Development of Clean Fuel Ammonia Value Chain

23/07/2024

Clean Fuel Ammonia Association

Clean Fuel Ammonia Association

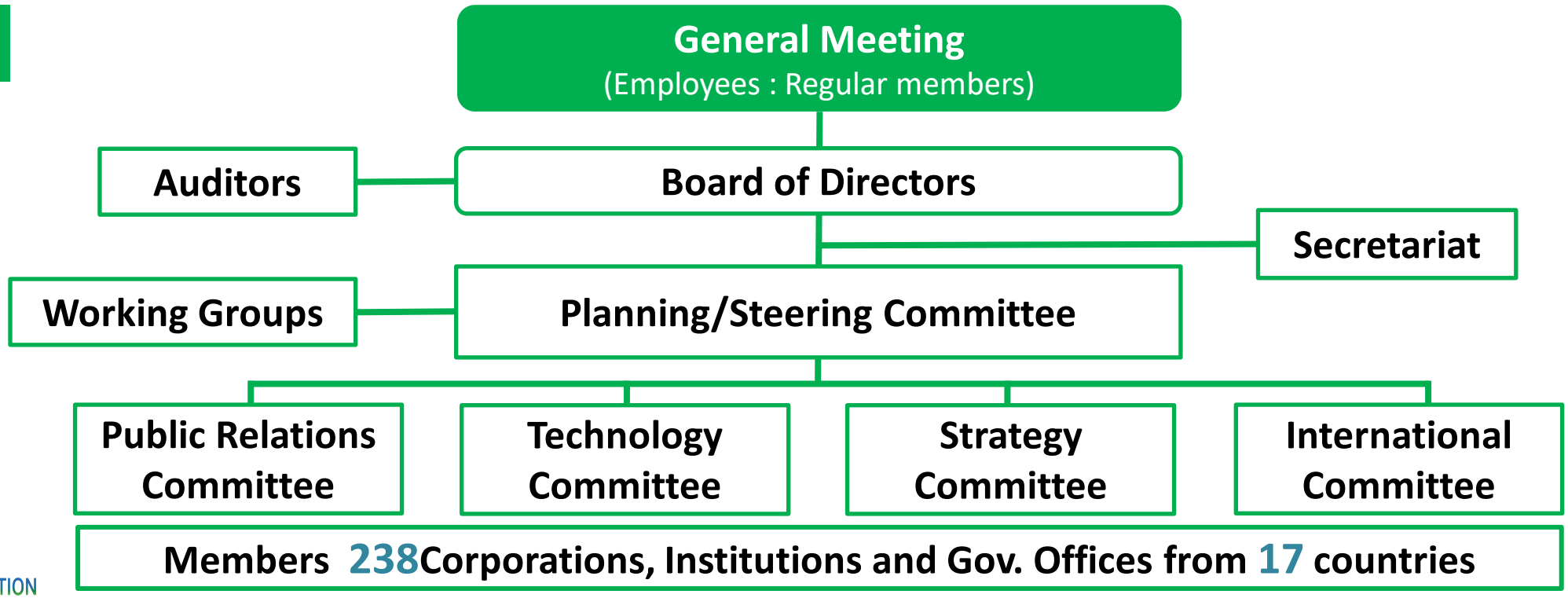
Establish

Apr. 1, 2019 Green Ammonia Consortium
Jan. 14, 2021 Clean Fuel Ammonia Association

Key Objectives

- Implementation of clean fuel ammonia value chain
- Promotion of policy and regulations
- Coordination of RD&D activities
- International relationship and collaboration

Organization



Member List of Clean Fuel Ammonia Association

As of July 16 , 2024

[Board Member] 15 companies

- Idemitsu Kosan
- IHI
- ITOCHU
- JERA
- JGC
- Marubeni Corporation
- Mitsubishi Corporation
- Mitsubishi Heavy Industries
- Mitsui Chemicals
- MITSUI & CO.
- MUFG Bank
- NYK Line
- SUMITOMO CHEMICAL
- Tokyo Gas
- Toyo Engineering

