Our Journey and the Future: Achieving Decarbonization through CO_2 Capture Technology

IEAGHG Post Combustion Capture Conference 8
17th September 2025

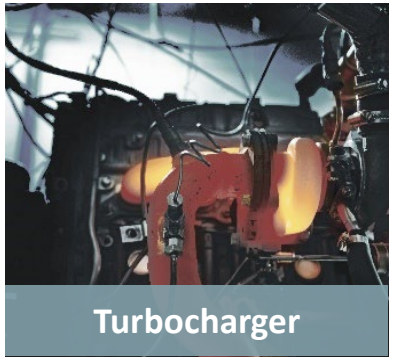
Takashi Kamijo

Mitsubishi Heavy Industries (MHI) group

- Foundation: 1884, 140 years history
- Employees: 77,778, consolidated as of March 2025
- Group Companies: 259, consolidated as of March 2025
- Order Received: 6,684 bil. yen, consolidated as FY2024
- Revenue: 4,657 bil. yen, consolidated as FY2024


H-IIA Launch Vehicle


Fighter

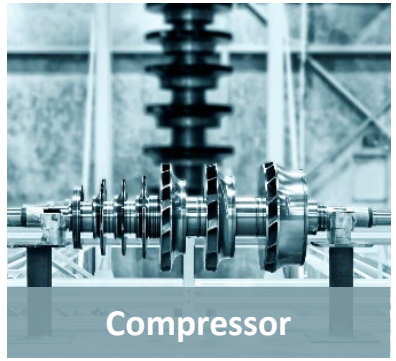

Turbocharger


Carbon Capture Plant


Chemical Plant


Transportation System

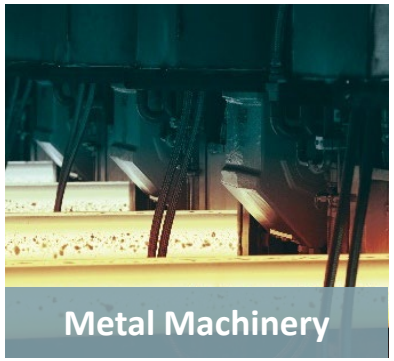

Gas Turbine


Compressor

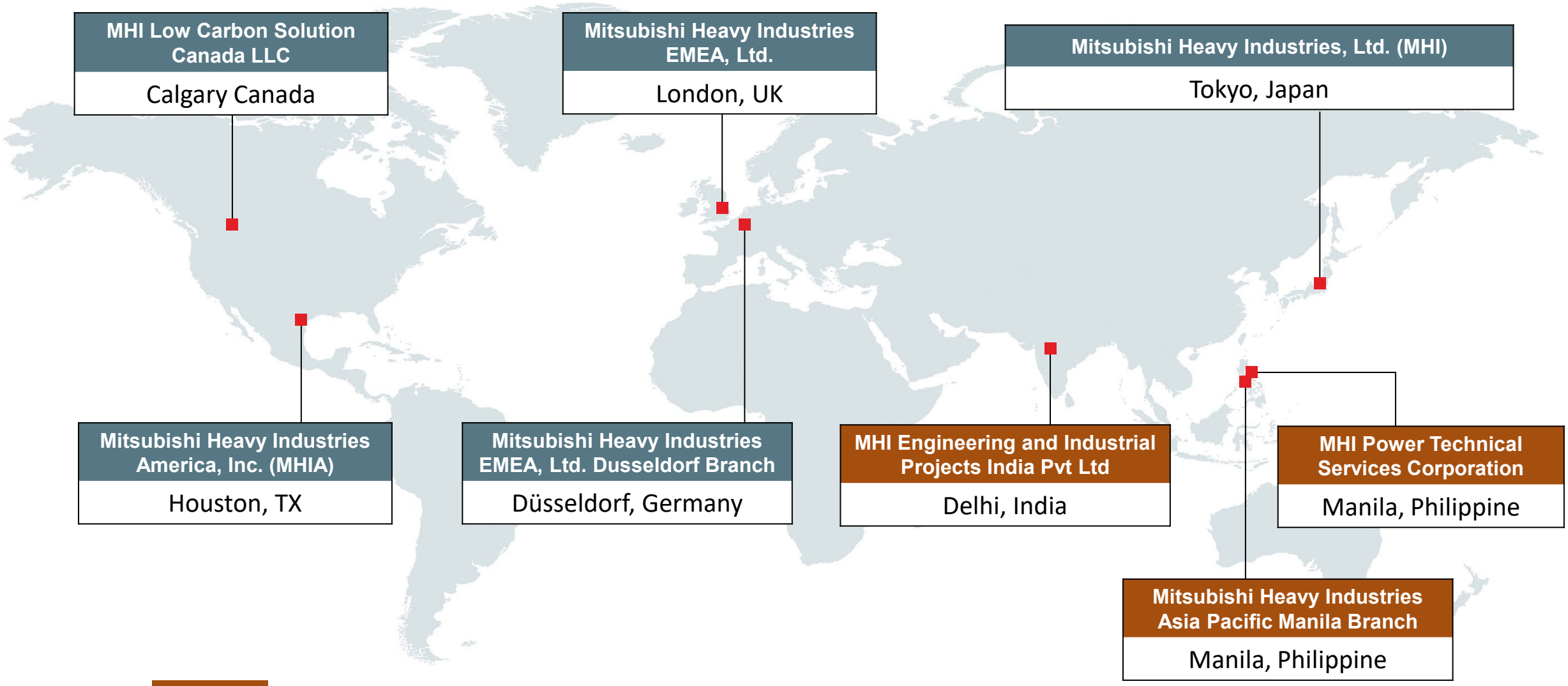

LE-7A Engine


Aero Engine


Waste-to-Energy


Metal Machinery

Overseas network for CO_2 capture business



