



IChE-NR, IIT-Delhi & FAI TOYO's Carbon Neutral Business Activities & Green Ammonia

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1. Introduction-TOYO's Carbon Neutral Business



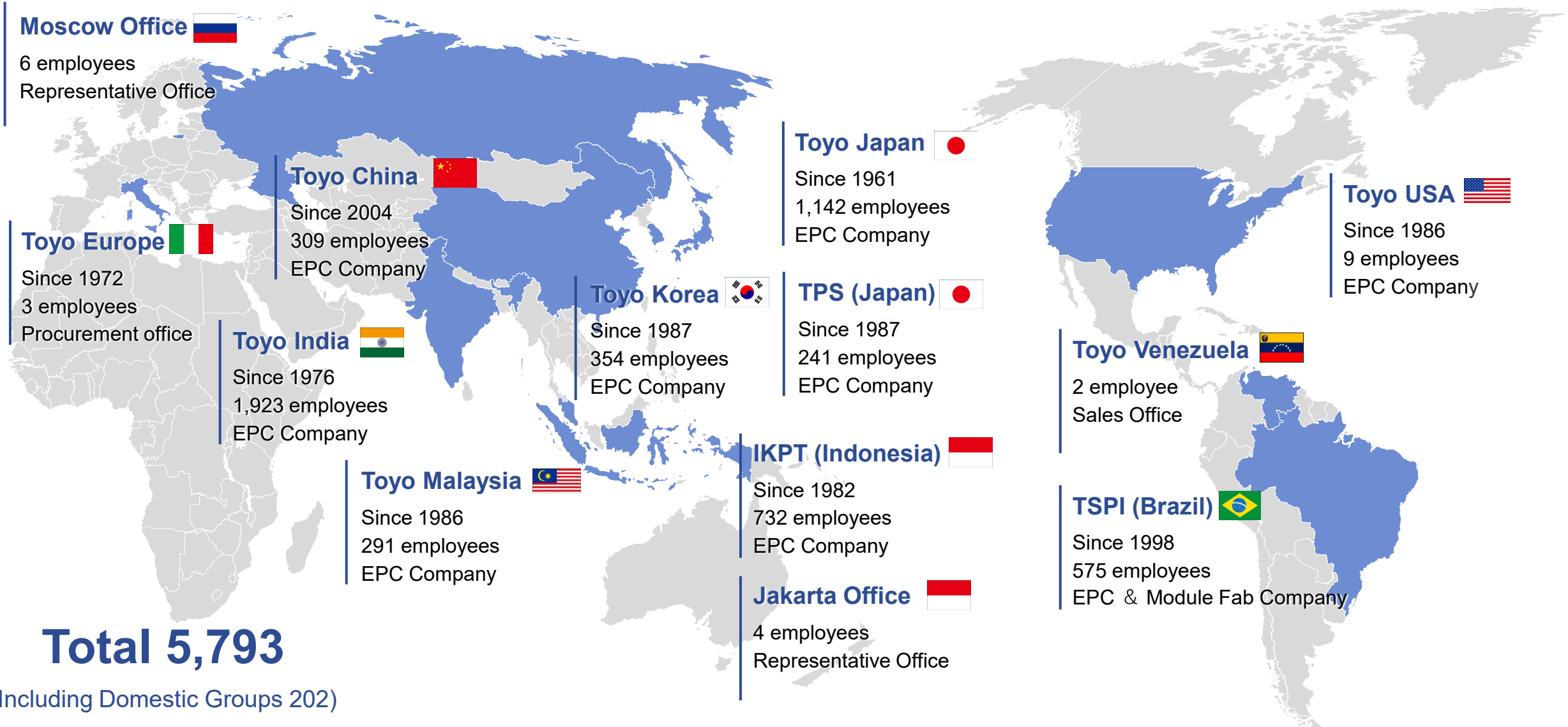
TOYO ENGINEERING CORPORATION

Corporate Profile

- Established** : May 1, 1961
- President & CEO** : Haruo Nagamatsu
- Listed** : The Prime section of Tokyo Stock Exchange
- Offices** : Head Office (Chiba) & Tokyo Head Office
- Capital Stock** : US\$ 0.16 Billion



TOYO Group Overview



Total 5,793

(Including Domestic Groups 202)



TOYO's Business Fields

Process Plants

- Oil & Gas Production
- FPSO / Offshore Platform
- Gas Processing
- LNG
- GTL
- Petroleum Refinery
- Aromatics
- Petrochemicals
- Polymers
- Fertilizers / Chemicals

