Development of Clean Fuel Ammonia Value Chain

Aug. 16, 2023

Susumu Miyazaki
Clean Fuel Ammonia Association

Clean Fuel Ammonia Association

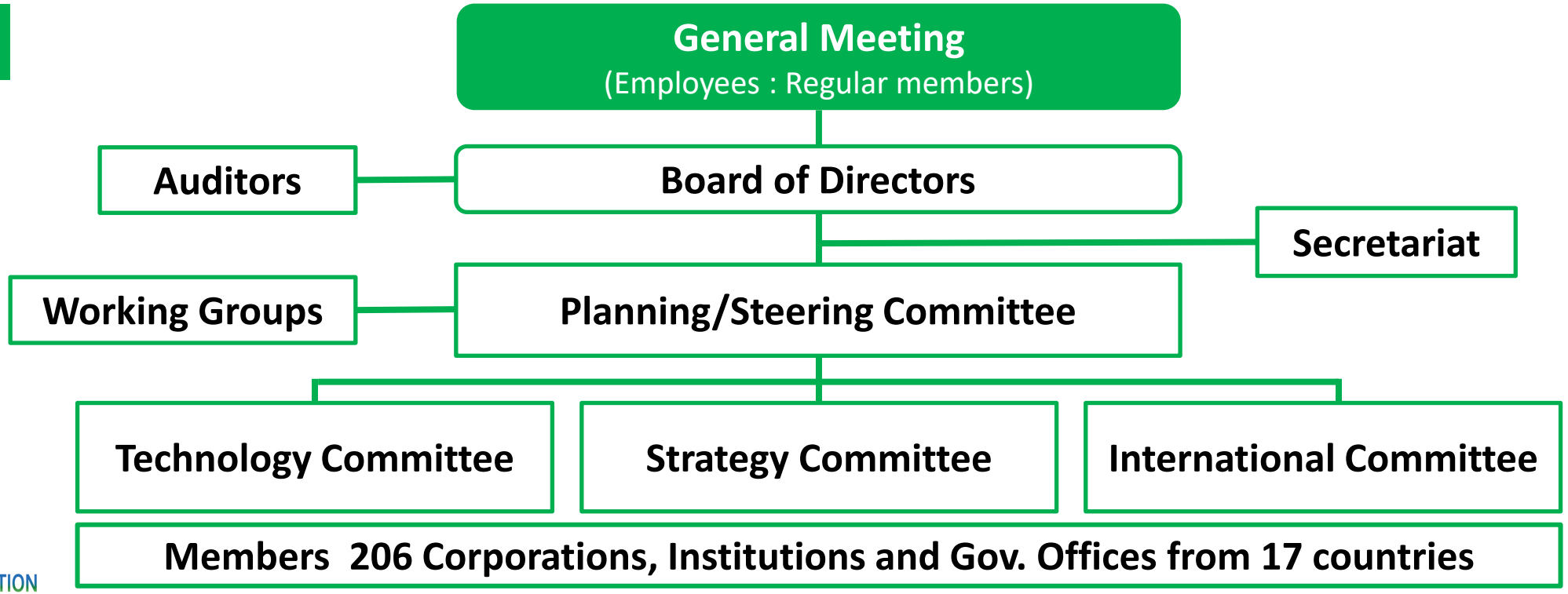
Establish

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 (1)