FEED Experiences of KM CDR Process™ / Advanced KM CDR Process™ since 2022

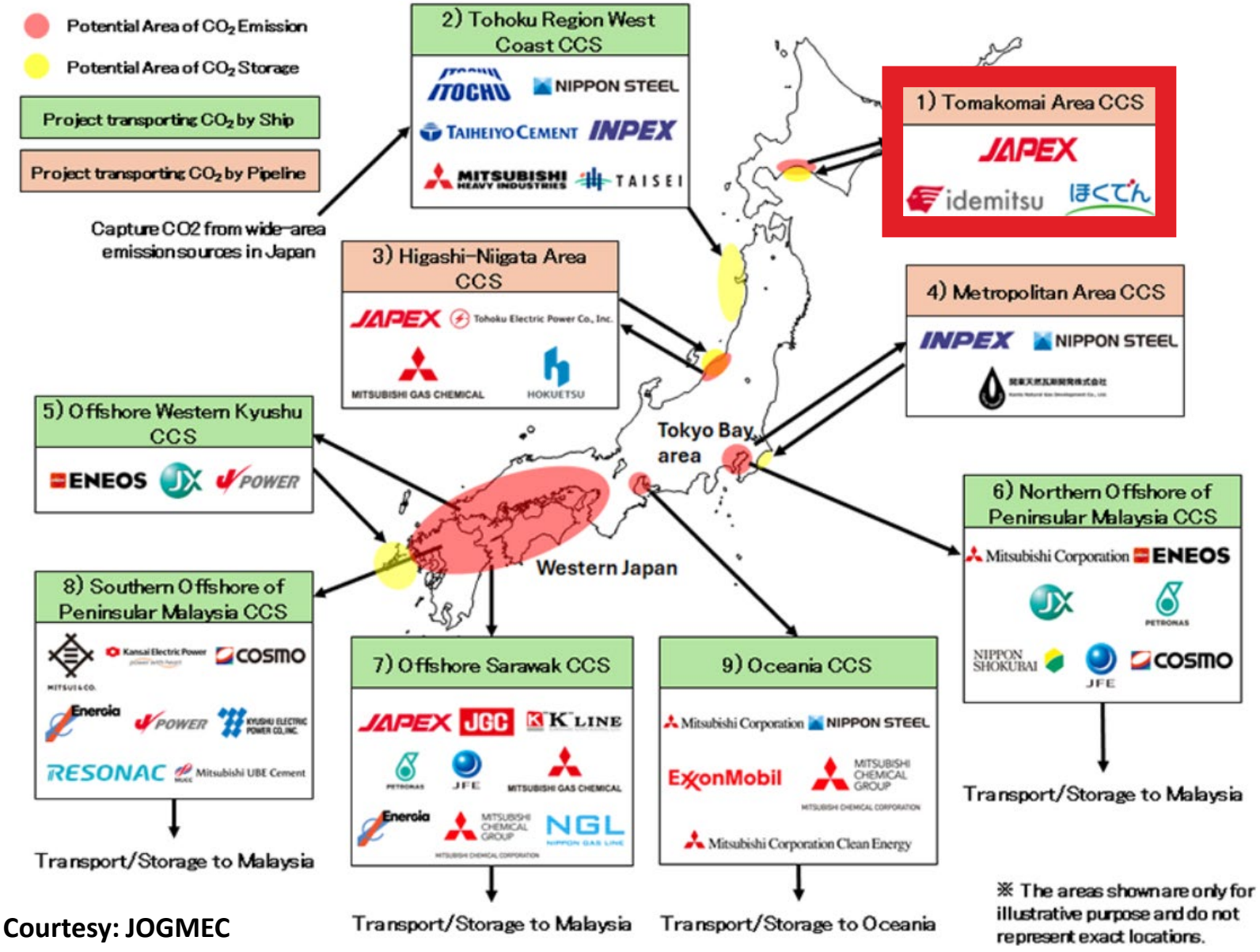
No.	Year of Award	Country	Flue Gas Source	Type	CO_2 Capacity (t/d)	Application
1	2022	UK	Power Plant	FEED	6,000	Geological Sequestration
2	2022	Canada	Power Plant	FEED	12,000	Geological Sequestration
3	2023	UK	Cement Plant	Pre-FEED	2,695	Geological Sequestration
4	2023	USA	Power Plant	FEED	26,000	Geological Sequestration
5	2023	USA	Power Plant	FEED	11,793	Geological Sequestration
6	2023	USA	Power Plant	Pre-FEED	14,000	Geological Sequestration
7	2023	Netherland	Biomass Power Plant	Pre-FEED	24,000	Geological Sequestration
8	2023	UK	Cement Plant	FEED	2,600	Geological Sequestration
9	2024	Canada	Cement Plant	FEED	4,077	Geological Sequestration
10	2024	USA	NG Fired Furnace	FEED	3,684	Geological Sequestration
11	2024	USA	Power Plant	FEED	14,658	Geological Sequestration
12	2024	Croatia	Cement Plant	Pre-FEED	2,282	Geological Sequestration
13	2024	USA	Power Plant	Pre-FEED	21,600	Geological Sequestration
14	2024	USA	Power Plant	Pre-FEED	40,000	Geological Sequestration
15	2025	USA	Cement Plant	Pre-FEED	6,473	Geological Sequestration
16	2025	USA	Gas Turbine for FPSO	Pre-FEED	2,574	Geological Sequestration
17	2025	USA	Power Plant	FEED	5,450	Geological Sequestration
18	2025	USA	Power Plant	FEED	8,400	Geological Sequestration
19	2025	Japan	Power Plant	FEED	5,200	Geological Sequestration

FEED(Front End Engineering Design): Basic Engineering conducted after completion of Conceptual Design or Feasibility Study
FPSO(Floating Production Storage and Offloading vessels): Floating systems for vessels that produce, store and offload oil and gas at sea

Many Feasibility Studies are also executed in addition to above.