Non-Process Plants

- Power Plants
 - Combined Cycle
 - Conventional Steam
 - Renewable Power (Photovoltaic, Biomass & Geothermal)
 - Nuclear
- Transportation
 - Railway
 - Urban Transportation
- Environmental
 - Effluent Water & Gas Treatment
 - Waste Material Treatment
- Pipeline
 - Water Treatment
 - Water Treatment
 - Desalination
 - Waste Water Treatment
- Utility Facilities
- Pharmaceutical
- Plant
 - Fine Chemicals
 - Agriculture / Food Plant
 - Flavor / Fragrance

TOYO Energy Transition Roadmap

Social Implementation Levels → High



NEDO Bio Jet Fuel technology development project (2020)

Short-term(2020-2022)

- ✈ Bio Jet Fuel Demonstration
- ✈ Technology Development of using CO₂ Feedstock
- ♻ Study of CO₂ capture/value chain
- ♻ CO₂ Free Methanol (g-Methanol™)
- Engineering development
- 🌱 Study of value chain
- 🌱 Engineering Implementation of CO₂ Free NH₃ technology

Middle Term(2022-2025)

- ✈ Bio Jet Fuel scaleup & commercialization
- ✈ CO₂ Reduction route social demonstration
- ♻ CO₂ value chain technology demonstration
- ♻ g-Methanol® plant social demonstration
- 🌱 Value chain demonstration
- 🌱 Small scale supply demonstration

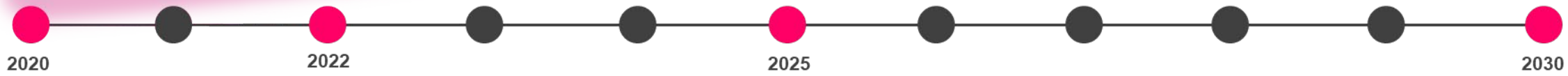
SAF Implementation

CO₂ Value Chain

CO₂ Free NH₃

Long Term(2025-2030)

- ✈ Bio Jet Fuel social wide-spreading
- ✈ CO₂ Reduction route commercialization
- ♻ CO₂ value chain (capture to CCUS)solution provision
- ♻ Next generation technology development (carbonate, DAC, etc.)
- 🌱 CO₂ Free NH₃ commercialization
- 🌱 NH₃ utilization technology expansion



SAF: Sustainable Aviation Fuel
FT synthesis: Fischer-Tropsch synthesis

The Energy Transition utilizing TOYO's Core Technologies

- Comprehensive design of SAF plant utilizing FT synthesis technology
- Syngas technology with Methanol Synthesis (MRF-Z® reactor)
- NH₃ plant technology through the 86 EPC NH₃ projects



Focus on Three Fields

- ✈ SAF Development
- ♻ CO₂ Value Chain
- 🌱 CO₂ free NH₃ chain

Business Alliance with JGC for Fuel Ammonia Projects

Scope : Execution of EPC projects starting from FS and front-end engineering design (FEED) for (1) fuel-ammonia plants and (2) ammonia receiving terminals.

26 April 2022 ~



Strengths

- Extensive experience with KBR licensed ammonia plant
- 86 Track records



Strengths

- Extensive experience in the countries where the ammonia plants are being planned
- More than 20,000 projects in over 80 countries