As of July 24 , 2023

[Board Member] 14 companies

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

[General Member] 128 companies

ABE NIKKO KOGYO
AGC
Air Liquide Japan
Air Water Inc.
AISAN INDUSTRY
Aramco Asia Japan
Asahi Kasei
Asahi Tanker
BP Japan
Chiyoda
Chubu Electric Power Company
CHUGAI RO
CLEARIZE
Cosmo Oil
Daihatsu Diesel
DAIICHI JITSUGYO
Diamond & Zebra Electric Mfg
EBARA
Electric Power Development
ENEOS
Emerson Japan
Fuji Car Manufacturing
Fuji Electric
Fuji Oil
Fujitsu
FUKUI SEISAKUSHO
GYXIS
HANWA
HAZAMA ANDO
HIROSHIMA GAS
Hitachi Industrial Products
Hitachi Zosen
Hokkaido Electric Power
Hokuriku Electric Power Company
HORIBA
IINO KAIUN
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
MIKUNI KIKAI KOGYO
Mitsubishi Electric
MITSUBISHI GAS CHEMICAL
Mitsubishi Materials
Mitsui E&S
Mitsui O.S.K. Lines
Mitsui Sumitomo Insurance
Mizuho Research & Technologies
MUFG Bank
NGK INSULATORS
NICHIAS
NIKKISO
Nikki-Universal
Nippon Kaiji Kentei Kyokai
Nippon Kaiji Kyokai (ClassNK)
Nippon Kayaku
Nippon Oil Pump
Nippon Paper Industries
NIPPON SHOKUBAI
NIPPON STEEL
NIPPON STEEL PIPELINE&ENGINEERING
NIPPON STEEL Stainless Steel
NIPPON STEEL TRADING
Niterra
Nitto Denko
NS UNITED KAIUN KAISHA
NRS CORPORATION
OBAYASHI
Okinawa Electric Power
Osaka Gas
OVAL Corporation
Penta-Ocean Construction
Resonac Holdings
Safar International
Senko Line
Shell Japan
Shikoku Electric Power Company
Shimadzu
SHIMIZU
SHIN NIHON KENTEI KYOKAI
Shinsho Corporation
Shizuoka Gas
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
TSUNEISHI SHIPBUILDING
UBE Corporation
Uyeno Transtech
Vena Energy Japan
Wärtsilä Japan
YANMAR HOLDINGS
Yokogawa Electric

Member List of Clean Fuel Ammonia Association (2)

9 Australian Companies and 5 organizetions

As of July 24 , 2023

[Associate Member (foreign company)] 32 companies

ACME Cleantech Solutions Private Limited (IND)
Adani New Industries Limited (IND)
AES Andes (CHL)
AMEA Power LLC (UAE)
AustriaEnergy International GmbH. (AUT)
Avaada Green H2 Private Limited. (IND)
Baker Hughes (GBR, USA)
CF Industries (USA)
Clean Hydrogen Works (USA)
DNV (NOR)
Energy North Pty Ltd (AUS)
Engie - Hydrogen Business Unit (FRA)
Equinor ASA (NOR)
ExxonMobil LNG Market Development Inc.(USA)
Fortescue Metals Group (AUS)
Karachaganak Green Energy Corporation (KAZ)
Kellogg Brown & Root Asia Pacific Pte. (SGP)
LSB INDUSTRIES (USA)
Novatek Gas and Power Asia Pte. Ltd. (SGP)
NTPC Limited (IND)
NW interconnected Power Pty Ltd
(Asian Renewable Energy Hub) (AUS)
Origin Energy Limited (AUS)
Pilot Energy Limited (AUS)
Purus Marine (GBR)
Sasol South Africa Limited (S.A.)
SQM Industrial S.A. (CHL)
Stanwell Corporation (AUS)
The Hydrogen Utility (AUS)
TotalEnergies Japan S.A.(CHE)
UGL Pty Limited (AUS)
Woodside Energy (AUS)
Yara International ASA (NOR)

[Advisory Member] 3 persons, 32 institutions

Bunro Shiozawa (ex-SIP Deputy PD)
Kenichi Aika (ex-SIP Deputy PD)
Takeo Kikkawa (International University of Japan)
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)
Electric Power Research Institute (USA)
Embassy of Canada to Japan
Embassy of Norway in Tokyo, Japan
Embassy of the Kingdom of the Netherlands
Government of Queensland (AUS)
Government of South Australia (AUS)
Government of Western Australia (AUS)
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) (NZL)
YOKKAICHI CITY