[General Member] 140 companies

- ABE NIKKO KOGYO
- AGC
- Air Water Inc.
- AISAN INDUSTRY
- Aramco Asia Japan
- Asahi Kasei
- Asahi Tanker
- BP Japan
- Cataler
- Central Tank Terminal
- Chiyoda
- Chubu Electric Power Company
- CHUGAI RO
- CLEARIZE
- ConocoPhillips Japan
- Cosmo Engineering
- Cosmo Oil
- Daihatsu Diesel
- DAIICHI JITSUGYO
- Diamond & Zebra Electric Mfg
- EBARA
- Electric Power Development
- ENEOS
- Emerson Japan
- Fuji Car Manufacturing
- Fuji Electric
- Fuji Oil
- FUKUI SEISAKUSHO
- GYXIS
- HANWA
- HAZAMA ANDO
- HIROSHIMA GAS
- Hitachi Industrial Products
- Hitachi Zosen
- Hokkaido Electric Power
- Hoku energy
- Hokuriku Electric Power Company
- HORIBA
- IINO KAIUN
- INFLUX
- INPEX
- ISHII IRON WORKS
- Iwatani Corporation
- Iwatani Gas
- Japan Oil Engineering
- Japan Oil Transportation
- Japan Petroleum Exploration
- JFE Engineering
- JFE Steel Corporation
- JGC Catalysts and Chemicals
- Kajima
- Kawasaki Kisen Kaisha
- Kawasaki Heavy Industries
- KOBELCO WIRE COMPANY
- KOBE STEEL
- Kowa Company
- Kyushu Electric Power
- LRQA Limited
- MAEDA CORPORATION
- Maruzen Petrochemical
- Mitsubishi Electric
- MITSUBISHI GAS CHEMICAL
- Mitsubishi Materials
- Mitsui E&S
- Mitsui O.S.K. Lines
- Mitsui Sumitomo Insurance
- Mizuho Research & Technologies
- N.E. CHEMCAT CORPORATION
- NGK INSULATORS
- NICHIAS
- NIKKISO
- Nikki-Universal
- Nippon Kaiji Kentei Kyokai
- Nippon Kaiji Kyokai (ClassNK)
- Nippon Kayaku
- Nippon Oil Pump
- Nippon Paper Industries
- NIPPON SHARYO, LTD.
- NIPPON SHOKUBAI
- NIPPON STEEL
- NIPPON STEEL PIPELINE&ENGINEERING
- NIPPON STEEL Stainless Steel
- NIPPON STEEL TRADING
- Niterra
- Nitto Denko
- Non-Destructive Inspection
- NRS CORPORATION
- NS UNITED KAIUN KAISHA
- OBAYASHI
- Okinawa Electric Power
- Osaka Gas
- OVAL Corporation
- Penta-Ocean Construction
- Planning and Design Center for Greener Ships
- Resonac Holdings
- Safar International
- Senko Line
- Shell Japan
- Shikoku Electric Power Company
- Shimadzu
- SHIMIZU
- SHIN NIHON KENTEI KYOKAI
- Shin Nippon Machinery
- Shinsho Corporation
- Sojitz
- SUMITOMO CORPORATION
- Sumitomo Mitsui Banking
- Sumitomo Mitsui Construction
- Suzuyo Shoji
- Taisei Corporation
- TAIYO NIPPON SANSO
- Takenaka
- TB Global Technologies
- TEIKOKU ELECTRIC MFG.
- The Chugoku Electric Power Company
- The Kansai Electric Power Company
- thyssenkrupp nucera Japan
- TOHO GAS
- Tohoku-Electric Power
- TOKYO ELECTRIC POWER SERVICES
- Toray Industries
- Torishima Pump Mfg
- TOYO KANETSU
- TOYOTA CENTRAL R&D LABS
- TOYOTA ENERGY SOLUTIONS
- TOYOTA INDUSTRIES
- Toyota Tsusho Corporation
- TSUKISHIMA KANKYO ENGINEERING
- TSUNEISHI SHIPBUILDING
- UBE Corporation
- Uyeno Transtech
- Vena Energy Japan
- VOLCANO
- Wärtsilä Japan
- Weathernews Inc.
- YANMAR HOLDINGS
- Yokogawa Electric