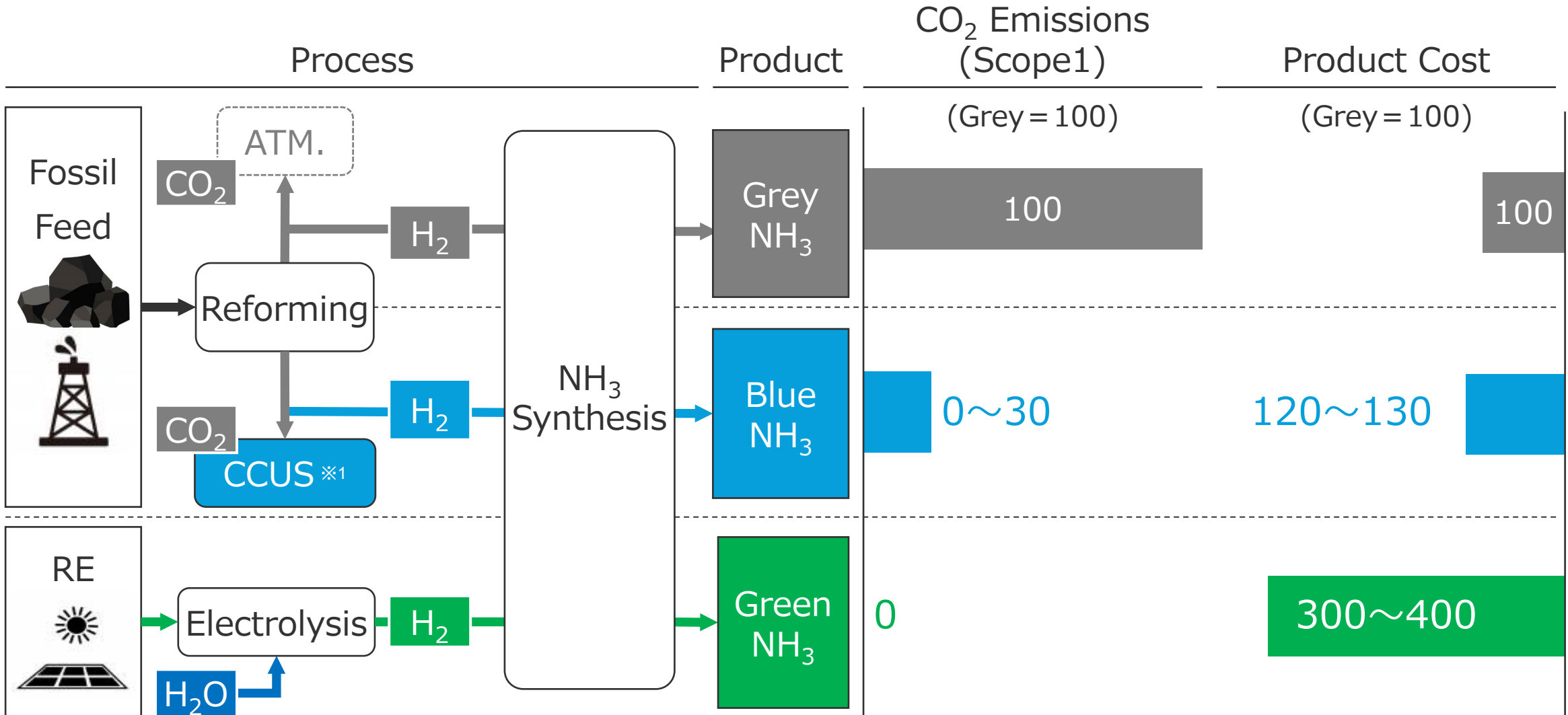
TOYO/JGC Ammonia Alliance can

- provide **one stop high value solution** from planning phase to EPC in a timely manner with KBR licensed ammonia process
- offer **the competitive proposal** based on the extensive experience of both parties