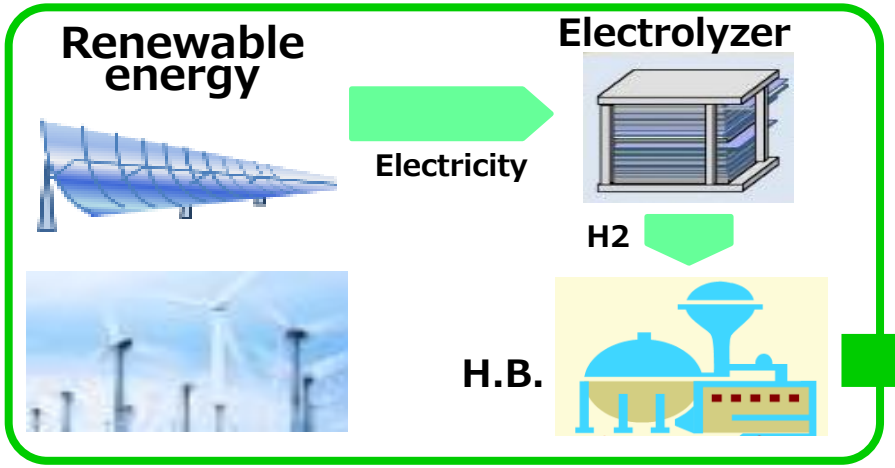
[Honorary Member] 1 person

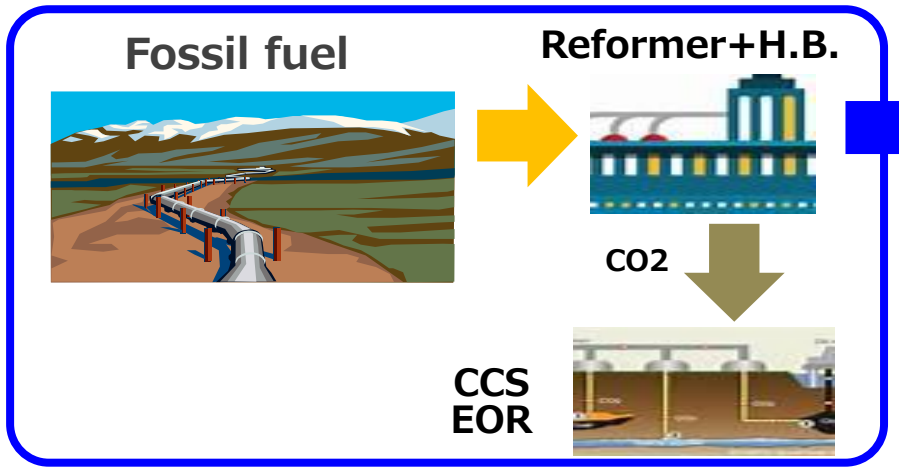
Osamu Ishitobi (Former Chairman)

[Associate Member (individual)] 7 persons

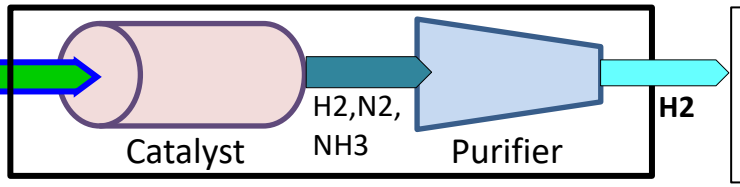
Fumiteru Akamatsu
Hideaki Kobayashi
Hirohumi Taba
Jyun Kubota
Kiyohiko Nakae
Norihiko Nakamura
Yoshitsugu Kojima

Fuel Ammonia Value Chain



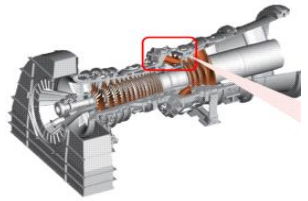


Transportation across the Ocean by H2 Energy Carriers (Ammonia, LH2, and Organic Hydride) from Australia to Japan, **Ammonia is likely the cheapest mechanism** ("The Future of Hydrogen"; prepared by the IEA for the G20, Japan in 2019)