Member List of Clean Fuel Ammonia Association

As of July 16 , 2024

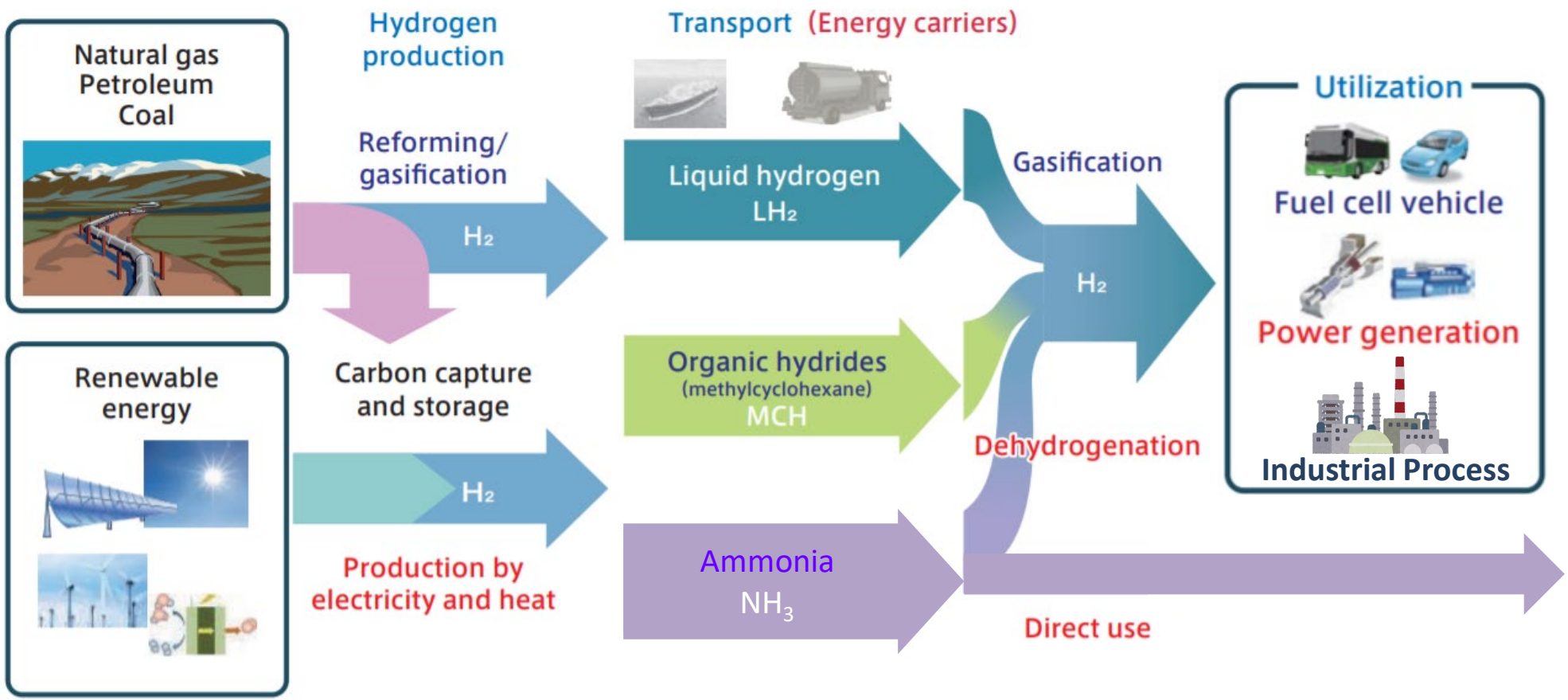
[Associate Member (foreign company)] 42 companies
ACME Cleantech Solutions Private Limited (IN)
Adani New Industries Limited (IN)
A-Enviro Chile GmbH – Austria Energy - (AUT)
AES Andes (CHL)
AMEA Power LLC (UAE)
Amogy Inc（US)
Argus Media Japan KK（JAP）
Avaada Green H2 Private Limited. (IN)
Baker Hughes (UK, US)
CF Industries (US)
Chevron New Energy International Pte.Ltd.(SIN)
Clean Hydrogen Works (US)
DNV (NOR)
Energy North Pty Ltd. (AUS)
Equinor ASA (NOR)
ExxonMobil LNG Market Development Inc.(US)
Fortescue Metals Group (AUS)
Green Hydrogen International Corp. (US)
Hexagon Energy Materials Limited (AUS)
Hygenco Green Energies Private Limited,（IN）
KBR,Inc.(US)
LSB INDUSTRIES (US)
Meridian Energy ltd（NZ）
Novatek Gas and Power Asia Pte. Ltd. (SIN)
NTPC Limited (IN)
NW interconnected Power Pty Ltd
(Asian Renewable Energy Hub) (AUS)
OCI N.V.（NLD）
Orica Limited（AUS）
Origin Energy Limited (AUS)
Pilot Energy Limited (AUS)
Purus Marine (UK)
Sasol South Africa Limited (S.A.)
SQM Industrial S.A. (CHL)
Stanwell Corporation (AUS)
The Hydrogen Utility (AUS)
THERMON IN (US)
TotalEnergies Japan S.A.(CHE)
Vopak Asia Pte Ltd（SIN）
UGL Pty Limited (AUS)
Welspun New Energy Limited (IN)
Woodside Energy (AUS)
Yara International ASA (NOR)