2. Definition and Overview of Blue / Green Ammonia

Color Classification, CO₂ Emissions and Estimated Costs

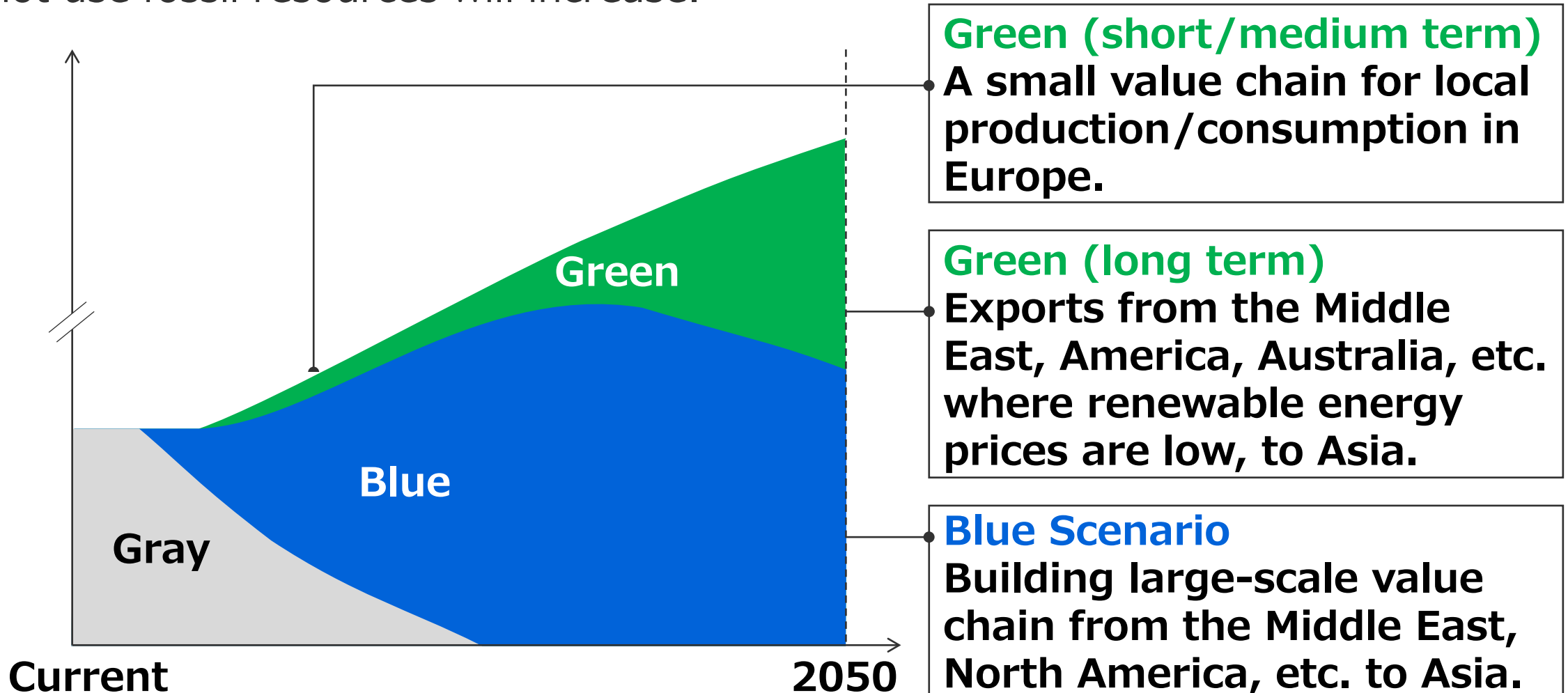
For the time being, cost-competitive "blue" ammonia will take the lead



※1 □ CCUS □ Carbon Capture, Utilization and Storage

Social implementation Image of Each Color

Blue ammonia will implement first, and then green ammonia, which does not use fossil resources will increase.



Source: Created by TOYO based on Center for Houston 's Future: Building a Houston Hydrogen Hub:

A Discussion with Hydrogen Council CEO Daryl Wilson (Feb.18, 2021)

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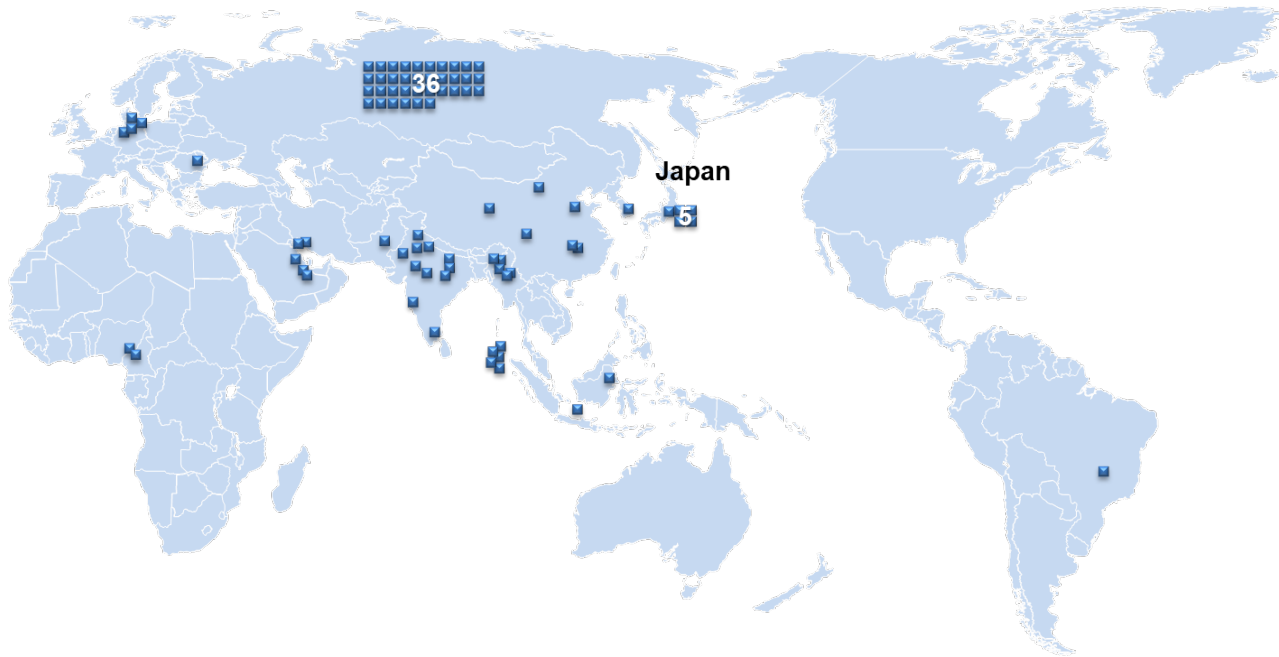
Your Success, Our Pride.

