MOVE THE WORLD FORWARD MITSUBISHI HEAVY INDUSTRIES GROUP

Update of MHI CO_2 Capture Technology

20th October 2021

Mitsubishi Heavy Industries, Ltd.

MITSUBISHI HEAVY INDUSTRIES

MITSUBISHI HEAVY INDUSTRIES GROUP

1884 Foundation
over 130 years history

80,000+ Employees
(Consolidated)

200+ Group Companies
(Consolidated)

$30.3BLN Net Sales
(FY2020, Consolidated)

$2.4BLN Capital
(As of March 31, 2020)

Diverse **Products**
on Land, at Sea, in the Sky, in Space

MITSUBISHI HEAVY INDUSTRIES ENGINEERING

2018 Foundation

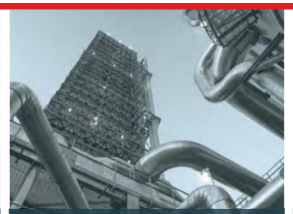
Dedicated to **Engineering Business**
- EPC
- Manufacturing
- O&M


H-IIA Launch Vehicle


Fighter

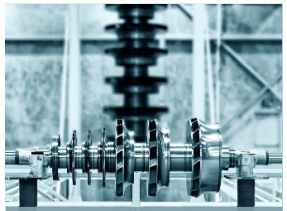

Turbocharger

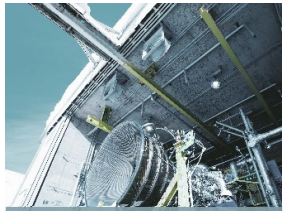

Chemical Plant


CO_2 Capture Plant


Transportation


Gas Turbine


Compressor


LE-7A Engine


Aero Engine


Waste-from-Energy

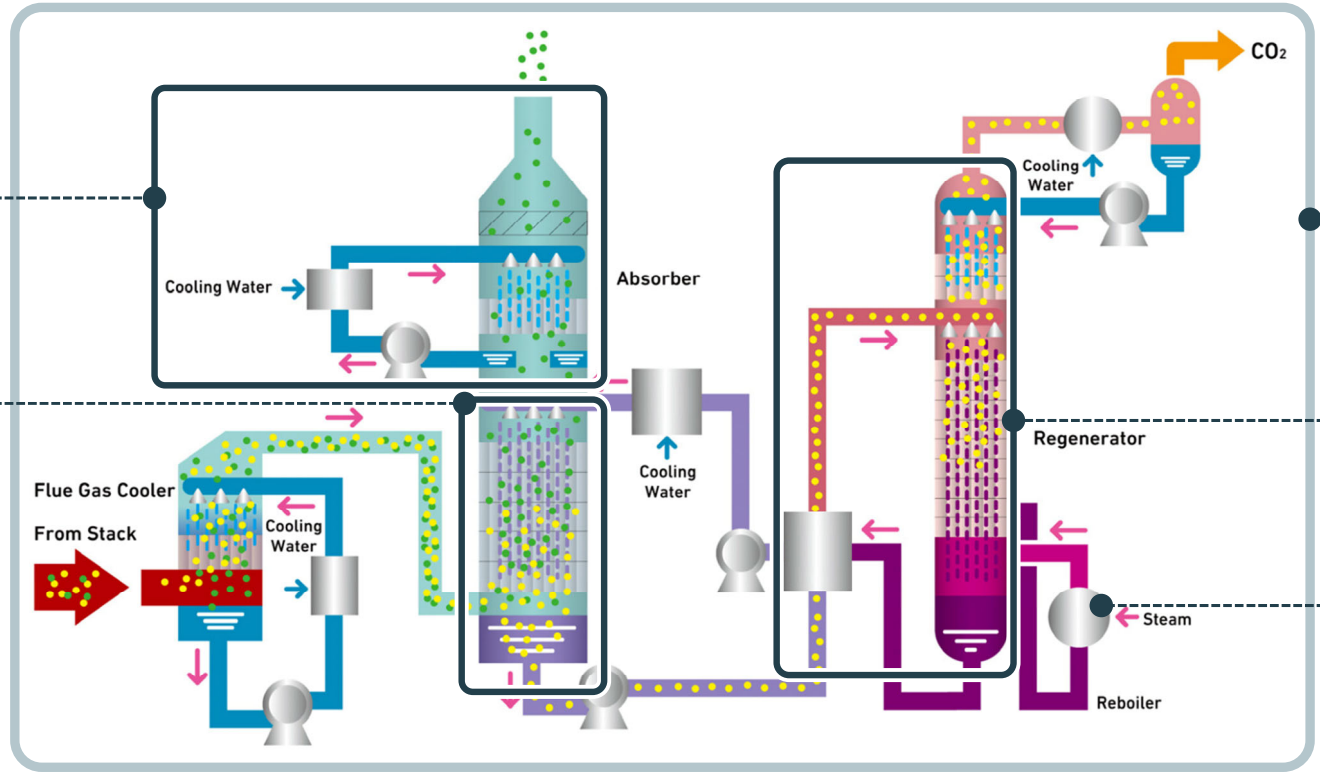

Metal Machinery

KM CDR Process™ - Overview and Features

- KM CDR Process™ = ***Kansai Mitsubishi Carbon Dioxide Recovery Process***
