METI
Ministy of Economy, Trade and Industry

Direction for the Chemical Industry Based on 2050CN

February 27, 2023

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Materials Industry Division

Past developments on carbon neutrality in Japan

July 3, 2020: Minister Kajiyama's order to study the phasing out of inefficient coal-fired power plants

October 26, 2020: **Prime Minister Suga's Policy Speech (2050CN Declaration)**

> The Suga administration will focus on realizing a green society to the extent possible by setting up a virtuous cycle for the environment and economy as a pillar of its growth strategy.
>
> I now declare that **Japan aims to reduce its greenhouse gas emissions to net-zero by 2050, namely realizing 2050 Carbon Neutrality and a decarbonized society.**
>
> Responding to global warming will no longer constrain our economic growth. We need to change our mindset to the notion that proactively taking measures against global warming will bring about changes in industrial structure and economic society and lead to significant growth.

December 25, 2020: Formulation of the **Green Growth Strategy** associated with 2050 Carbon Neutrality

March 12, 2021: Formulation of basic policies for the **Green Innovation Fund Project**

April 22, 2021: Prime Minister Suga raised the greenhouse gas reduction targets at the Global Warming Prevention Headquarters

> Japan is taking a major step toward solving this global issue. **To be consistent with the 2050 target, we have set an ambitious target of reducing our greenhouse gas emissions by 46% in FY2030 compared to FY2013 levels.** Moreover, we will continue to take on the challenge of reaching a **target of 50%.** After this speech, we will also make the same statement to the international community at the Climate Summit.
>
> The 46% reduction in greenhouse gas emissions is **at least 70% higher than the current target, meaning that it is hardly an easy target to achieve.** However, we want to lead the world in discussions as a country that supports the world's *monozukuri* (manufacturing) by setting up ambitious, top-level targets commensurate with future growth strategies.

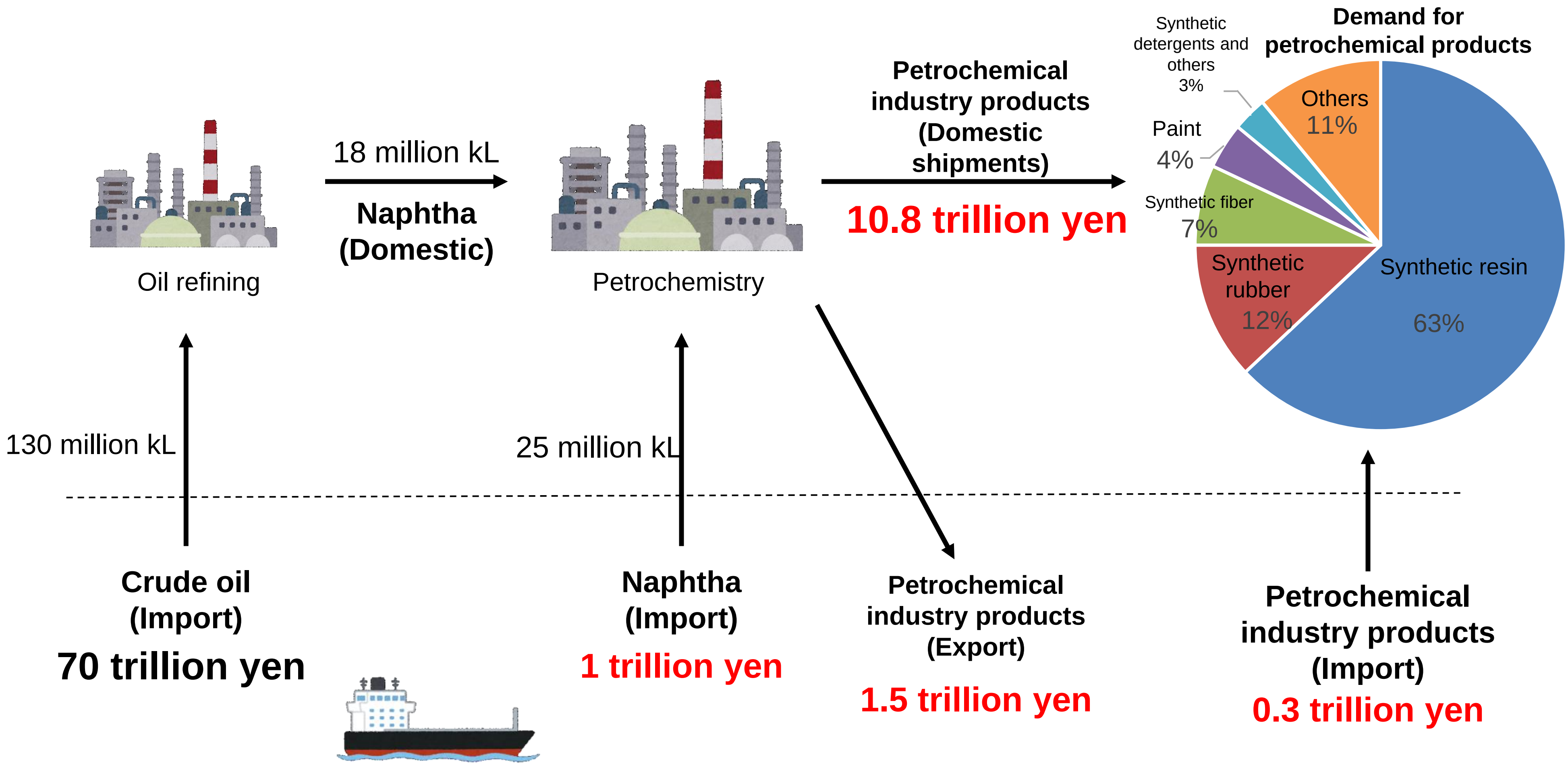
June 18, 2021: Revision of the Green Growth Strategy associated with 2050 Carbon Neutrality

May 19, 2022: Clean Energy Strategy - Interim Report

February 10, 2023: **Basic Policy for Realization of GX (Cabinet Decision)**

Overall Picture of the Petrochemical Industry

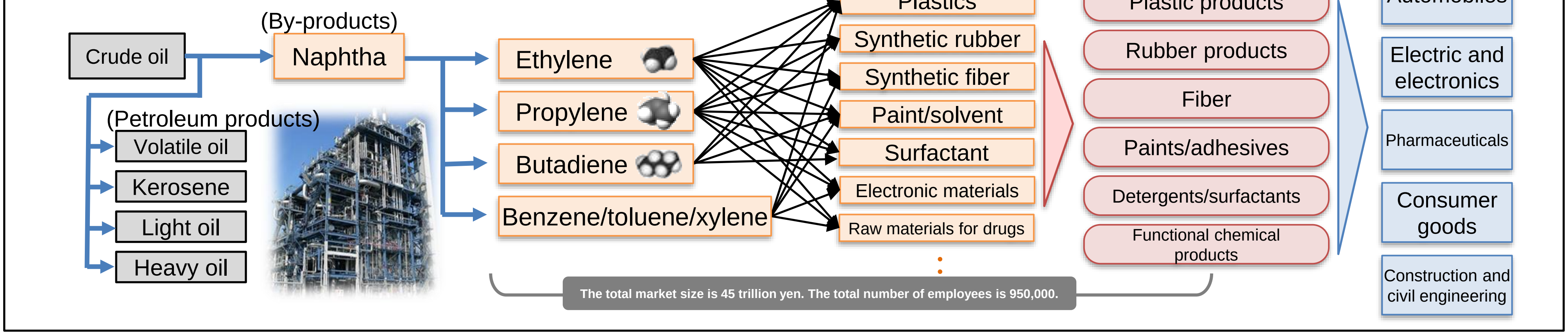
- The petrochemical industry uses imported and domestic naphtha as a raw material to process a variety of products. The industry is centered on the domestic market, **with domestic shipments totaling approximately 11 trillion yen. Exports account for about 10% of the total shipments.**



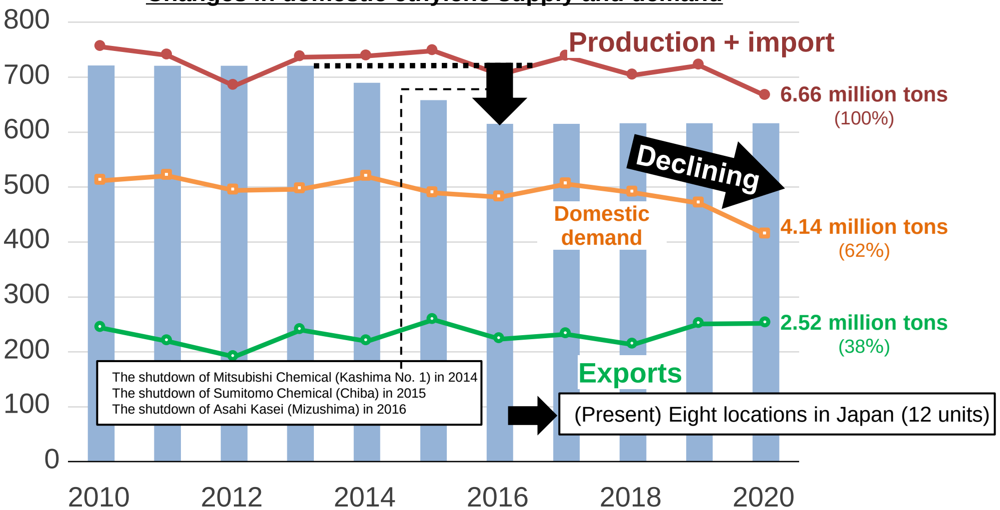
Current Situation (Chemical Industry)

The chemical industry supports a wide range of industries such as automobile and medical care, centered on their supply chains (a variety of chemical products) made from "naphtha," a by-product of crude oil refining. The issues to be solved in the future are how to deal with the shrinking domestic demand, oversupply, and aging facilities.