3. TOYO's Value to Ammonia Business

As Leading Contractor of Ammonia Plant

- 86 Project Experience
- 12 Project in India
- 13% Share of Ammonia Plant Market

- More Than 50 Years Continued Alliance with Top Licensor KBR.



KBR' Experience

- 77 Years Design Experience since 1943
- Maximum 3,300 MTPD Ammonia Capacity experience so far
- More than 50% of world's ammonia is produced using KBR's ammonia process
- Purifier Process has been licensed to 39 plants in 2019



TOYO's Experience

- Establishment of Toyo in 1961
- Start of Partnership with KBR in 1968
- Since 1969, Starting Ammonia EPC Contractor (Process Licensed by KBR)
- Continued Awards for more than 50 years
- Up to now TOYO's experience in ammonia plant including the plants based on our own and other processes amounts to 86 projects

26 April 2022 ~



<TOYO's Ammonia Experience as of June.2022>

Fuel Ammonia : TOYO's Recent Orders of Ammonia Plant

S/U Year	Country	OWNER	Capacity (MT/D)
2021	Nigeria	Indorama Eleme Fertilizer and Chemicals Limited(2nd Train)	2,300



Fastest start up record – only 11 days from NG feed-in to the 1st drop

2021	India	Hindustan Urvarak and Rasayan Ltd.	2,200
2019	India	Chambal Fertilizers and Chemicals Ltd.	2,200

Indorama Eleme Fertilizer and Chemicals Limited(1st Train)

World's most energy efficient ammonia plant 6.27Gcal/MT

2016	Nigeria	Indorama Eleme Fertilizer and Chemicals Limited(1st Train)	2,300
2015	Indonesia	P.T. Pupuk Kalimantan Timur	2,700