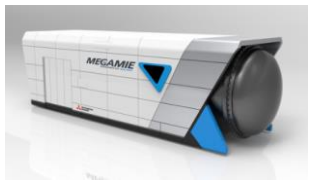


Dehydrogenation

Coal Fired Boiler
- 20%-60% mix combustion is achieved
- 1GW demonstration (2021-2023)



Gas Turbine
- Single fuel system up to 60MW by 2025
- ACCGT: ammonia cracking H2 turbine by 2030



Solid Oxide Fuel Cell (SOFC)
- 1kw system is completed
- 10-200kW under development

Industrial Furnace
- Demonstration in glass melting furnace

Marine Diesel Engine
- 4 stroke sub-engine by 2024
- 2 stroke main engine by 2026

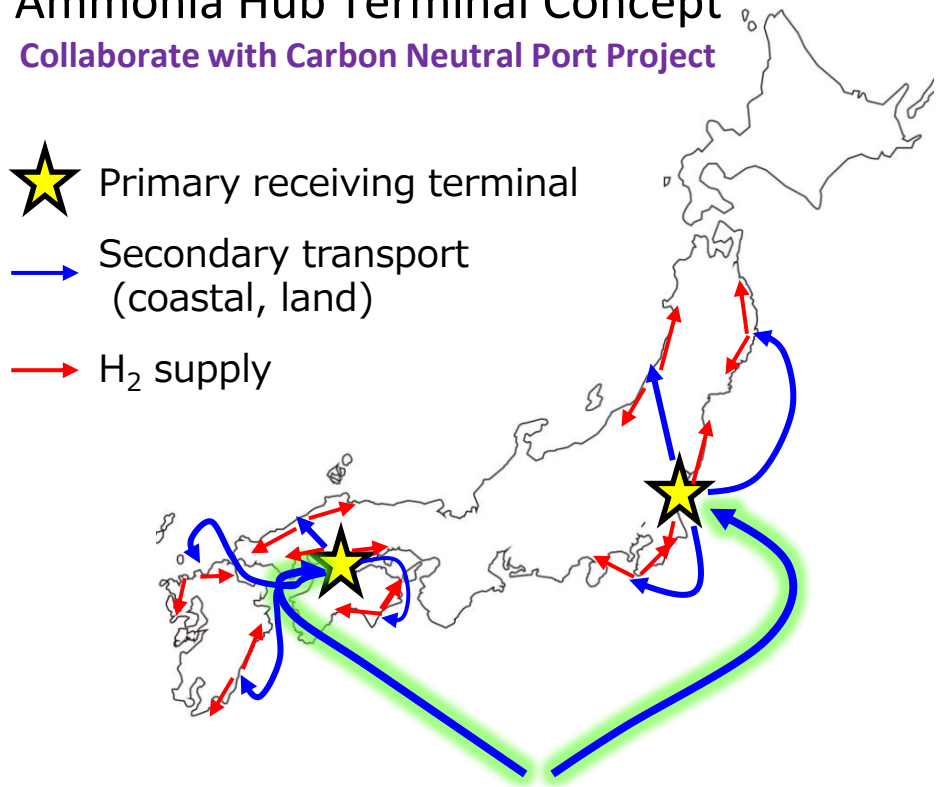
H2 Supply to power market, industrial complex, commercial & residential markets

Implementation Plan of Clean Fuel Ammonia Value Chain

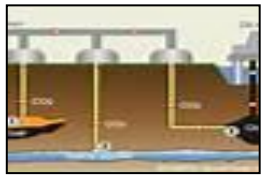
Supply Infrastructure Development

Ammonia Hub Terminal Concept

Collaborate with Carbon Neutral Port Project



Natural Gas+CCS/EOR (Blue) NH_3 **Renewables (Green)**



Australia, USA, Middle East, etc.

