Sustainable Technology and Business Development Strategy

TOYO's value-added approach toward the realization of a carbon-neutral society

December 12, 2022

Toyo Engineering Corporation
Carbon Neutral Business Division, Next-Generation Technology & Application Division

TOYO ENGINEERING

Creating new revenue sources in the domain of carbon neutrality through co-creation from the concept stage of business development

Strategy "Sustainable Technology and Business Development"

Priority Areas: Environment and Energy

Co-creation with clients/partners from the concept

< BACKGROUND>

- Carbon neutral is the area to contribute
  - → Efforts against global warming
  - → Improving Quality of Life in Emerging Countries
  - → Their coexistence are directly linked to Toyo's Mission.
- Proprietary solutions (CCUS, synthetic gas technology, etc.)
  - → Fuel ammonia
  - → Sustainable aviation fuels (SAF)
  - → Green methanol, etc.

New Knowledge and Business Opportunities returned to EPC

SUSTAINABLE DEVELOPMENT GOALS

Invest knowledge, experience and benefits gained through EPC

Strategy "Advanced EPC Operation"

Group operations

x

DXoT (Digitalization without sanctuary)

Ensuring Excellent Quality and Profitability

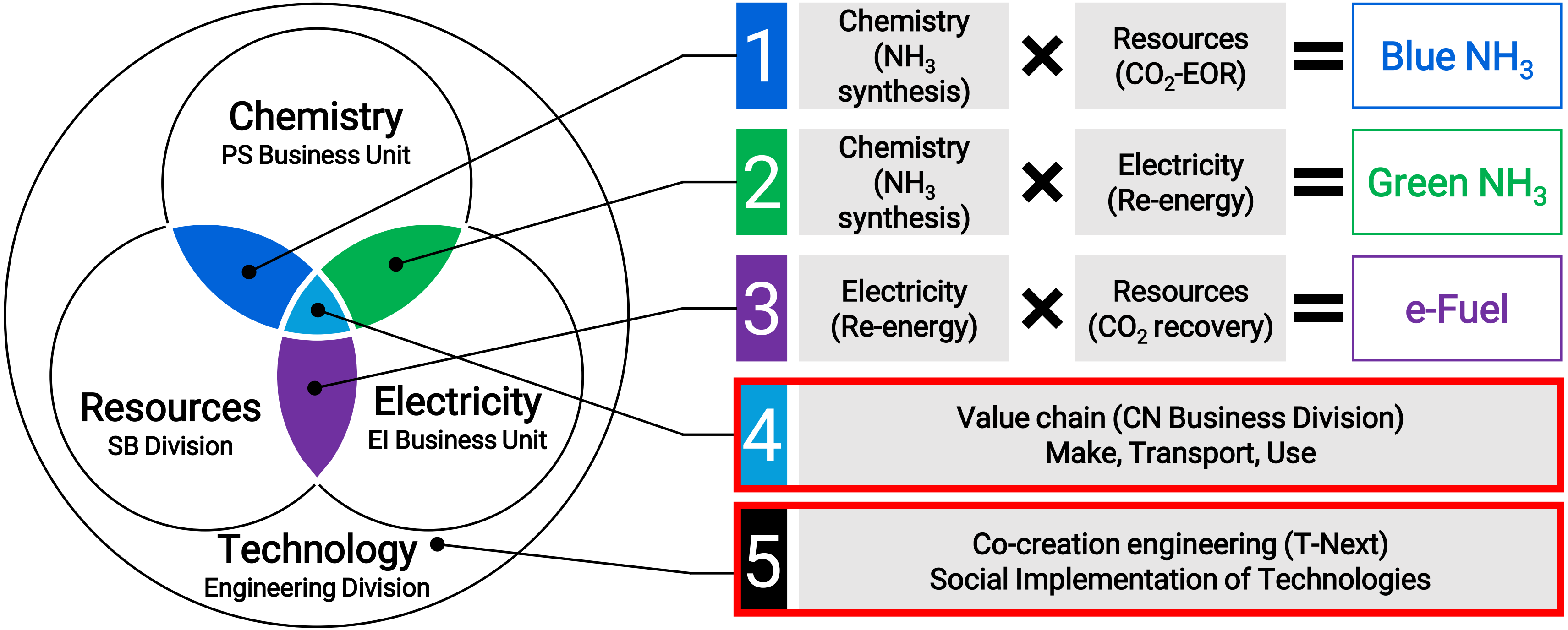
< BACKGROUND>

- TOYO's definitive advantages
  - → Group companies' capabilities to accomplish EPC works since 1960s
  - → Abundant records in India, Russia/NIS, Asia and Brazil whose demands are expected to grow
- EPC business continues to be the mainstay
  →Pursue "Dramatic" productivity increase