Structure of the petrochemical industry



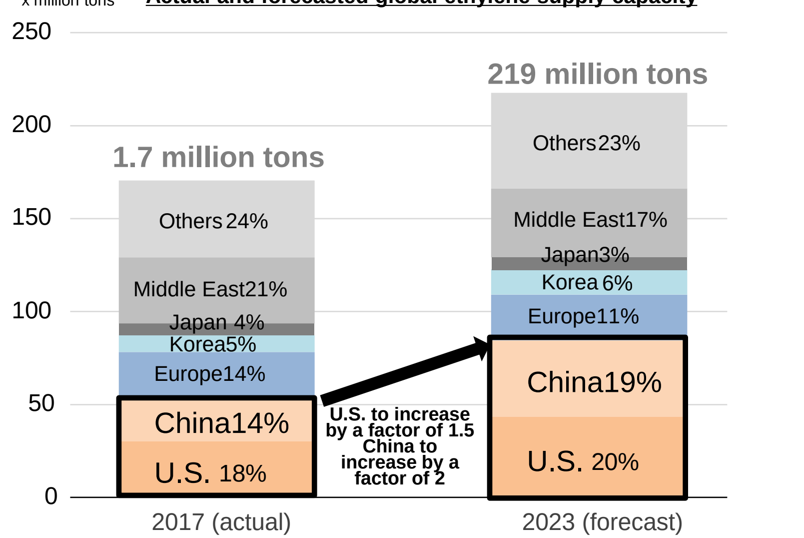
Changes in domestic ethylene supply and demand



*The column graph represents the installed capacity of ethylene production

Source: Ministry of Economy, Trade and Industry's Installed Capacity Survey and Trade Statistics

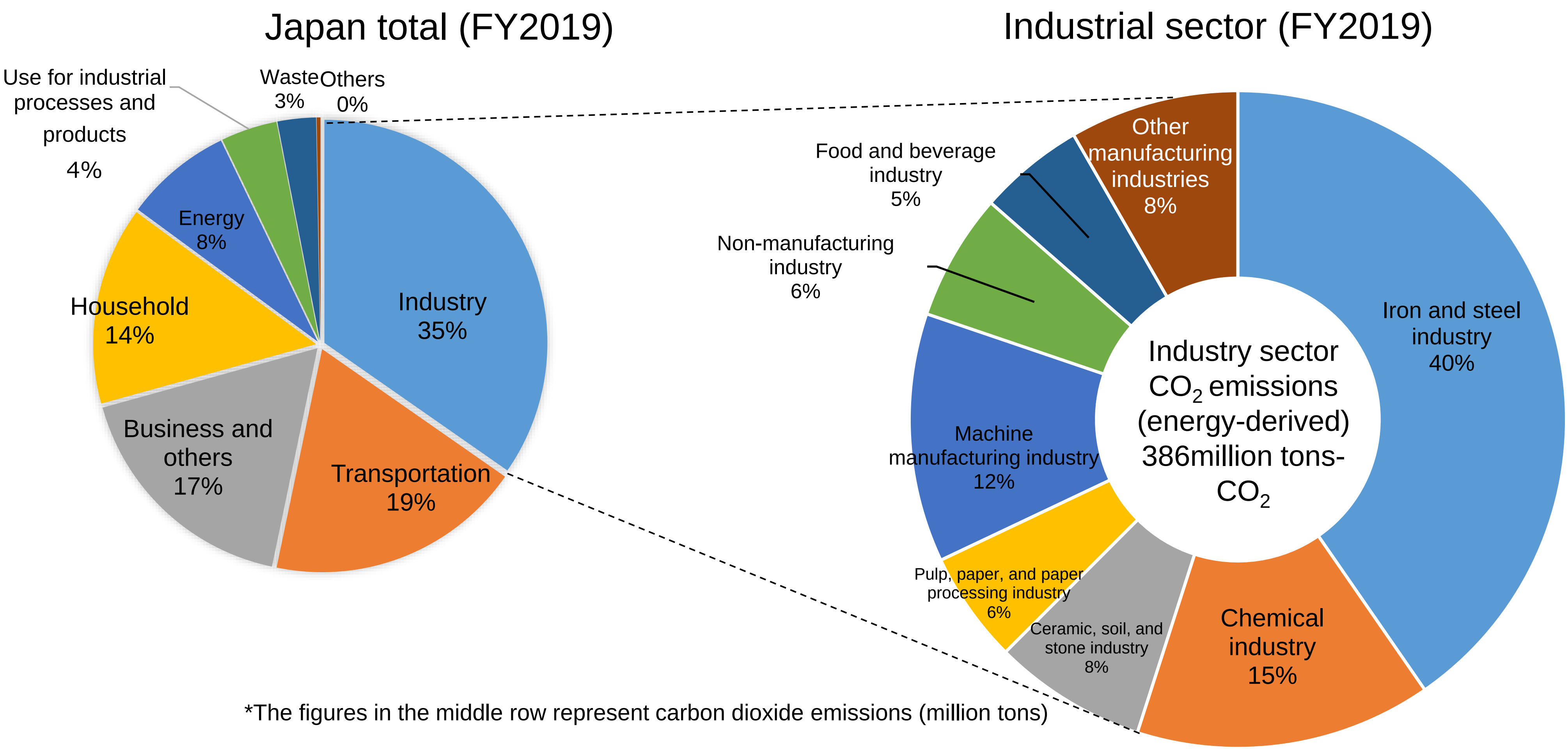
Actual and forecasted global ethylene supply capacity



Source: Ministry of Economy, Trade and Industry, "Future Supply and Demand Trends in Petrochemicals in the World (October 2019)"

Current Status of CO_2 Emissions in Japan

- **<u>The industrial sector accounts for 35%</u>** of Japan's total CO_2 emissions in FY2019.
- **<u>The basic industrial material industry</u>** <u>(the iron and steel industry, chemical industry, ceramic, soil, and stone industry, and pulp, paper, and paper processing industry)</u> accounts for **<u>about 70% of the total CO_2 emissions from the industrial sector.</u>**



*The figures in the middle row represent carbon dioxide emissions (million tons)

Source: National Institute for Environmental Studies, "Data on Greenhouse Gas Emissions in Japan" (final figures for FY2019)

Chemical Industry's competitiveness

➢ Changes in the domestic market

Example. Shrinking domestic demand and Increased risk of domestic production.

➢ Strengthen the high value-added business segment

Example. Global expansion of supply capacity for basic Chemicals (especially in China and the U.S.), and a shift toward functional products, mainly by U.S. and European companies

Basic and commodity products business as cost centers and functional chemicals business as profit centers

➢ Economic Security

Example . Major trend of enclosure between the U.S. and China / Relationship with China as a large market. Existence of key materials that should be prevented from leaking or newly produced domestically.

➢ Decarbonization and resource recycling

Example . Visualization of CO_2 emissions/recycling chain enhancement by advanced European companies

Respond to CN material supply requests from automotive, electrical and electronics, etc.