Market Development

- Mixed combustion in coal power plants
- Increase of co-firing ratio
- Gas turbines
- Industrial furnaces
- Marine diesel engines

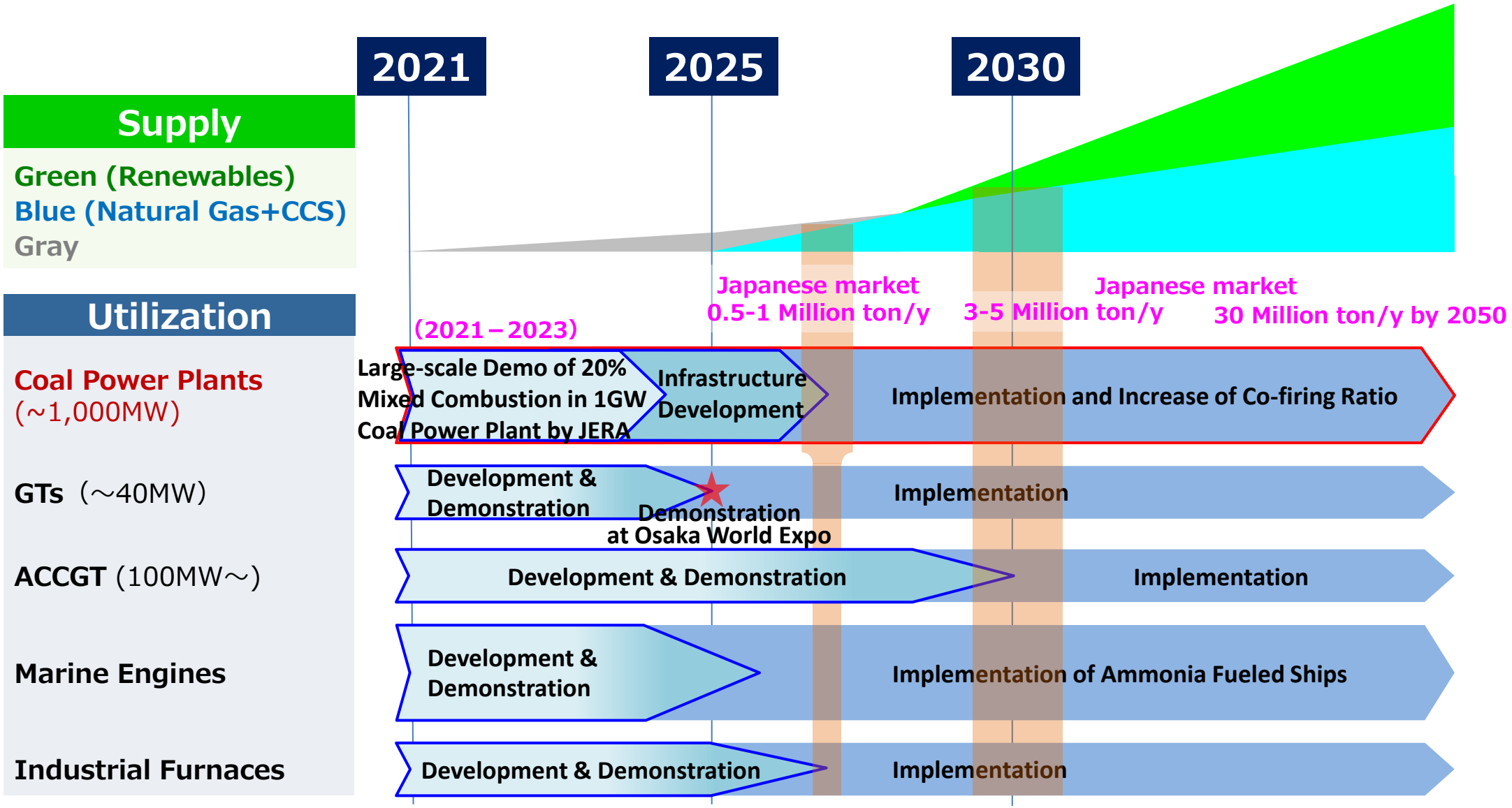
【C-free Power Generation】

- Ammonia single fuel combustion in coal power
- Ammonia single fuel GTs

【Contribution to Asia Zero-emission Community】

- Supply of Clean Fuel Ammonia
- Mix combustion in coal power plants
  (FS Agreements with Malaysia, Indonesia, India)
- H_2 supply by ammonia cracking