[Advisory Member] 4 persons, 41 institutions
Bunro Shiozawa (ex-SIP Deputy PD)
Kenichi Aika (ex-SIP Deputy PD)
Takeo Kikkawa (International University of Japan)
Tetsuro Hitoshi
Aichi Prefectural Government
Akita Industrial Technology Center
Alberta Japan Office (CA)
Ammonia Energy Association (USA)
Austrade Tokyo Office (Embassy)
Central Research Institute of Electric Power Industry
CSIRO (AUS)
Department of Science and Innovation (S.A.)
Electric Power Research Institute (USA)
Embassy of Canada to Japan
Embassy of Norway in Tokyo, Japan
Embassy of the Kingdom of the Netherlands
Embassy of the Republic of Korea in Japan
German Chamber of Commerce and
Industry in Japan (AHK Japan)
Government of Queensland (AUS)
Government of South Australia (AUS)
Government of Victoria(AUS)
Government of Western Australia (AUS)
Hokkaido Government
Ibaraki Prefectural Government
InvestChile (CHL)
Japan Bank for International Cooperation
Japan Coal Frontier Organization
Japan Fertilizer & Ammonia Producers Association
Japan Organization for Metals and Energy Security
Japan Ship Technology Research Association
National Institute of Advanced Industrial Science and Technology (AIST)
New Zealand Embassy, Tokyo, Japan
Niihama City
National Institute of Maritime, Port and Aviation Technology
Research Institute for Applied Sciences
Shin-Mutsu-Ogawara Inc.
SHUNAN CITY
The Australian Hydrogen Council(AHC) (AUS)
The High Pressure Gas Safety Institute of Japan
The Institute of Applied Energy (IAE)
The Institute of Energy Economics, Japan
The New Zealand Hydrogen Council (NZHC)(NZ)
THERMAL AND NUCLEAR POWER ENGINEERING SOCIETY
TOMAKOMAI CITY
YOKKAICHI CITY

[Honorary Member] 1 person
Osamu Ishitobi (Former Chairman)

[Associate Member (individual)] 7 persons
Fumiteru Akamatsu
Hideaki Kobayashi
Hirohumi Taba
Jyun Kubota
Norihiko Nakamura
Suguru Kimura
Yoshitsugu Kojima

Hydrogen Energy Carrier



Power Generation

Mix combustion in coal fired boiler

Gas turbine

Industrial

Furnace

Maritime

Deep-sea shipping

Transportation across the Ocean by H_2 Energy Carriers (Ammonia, LH_2, and Organic Hydride) from Australia to Japan, **Ammonia is likely the cheapest mechanism.**

("The Future of Hydrogen"; prepared by the IEA for the G20, Japan in 2019)

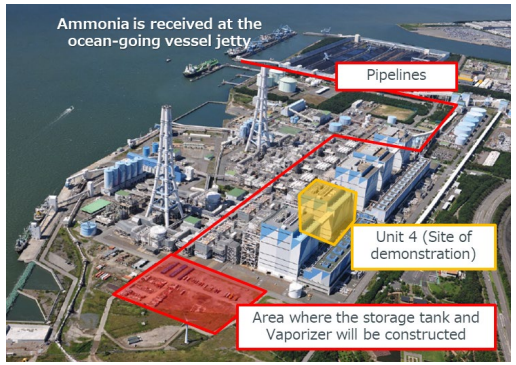
Why Ammonia

- Directly combusted without CO_2 emissions.
- Largest H_2 content among 3 carriers and most efficient in marine transportation.
  (NH_3 **121** kg-H_2/m^3 liquid , LH_2 71 kg-H_2/m^3 , MCH 47 kg-H_2/m^3)
- Large commercial supply chain is established, and cost structure is clear.
  (Global production: 200 million tons, International trade: 20 million tons)
- NOx emissions can be controlled by technologies.
  (Air-fuel ratio , Two staged combustion etc.)
- Technologies are becoming ready for commercial use.
- Safety standards are practically used in chemical and power industries.
- Primary markets are controlled facilities with trained operators such as power plant, industrial factories and data centers.