Source: Toyo Medium-Term Management Plan 2021-2025

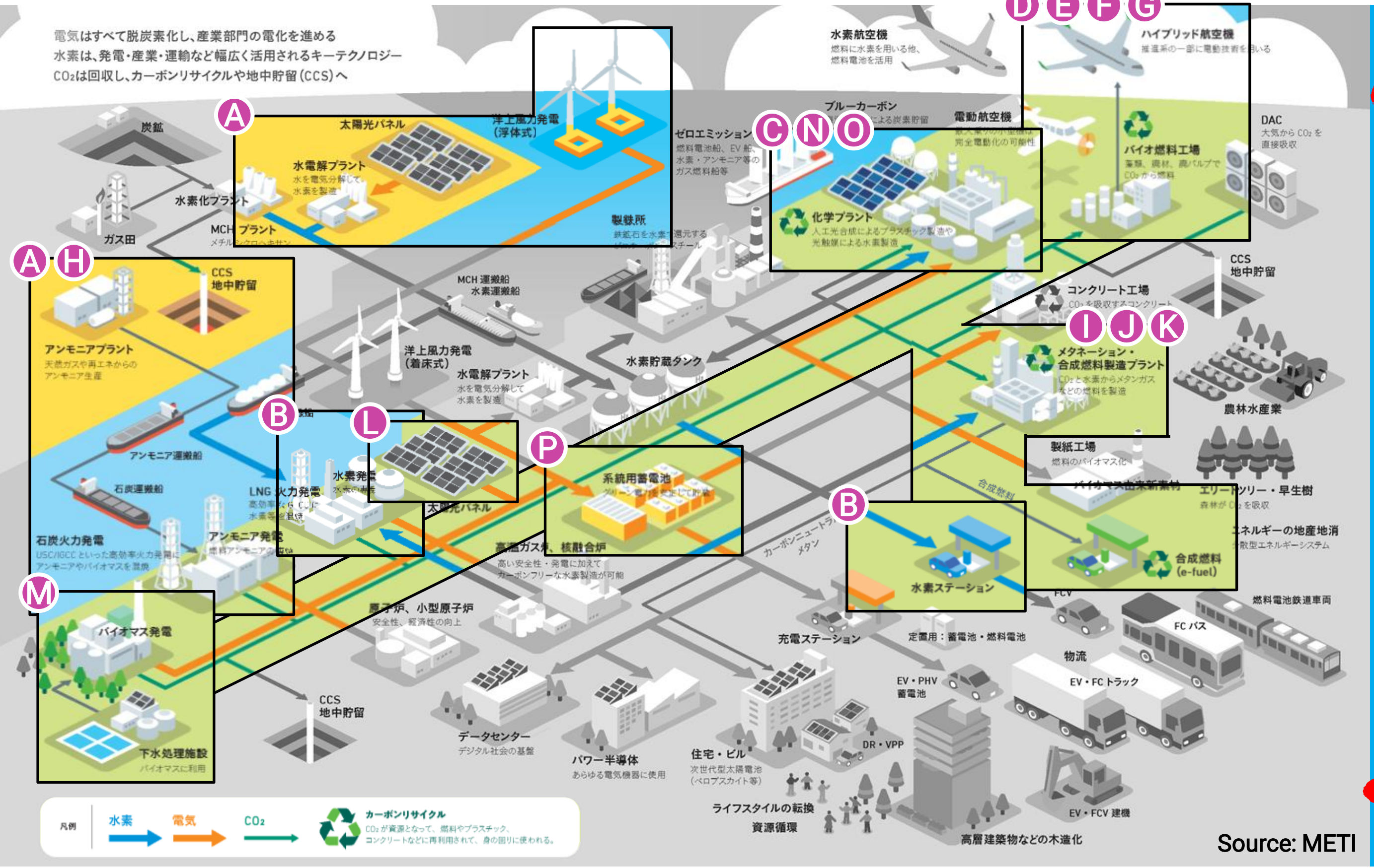
Introduction (2/3): Mission of T-Next[1] and the CN Business Division[2]

Understand and implement technologies and businesses beyond the framework of existing organizations



1. Next-Generation Technology & Application Division
2. Carbon Neutral Business Division

Introduction (3/3): TOYO's Activities for a Carbon Neutral Society



Source: METI

Clean NH_3/H_2

- Ⓐ Blue/Green NH_3
- Ⓑ NH_3 Cracking
- Ⓒ Artificial Photosynthesis

SAF

- Ⓓ Gasification/FT
- Ⓔ Alcohol to Jet
- Ⓕ Power to Liquid
- Ⓖ Bioethanol

CCUS

- Ⓗ CO_2-EOR/CCS
- Ⓘ g-Methanol®
- Ⓙ e-Fuel
- Ⓚ Methanation

Renewable Energy

- Ⓛ Solar Power
- Ⓜ Biomass Power

Energy Saving/Recycling

- Ⓝ SUPERHIDIC®/HERO
- Ⓞ Feedstock/Recycled PET
- Ⓟ Redox Flow Battery

Today's content

1. Status of development of fuel ammonia and hydrogen businesses
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2. Status of development for turning post-consumer plastics into recycled feedstock for petrochemicals

Investment highlights

A) Ultra-long-term growth market

Coal-fired power generation, marine shipping and hydrogen carriers (gas-fired power generation/FCV, etc.) will be approx. 1 billion tons/year in 2070

B) Overwhelming track record

Constructed more than 86 ammonia plants and 48 ammonia tanks

C) Entering the fuel value chain business

Pursuing EPC, income and capital gains through joint capital investment (reinforcement of profit structure)

D) Development of domestic receiving infrastructure

First develop commercial ammonia distribution and infrastructure, then expand to hydrogen applications (long-term use)

E) Creation of new demand

Conduct demonstration of the fuel conversion of naphtha crackers by 2030.
Potential demand in Asia: 100 million tons/year

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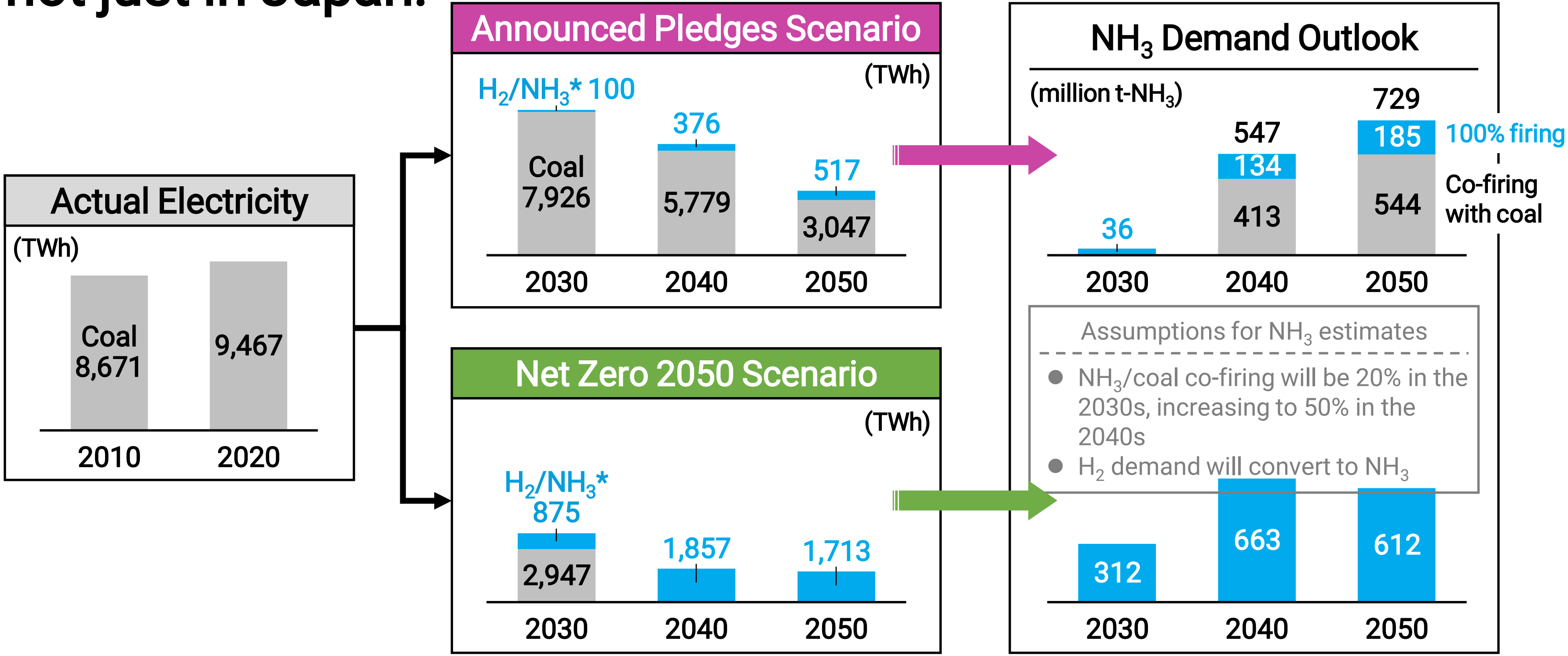
Coal-Fired Power Generation Outlook (Global)

Demand for NH_3 fuels is expected to increase globally, not just in Japan.



