Clean Fuel Ammonia Value Chain Development

Ammonia Energy Conference 2022-Australia

August 25, 2022

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Clean Fuel Ammonia Association

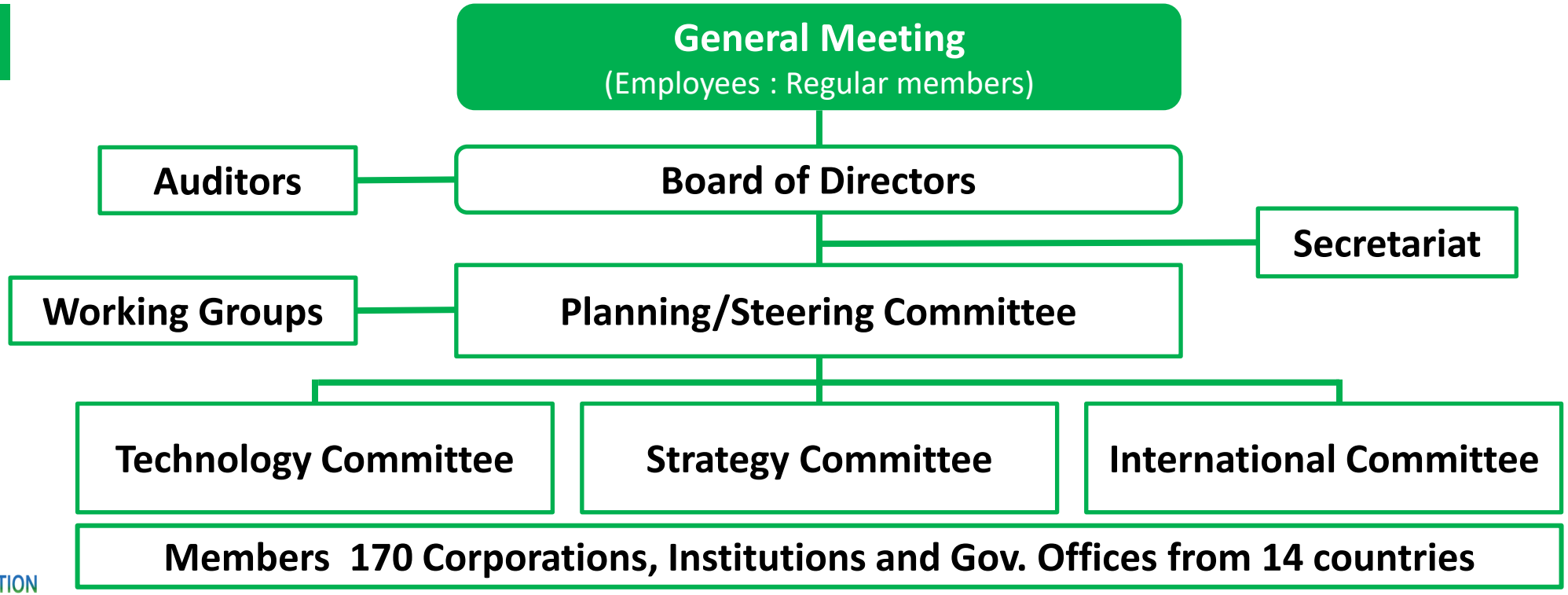
Establish

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



Public-Private Council on Fuel Ammonia Introduction

Established : October 2020 under Natural Resources and Fuel Department of METI
Interim Report : February 2021
Task Force : November 2021　Studies on cost reductions of supply chain and policy supports

1. Objectives

- Identifying issues for expanding the use of fuel ammonia, and sharing the roles and timelines of public and private sectors in solving these issues with the aim of promoting unified approach.
- Discussions on the implementation of Gov. supports for Fuel Ammonia Value Chain

2. Members

Public sector	Private sector
Natural Resources and Fuel Department, Agency for Natural Resources and Energy, METI	IHI Corporation
Japan Oil, Gas and Metals National Corporation (JOGMEC)	JERA Co., Inc.
Japan Bank for International Cooperation (JBIC)	Electric Power Development Co., Ltd. (J-POWER)
Nippon Export and Investment Insurance (NEXI)	JGC HOLDINGS CORPORATION
	Nippon Yusen Kabushiki Kaisha (NYK Line)
（Observers）	Marubeni Corporation
Material Industries Division, Manufacturing Industries Bureau, METI	MITSUBISHI HEAVY INDUSTRIES, LTD.
Ports and Harbours Bureau, Ministry of Land, Infrastructure, Transport and Tourism	Mitsubishi Corporation
Maritime Bureau, Ministry of Land, Infrastructure, Transport and Tourism	The Institute of Energy Economics, Japan (IEEJ)
	Clean Fuel Ammonia Association (CFAA)

Public-Private Council on Fuel Ammonia Introduction

Outline of Interim Report

- Promotion of involvements by Japanese companies in Clean Fuel Ammonia Value Chain from production, transportation, storage, utilization to finance for cost reductions and mid to long term supply security.