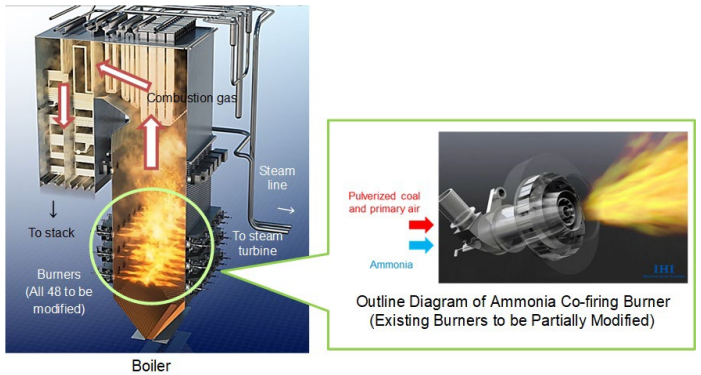
Key Technologies of Ammonia Utilization in the Energy Market

Combustion in Coal fired Boilers (IHI,MHI)

- 20 % firing is achieved.
- Over 50% - up to 100 %NH_3 firing is under development.
- Large Scale Demonstration(March-June 2024)
  (20 %NH_3 in 1 GW Coal Power of JERA)
- Feasibility Study with Malaysia, Indonesia, India, Thailand, Taiwan



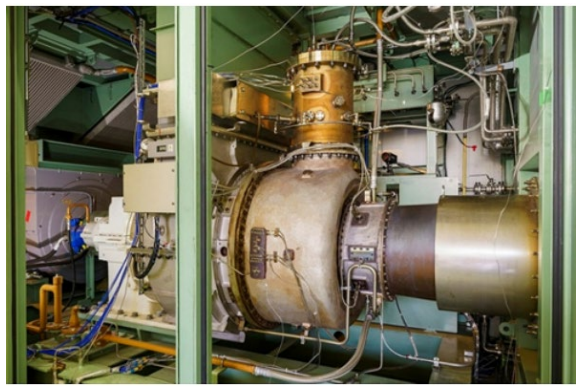
Provided by JERA



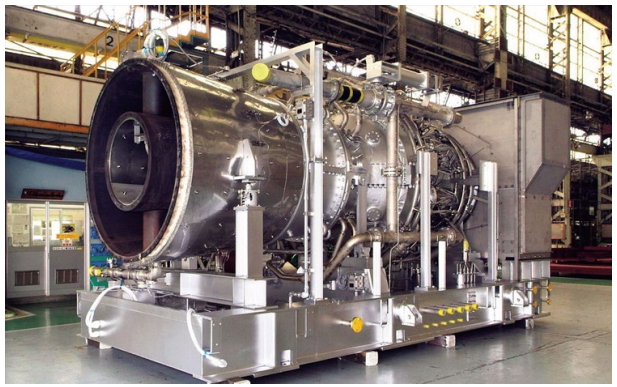
Provided by IHI

Gas Turbines (IHI, MHI)

- 2 MW-60 MW
  Development of NH_3 Single Fuel GTs by 2025
- 400 MW Class
  Developments of NH_3 Sigle Fuel System and H_2 Turbine with NH_3 Cracking System by 2030



Provided by IHI



Provided by ©Mitsubishi Heavy Industries, Ltd.

Key Technologies of Ammonia Utilization in the Energy Market

Industrial Furnaces (AGC, Taiyo Nippon Sanso)

- Development of NH_3 Single Fuel Glass Melting Furnace by 2025

Provided by AGC

Marine Diesel Engine (NYK, Japan Engine, IHI power system, Japan Shipyard)