Source: IEA World Energy Outlook 2021

*H_2/NH_3 = 100% full conversion only, not including co-firing with natural gas or coal

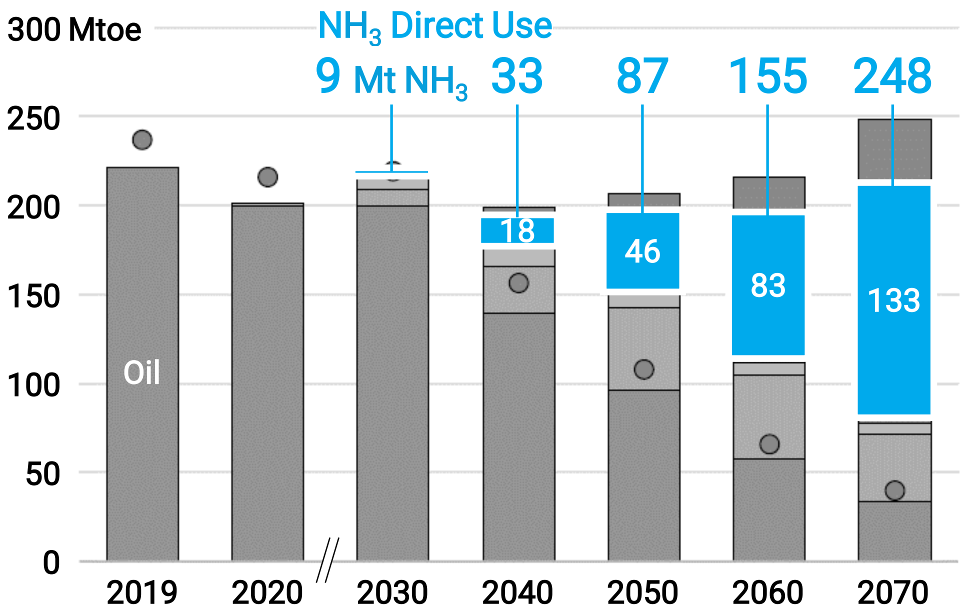
Shipping Fuel Outlook

NH_3 fuel is the mainstream for decarbonizing ships

NH_3-fueled Ships

Under development
for commercialization in the late 2020's

NH_3 Shipping Fuel Demand Outlook



Source: NYK Line, MOL, IEA Energy Technology Perspective 2020 (Link)

Comparison of Hydrogen Carriers

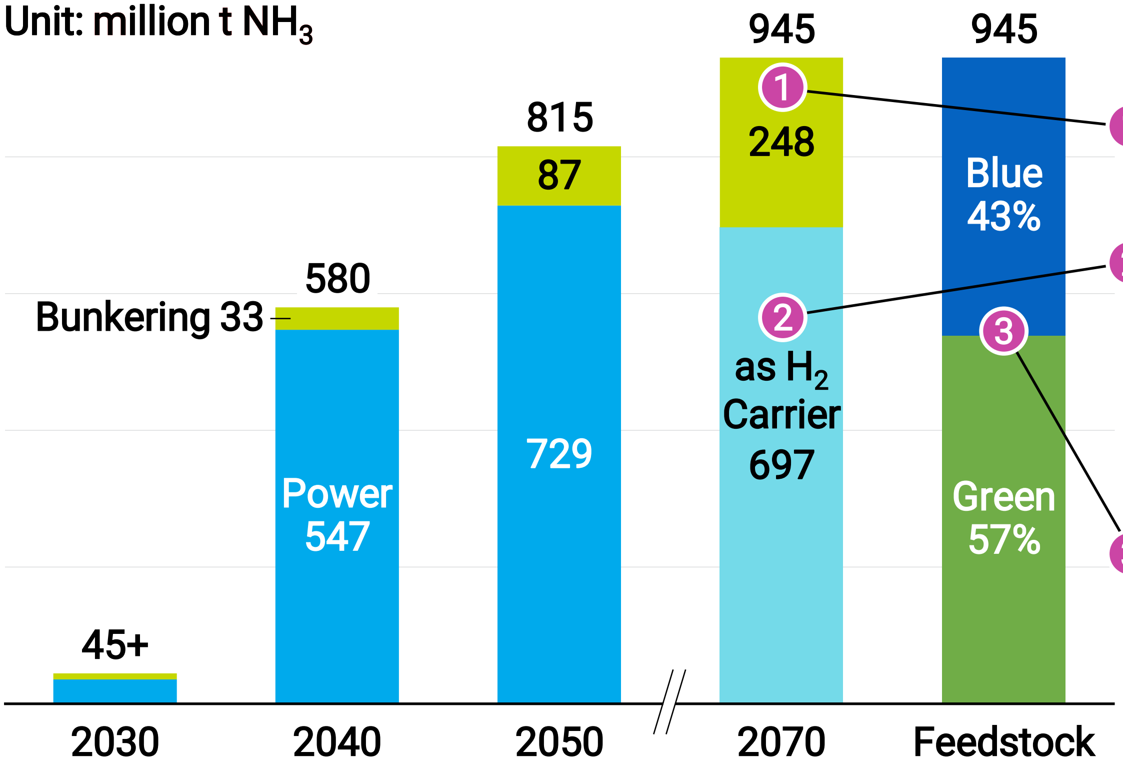
NH_3 dominates in terms of hydrogen density, maturity of transport and storage technology, and cost

	NH_3 (Direct Use)	H_2 Carrier		
		NH_3	Liquefied H_2	MCH
Heating Value	GOOD 9.41 MJ/Nm³	EXCELLENT 10.88 MJ/Nm³	EXCELLENT 10.88 MJ/Nm³	EXCELLENT 10.88 MJ/Nm³
Condition in Transportation	PROVEN -33 °C	PROVEN -33 °C	UNDER DEVELOPMENT -253 °C	PROVEN Normal Temp.
Efficiency in Transportation	HIGH 121 kg H_2/m^3	HIGH 121 kg H_2/m^3	MIDDLE 70.6 kg H_2/m^3	LOW 47.3 kg H_2/m^3
Cost to Japan[1]	LOWEST	LOW Approx. 5.5 USD/kg H_2	HIGH Approx. 7 USD/kg H_2	MIDDLE Approx. 6 USD/kg H_2