- Amine-based technology
- Capable of capturing CO_2 from various combustion gas
- Proprietary features developed over three decades

Amine washing system reduces VOC emissions and amine emission

KS-1/KS-21™ solvent with high CO_2 capacity, low degradation, and low regeneration energy



- **Automatic load adjustment control** (ALAC) for dispatchability operation
- Amine filtration and purification systems
- Proven tower design for even gas/liquid distribution

Regenerator system design for lower heat duty

Reboiler design for large-scale

History of MHI's technology development

KM CDR Process™ Reliable Solution

Accumulation of technologies and experiences

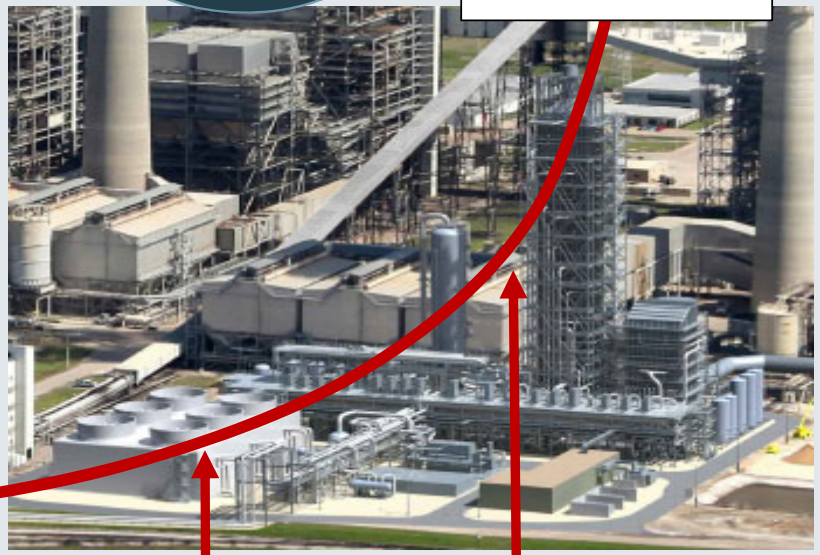
1 T/D Pilot

10 T/D Small Scale Demonstration

500 T/D Large Scale Demonstration

5,000 T/D Larger Scale Commercial

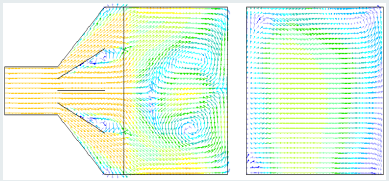
10,000+ TPD



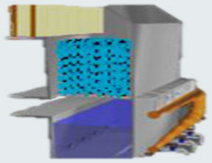
MHI Commercial Experiences

MHI Test Facility
36'L x 18'W x 105'H

MHI R&D Simulators (CFD etc.)