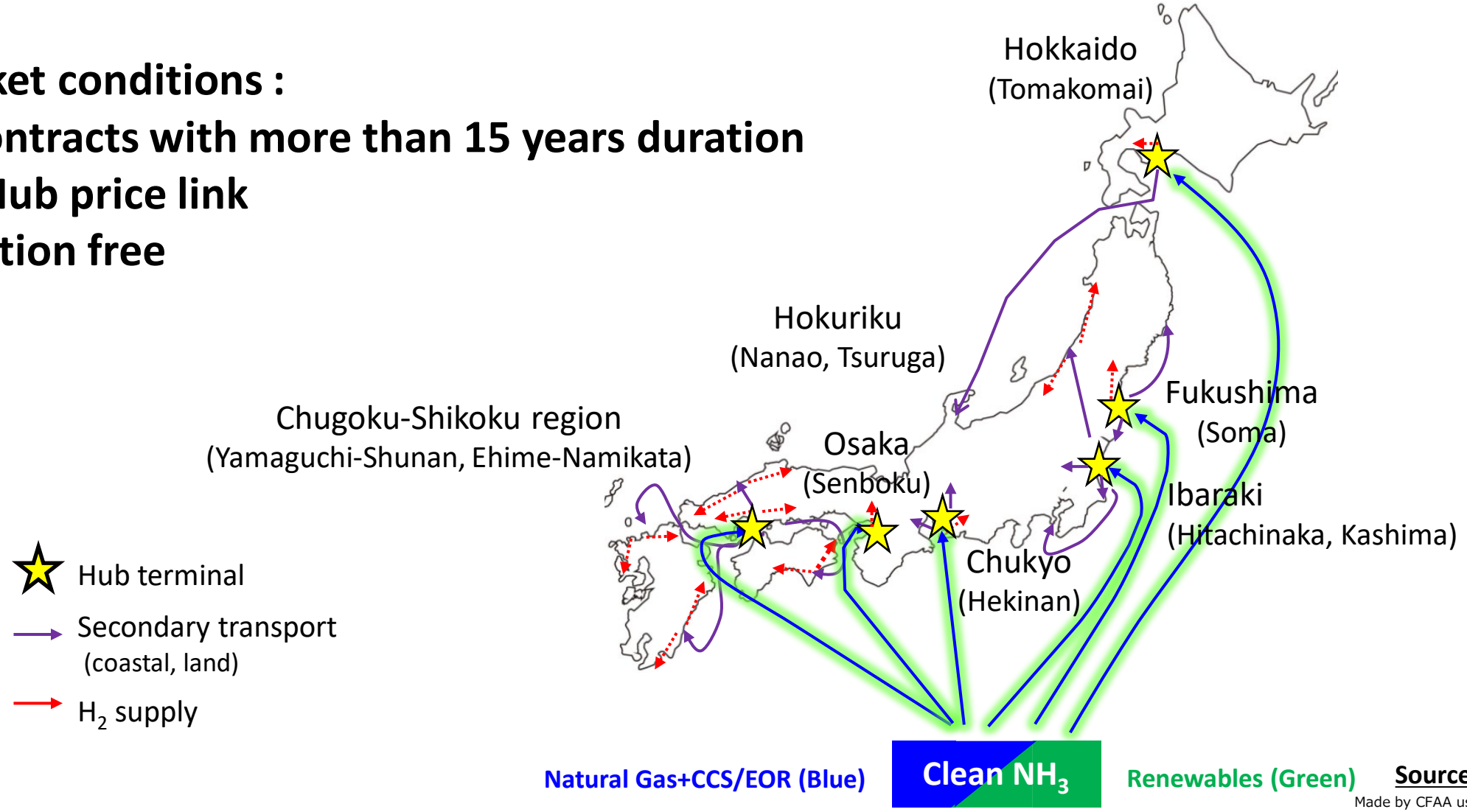
- Small 4 Stroke Engine by 2024
- Large 2 Stroke Engine by 2026
- NH_3 Engine Tugboat in 2024
- First NH_3 fueled NH_3 carrier is planned to be launched in Nov. 2026.

Provided by NYK

Fuel Ammonia Infrastructure Development in Japan
-Hub & Spoke System-

Key market conditions :