1. Cost of delivering hydrogen or ammonia produced via electrolysis from Australia to an industrial customer in Japan in 2030, IEA's The Future of Hydrogen

Long-term Fuel NH_3 Demand Outlook

NH_3 demand will expand to about 1 billion tons by 2070



Source: TOYO Analysis based on IEA reports

Assumptions

1 NH_3 direct use demand for bunkering is strong & firm

2 Hydrogen society will be realized by 2070
- 30% of H_2 is transported by sea, the same as LNG currently
- NH_3 as an H_2 carrier is superior to other H_2 carriers

3 Blue and Green will coexist
- Green has location issues especially in Asia
- Blue will be zero-emission with cheap gas and CCUS

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Features of TOYO

Business partner that contributes to the social implementation of clean fuel NH3

Global Leading Engineering Partner

Total HO Workers **5,700**

Overseas Workforce **75%**

×

Highly Experienced NH_3 Professional

NH_3 Plant Projects **86**

NH_3 Tank Projects **48+**

×

Decarbonization Engineering Pioneer

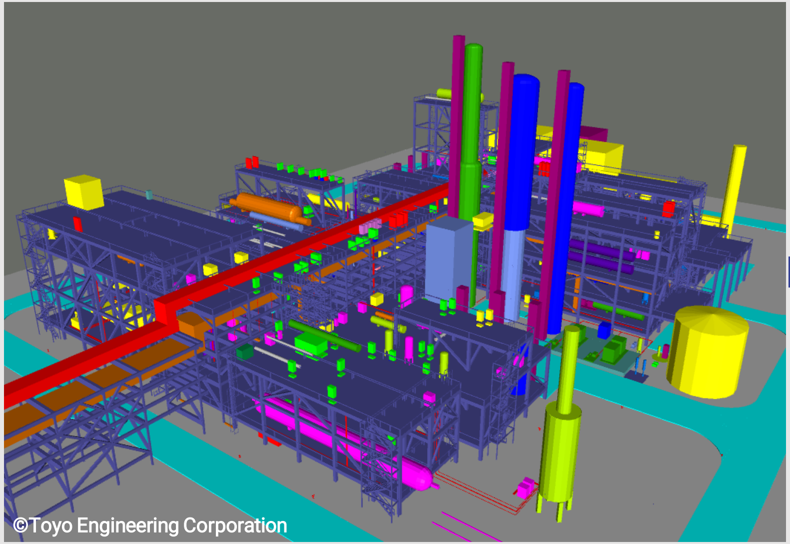
BIO RE Plant Projects **1.4GW**

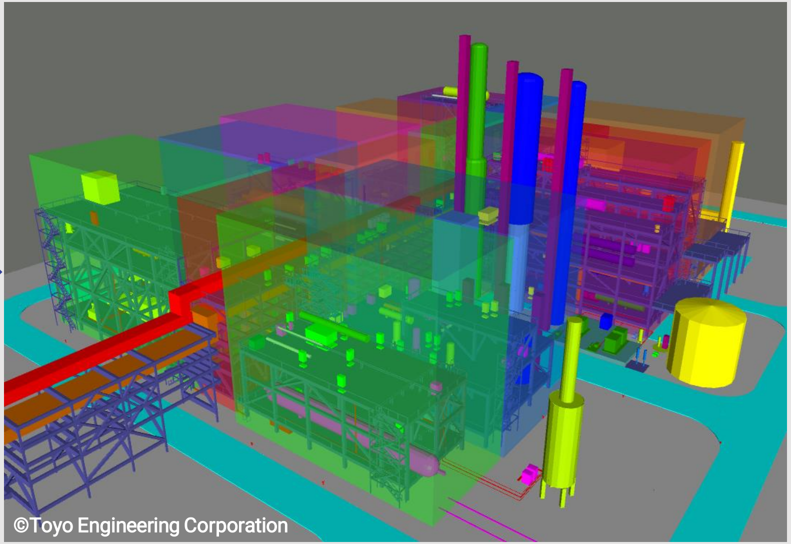
CO_2-EOR/CCS Since **the 80s**

Mission: Engineering for Sustainable Growth of the Global Community

Developed 3D model & BOQ for 3,000 MTPD modularization

3,000 MTPD NH_3 module

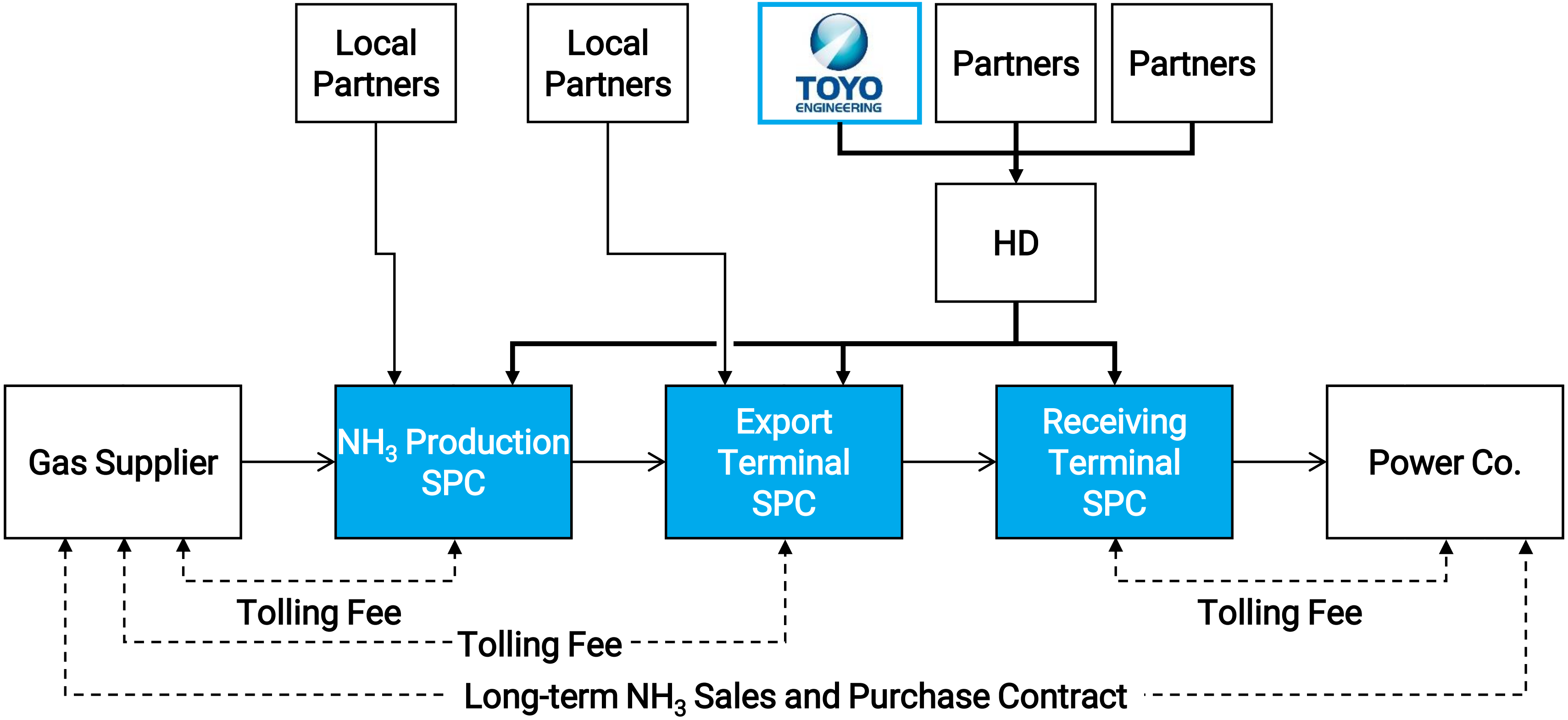




Evaluated the design of 6,000 MTPD NH_3 plant, and become ready for FEED

Structure (Example)

TOYO will co-invest in a receiving terminal as owner's Eng'g



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TOYO's Ongoing H_2/NH_3 Projects

Developing 30+ projects with various partners worldwide

TOYO, PIHC and PIM have signed a collaboration agreement regarding a feasibility study for Green NH_3 production in Indonesia

Introduction of PIHC

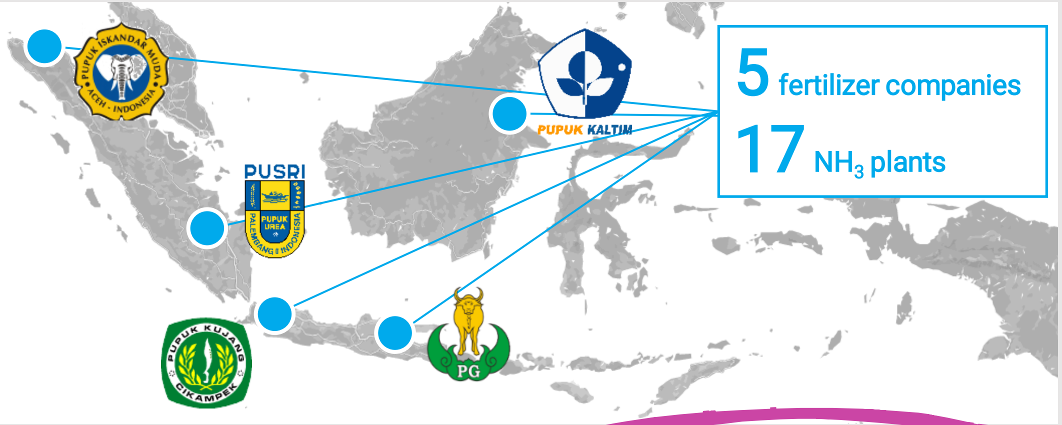
World-class agrochemical and food conglomerate

1970
Established

100%
State-Owned