Role of Chemical Industry

-New Role of **Support the carbon cycle**

-Innovations of the way of manufacturing and using

-Industries that supply both of **basic chemicals** and **advanced materials**

-Contribution to **local economy and employment**

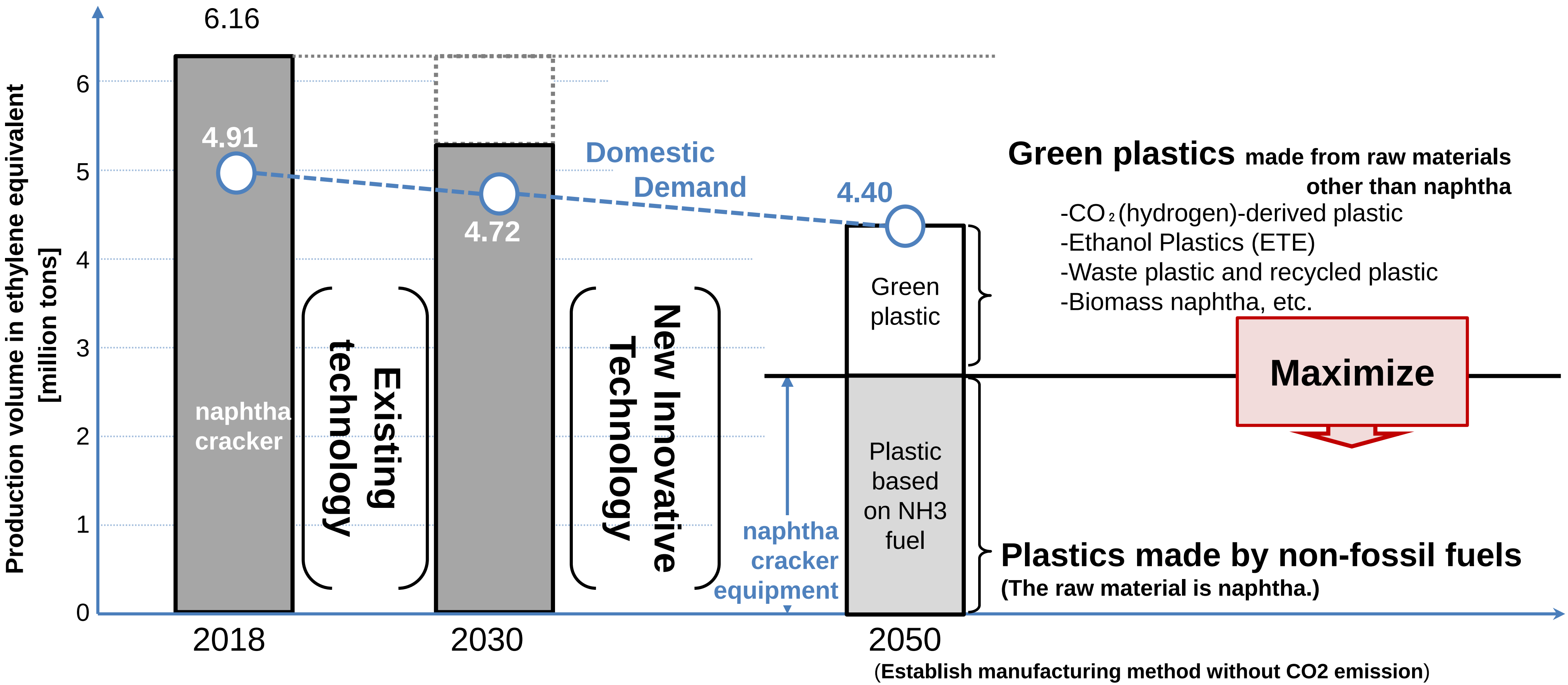
Tasks to be accomplished

1) **Innovation in manufacturing**
   (e.g., CO2 emission-free manufacturing methods, recycling of waste plastic, etc.)
2) Competitive **utilities** (electricity, LNG, biomass, ammonia, hydrogen)
3) Social **recycling system** for sorting and collection of waste plastic
   (In Japan, collection rate of waste plastics is already 90%)
4) Mechanism for gaining **consumer understanding**
   (CFP, mass balance rules, carbon pricing)
5) **Restructuring the supply chain** at industrial complexes
6) **Transition** Finance

Future prospects for ethylene as an example

- Production of plastics from sources other than naphtha is a future challenge

Image of future supply capacity in the case of ethylene conversion



-Dotted blue line indicates domestic demand (assumption); bar chart indicates production capacity

Challenges and Responses to GX

- Realizing GX by **establishing green material markets through foodstock conversion, resource recycling and fuel conversion.**

- Lists of the possible options

	raw materials	production	Shipping/Use	disposal
direction	**feedstock conversion**	**fuel conversion** **feedstock conversion**	**Creation of CN market**	**Establishment of recycling system**
issue	Securing waste plastics Securing Biomass Competitive hydrogen	Facility utilization rate CN technology Competitive ammonia CAPEX, OPEX Regulations	Definition of CN Value Demand for CN product Marketization of CN Value	Clarification of waste plastic Clarification of CN value

support

support (Budget and Institutional)

- (1) **Support for price for** raw materials and fuel
- (2) **Technology** development and demonstration support
- (3) Support for **Capital investment** and **capacity optimization**
- (4) **Capital Investment** Support
- (5) **Clarification of rules for joint actions about competition law**

Clarification of CN value

- (6) Establish guidelines for **CFP calculation**
- (7) Utilize **mass balance methods**
- 8) Develop a **platform for CN value evaluation and measurement**

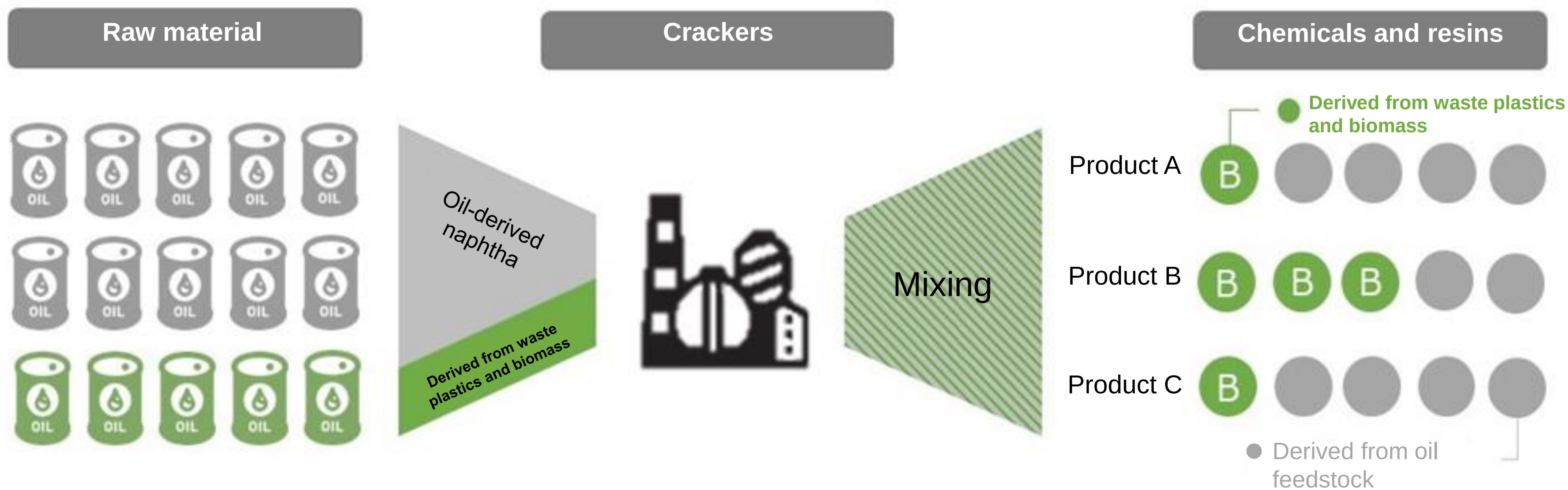
market creation

- (9) **Green Procurement**
- (10)**FMC**
- (11) **Creation of** recycle market
- (12)Plastic **Circulation Law**
- (13) GX-ETS , Carbon levy system
- (14) Border adjustment measures
- (15) Expansion of new technologies into **foreign markets**

Consumer awareness

An Example of a Measures to Promote Plastics Made from Recycled Carbon

- In promoting plastics made from recycled carbon, **it is essential to appropriately deliver products to those who value products using recycled materials.**
- To make it happen rationally, using **the mass balance approach** is effective. Depending on the input amount of feedstock with specific characteristics, the mass balance approach regards that part of the product "is manufactured with (only) the feedstock with specific characteristics."
- **In order to formulate the international standards** for the chain of custody, including the mass balance approach, the **establishment of a technical committee (TC308) under the ISO** was officially decided this year. **Japan will participate in the discussion** (represented by the Japan Chemical Industry Association).
- With **related certification systems already underway mainly in Europe**, **some Japanese companies are beginning to make concrete plans for these systems**, showing a growing interest in this approach.