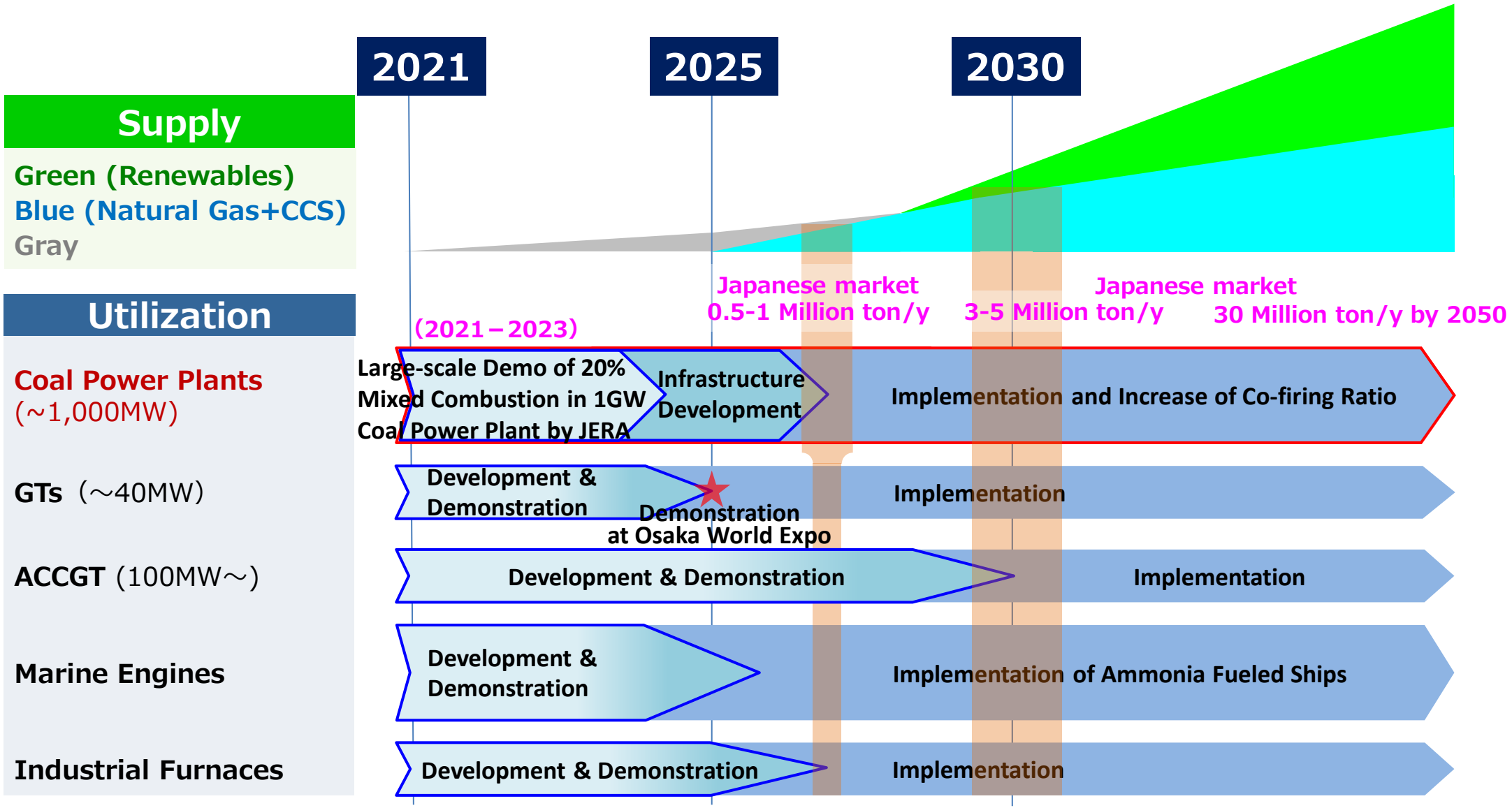
- **Term contracts with more than 15 years duration**
- **Henry Hub price link**
- **Destination free**