- Contribution to the decarbonization of the world and Asia where thermal power generation will continue to be significant portion of power supply.

- Expected demand in Japan is 3MMtons in 2030, 30MMtons in 2050 and 100MMtons for global supply chain by Japanese companies in 2050.

- Targeted price by 2030 is upper 10yen range per Nm^3 hydrogen equivalent (upper $1 range per kg).

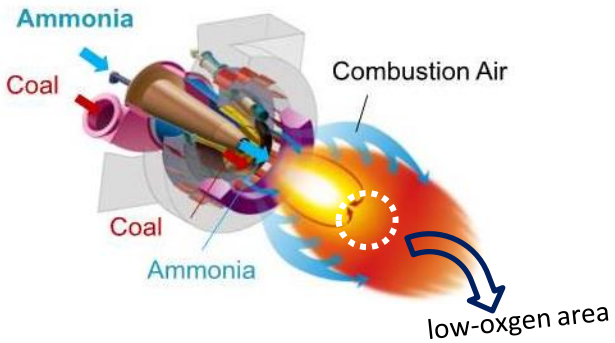
- Development of technologies for ammonia GTs, CHPs, industrial furnaces, marine diesel engines, low cost and high efficiency production and CCS.

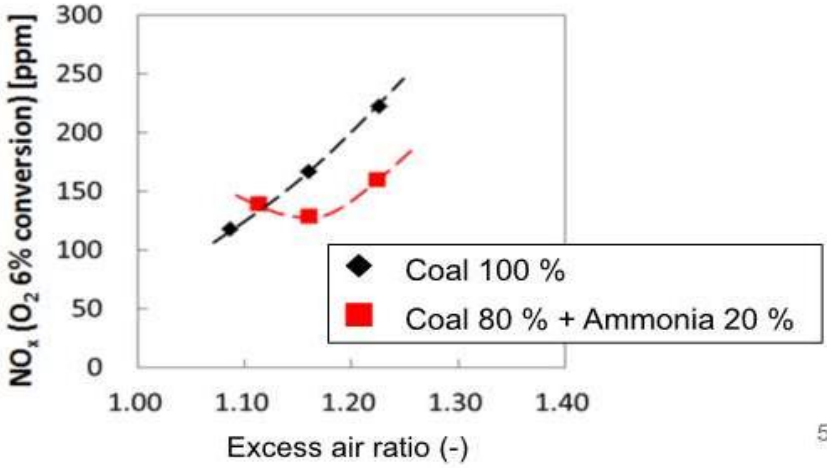
- Establishment of international standards and criteria.

Key Technologies of Ammonia Utilization in the Energy Market

Mix combustion in coal fired boilers

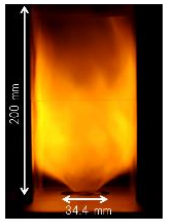
- 20%-60%NH_3 in Coal is achieved.
- Up to 100%NH_3 in coal boiler is under development.
- Large Scale Demonstration from 2021-23
  (20%NH_3 in 1GW Coal Power of JERA)