Japan CCS Projects

- ✓ Managed by Japan Organization for Metals and Energy Security (JOGMEC) collaborating with the government
- ✓ The Act on Carbon Dioxide Storage Business was passed in May 2024
- ✓ 9 projects selected aiming to store a total of app. 20 million tons of CO2 per year, with 5 projects for storage in Japan and 4 projects for storage in the Asia-Pacific region.
- ✓ FID is expected to begin by FY2026
- ✓ MHI is working on many these projects



Courtesy: JOGMEC

CO_2 Capture project for Hokkaido Electric Power Co., Inc

- ✓ FEED for the CO_2 capture plant
- ✓ Will be Japan's largest CO_2 capture plant, with the capacity of 5,200 tons of CO_2 per day from the flue gas of power plant boiler
- ✓ Hokkaido Electric Power (HEPCO) concluded a FEED contract with “JOGMEC”, a Japanese government Incorporated Administrative Agency, with Idemitsu Kosan Co., Ltd. and Japan Petroleum Exploration Co., Ltd

PRESS INFORMATION

MHI Awarded Contract for Basic Design of Japan's Largest CO_2 Capture Plant at Hokkaido Electric Power's Tomato-Atsuma Power Station -- One of Advanced CCS Projects in Japan, Moving Forward toward the Realization of a Carbon-Neutral World --

2025-07-07

- Investigation of the facility's main equipment and specifications for capture of 5,200 tons of CO_2 per day through MHI's proprietary CO_2 capture technology
- Concept to store captured CO_2 in the sea area off Tomakomai, based on JOGMEC's advanced CCS projects

