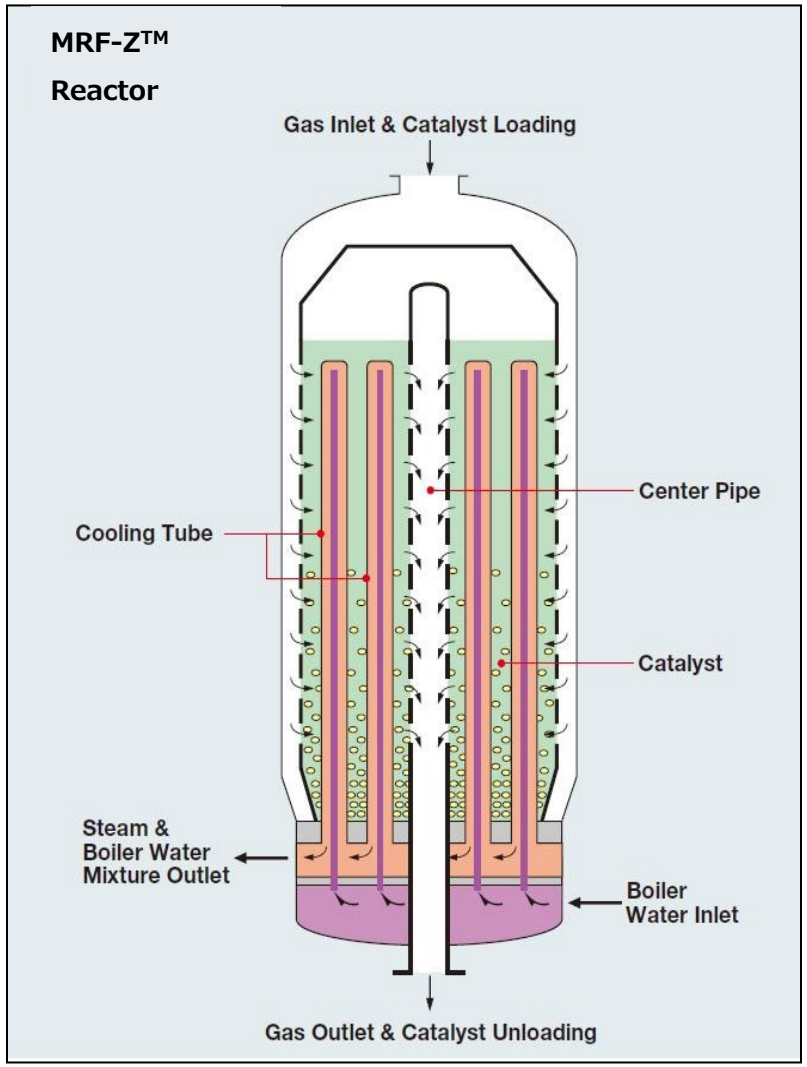
g-Methanol™ (Operation Soon)

10 t/d

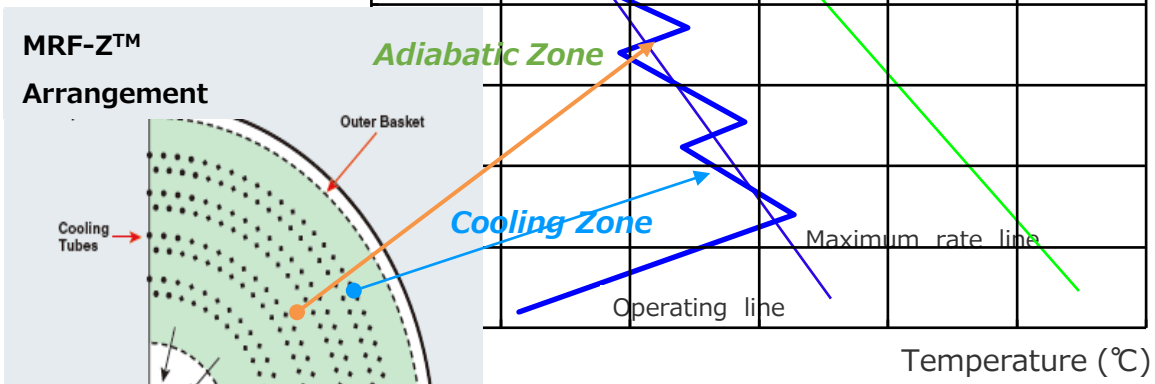
* Converted into natural gas feedstock case

Methanol Synthesis

Concept of MRF-Z™ Rector: Realizing an ideal temperature profile through multi-stage cooling, designed with minimum catalyst quantity

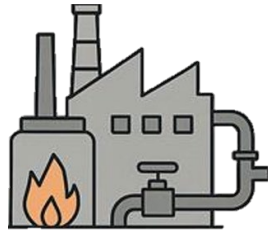


- Multi-stage cooling
- Radial Flow
- Type-Z temp profile



Methanol Synthesis

Combining off-gas utilization **with g-methanol™ technology** enables deeper decarbonization by converting waste methane into valuable product & fuel.