5.3 billion USD
Income

NH_3 Plant Locations



Production Capacity **7.3** million tpa

UNUSED Capacity **1.2** million tpa

▶ Now, transforming into a sustainable energy company

Source: PIHC

Unique Points of the Project

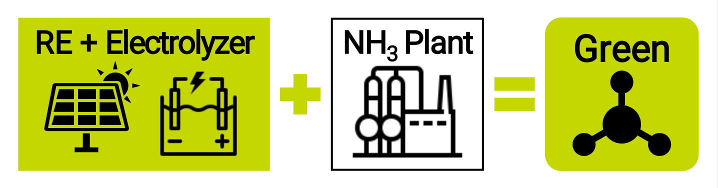
Increase the value of PIHC's existing assets for the achievement of carbon neutrality

QUICK

Utilize PIHC's existing facilities

→ Add electrolyzer to NH_3 plants

→ Get RE electricity from the grid

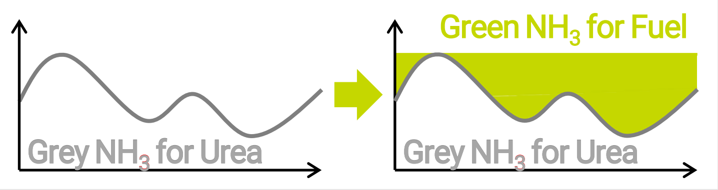


ECONOMIC

Minimize CAPEX and OPEX

→ Utilize unused NH_3 capacity

→ Level out annual NH_3 production

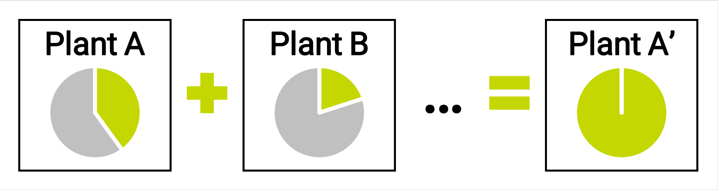


LARGE

Swap green value with other plants

→ Earn RE & Green NH_3 Certification

→ Virtually aggregate green NH_3



Alaska Blue NH_3 business

MOU signed with Alaska Gas Development Corporation, Hilcorp and Mitsubishi Corporation

LEADING ENERGY ORGANIZATIONS TO COLLABORATE ON COOK INLET AMMONIA PRODUCTION AND CARBON SEQUESTRATION ASSESSMENT

ANCHORAGE, AK (Oct. 4) – Today, the Alaska Gasline Development Corporation (AGDC) announced an agreement between leading energy organizations to assess the potential to produce zero-carbon ammonia in the Cook Inlet region of Southcentral Alaska.

The parties – AGDC, Mitsubishi Corporation, TOYO Engineering Corporation and Hilcorp Alaska – have signed a memorandum of understanding to evaluate the commercial feasibility of utilizing North Slope natural gas delivered to Southcentral Alaska via the Alaska LNG Project to produce carbon-free ammonia. The carbon dioxide generated from this process is able to be captured and sequestered in secure underground geologic formations, and Alaska's Cook Inlet basin has been identified by scientists as having world-class carbon sequestration potential. This assessment project will further define Cook Inlet's sequestration potential and the economics for producing clean ammonia alongside LNG in Alaska.