IHI Corporation

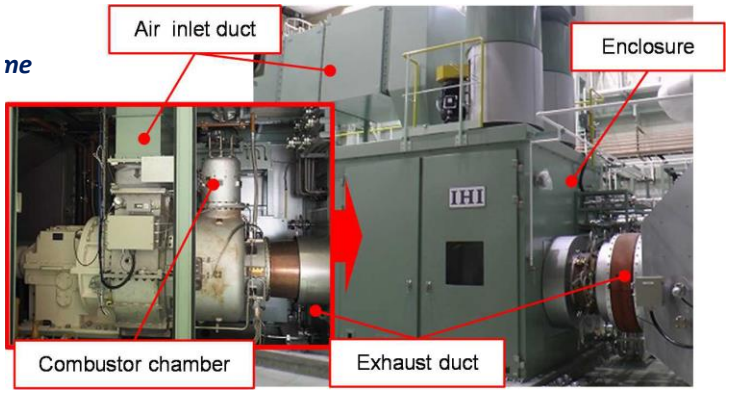
Gas turbines

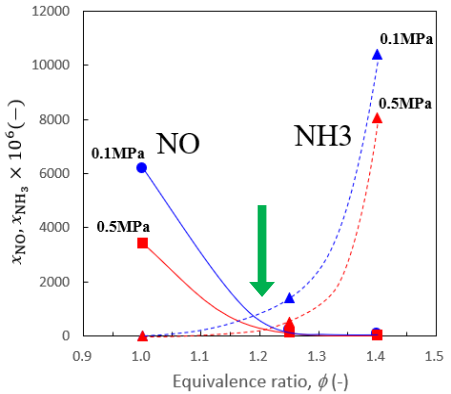


【50 kW, 300 KW】
NH_3 Single Fuel

Toyota Energy Solutions

【2MW】
20%-70%NH_3 in Natural Gas
Development of NH_3 Single Fuel System by 2023



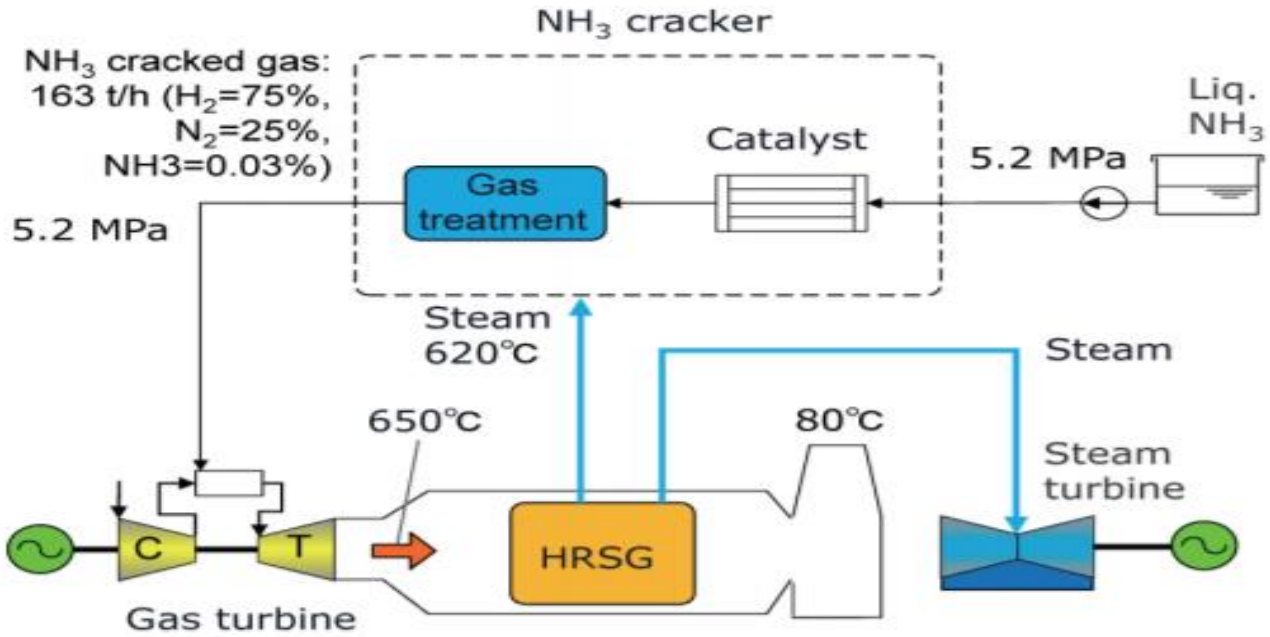


IHI Corporation

Key Technologies of Ammonia Utilization in the Energy Market

Advanced Combined Cycle Gas Turbines

Decomposition of NH_3 using part of exhaust heat and H_2 is supplied to turbine.
Efficiency is equivalent to CH_4.

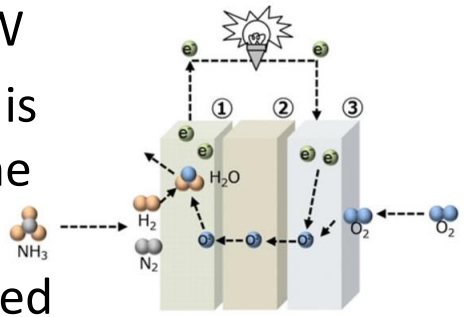


Mitsubishi Heavy Industries

SOFC

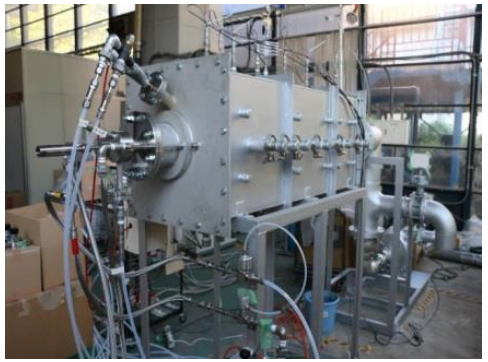
10kW～200kW

The efficiency is about the same as that of hydrogen-fueled systems.