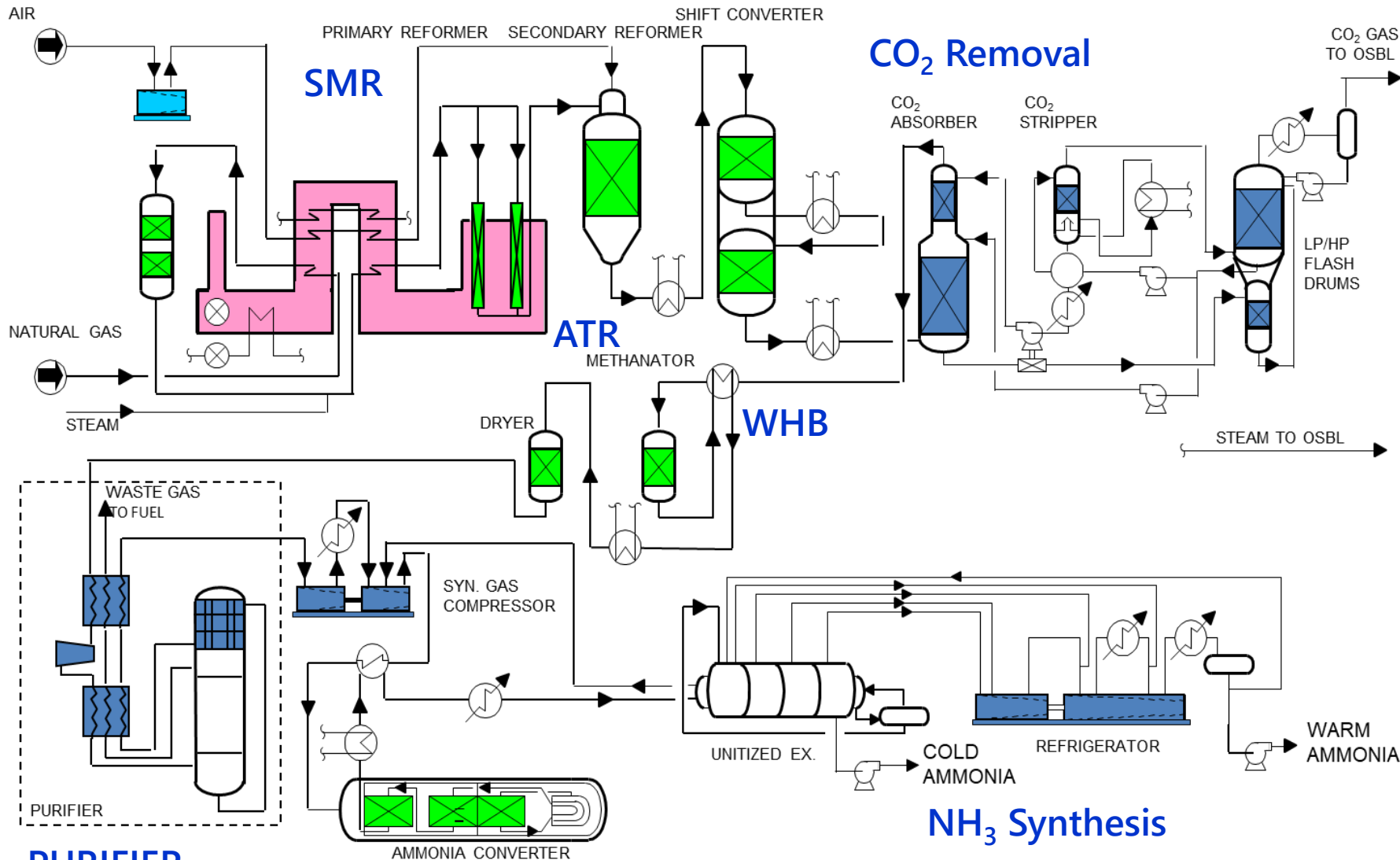
P.T. Pupuk Kalimantan Timur

KBR – Purifier™ for 6000MTPD Ammonia Plant



- ▣ Oxygen Free Safety Process
- ▣ High Reliability and on-stream factors which has been demonstrated in worldwide commercial plants.
- ▣ All single equipment items throughout flowsheet (except installed spare water pumps):

- ▣ One Primary Reformer
- ▣ One Secondary Reformer without metallic burner
- ▣ One Waste Heat Boiler
- ▣ One CO₂ Absorber, HP/LP Flash Column & Stripper
- ▣ One Methanator
- ▣ One Purifier unit – No Purge Gas Recovery Unit
- ▣ One Synthesis Loop
- ▣ One each of each air compressor, refrigeration Compressor & Synthesis Compressor
- ▣ One Unitized Chiller
- ▣ All exchangers in single unit
- ▣ One ammonia converter