Input fuels derived from waste plastics and biomass

Existing manufacturing process/production chain

The use of feedstock derived from waste plastics and biomass is allocated to specific products

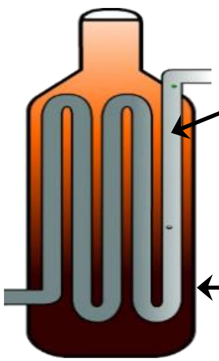
Source: Mitsui Chemicals' press release with partial modification
https://jp.mitsuichemicals.com/jp/release/2021/2021_0520.htm

Overseas development of the technology to manufacture feedstock for plastics from recycled carbon

- Japan will **pursue the international standards for the technology to manufacture feedstock for plastics from recycled carbon, making extensive use of the international standards through licensing business**, which is widely seen in the chemical industry. As a result, Japan will **proactively acquire new demand in emerging countries.**

Sophisticated technology of naphtha cracking furnaces

Present

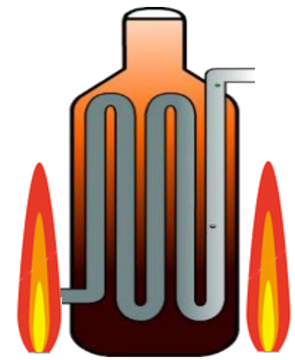


Licensed by overseas companies

Engineered by Japanese companies

Operated in naphtha cracking furnaces in Japan

Future



Japanese ammonia burner/furnace technologies

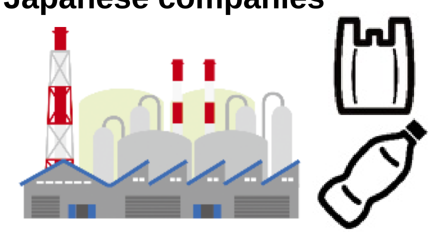
→ To be licensed to the emerging countries that have a plan to build new naphtha cracking furnaces*

China, ASEAN, etc.

Technology to manufacture chemicals from waste plastic and rubber

Present

Japanese companies



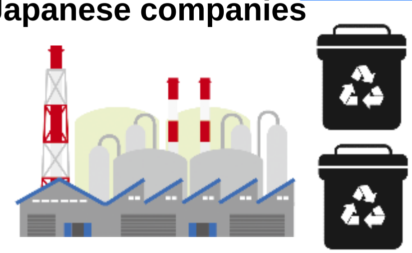
High-density polyethylene (HDPE) and others
Manufacturing technology for general-purpose plastics

→ License to emerging countries

Russia, India. ...
:

Future

Japanese companies



Chemical recycling and others
CO_2 reducing technology

→ Standardization to international standards

ISO/TC47
ISO/TC61

→ License to emerging countries

R&D Trends by Japanese government

-10 Year Project by Green innovation Fund
-Technology Roadmap for Transition Finance

The Chemical Industry's Contribution to Each Field of the Green Growth Strategy

- The chemical industry contributes to **hydrogen production using photocatalysts** and **the production of chemicals using CO_2 as feedstock**.
- In addition to the above, the **materials used for batteries and semiconductors and lightweight materials such as carbon fiber that the chemical industry supplies contribute to many industries.**

Industry field	Related areas	Chemical industry contribution
(1) Offshore wind power, solar power, and geothermal power industries	(Wind turbine main units, components, floating wind turbines)	
(2) Hydrogen and fuel ammonia industries	(Hydrogen reduction steelmaking, liquid hydrogen carriers, water electrolysis, burners for NH_3 power generation)	Photocatalyst, next-generation ammonia synthesis
(3) Next-generation heat energy industry	(Methanation, direct hydrogen combustion)	
(4) Nuclear industry	(SMRs, nuclear hydrogen production)	
(5) Automobile and storage battery industries	(EVs, FCVs, next-generation batteries)	Materials used for all-solid-state batteries
(6) Semiconductor and information and telecommunications industries	(Data centers, energy-saving semiconductors)	Parts and materials used for semiconductors
(7) Shipbuilding industry	(Fuel cell vessels, electric vessels, gas-fueled vessels)	
(8) Logistics, human flow, and civil infrastructure industries	(Smart transportation, drones for logistics, FC construction equipment)	
(9) Foods, agriculture, forestry, and fisheries industries	(Smart agriculture, wooden high-rise buildings, blue carbon)	Cellulose nanofiber
(10) Aircraft industry	(Hybridization, hydrogen-fueled aircraft)	Carbon fiber, fine ceramics
(11) Carbon recycling and materials industries	(Chemicals, decarbonized heat sources, CN complexes, cement)	Naphtha cracker decarbonization, artificial photosynthesis, cement
(12) Housing and building industry/next-generation power management industry	(Solar power generation)	
(13) Resource recycling-related industries	(Bio-based materials, recycled materials, waste power generation)	
(14) Lifestyle-related industries	(Regional decarbonization)	

A List of the Projects Expected to Start in FY2021

(1) Reducing the cost of offshore wind power generation: Developing the element technologies (wind turbine components, floats, cables, etc.) for reducing the cost of floating offshore wind power generation to demonstrate an integrated design and operation

(2) Developing next-generation solar cells: Developing/demonstrating next-generation solar cells mountable on wall surfaces for cost reductions, including Perovskite solar cells

(3) Establishing a large-scale hydrogen supply chain: Developing/demonstrating technology related to hydrogen production, transportation, storage, and power generation for supply capacity increases and cost reductions

WG1 Green electricity promotion area

(4) Hydrogen production by water electrolysis utilizing renewable energy-derived electric power: Developing/demonstrating a water electrolysis device to produce hydrogen at lower costs

(5) Utilizing hydrogen in the steelmaking process: Developing/demonstrating the technology to produce steel using hydrogen instead of coal (hydrogen reduction steelmaking technology)

(6) Establishing a fuel ammonia supply chain: Developing/demonstrating technology related to ammonia production, transportation, storage, and power generation for supply capacity increases and cost reductions

(7) Developing the technology to manufacture feedstock for plastics from CO_2 and the like: **Developing the technology to manufacture feedstock for plastics from CO_2, waste plastics, waste rubber, etc.**

(8) Developing the technology to manufacture fuels from CO_2 and the like: Developing the technology to manufacture fuels for automobiles, jet airplanes, households, and industrial gases from CO_2 and the like

(9) Developing the technology to manufacture concrete using CO_2 and the like: **Developing concrete manufactured through CO_2 absorption for cost reductions and improved durability**

(10) Developing the technology to separate and capture CO_2: Developing various types of techniques to separate and capture CO_2 depending on the scale of emissions and concentrations while comparing pros and cons

(11) Developing the technology to reduce CO_2 emissions during waste disposal: Developing the combustion control technology and the like to facilitate CO_2 capture from incineration facilities

WG2 Energy structure transformation area

(12) Developing next-generation storage batteries and next-generation motors: Developing the technology related to parts/materials, production processes, and recycling for the storage batteries and motors used for EVs, drones, and agricultural machines

(13) Developing/demonstrating supply chain reform technology associated with automotive electrification: Development/demonstration for the electrification of mini vehicles and commercial vehicles and supplier business transformation

(14) Establishing a smart mobility society: Developing/demonstrating automated driving and digital technologies to promote the use of electric vehicles in passenger transportation and logistics

(15) Establishing a next-generation digital infrastructure: Developing energy-saving technologies for data centers and power semiconductors

(16) Developing next-generation aircraft: Developing element technologies for the engines, fuel tanks, and fuel supply systems required for hydrogen-fueled aircraft and aircraft electrification

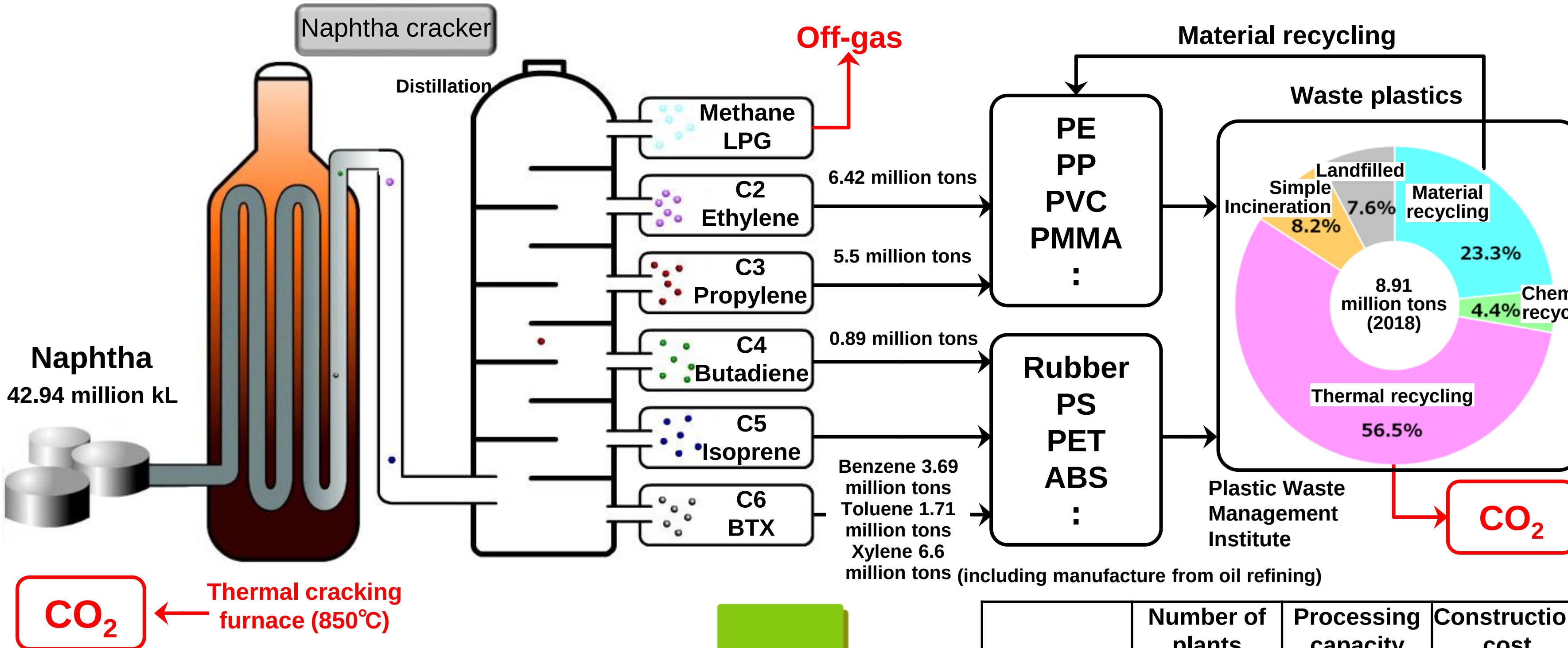
(17) Developing next-generation vessels: Developing element technologies for the engines, fuel tanks, and fuel supply systems required for hydrogen-fueled vessels and ammonia-fueled vessels