IHI Corporation

Industrial Furnaces



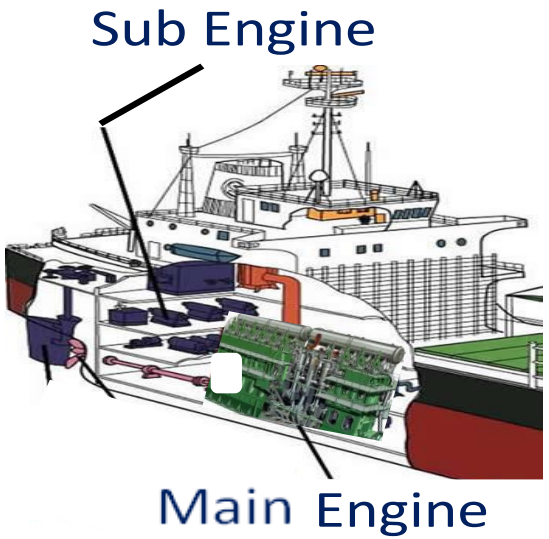
Taiyo Nippon Sanso

Taiyo Nippon Sanso, AGC

Demonstration in Glass Melting Furnace

Potential in Maritime Fuel

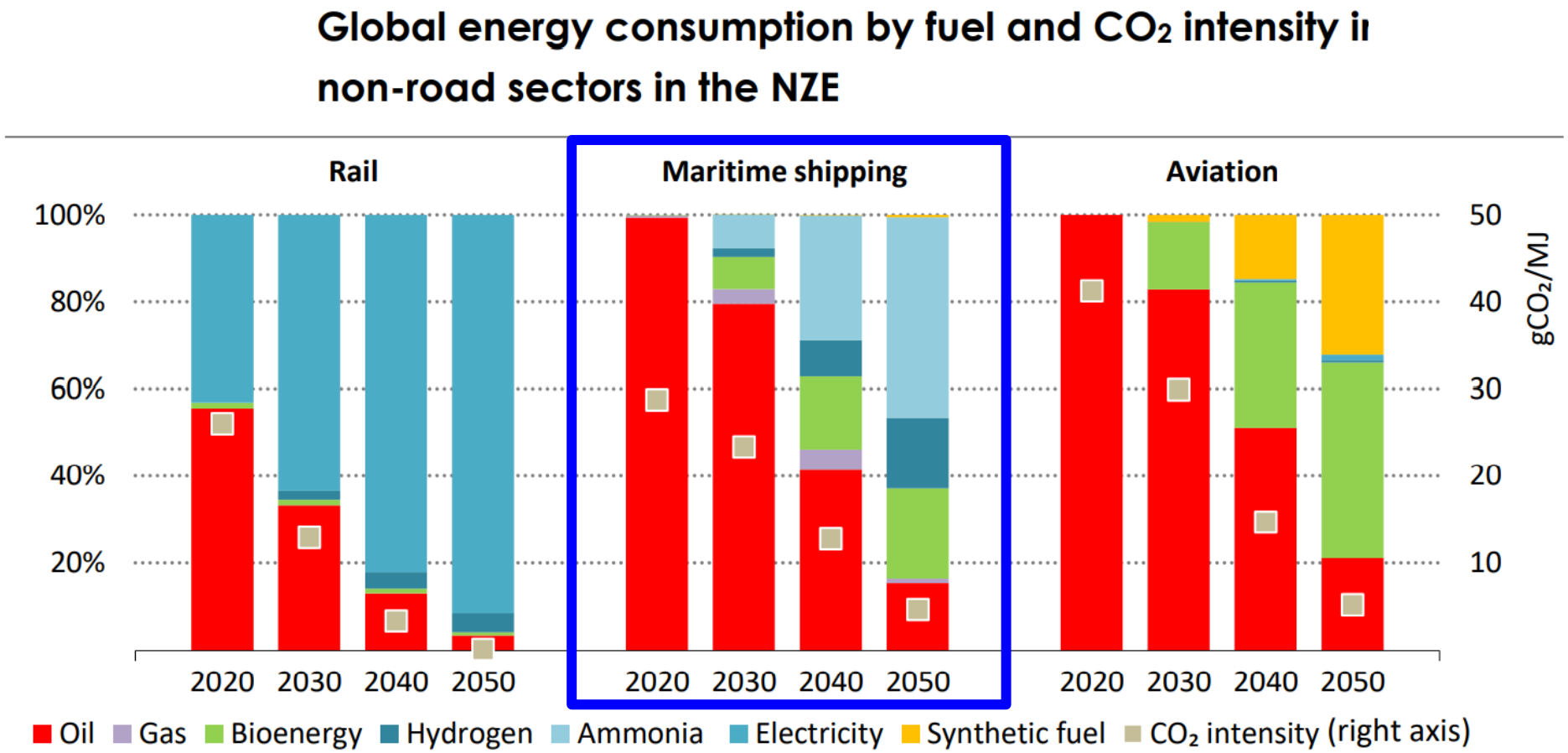
Marine Diesel Engine