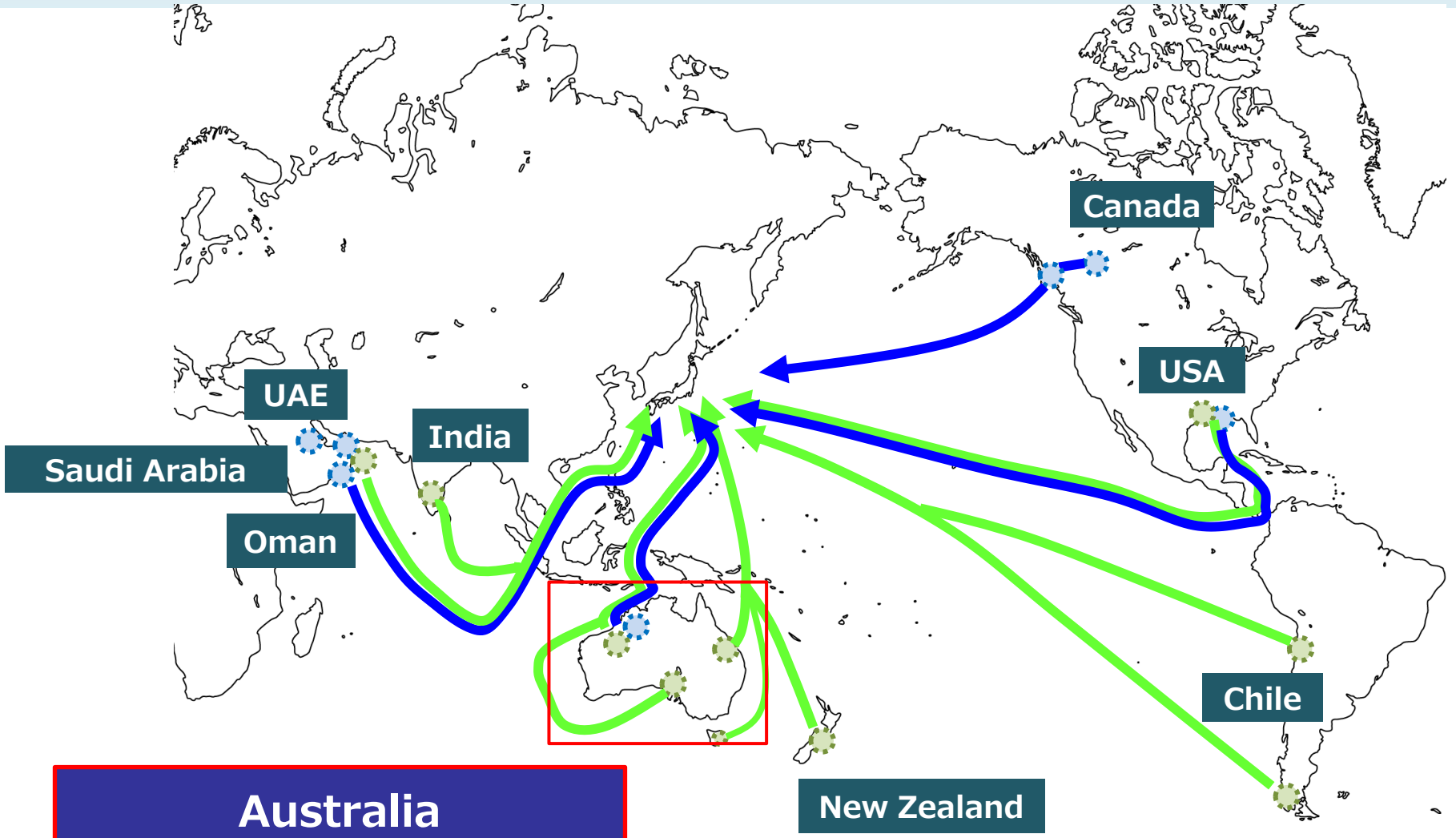
Roadmap of Fuel Ammonia Value Chain



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

Supply Chain

(Development of Dedicated Supply Sources for Fuel Ammonia)