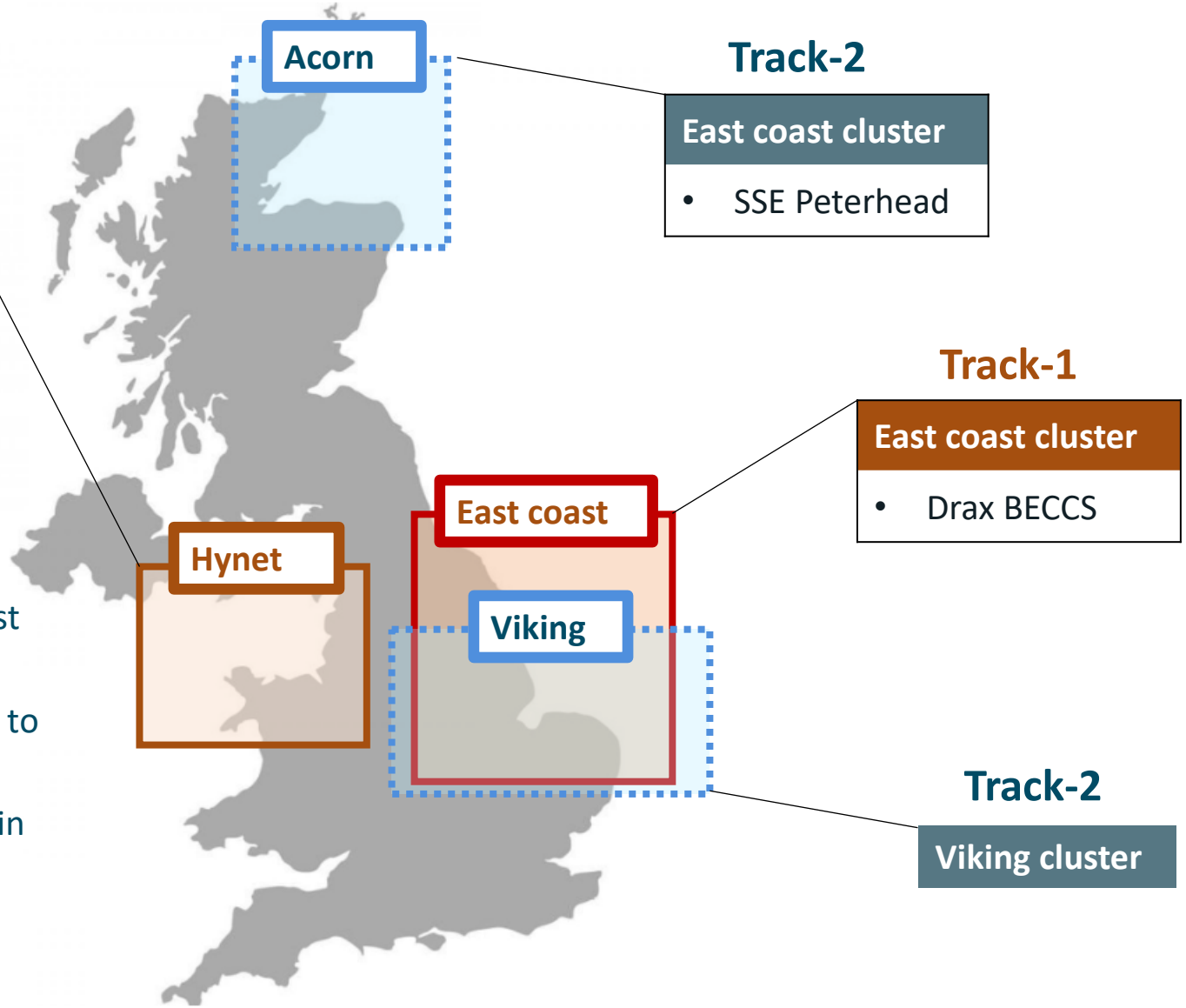
UK Cluster / MHI engagement projects

Track-1

Hynet Cluster

Priority projects by DESNEZ
- **Heidelberg Materials Padeswood**
- **Evero InBECCS**

Stand-by projects by DESNEZ
- EET ICC
- EET HPP2



Track-2

East coast cluster
- SSE Peterhead

Track-1

East coast cluster
- Drax BECCS

Track-2

Viking cluster

- Regional low carbon cluster across North West England & North Wales
- Livepoor Bay CO_2 transport & storage system to be operated by ENI
- Reached financial close with UK government in April 2025
- Initial sequestration around 4.5 $MtCO_2$/year, planning to scale towards 10 $MtCO_2$/year

Heidelberg Materials UK Padeswood project

- ✓ FEED by MHI and Worley for CO2 capture plant at Padeswood Cement Works in Flintshire, UK.
- ✓ Part of the HyNet CCUS cluster in the North West of the UK
- ✓ Capture up to 800,000 tons of CO2 annually and store it in a depleted gas field off Liverpool Bay
- ✓ Implement the basic design of the CO2 capture plant using the "Advanced KM CDR Process™" proprietary CO2 capture technology

PRESS INFORMATION

MHI and Worley Awarded FEED Contract for UK's First CO_2 Capture Plant at a Cement Production Facility
-- Contract Awarded Following Successful Pre-FEED in 2022, Further Promoting Decarbonization of the Cement Industry --

2024-02-06

- Contract awarded for Padeswood CCS project, selected in Track-1 for the HyNet CCUS cluster in the UK.
- It will capture and store up to 800,000 tons of CO_2 annually from the cement plant flue gas by applying proprietary CO_2 capture technology.
- Plant operations could commence in 2028

Padeswood cement works (photo courtesy of Heidelberg Materials UK)

Evero InBECCS project

- ✓ Retrofit carbon capture to Evero's Ince Bio Power site, a waste wood to energy facility located in the North-West of England
- ✓ A priority project by the UK government, connecting to HyNet
- ✓ 250,000 tonnes of potential carbon captured annually
- ✓ Operation planned from 2029

PRESS INFORMATION

Evero partners with Mitsubishi Heavy Industries on Carbon Capture technology for BECCS project in UK's North-West

2023-11-09

Evero Energy Group Limited
Mitsubishi Heavy Industries, Ltd.

Ince Bio Power (Photo courtesy of Evero Energy Group)

ArcelorMittal's Steel / Iron Making Plant

- ArcelorMittal, the world's leading global steel and mining company, BHP, Mitsubishi Development Pty Ltd, and MHI are collaborating on a multi-year trial of MHI's carbon capture technology with ArcelorMittal

Project Formation	✓ ArcelorMittal is facilitating the trial at its 5 million tons per year steel plant in Gent, Belgium, and at another location in North America ✓ MHI demonstrate its proprietary technology by small scale test unit and perform engineering study for full scale plant
Plant Location	✓ Gent, Belgium (Blast Furnace) ✓ North America (DRI plant)
CO2 Source of Emissions	✓ Blast Furnace gas ✓ Hot Strip Mill Heater flue gas ✓ DRI reformer flue gas
CO2 capacity	0.3 t/d