JFE Engineering /
National Institute of Maritime,
Port and Aviation Technology

Sub Engine by 2024
Main Engine and Ammonia fueled ship by 2026

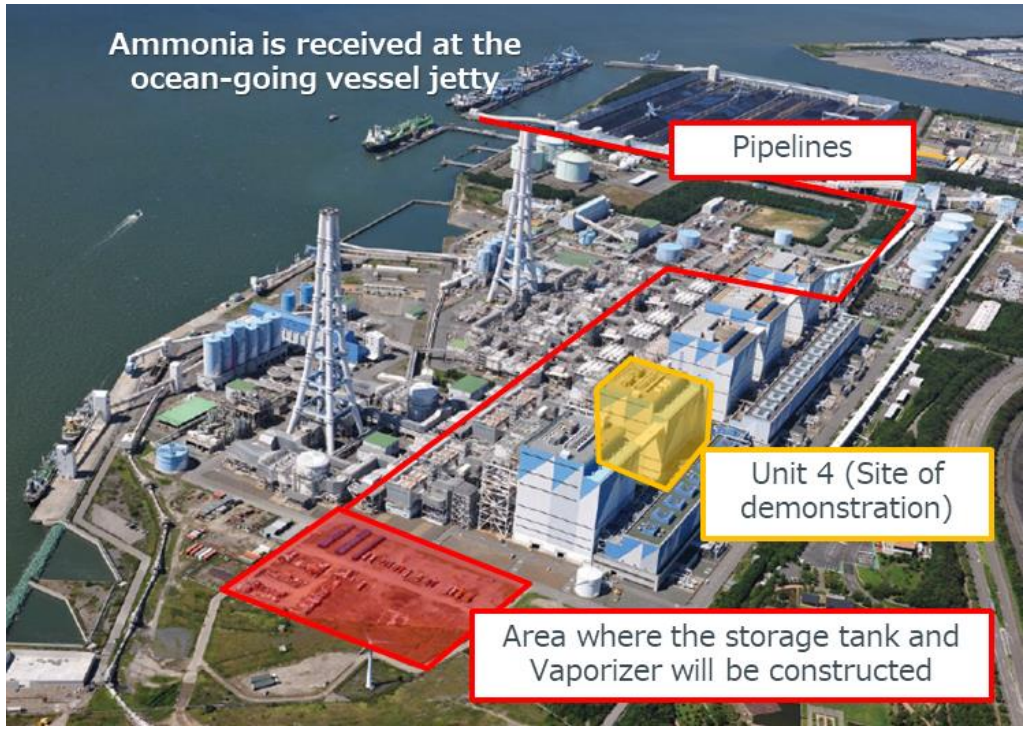
Share of Ammonia to reach 46% by 2050 (230 MMtons of Ammonia)