Source: CFAA

Made by CFAA using published information

Roadmap of Fuel Ammonia Value Chain



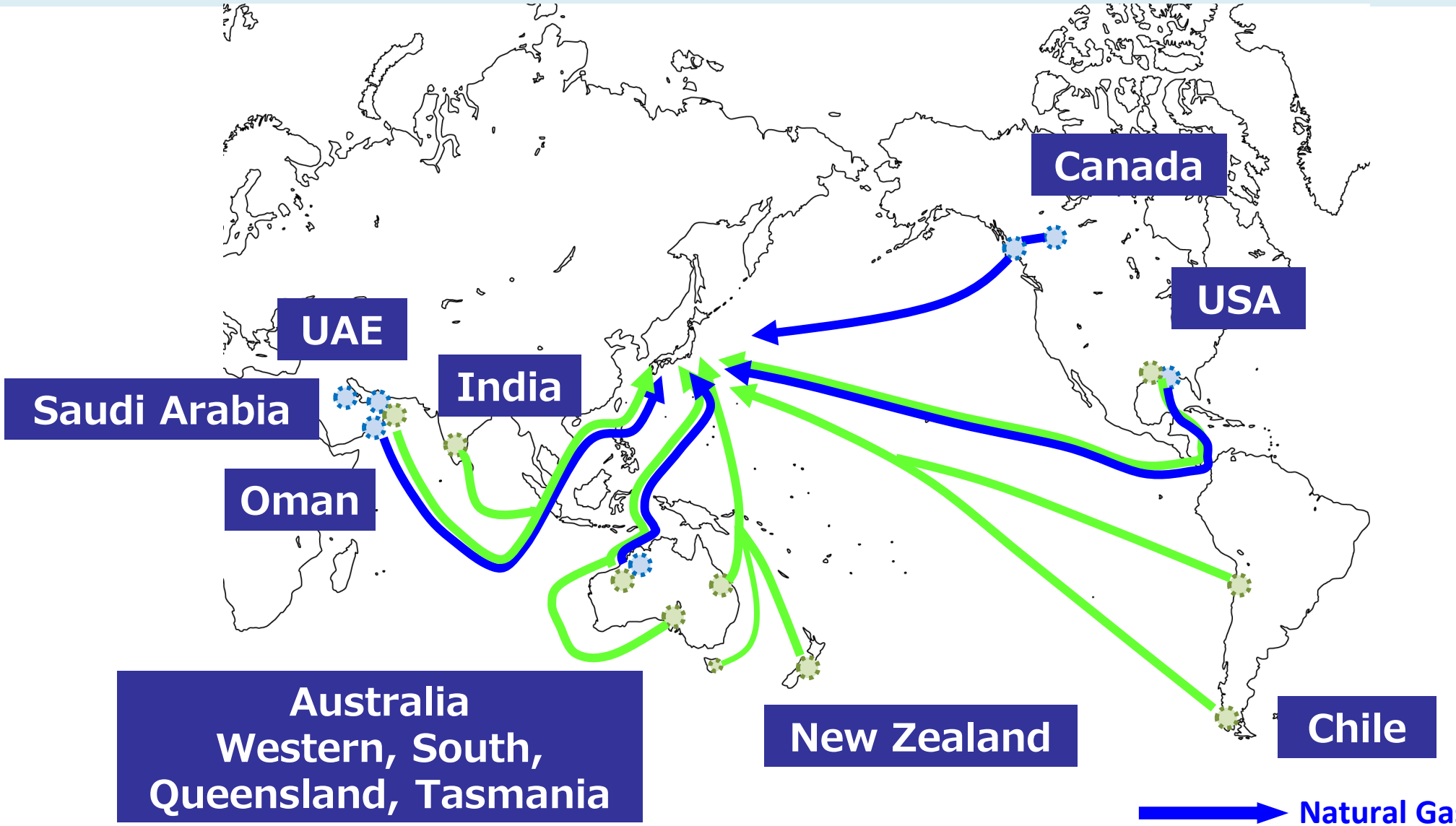
Expansion to Asian Power & Maritime Markets
Over 100 Million tons Supply Chain

CLEAN FUEL AMMONIA ASSOCIATION

Source: CFAA

Supply Chain

(Development of Dedicated Supply Sources for Fuel Ammonia)



Source: CFAA

Framework of GX Economic Transition Bond

- Japanese Gov. will issue ¥20 trillion ($130 billion) GX Bond for the next 10 years to promote over ¥150 trillion ($1 trillion) investments for decarbonization and economic growth.
- Over ¥7 trillion ($47 billion) is planned for the development of clean fuel supply chains and markets (Hydrogen, Ammonia, e-fuel, e-methane).
- From GX Bord, ¥3 trillion ($20 billion) will be allocated to subsidize price gap between clean fuels and replaced fuels for 15 years (¥200 billion, $1.3 billion/year).
  - Supply Security : 15 years + 10 years supply commitment with secure offtake agreements in Japan
  - Environment : Low carbon intensity (Well to gate, 0.87 kg-CO_2/kg-NH_3)
  - Economic Efficiency & Contribution to Decarbonization and Economic Growth : Cost transparency, Cost reductions, Presence of Japanese industries in supply chains
- ¥1 trillion ($6.7 billion) will be allocated to subsidize clean fuel market development (Infrastructures for introduction of clean fuels).

Thank you for your kind attention