Ammonia emits no carbon dioxide when burned to produce energy, is rich in hydrogen, and is easier to transport than hydrogen. Ammonia is central to the zero-carbon energy strategies of nations across the Pacific Rim, including goals by Japan and Korea to become carbon neutral by 2050. Japan plans to grow ammonia use in energy production to three million tons per year by 2030, up from zero today.

In addition to Cook Inlet's carbon sequestration capabilities, the parties factored other unique Alaska advantages into the decision to initiate the ammonia assessment. Round-trip tanker transport from Alaska to key Asian markets is more than 12,000 miles shorter than from the U.S. Gulf Coast, reducing costs and shipping emissions. Alaska delivered a 45-year record of success exporting LNG to Asia.

Interview with Alaska Governor about the development of the Blue NH_3 business Cooperation confirmed

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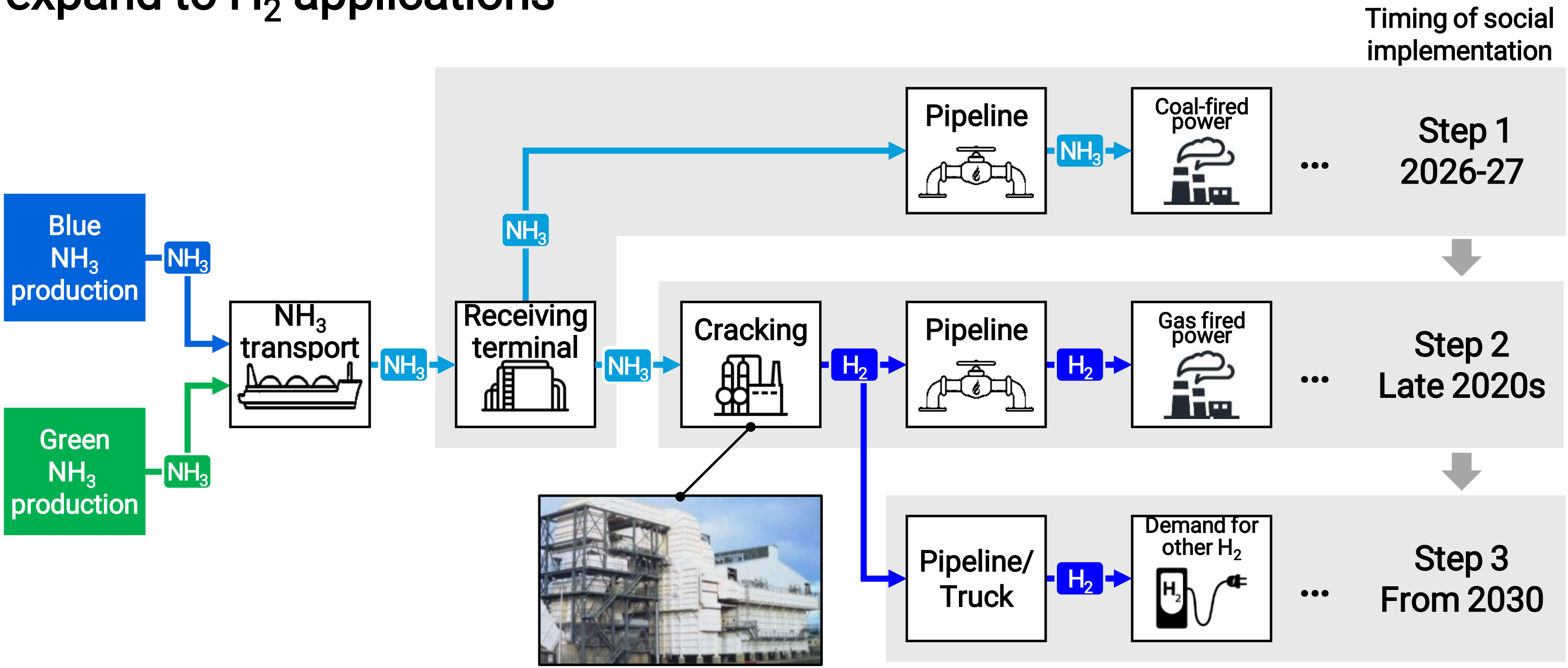
Domestic NH_3 Receiving Terminal (1/2): Infrastructure Development Steps

First, develop commercial distribution/infrastructure for NH_3 and then expand to H_2 applications



Domestic NH_3 Receiving Terminal (2/2): Contents of the Feasibility Study

Optimize OPEX and CAPEX based on needs/constraints/related technologies/laws

Input/discussion (examples)

NH_3 utilization plan
- GHG reduction targets
- Facilities subject to co-firing
- Co-firing rate
- Electricity demand
- Seasonal variation
- Demand from peripheral users

NH_3 procurement plan
- NH_3 supply
- Transportation route/day of navigation
- Possibility of joint procurement, etc.

NH_3 storage facility requirements
- Safe inventory
- Backup policy
- Possibility of joint possession, etc.

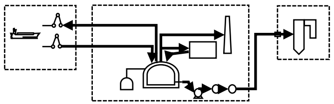
Existence/degree of constraint
- Available site
- Vessels capable of berthing, etc.

Trends in related technology development

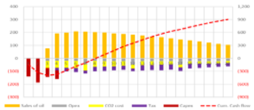
Trends in related laws and regulations

Output (examples)

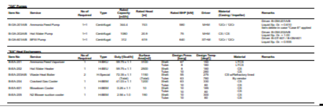
Block flow diagram



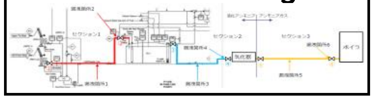
OPEX and CAPEX estimation



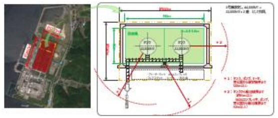
Equipment short specification



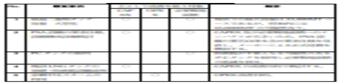
Analysis and countermeasures in case of leakage



Typical plot plan



Identify issues for implementation



Activities of the Clean Fuel Ammonia Association (CFAA)

As a member of the CFAA's Board of Directors, we will contribute to the implementation of ammonia in society

CLEAN FUEL AMMONIA ASSOCIATION

(13 board members)

TOKYO GAS
JGC
TOYO ENGINEERING
Marubeni
UBE
IHI
ITOCHU
MITSUBISHI HEAVY INDUSTRIES
SUMITOMO CHEMICAL
NYK LINE NIPPON YUSEN KAISHA
Mitsubishi Corporation
MITSUI & CO.
jera

Source: Clean Fuel Ammonia Association

Toward the Formation of Public Acceptance

A careful explanation of the definition, validity and response to risks is required

Q: What is NH_3? Is it dangerous?