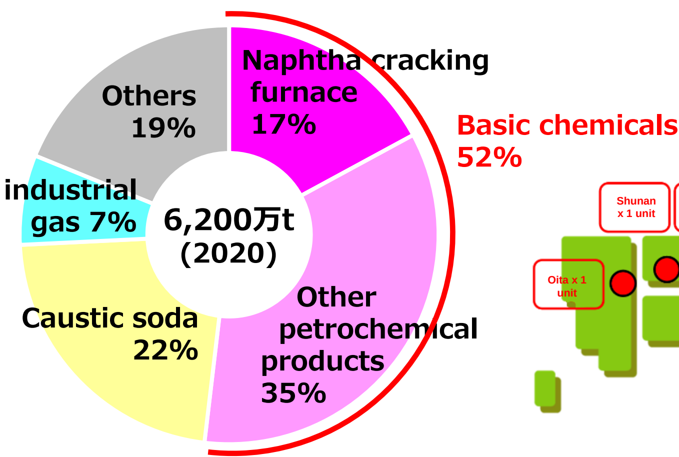
(18) Developing the technology to reduce/absorb CO_2 in the foods, agriculture, forestry, and fisheries industries: Developing the technology to reduce/absorb CO_2 considered marketable in the agriculture, forestry, and fisheries industries

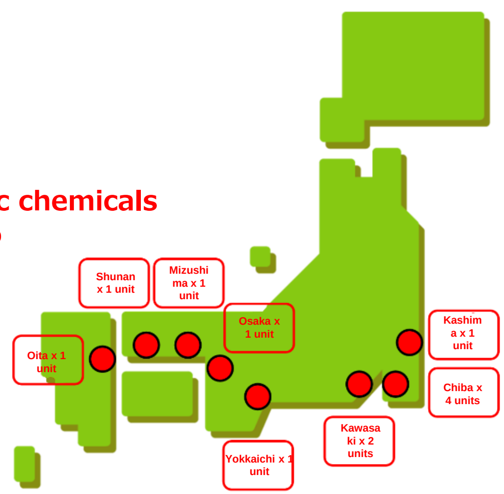
WG3 Industry structure transformation area

Manufacturing Chemicals from Naphtha Crackers

Current Production System for Basic Chemicals







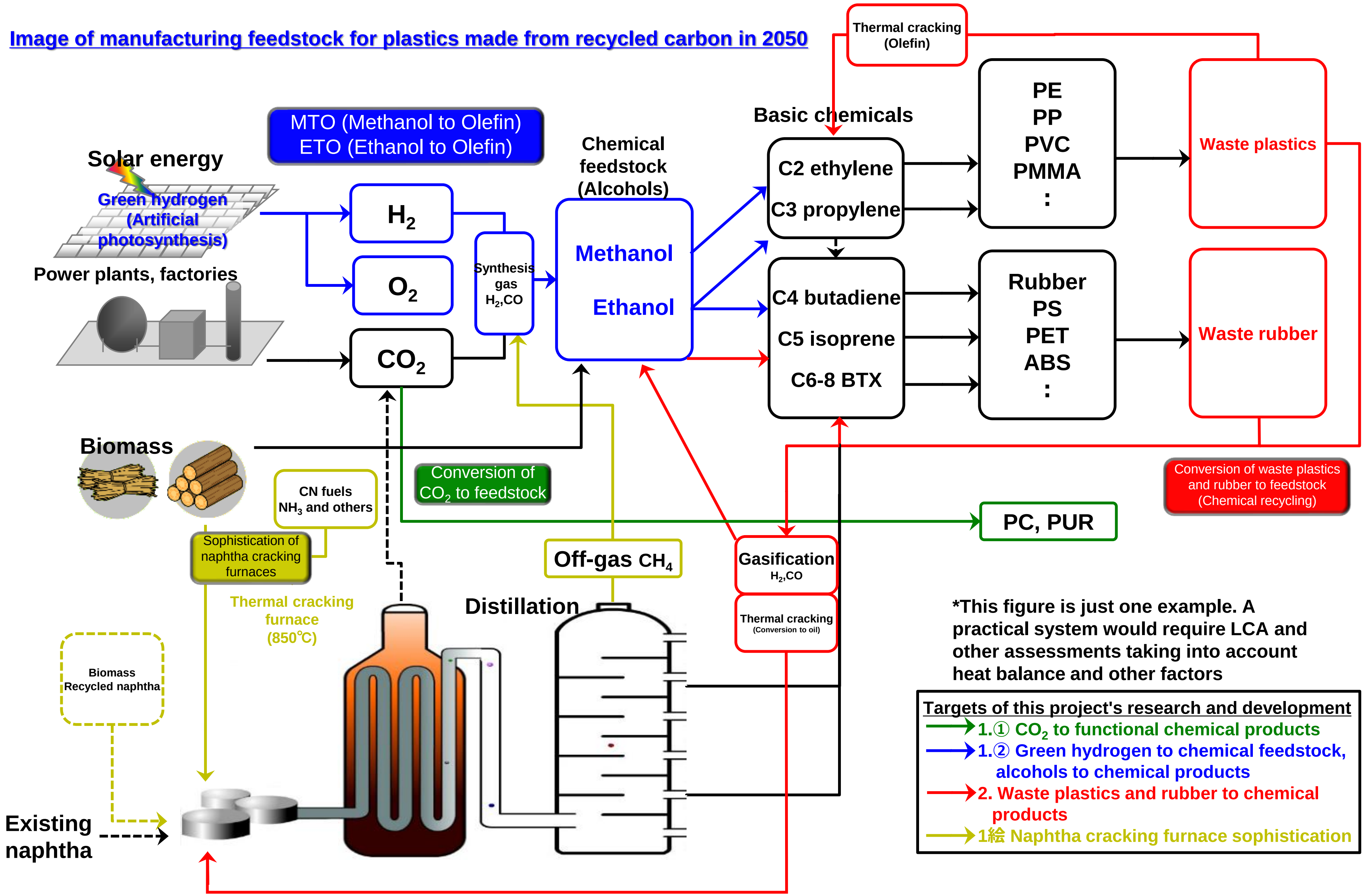
	Number of plants	Processing capacity	Construction cost
Naphtha cracker	12 units	6 million tons	100 billion yen/unit

The U.S.
Ethane crackers using shale gas
Ethylene: 15 million tons

China
From coal gasification to methanol-to-olefin (MTO)
Ethylene: 3.5 million tons, propylene: 4.0 million tons

Carbon Neutrality in Manufacturing Chemical Products

Image of manufacturing feedstock for plastics made from recycled carbon in 2050



*This figure is just one example. A practical system would require LCA and other assessments taking into account heat balance and other factors

Targets of this project's research and development

- 1.① CO_2 to functional chemical products
- 1.② Green hydrogen to chemical feedstock, alcohols to chemical products
- 2. Waste plastics and rubber to chemical products
- 1絵 Naphtha cracking furnace sophistication

Image of Converting Production Systems toward 2050

- Aim for carbon neutrality through **(1) conversion of raw materials, (2) circulation of raw materials,** and **(3) conversion of heat sources,** while overcoming the aging of naphtha cracking furnaces.
  Secure production systems that can produce necessary chemical products as much as required.