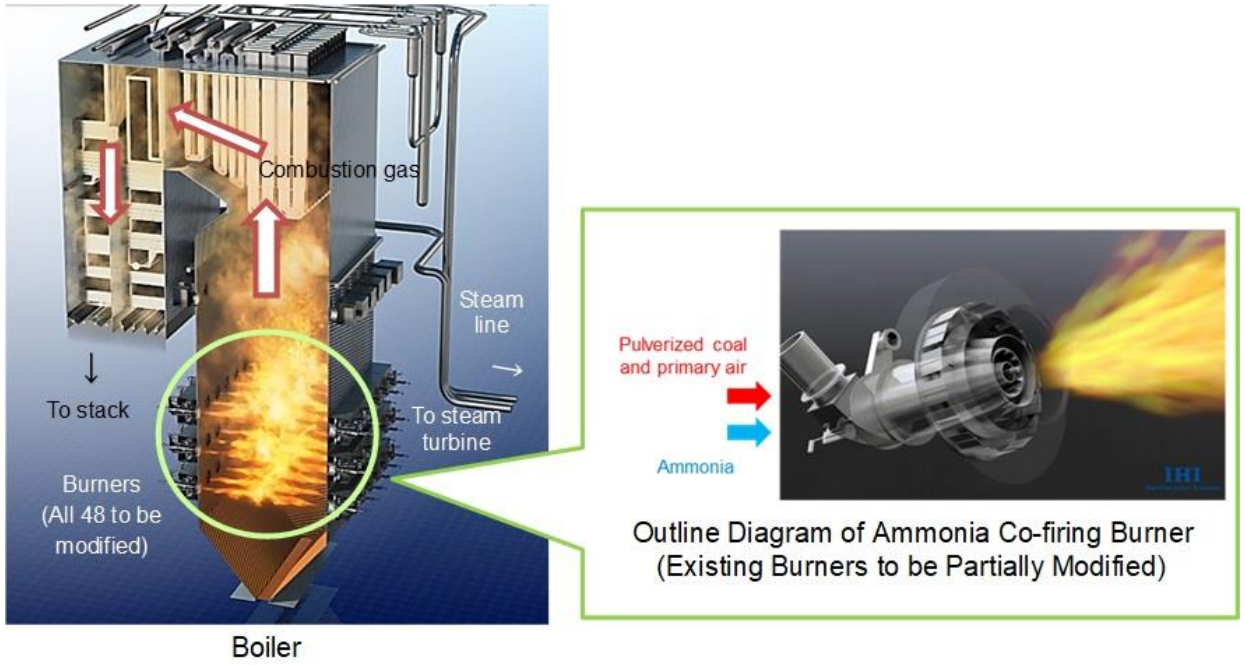


"Net Zero by 2050", IEA, May 2021

Large Scale Demonstration in Coal Power Station

- 2021-2023 subsidized by Government
- 20% mixture of fuel ammonia in 1GW Coal Power at Hekinan Power Station owned by JERA





https://www.jera.co.jp/english/information/20210524_677

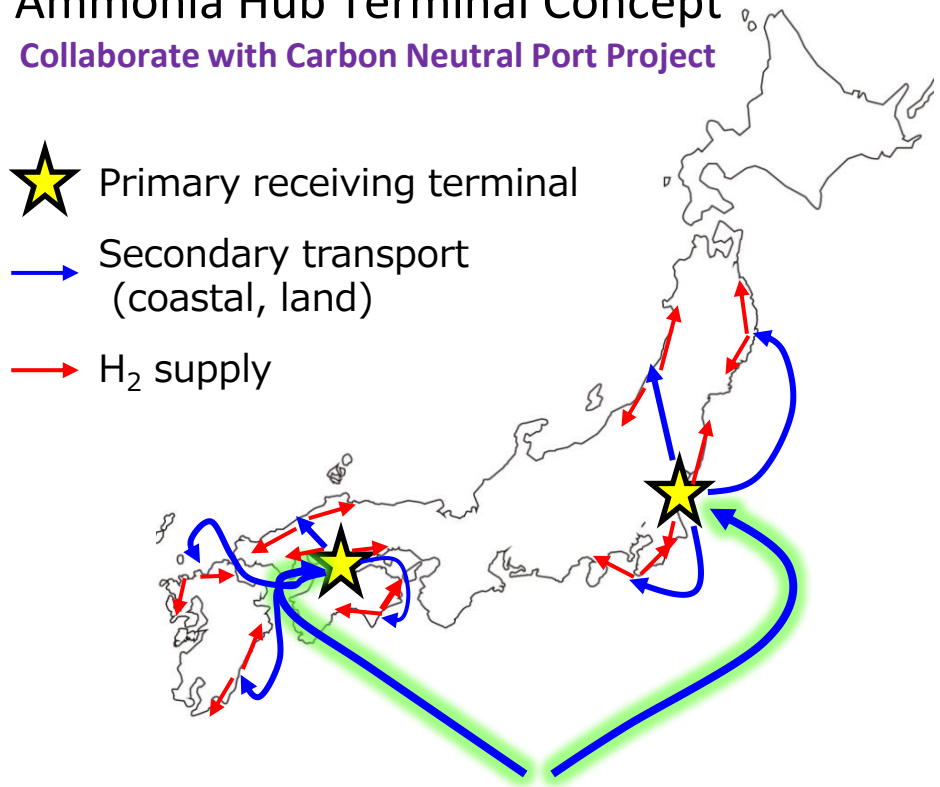
(20% ammonia in 1GW coal power requires 500,000 tons of fuel ammonia per year)