ArcelorMittal Steel/Iron Making Plant

Pilot plant in Gent, Belgium

https://www.mhi.com/news/24052102.html

Partnership Agreement with SBM Offshore for FPSO CO2 Capture Solution

- ✓ Install a CO2 capture module based on the Advanced KM CDR Process™ technology in the FPSO to capture CO2 from the gas turbines
- ✓ CO2 capture from onboard gas turbines is estimated to reduce CO2 emissions from the FPSO by up to 70%
- ✓ Started a study to apply CO2 capture modules to Petroleo Brasileiro S.A. (Petrobras) and other clients together with SBM Offshore

PRESS INFORMATION

SBM Offshore and MHI Sign Partnership Agreement for FPSO CO_2 Capture Solution

2023-09-15

SBM Offshore
Mitsubishi Heavy Industries, Ltd.

Visit to MHI headquarters by SBM Offshore executives

Recent effort including R&D activities

Demonstration test for proprietary solvent

MHI, PCCC-6

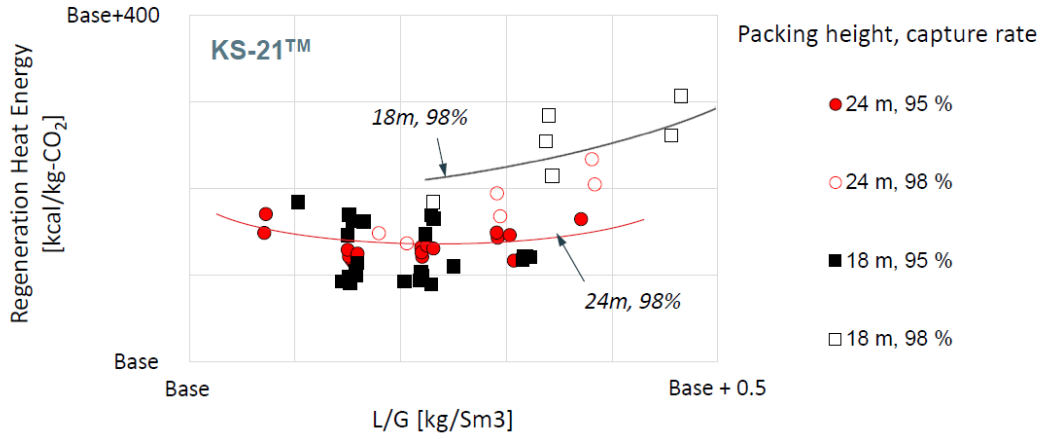
Regeneration energy as parameters of L/G, absorber packing height, and CO2 capture rate. Degraded amine emission measurement (continuous basis) by PTR-TOF-MS . . . . . .

TCM in Norway in 2021

Demonstration test in TCM - Regeneration Energy

MITSUBISHI HEAVY INDUSTRIES

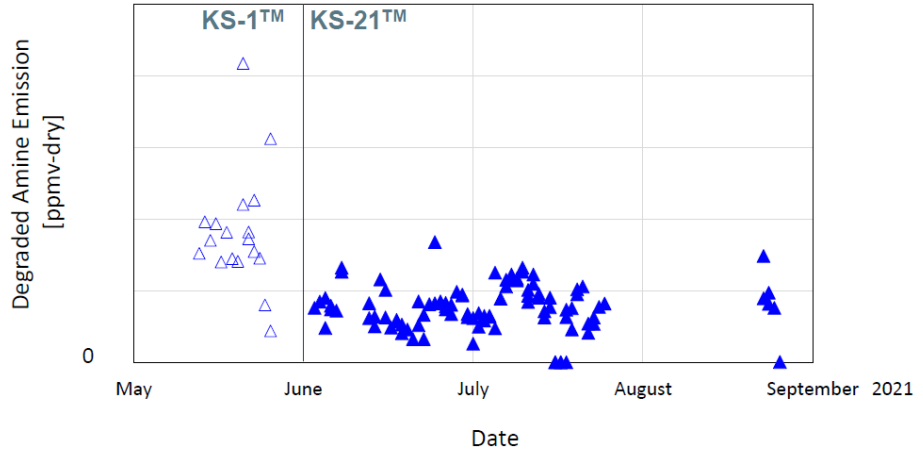
- ✓ KS-21™ Regeneration Heat Energy results for 95%, 98% CO_2 capture rate
- ✓ Comparable reboiler duty at same absorber packing height & Regenerator pressure.