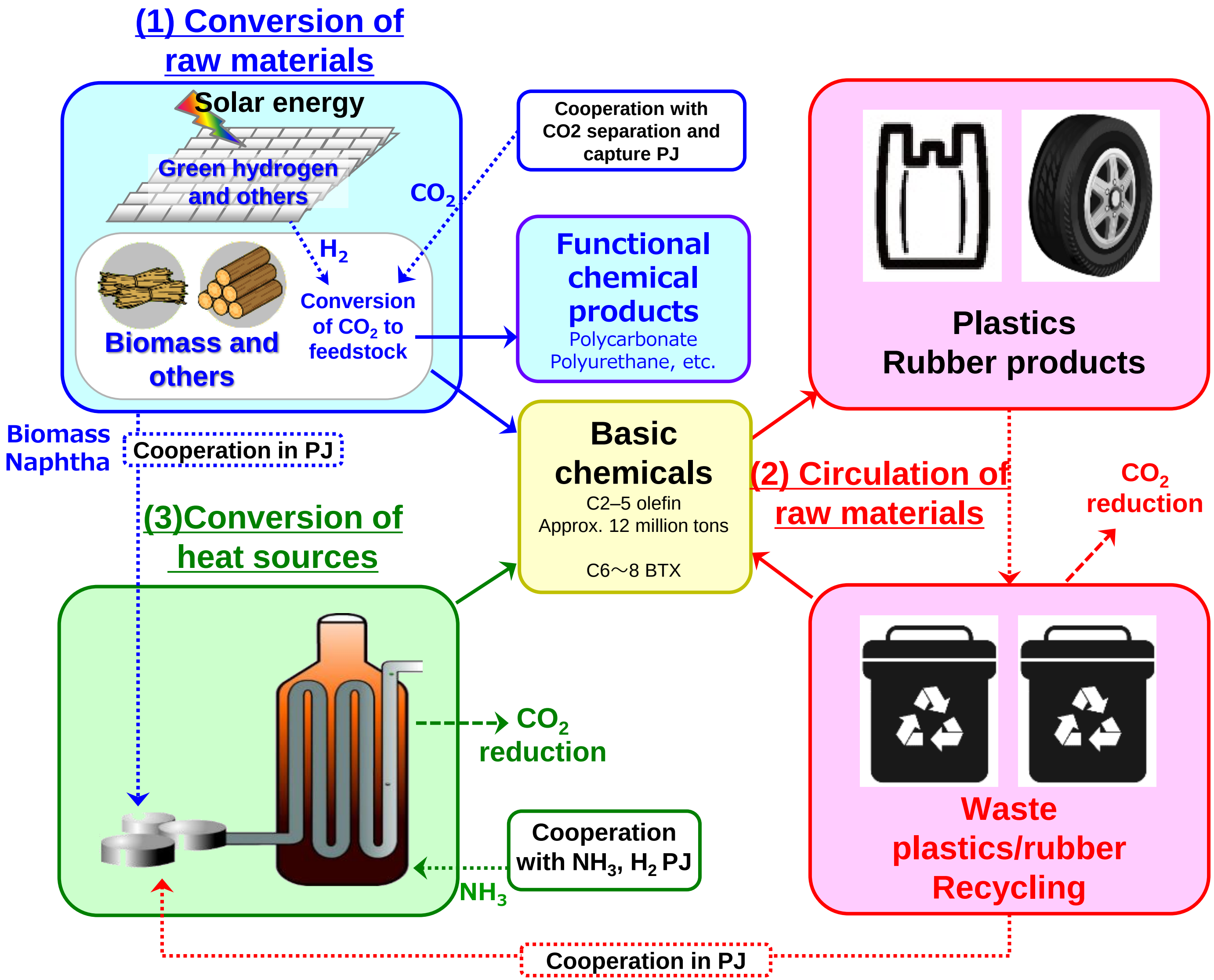
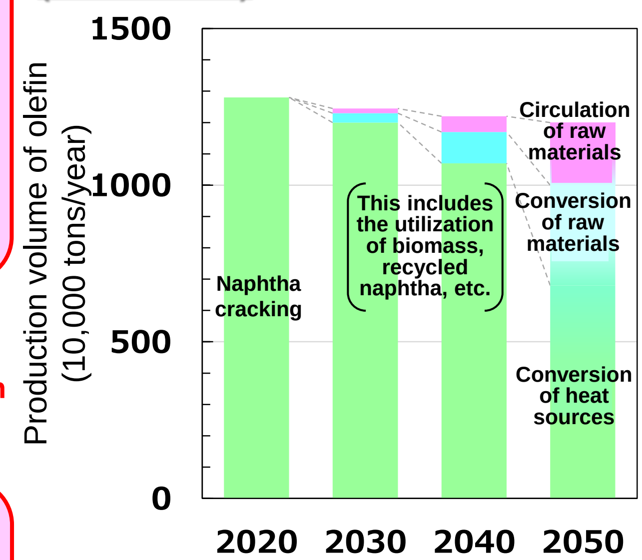


Image of transition of basic chemicals manufacturing (domestic)



In the above figure, the ratio of the three approaches varies depending on the production status of petroleum products, technology evolution, etc. Despite that, our goal is to build a system that will balance basic chemicals production and carbon neutrality and allow multilateral approaches such as overseas expansion.

Development of Manufacturing Technology of Feedstock for Plastics Using CO_2 and Others

(The amount of subsidies from the Government: upper limit 126.2 billion yen)

- Most of the feedstock for plastics is derived from naphtha (crude gasoline) obtained from oil refineries. **About half of the CO_2 emitted by the chemical industry** comes from **the process of cracking naphtha to produce basic chemicals such as ethylene and propylene.**
- Furthermore, about 84% of waste plastics are recycled today, and **about 57% of the recycled waste plastics are used as heat sources for waste incinerating power generation (thermal recycling), eventually emitting CO_2.** Therefore, this process requires drastic measures.

[R&D item 1]
Development of the technology to manufacture functional chemical products from CO_2

- It is theoretically possible to synthesize functional chemical products such as polycarbonate and polyurethane from CO_2 without hydrogen.
- This R&D item also includes **the improvement of functionalities such as electrical, optical, and mechanical properties.**

High-performance polycarbonate (camera lenses)

[Aim for conversion of CO_2 to feedstock]

[R&D item 2]
Development of the technology to manufacture chemical products from alcohol

[Manufactured from green hydrogen and CO_2)

- Improving the catalyst yield (up to 80 to 90%) **when producing olefins like ethylene and propylene from methanol (MTO).**
- Our aim in artificial photosynthesis is **to develop** and commercialize **photocatalysts that can balance high conversion efficiency and excellent mass productivity.**

MTO demonstration

Large-scale demonstration of photocatalyst panels

[R&D item 3]
Development of the technology to manufacture chemical products from waste plastics/rubber

- Establish **the technology to manufacture feedstock for plastics such as ethylene and propylene from waste plastics/rubber.**
- Our goal is to manufacture the feedstock at a 60 to 80% yield rate and reduce CO_2 emissions during production to about half of the conventional processes.

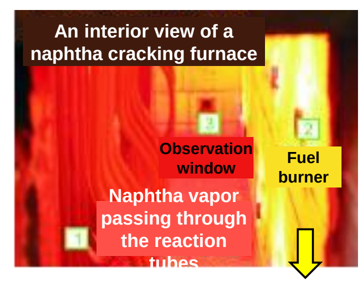
Oil made from the thermal cracking of waste plastics (Feedstock of plastics)

[Aim for an about 50% reduction in CO_2 emissions]

[R&D item 4]
Development of sophisticated technologies for naphtha cracking furnaces using carbon-free heat sources

- The current heat source is off-gas (methane and the like) generated from naphtha cracking furnaces.
- This PJ will develop the world's first technology to **convert** the heat source of naphtha cracking furnaces **to ammonia, a carbon-free heat source**.

[Aim for an about 70% reduction in CO_2 emissions]

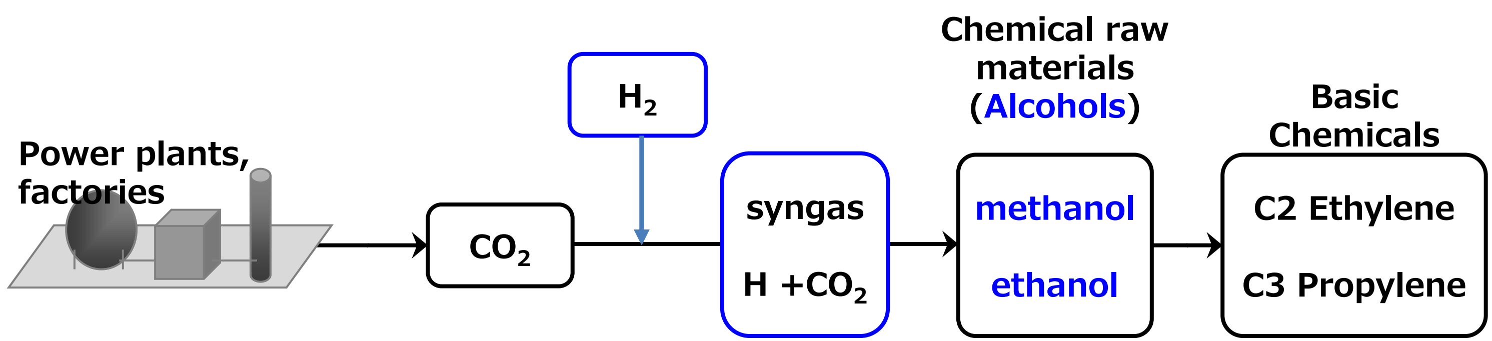


Convert the heat source of the furnace for naphtha thermal cracking at about 850ºC to ammonia

Production of plastics from CO2 (raw material conversion)

- In the chemical industry, plastics can be produced from ethanol, CO_2 etc.