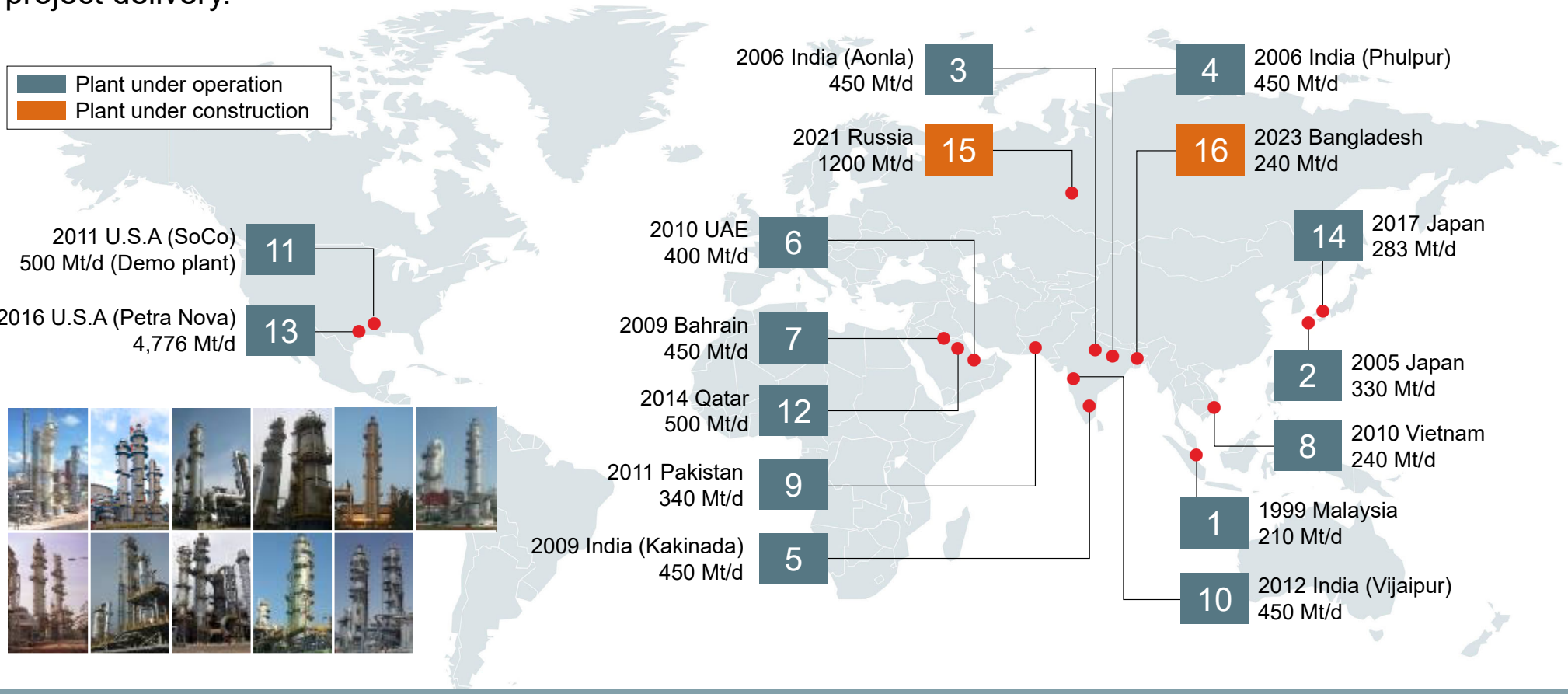


MHI Large Scale FGD Experiences
Large amount of flue gas
>200 commercial plants



KM CDR Process™ - Worldwide Commercial Experience

MHI's experienced global KM CDR Process™ team stands ready to meet customer requirements for commercial CO_2 capture plants on various exhaust from conceptual design through detailed engineering and project delivery.