PURIFIER

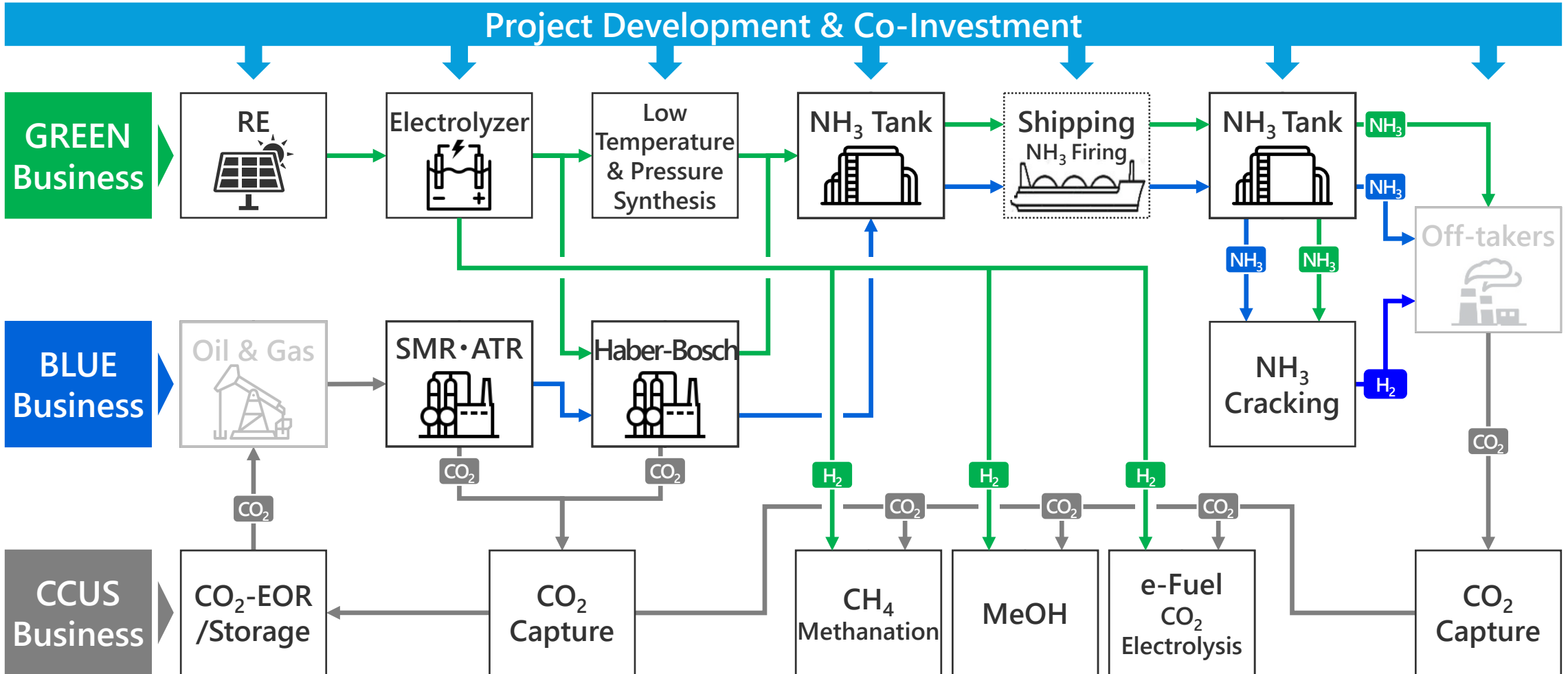
NH₃ Synthesis

4. TOYO's Approach to Blue / Green Ammonia

TOYO's Approach to Blue / Green Ammonia

Building an entire value chain initiated by technologies

TOYO's Coverage
 Complemented by Partnering



Definition of Low carbon Ammonia

Definition has not been standardized yet in EU, US, and Japan



60% + ※1

Defined by
CertifHy Project

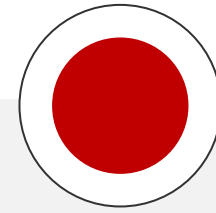
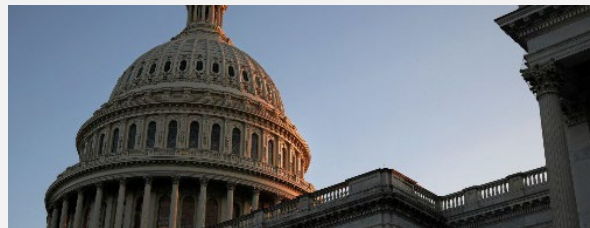