<Process for manufacturing plastics from CO2>



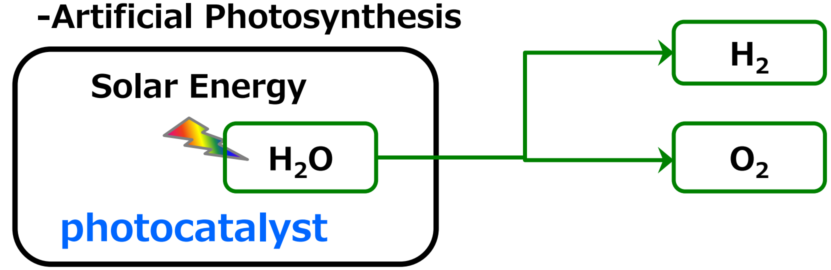
MTO (Methanol to Olefin)
ETO (Ethanol to Olefin)

< Competitive hydrogen production method >

-Byproduct hydrogen in suitable overseas locations

-Hydrogen production using heat from nuclear power plants

-Artificial Photosynthesis

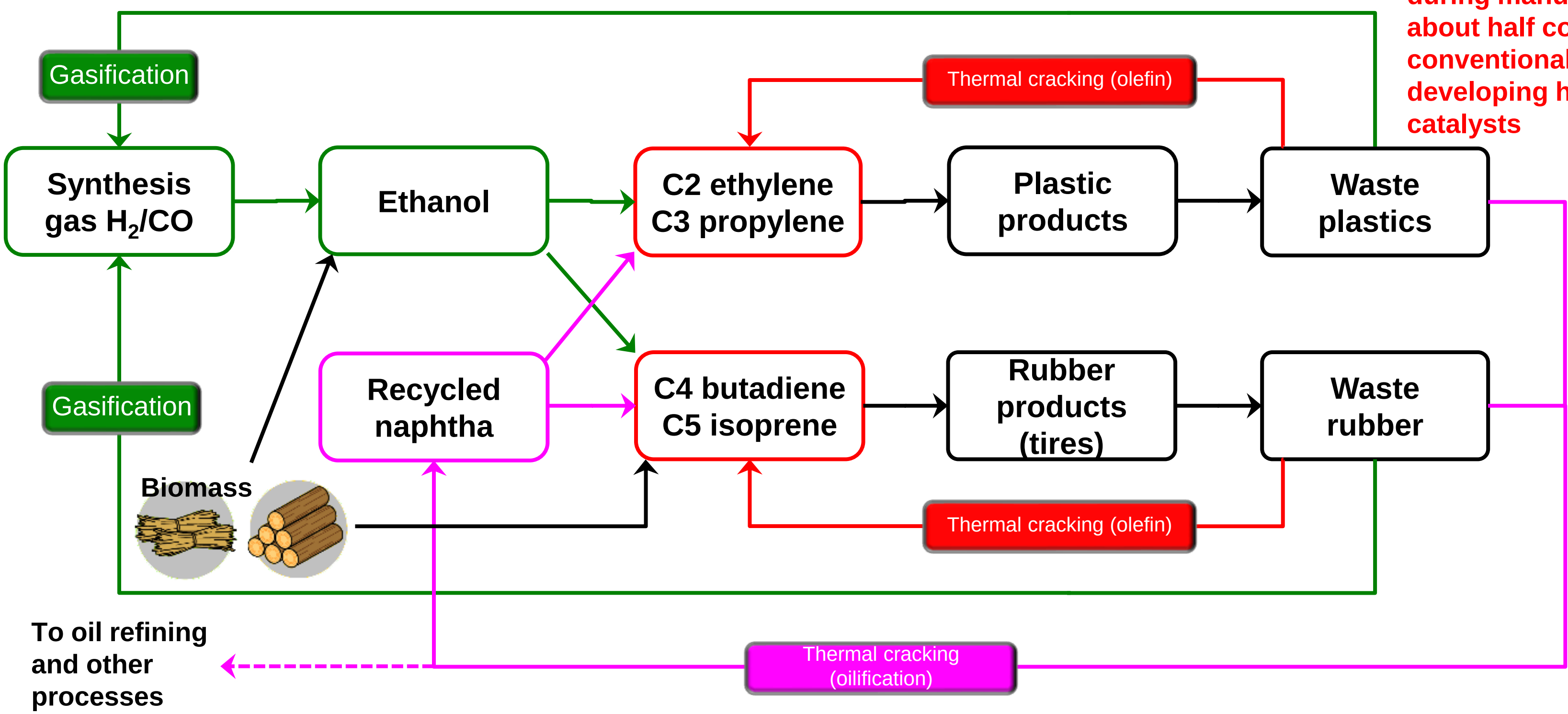


Chemical recycling

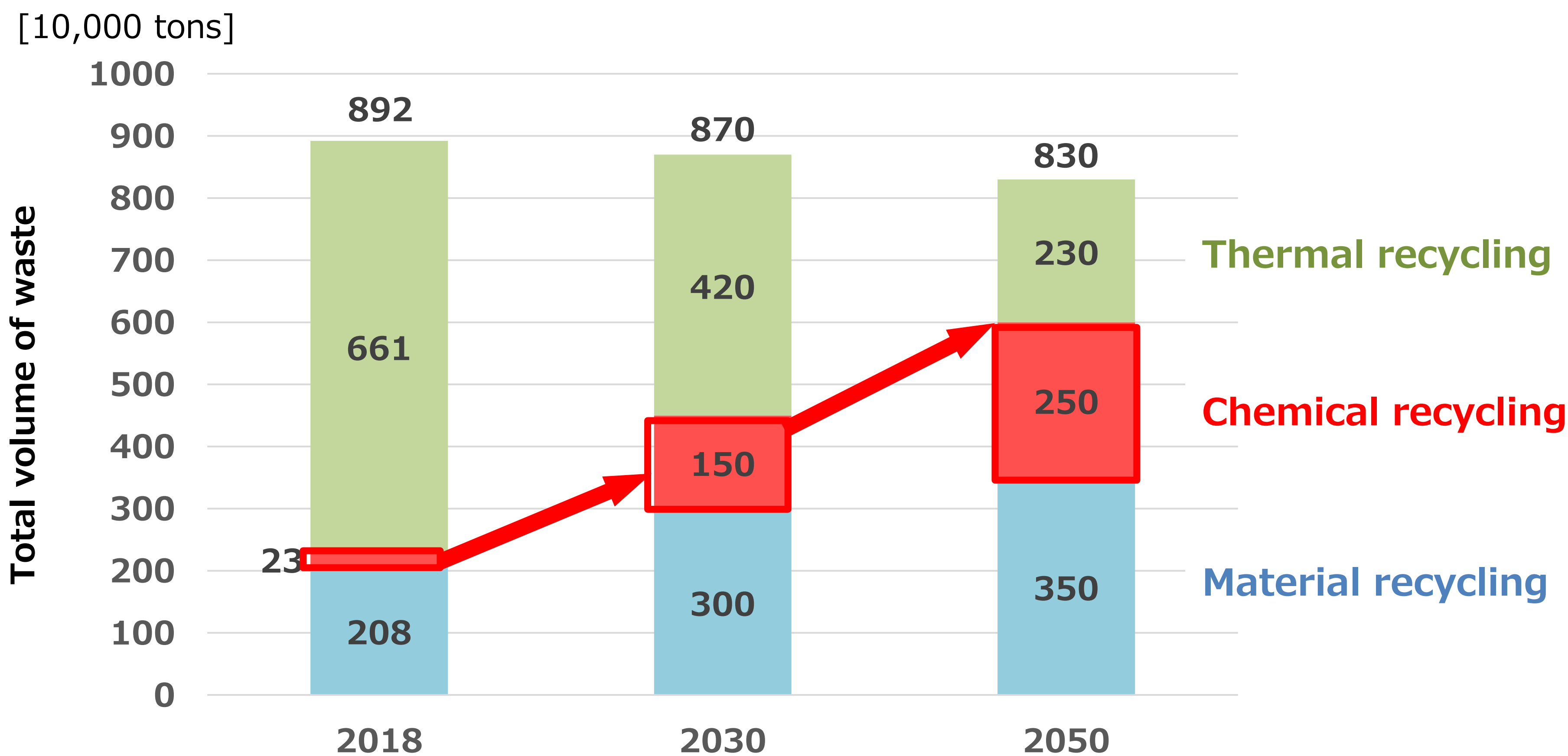
- Chemical recycling of waste plastics and rubber is applied only to some plastics such as polystyrene and PET. As a result, **the chemically recycled waste plastics account for only about 3% of the total recycled waste plastics.**
- This project will establish a chemical recycling technology to manufacture basic chemicals like ethylene, propylene, and butadiene at a yield rate between 60% and 80%, aiming for **demonstration production at a scale of several thousand to several tens of thousand tons/year** by 2030.