→ Health hazards: It is classified as the lowest of the three as "Category 4: Hazardous if ilevels established by the Poisonous and Deleterious Substances Control Law. The MHLW Safety Data Sheet classifies acute toxicity nhaled," the second lowest of five levels.

→ Handling record: Though it must be handled by specialists, it has been used since the beginning of the 19th century and extensive experience has been accumulated by industry.

→ Benefits: In addition to being used as direct fuel (co-firing with coal-fired power generation, exclusive firing and bunkering), it is promising as a hydrogen carrier with a high hydrogen energy density and high economic potential.

Q: Is it safe in light of the fact that it is used for fuels (in large quantities) that are different from conventional chemicals (in small quantities)?

→ NH_3 is not handled by the public, but managed and handled under the supervision of specialists.

- Fuel NH_3 is expected to be imported in large quantities from overseas through receiving terminals.
- Combined combustion in coal-fired thermal power generation and transportation by pipeline/truck after H_2 conversion

→ CFAA will organize existing regulations and international trends in FY 2021 and consider necessary standardization.

- Tank: An ammonia version of the LNG storage tank guidelines in the High Pressure Gas Safety Law, Electric Utility Law, etc. is necessary.
- Other facilities: Prevention of leakage in the design stage and prompt detection and response in the operation and maintenance stages are essential.
- Risk Assessment: Need to determine both disaster scenarios and criteria within reasonable limits.

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Selection of Naphtha Decomposition Furnaces in Japan as a Target Related to the Energy Consumption of the Petrochemical Industry

Segment analysis

Conversion to ammonia fuel is easy, and Naphtha crackers in Japan are selected as a target because there is significant latent demand is large

- It is assumed that electrification will proceed in areas where the price of renewable energy is low.
- On the other hand, Japan assumes that ammonia fuels will dominate in electrification because of the high cost of renewable energy and geographical constraints.

Likelihood of ammonia fuel conversion by heat source and region in the petrochemical industry

Scale of the heat source (Large → Small)		Europe	Middle East Africa	North America South America	Asia	Japan
Large	Naphtha cracker	electrification	electrification	electrification	NH_3	NH_3
	Purification system	electrification	electrification	electrification	NH_3	NH_3
	Reaction system	electrification	electrification	electrification	NH_3	NH_3
	Compression system	electrification	electrification	electrification	NH_3	NH_3
Small	Transport system	electrification	electrification	electrification	NH_3	NH_3

Target overview

The potential demand for ammonia as a fuel for naphtha crackers in Japan is about 8 million tons per year.

- Fuel ammonia required per ton of ethylene plant production capacity: 1.34 tons (on a 100% fired basis) (1)
- Production capacity of ethylene plants: 6.16 million tons (based on consideration of fixed repairs) (2)
- Annual demand for fuel ammonia: 1 x 2 = 8.25 million tons

Note: Assuming all naphtha crackers are converted to ammonia fuel by 2050

TOYO's target market share: over 50% as the Leader in 2050

Reference: Production capacity of ethylene plants in Japan (based on consideration of fixed repairs)*50-sound order

Source: Petrochemical Industry Association

Idemitsu Kosan	99.7
ENEOS	40.4
Osaka Petrochemical	45.5
Keiyo Ethylene	69.0
Showa Denko	61.8
Tosoh	49.3

Tonen Chemical	49.1
Maruzen Petrochemical	48.0
Mitsui Chemicals	55.3
Mitsubishi Chemical	48.5
Mitsubishi Chemical Asahi Kasei Ethylene	49.6
Total	616.2

Reference: Potential demand in Asia is about 100 million tons per year.
(ethylene plant production capacity of approximately 76 million tons in 2022 * 1.34 tons)

Source: METI, Future Global Petrochemical Product Supply and Demand Trends (General Summary)

Creating/Expanding Businesses with Integrated Value Chains from Production of Fuel Ammonia until Naphtha Crackers

Value provided to society and customers

Decarbonization of naphtha crackers and the balancing of economic efficiency

- CO_2 reduction targets: Zero by 2050
- Ethylene production costs considering carbon pricing: Equivalent to current fossil fuels

Reference: Carbon Pricing Outlook (Source: IEA)

- 2025: 75 USD/ton
- 2030: 130 USD/ton
- 2040: 205 USD/ton
- 2050: 250 USD/ton

Relationship between business model overview and R&D plan

Make → Transport → Use

Novelty and efficacy

- Development of ammonia burners
- Optimization of energy use in ethylene plants
- Extensive experience in naphtha cracker EPC

Uniqueness and continuity

- Self-development of upstream interests
- Advanced carbon neutralization
- Construction of a stable supply network

Petrochemical companies (Naphtha cracker owners)

NH3 supply

Reward

EPC

Reward

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- production, transportation and sales of blue and green ammonia
  - Joint business development with partners
  - Invest as a business operator and participate in the project.
  - Construct the entire value chain

Engineering(EPC)

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- Burner renovation
- New construction and remodeling of crackers