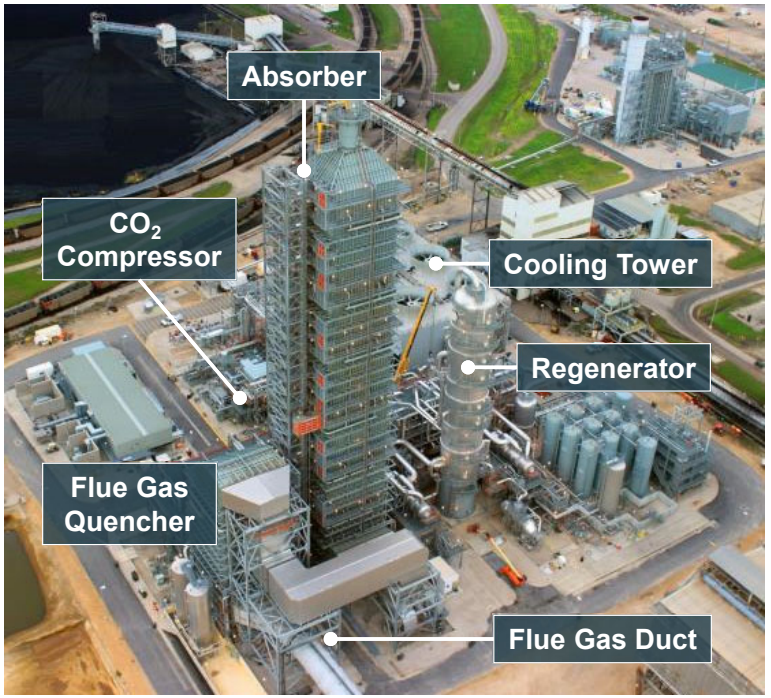
Commercial Plants of KM CDR Process™

Year of Delivery	Country	Flue Gas Source	CO_2 Capacity (TPD)	Application
1999	Malaysia	NG Fired Furnace	210	**Urea Production**
2005	Japan	NG and Heavy Oil Boiler	330	**General Use & Chemical Production**
2006	India	NG Fired Furnace	450	**Urea Production**
2006	India	NG Fired Furnace	450	**Urea Production**
2009	India	NG Fired Furnace	450	**Urea Production**
2009	Bahrain	NG Fired Furnace	450	**Urea Production**
2010	UAE	NG Fired Furnace & NG Boiler	400	**Urea Production**
2010	Vietnam	NG Fired Furnace	240	**Urea Production**
2011	Pakistan	NG Fired Furnace	340	**Urea Production**
2012	India	NG Fired Furnace	450	**Urea Production**
2014	Qatar	NG Fired Furnace	500	**Methanol Production**
2016	USA	Coal-Fired Boiler	4,776	**Enhanced Oil Recovery**
2017	Japan	Gas Fired Furnace	283	**General Use**
2021	Russia	NG Fired Furnace	1,200	**Urea & melamine Production**
2023 (Planned)	Bangladesh	NG Fired Furnace	240	**Urea Production**

Petra Nova Project - World largest Carbon Capture plant

- **The world's largest CO_2 capture plant** on coal-fired flue gas has been delivered in December 2016
- Supported by DOE (U.S. Department of Energy) grant program (Clean Coal Power Initiative Round 3) and Japanese government finance (JBIC / NEXI)

Plant location	NRG WA Parish Power Plant (Thompsons, TX)
Project owner	Petra Nova – partnership between NRG Energy and JX Nippon Oil & Gas
Plant scale	240 MW_{eq}
CO_2 capacity	4,776 TPD (1.4 Mmtonne/year)
CO_2 conc.	11.5 mol%-wet
CO_2 removal	90%



*U.S. Department of Energy "W.A. Parish Post-Combustion CO_2 Capture and Sequestration Project Final Environmental Impact Statement Volume I" (Feb, 2013), DOE/EIS-0473

Drax BECCS – Carbon capture from Biomass (Design stage)

Drax and MHI have agreed a long-term contract for use of MHI's carbon capture technology at Drax BECCS Project. (Press Release on 10th June 2021)