May become stricter



83% + ※2

Defined by Bipartisan
Infrastructure Law,
Infrastructure Investment
and Jobs Act



N/A

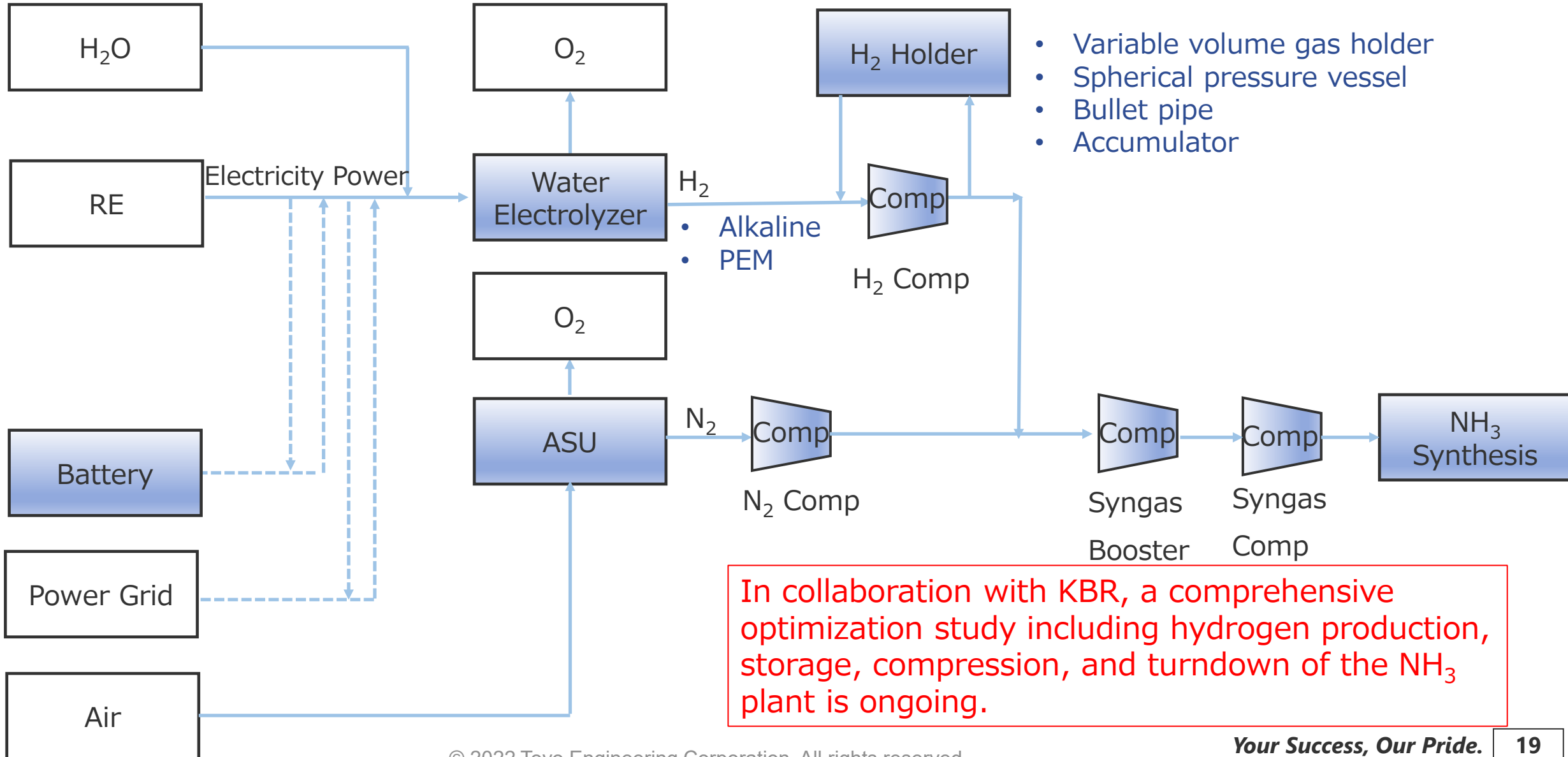
Under discussion
at CFAA
(CLEAN FUEL
AMMONIA
ASSOCIATION)

※1 : CO₂ capture rate compared to H₂ production by natural gas reforming: GO labels - CertifHy CERTIFICATION SCHEMES, <https://www.certifyhy.eu/go-labels/>

※2 : Suppressing CO₂ emissions to 2 kg or less during the production of 1 kg of H₂ : Congressional Research Service, Energy and Minerals Provisions in the Infrastructure Investment and Jobs Act, <https://crsreports.congress.gov/product/pdf/R/R47034>

Optimization of Green Ammonia Process

Study target



Challenges for Green Ammonia Production

- Hydrogen production cost from RE
 - ✓ Hydrogen production cost – current 8.8USD/kg \Rightarrow 2030: 2.7USD/kg \Rightarrow Future target: 1.8USD/kg
 - Improvement of RE power generation cost
 - Improvement of hydrogen production efficiency and equipment cost of water electrolyzer
 - ◆ Hydrogen production efficiency: PEM 50-83 \Rightarrow <45kWh/Kg @2050 / AEC 50-78 \Rightarrow <45kWh/Kg @2050
 - ◆ Equipment cost: PEM 700-1,400 \Rightarrow <200USD/kW @2050 / AEC 500-1,000 \Rightarrow <200USD/kW @ 2050
- Response to fluctuation in hydrogen production due to fluctuation in RE
 - ✓ Ammonia synthesis process – absorbing renewable energy fluctuations by turning down the plant load
 - ✓ Battery - Low cost, upsizing
- Plant scale optimization
 - ✓ Plant scale in consideration with water electrolyzer, hydrogen storage capacity, etc.
 - ✓ Large scale vs small scale - Large scale: 2,200 – 3,000 MTPD, MAX 6,000MTPD
Small scale: <50MTPD
 - ✓ Small scale case - Optimization of synthetic pressure by developing new catalyst

Summary

- As Leading Contractor of Ammonia Plant, TOYO has extensive experience with KBR licensed ammonia plant.
- For Green Ammonia, it is important to optimize green system configurations and plant turn down operation for reducing production cost.
- TOYO will provide high value solution for entire value chain of Blue / Green Ammonia.



TOYO
ENGINEERING

Thank you