Demonstration test in TCM – Degraded Amine

MITSUBISHI HEAVY INDUSTRIES

- ✓ KS-21™ showed lower Degraded Amine emission (PTR-TOF-MS)



Challenges to CCUS project implementation by Post-Combustion

Many Post-combustion CCUS projects have been slow to materialize until now,
but are gradually gaining momentum

Technical Challenges

- Cost (Capture, Transportation, Storage, CO2 Utilization)
- Technology Maturity (from bankable perspective)
- Supply Chain
- Location of Emission Sources and Storage Sites

Commercial challenges

- Economics and Profitability
- Law and regulation
- Policies and Incentives
- Storage risks & liability
- Financing

→ ***For capture unit licensor***

- *CAPEX reduction*
- *Reduce Energy consumption*
- *Solvent degradation*
- *Adverse effect by gas impurities*
- *Reduce Footprint / Scale up*
- *Minimize amine emission*

New Pilot plant

PRESS INFORMATION

MHI Starts Operation of New CO_2 Capture Pilot Plant at KEPCO's Himeji No.2 Power Station -- Promoting Research and Development of CO_2 Capture Technologies to Further Strengthen Competitiveness --

2025-05-14

- Demonstration of next-generation CO_2 capture technologies being developed jointly with ExxonMobil
- State-of-the-art R&D facility to meet diverse customer needs in addition to reductions in greenhouse gas emissions

- ✓ A new CO2 capture pilot plant taking over the previous “Nanko Pilot Plant”
- ✓ Use gas turbine flue gas with app. 5 tons per day capacity
- ✓ Demonstration of next-generation, innovative CO2 capture technology being developed with ExxonMobil

Technology Alliance with ExxonMobil

- ✓ Partnering to implement MHI's CO2 capture technology within ExxonMobil's end-to-end carbon capture and storage (CCS) solution for industrial clients
- ✓ Aim to enhance carbon capture technologies to reduce CO2 capture cost
- ✓ The joint effort will build upon Advanced KM CDR Process™, developed by MHI and KEPCO

PRESS INFORMATION

ExxonMobil, Mitsubishi Heavy Industries Form Carbon Capture Technology Alliance

2022-11-30

ExxonMobil
Mitsubishi Heavy Industries, Ltd.

- ExxonMobil adds Mitsubishi Heavy Industries' carbon capture technology to its integrated CCS offering
- Companies bring complementary capabilities to facilitate industry decarbonization projects
- Agreement will advance next-generation carbon capture technologies

User Conference /Feedback from commercial units

- ✓ KM CDR users shared their own operation experiences with each user

  For example,

  <u>Operational issues and/or malfunction</u>

  - Countermeasure
  - Proper maintenance
  - Solvent management

  <u>Improvement & Modification</u>

  - Debottlenecking
  - Optimization by operation parameters
  - New developed technology

- ✓ Incorporate lesson & Learned here into KM CDR Process™ for improvement

@Bahrain,17-18 May 2023

Summary

Summary

- ✓ MHI is the industry-leading technology provider for the post-combustion process, and is involved in CCUS projects around the world
- ✓ MHI is working to improve the technology to address challenges that currently hinder the realization of CCUS projects
- ✓ Post-combustion CCUS projects, many of which have been delayed until now, are gradually moving toward full-scale commercialization, and MHI continues to contribute in any way possible to their realization

MOVE THE WORLD FORWARD

MITSUBISHI
HEAVY
INDUSTRIES
GROUP

Appendix