Project Information

Site Location	North Yorkshire, UK
Project Owner	Drax Power Limited
CO_2 Source	Biomass Boiler Flue Gas
CO_2 Capacity	At least 8 million tons per year
Capture Process	Advanced KM CDR Process™ KS-21™ Solvent

- **World's largest** carbon capture project **More than x5** of Petra Nova
- **World's first** negative emission project
- **UK's first** carbon capture project at scale

Lord Gerry Grimstone
UK Minister for Investment at the Department for International Trade

Rio Grande LNG Plant - Carbon Capture from LNG plant (Design stage)

CCS Project at Rio Grande LNG
NextDecade

- Permitted for full-scale development of **27 mtpa** (= 5.4 mtpa x 5 trains)
- Initial FID expected in 2021 on approx. **11 mtpa** (2 trains)
- MHIA is awarded **Process Design Package** for CCS (first 2 trains)
- Expected to be **the greenest** * LNG project in the world.

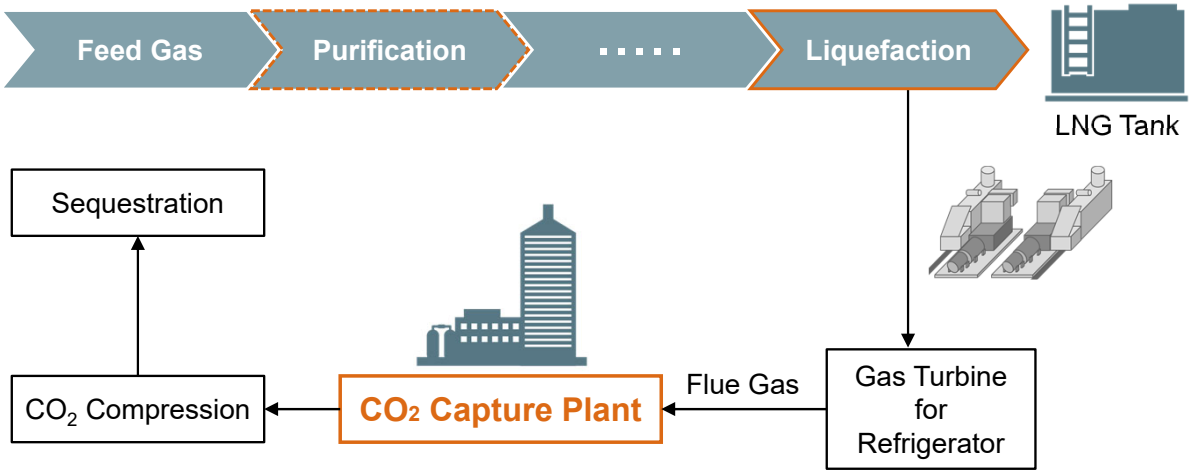
* more than **5 mtpa CO_2** is expected to be captured and stored (not only liquefaction but through the entire LNG production process)

Block Flow Diagram

- Refrigerator Driver (GT) at **Liquefaction** process
- Exhaust from **Gas Turbine** *
- Captured CO_2 to be put to **Sequestration**

* Mechanical drive for Refrigerator

Any LNG Liquefaction Plant with Gas Turbine can innovate KM CDR Process™



Lehigh Cement - Carbon Capture from Cement plant (Design stage)