Government Supports for Clean Hydrogen & Ammonia in Japan

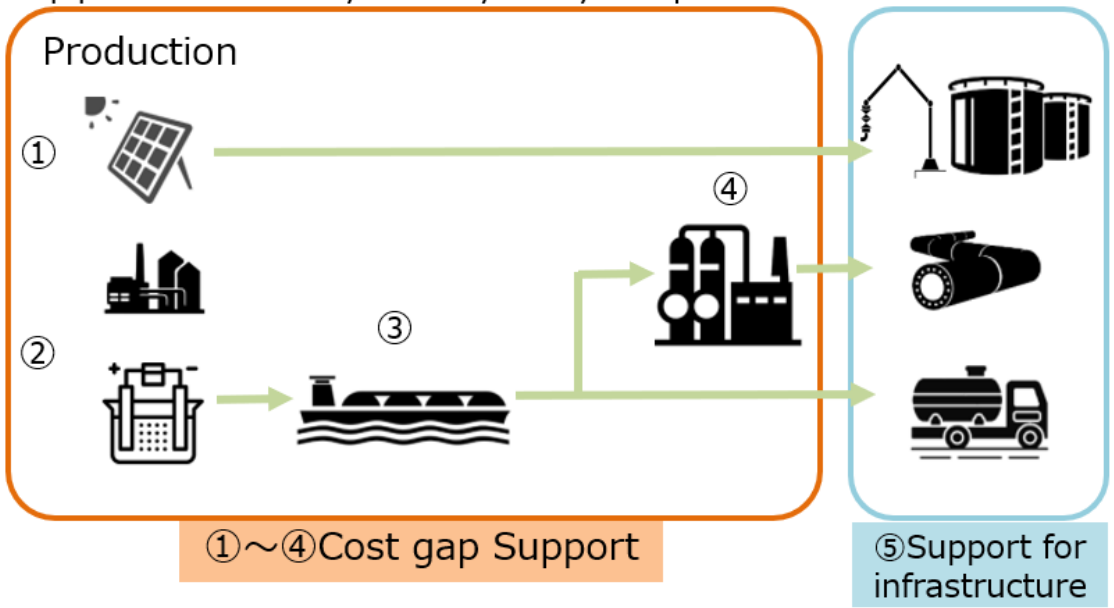
Financial supports for supply chain development and infrastructure development of clean hydrogen and ammonia in **The Green Transformation Economic Transition Bonds**.

○7 trillion yen ($54B) in 10 years from around 2027
- ・5 trillion yen ($38B) for supply chain development
- ・1 trillion yen ($8B) for infrastructure development
- ・1 trillion yen ($8B) for R&D

○Subsidies for certain portion of gap between supply costs and market costs
- ・15 years duration with periodical review by analyzing gap of costs
- ・Applied to clean hydrogen and ammonia
- ・Transparency and contributions for S+3E will be considered for the evaluation

Scope of Supports

- ①Domestic production, ②Overseas production, ③Marine transportation and ④Domestic dehydrogenation will be covered.
- ⑤Domestic infrastructure such as receiving terminals and pipelines commonly used by many companies



Formation of Comprehensive Partnership

— Collaborations in Public Sector & Private Sector —

【Public Sector】

Reciprocal Supports from Governments

Subsidies (Japan : Green Transformation Economic Transition Bond)

Project Support & Finance (Japan : JOGMEC, JBIC)

【Private Sector】

Partnership in Supply Chain

Technologies (Fuel Ammonia Utilization :
Ammonia Combustion Technologies)

Logistics (Transportation & Terminal :
Ammonia-fueled Ammonia Carriers)