Re-published: Investment Highlights

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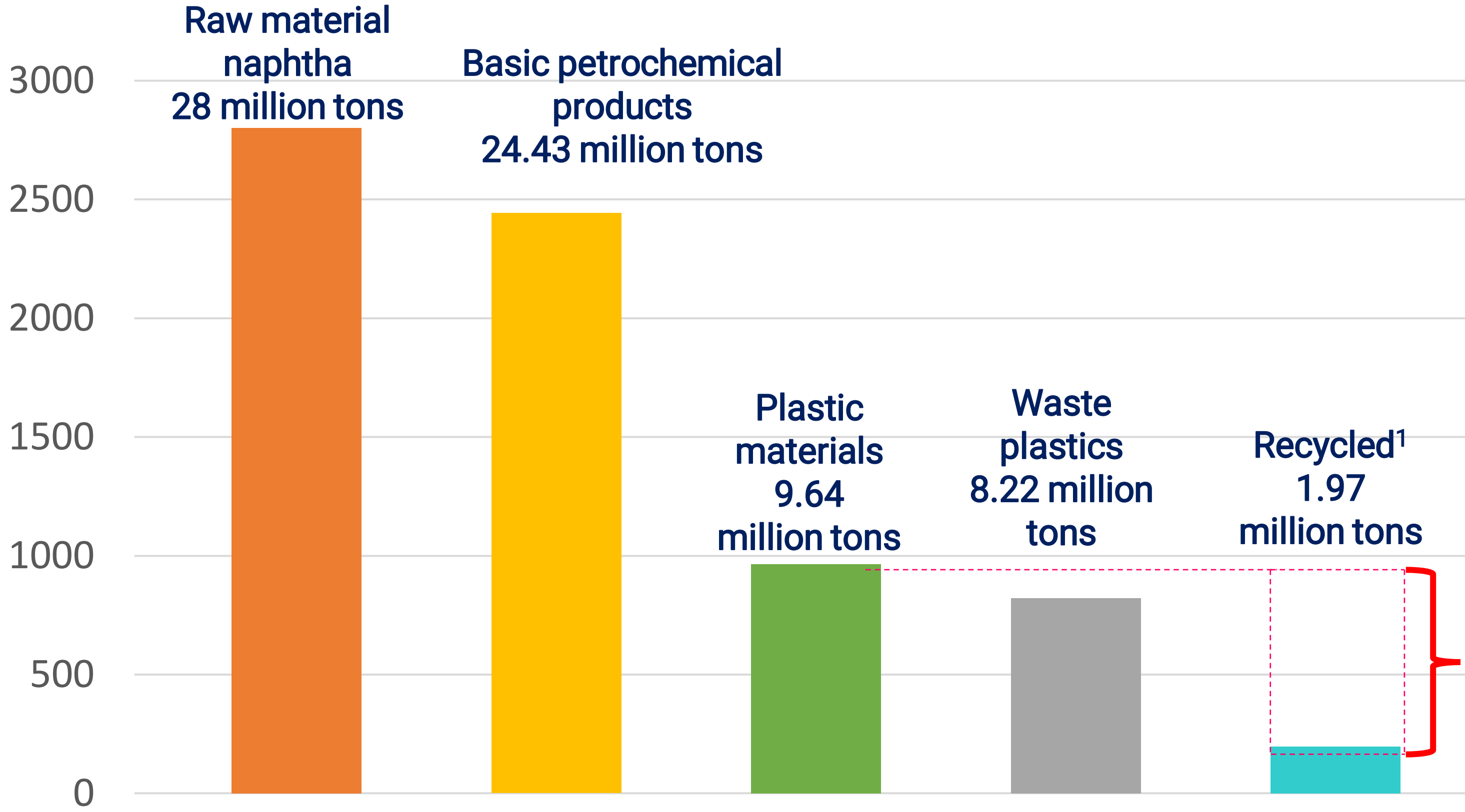
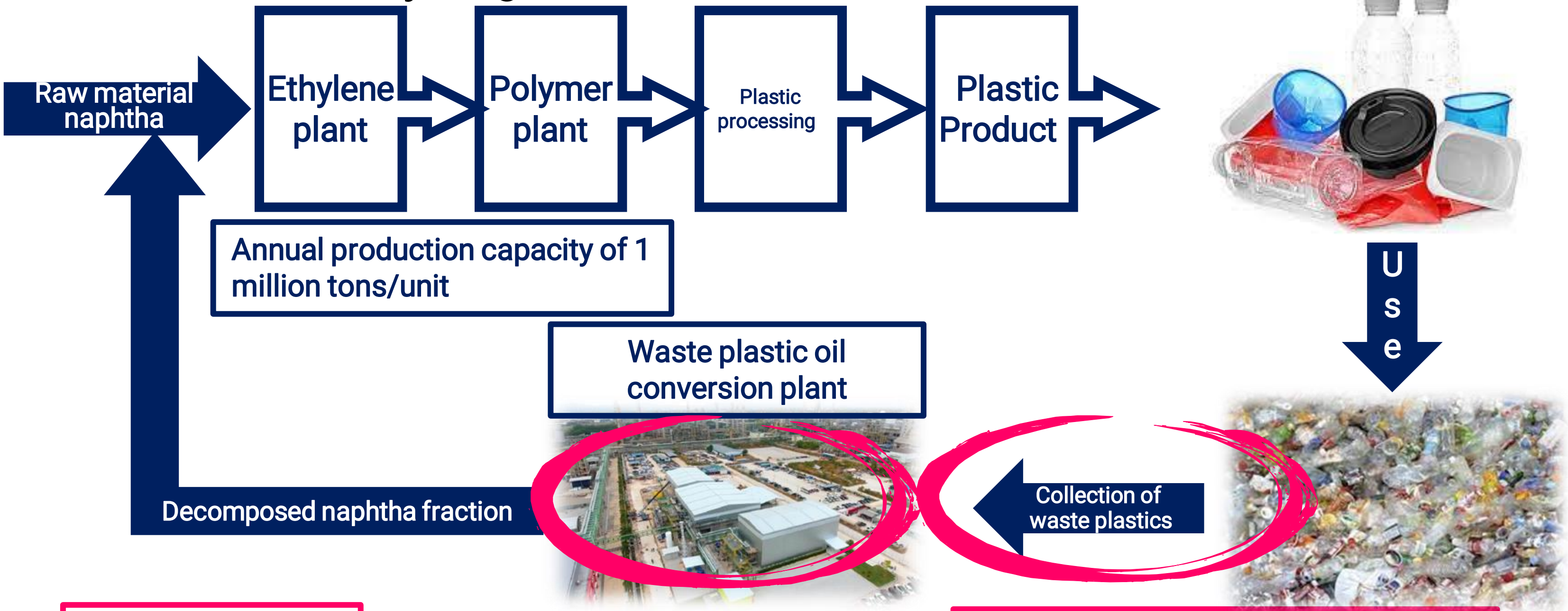
Mass Balancing of Plastics in Japan



9.64-1.97 = 7.67 million tons of waste to be recycled.
As the volume of recycled plastic increases, the consumption of raw material naphtha decreases, reducing by-product hydrocarbons such as off-gas (methane), by-product fuel oils and aromatics (gasoline-base materials).

1. Material recycling and chemical recycling

Waste Plastics Recycling: First Mile and the Scale of Oil Conversion Plants



Technical issues

Issue 2: Larger plants Establishment of large-scale thermal decomposition equipment

Social system issues

Issue 1: First mile system for collecting individual waste plastics from society

Joint Collaboration for Process Improvement for Turning Post-Consumer Plastics into Recycled Feedstock for Petrochemicals in Thailand (press release in January 2022)

SCGC CIRPLAS+

Photo: Demonstration plant for the advanced recycling process

- SCG Chemicals, Thailand, in a petrochemical plant
- Amount processed: 4,000 t/year (on a product basis)
- Completed in January 2021 and commenced operation

TOYO ENGINEERING

- ✓ Technical expertise and experience gained through the engineering and construction of petrochemical plants
- ✓ System construction of upstream and downstream processes and total optimization

↓

- ✓ Improving the performance of existing demonstration plants
- ✓ Scale up to a commercial plant
- ✓ By optimizing for ethylene and polymer plants, increase production capacity for plastics derived from waste plastics

↓

- ✓ Expansion to other SCG Chemicals plants and external sales

Toyo Engineering Corporation

URL https://www.toyo-eng.com

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