Ethylene Plant After Energy Transition

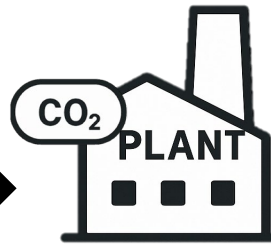
H_2
CH_4

Syngas Reforming

Further Modification

SAF

Olefin, Chemical Product



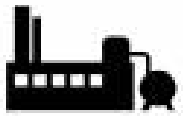
CO2 Capture

Syngas

Methanol Plant

MeOH

Renewable Energy



Water Electrolysis

H_2

g-methanol™

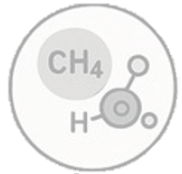
Bunkering Fuel

Waste Plastic Recycle

Sustainable feedstock for green plastics

Waste plastics recycle

Utilize excess Methane off gas



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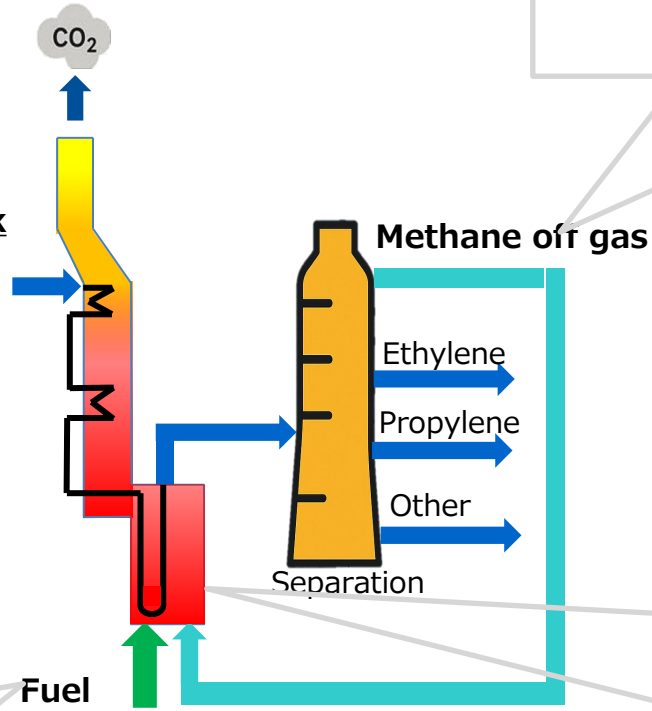


Carbon Neutral Fuel/Power

- ✓ Furnace electrification
- ✓ H_2 from Ammonia cracking

Reduce Boiler Steam

Motorization of 3 Main Compressor

Waste Plastics Recycle

Sustainable feedstock for green plastics

Conventional Naphtha → **Ethylene Plants** → Ethylene Propylene → LDPE・HDPE PP → Plastic Products

Advanced Recycle

Waste Plastics → **Recycled Naphtha** → **Ethylene Plants**

Under development by TOYO and Circular Plas Co.

Feature

- **Low TEMP.**
- **High ENERGY EFF.**

Waste Plastics Recycle

TOYO and Circular Plas Co., Ltd. are jointly developing Waste Plastics Advanced Recycling Process since 2022 for commercialization.

Successful Installed The New Type of The Reactor at Circular Plas Co., Ltd

Circular Plas Co., Ltd Demonstration Plant in Rayong

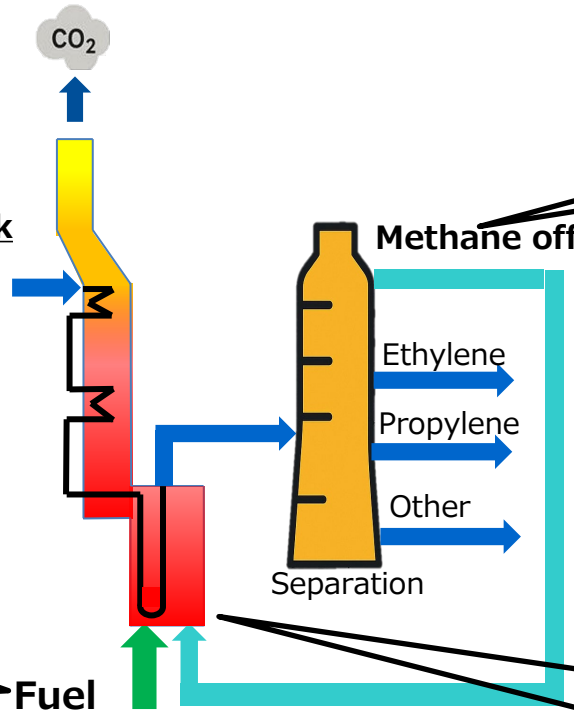
In 2025, we will launch our newly developed reactor, beginning its commercial application.

Towards Energy Transition

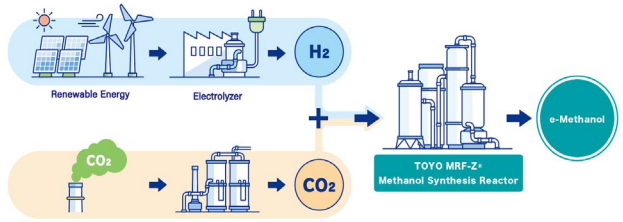
By integrating TOYO's technologies—**ammonia cracking, e-methanol production, and advanced plastic recycling**—TOYO enable comprehensive decarbonization of the ethylene plant.

Sustainable feedstock for green plastics
Waste plastics recycle

Advance Recycle Technology



Utilize excess Methane off gas
Methanol synthesis



g-methanol ™& Methanol Synthesis Reactor MRF-Z ™

Carbon Neutral Fuel/Power
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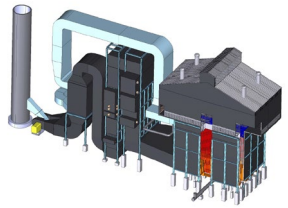

Ammonia Cracker

Reduce Boiler Steam
Motorization of 3 Main Compressor


TOYO
ENGINEERING
Your Success, Our Pride.