A conceptual diagram of the chemical recycling of waste plastics and rubber

Points of this development
Reducing CO_2 emissions during manufacturing to about half compared to the conventional method by developing high-yield catalysts



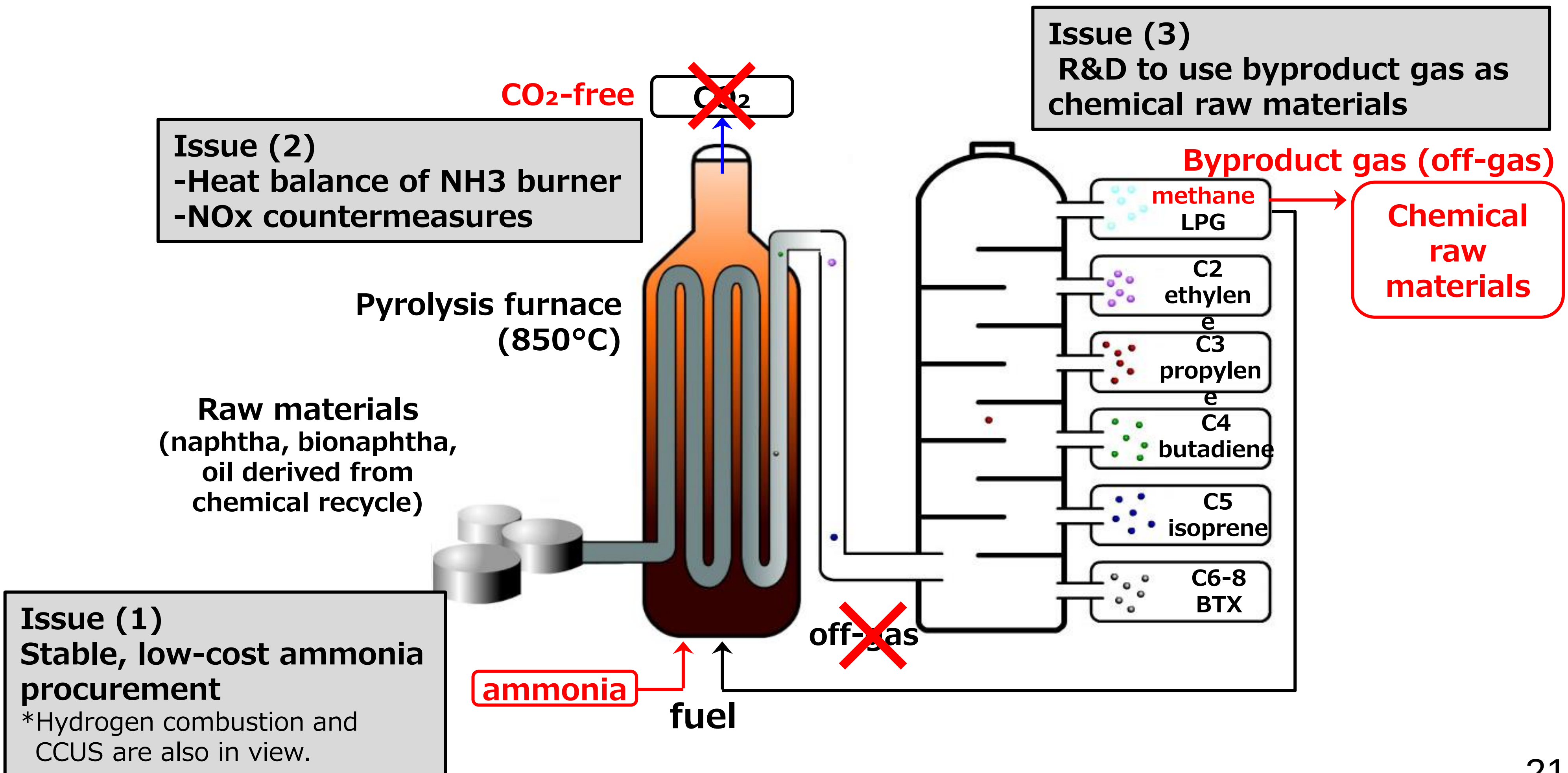
Chemical recycling targets



- Compiled by METI based on the Japan Chemical Industry Association's "The Ideal Chemical Industry for Chemical Recycling of Waste Plastics" (December 18, 2020) and other sources.

Naphtha cracking furnace fuel conversion

- There are some issues such as price of ammonia and the heat balance of the burner to Utilize ammonia instead of byproduct gas (methane gas) .



Development of a Technology Roadmap for Transition Finance

- **<u>Basic Guidelines on Climate Transition Finance will be formulated in May 2021</u>** (Ministry of Economy, Trade and Industry, Ministry of the Environment, and Financial Services Agency).
- **<u>A sector-specific roadmap will be developed as a</u>** reference for determining the eligibility of companies' transition strategies in individual sectors.

Formulation of basic guidelines

<u>Transition Finance Environmental Improvement Study Group</u>

Climate Transition Finance
Formulation of basic guidelines (May 2021)

(Ministry of Economy, Trade and Industry, Ministry of the Environment, Financial Services Agency)

← Roadmap Report

→ Opinions expressed as necessary

Develop sector-specific roadmaps (industry competent authorities)

<u>Economy and Industry</u>
Transition Finance in the Economic and Industrial Sector "Roadmap Development Study Group"

- Operated and formulated by METI
- Areas covered:Steel, **<u>chemicals</u>**, electric power, gas, petroleum, <u>pulp and paper</u>, <u>cement</u>, etc.

<u>Land transportation field</u> (shipping...)
<u>Agriculture, Forestry and Fisheries</u> (Foods...)
•
•

Technology roadmap for the chemical sector (1)
(Feedstock conversion, Recycling)

2020 — 2025 — 2030 — 2040 — 2050

Direction for decarbonization
(Further promotion through collaboration with other fields)

Feedstock conversion

- Produce basic chemicals using biomass as feedstock
- Produce polymers and their feedstock from biomass
- Artificial photosynthesis
- Generate methanol from hydrogen, CO_2, and synthetic gases
- MTO・ETO
- Produce hydrocarbons like olefin from CO_2
- Generate functional chemicals using CO_2 as feedstock
- Produce methane from CO_2

+Decarbonized power sources /CCUS

Direction for decarbonization:
- Establish production technology using CO_2 and biomass as feedstock If process CO_2 emissions become zero using renewable energy, it can be regarded as decarbonized.

Recycling

- Material recycling
- Chemical recycling (waste plastics)
- Chemical recycling (waste rubber)

+Decarbonized power sources /CCUS

Direction for decarbonization:
- Expansion of material/chemical recycling

Technology roadmap for the chemical sector (2)

(Naphtha cracking)

2020 — 2025 — 2030 — 2040 — 2050

Direction for decarbonization
(Further promotion through collaboration with other fields)

Naphtha cracking

- **Energy saving/energy efficiency enhancement:** Improvement of operation methods, recovery of discharged energy, process streamlining, improvement of facility/equipment efficiencies
- Conversion to natural gas
- Fuel conversion to ammonia, hydrogen, and the like
- Conversion of methane off-gas to feedstock

+CCUS

- Aim to reduce CO_2 emissions through energy saving / energy efficiency enhanceme nt and fuel conversion
- Introducing CO_2 capture is possible

Technology roadmap for the chemical sector (3)
(Inorganic Chemistry, In-House Power Generation)

2020 | 2025 | 2030 | 2040 | 2050

Direction for decarbonization
(Further promotion through collaboration with other fields)

Inorganic chemistry

Electrolytic soda
Various energy-saving and efficiency improvement: Sophisticated control, facility renewal/efficiency improvement, introducing zero-gap type brine electrolyzers, introducing bipolar electrolyzers, heat recovery from condensation facilities, etc.

Industrial gases
Various energy-saving and efficiency improvement: Introducing high-efficiency cryogenic separation units, inverter-based pumps/compressors, reviewing distribution centers, and others

+Decarbonization of in-house steam and electric power

+Decarbonized power sources

- Aim to reduce CO_2 emissions through energy saving/energy efficiency enhancement and fuel conversion
- CO_2 capture and electrification are possible

[Technology related to multiple fields]

In-house steam, in-house electric power

Various energy-saving and efficiency improvement: Downsized boilers, operation management, inverter-based induced draft fans, extended range of energy-saving steam traps, and cogeneration

Conversion to natural gas

Conversion to biomass

Fuel conversion to hydrogen, ammonia, etc.

Electrification

+Decarbonized power sources/ CCUS

- Energy-saving/efficiency improvement, conversion to renewable energy

CO_2 separation and capture

CO_2 separation and capture (chemical processes, cogeneration boilers, etc.)