Implementation Plan of Clean Fuel Ammonia Value Chain

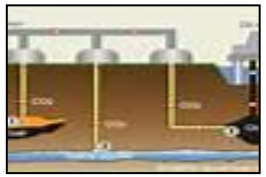
Supply Infrastructure Development

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

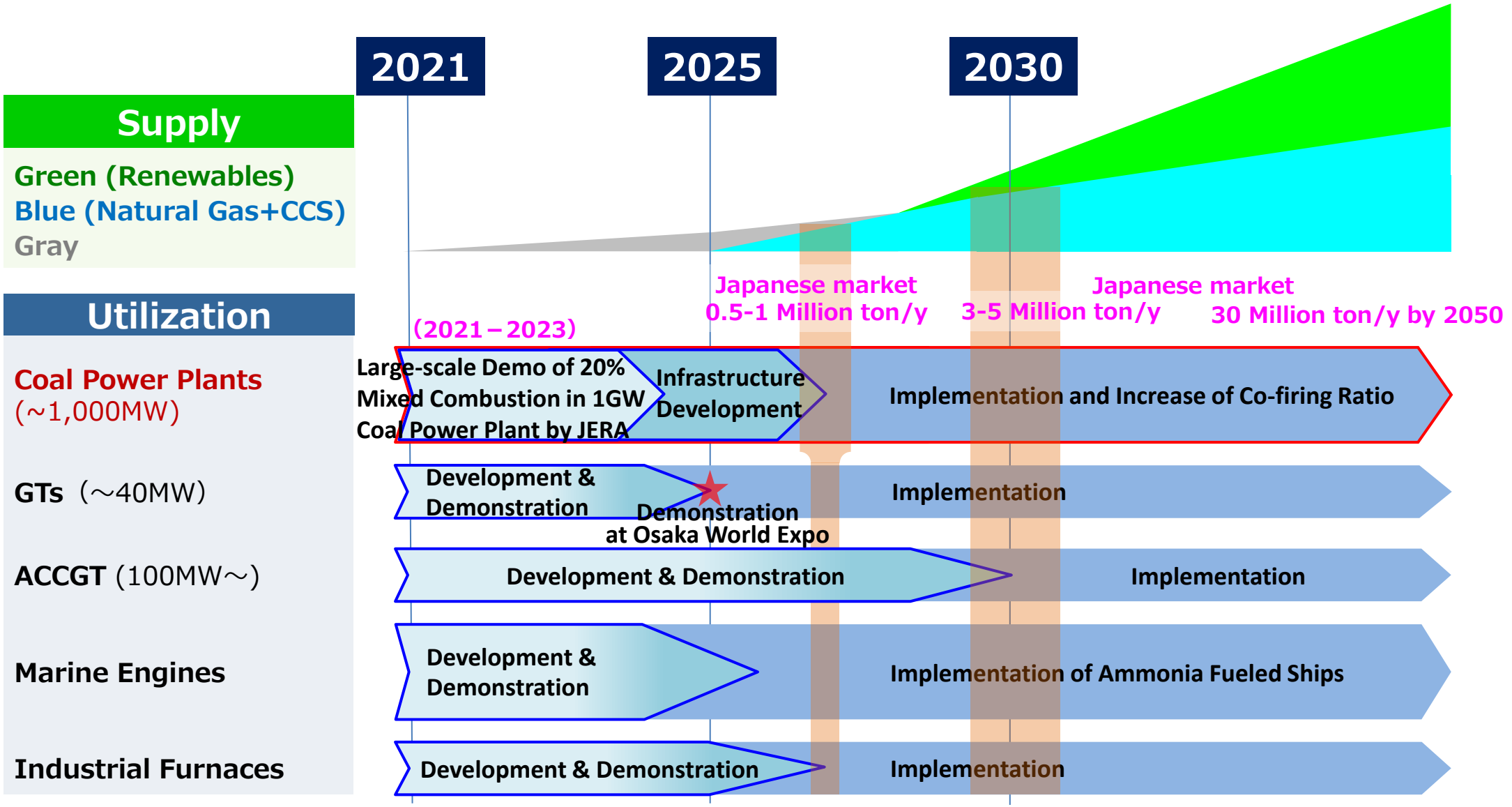
【C-free Power Generation】

- 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

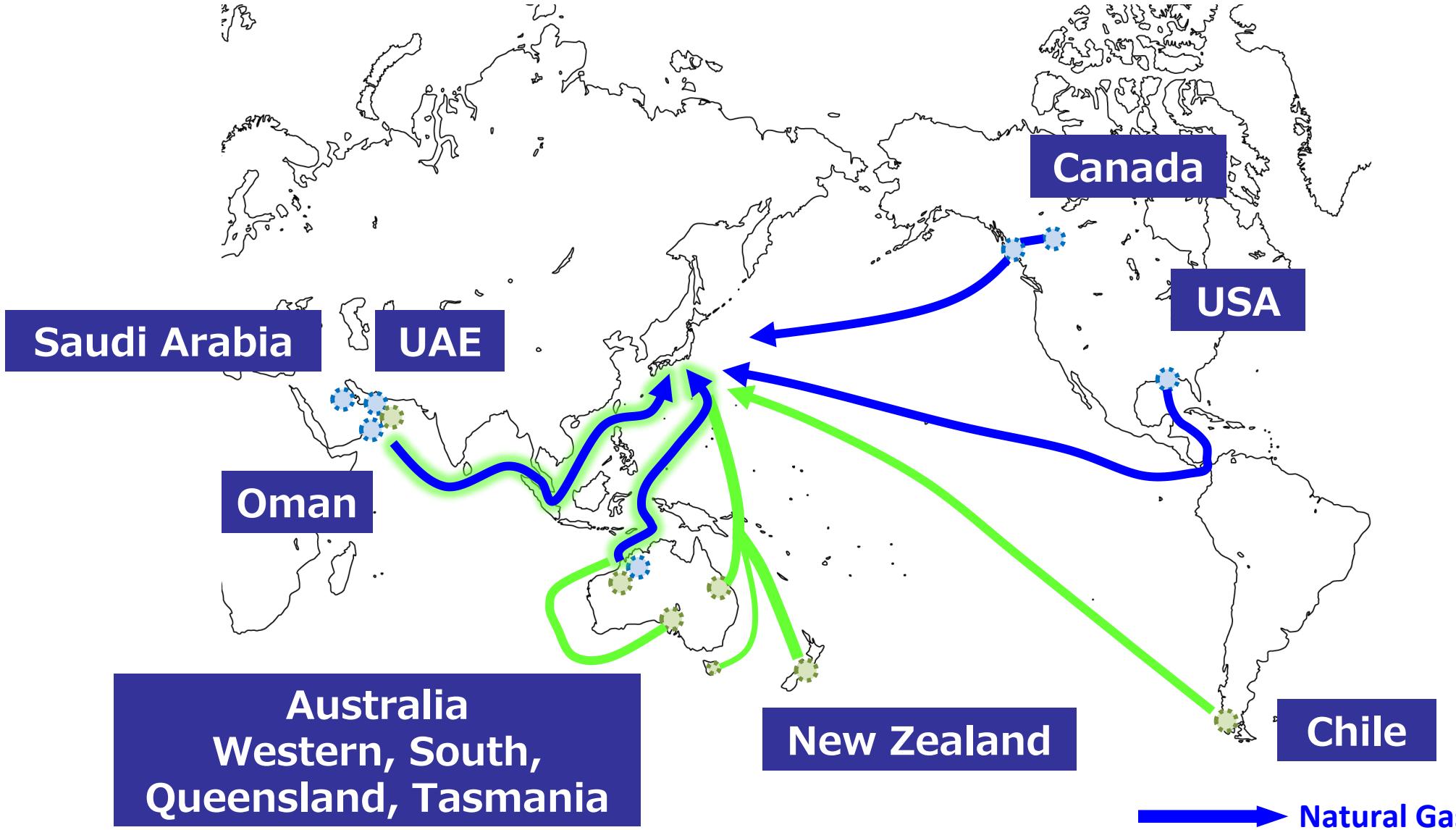
Roadmap of Fuel Ammonia Value Chain



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

CLEAN FUEL AMMONIA ASSOCIATION

Potential Supplies of Blue and Green Ammonia



Proposed Definition of Clean Ammonia

— to Achieve Increased Use and Steady Decarbonization —

Item	Initial Proposal	Future Considerations
Calculation Boundary	**Gate to Gate** Due to lack of data on GHG emissions from wells now, and disclosure of data from wells is recommended	Expansion to **"Well to Gate"** with precise CI data from wells
Threshold (Relative)	**At least 60%※ CO_2 reduction based on natural gas SMR process** ※ Considering the utilization of existing plants	Increase of **reduction ratio**※ ※ Reflecting diffusion of the latest technologies Ammonia production from **by-product H_2**
CO2 Reduction Method	**CCS and EOR**※ ※ EOR only eligible if “equivalent to CCS”	Other methods such as **offsets and CCU**