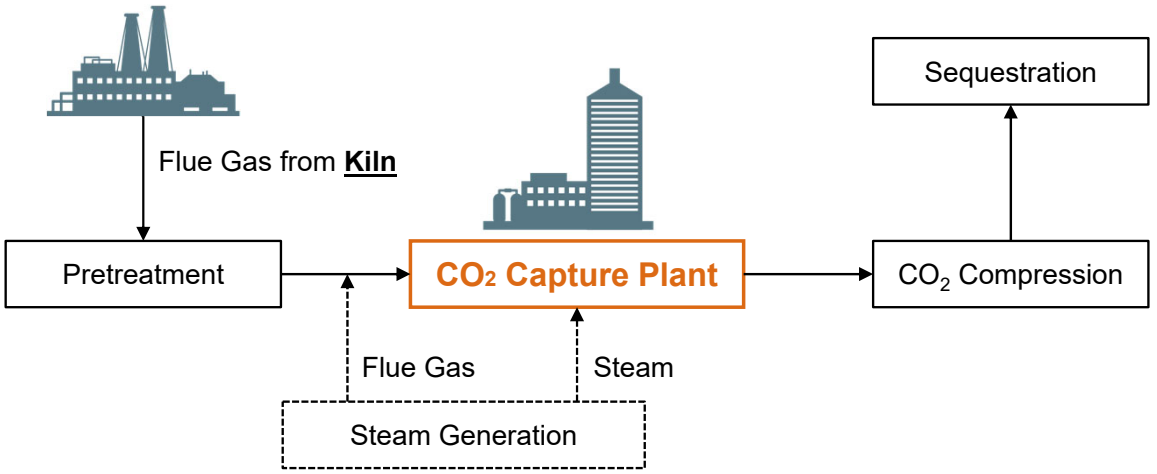
Lehigh Cement
Feasibility Study

- Advancing low carbon in cement industry contributing to **Canada Climate Plan**
- CCS on cement plant in **Edmonton, Alberta**
- Looking at a viability of capturing **90-95%** CO_2 (estimated **600,000tpa**)
- Co-study with **International CCS Knowledge Centre**
- Funded by **Emissions Reduction Alberta*** (local government)

  * invests innovative science and engineering that propels reducing GHG

Block Flow Diagram

- Flue gas from **Kiln**
  (over **90%** of CO_2 from Cement Plants)
- Optimization to **impurities** specific to cement plant



Prairie State Generating Station – Carbon Capture from Coal Plant (Design stage)

MHI was awarded the FEED contract for use of MHI's Advanced KM CDR Process™ with new KS-21™ solvent for Retrofitting the Prairie State Generating Station with an 816 MWe Capture Plant.

Project Information

Site Location	Urbana, Illinois, USA
Project Owner	University of Illinois
CO_2 Source	Coal Boiler Flue Gas
Sponsor	US Department of Energy
Capture Process	Advanced KM CDR Process™ KS-21™ Solvent

- **World's largest** CCS project from Coal fired power plant

URL : https://www.energy.gov/fe/foa-2058-front-end-engineering-design-feed-studies-carbon-capture-systems-coal-and-natural-gas

Pilot test - Carbon Capture from Marine

We support CC-OCEAN (Carbon Capture on the Ocean) together with Mitsubishi Shipbuilding.

Conceptual drawing of the CO_2 recovery demo plant

CC-OCEAN
CARBON CAPTURE ON THE OCEAN

PRESS INFORMATION

Mitsubishi Shipbuilding to Test World's First Marine-based CO_2 Capture System

-- "CC-Ocean" Project in Partnership with "K" Line and ClassNK Part of Japan Government Initiative to Support Development of Marine Resource Technologies --

2020-08-31

- World's first marine-based demonstration test of CO_2 capture to take place on "K" Line's coal carrier for Tohoku Electric
- Project will identify potential risks, and conduct operability and safety evaluations to determine ongoing specifications

Tokyo, August 31, 2020 - Mitsubishi Shipbuilding Co., Ltd., a part of Mitsubishi Heavy Industries (MHI) Group, is working in cooperation with Kawasaki Kisen Kaisha, Ltd. ("K" Line) and Nippon Kaiji Kyokai (ClassNK), to conduct test operations and measurements for a small scale ship-based CO_2 capture demonstration plant, in order to verify the equipment's use as a marine-based CO_2 capture system. This project is being conducted with support from the Maritime Bureau of Japan's Ministry of Land, Infrastructure, Transport and Tourism (MLIT), as part of its assistance project for research and development of technological advancements in marine resource development.

The demonstration involves converting the design of an existing CO_2 capture system for onshore power plants to a marine environment, and installing it on board an actual ship in service. This project, called "Carbon Capture on the Ocean" (CC-Ocean), is intended to achieve CO_2 capture at sea, a world first.

Press Release on Aug 31, 2020
https://www.mhi.com/news/20083101.html

Demonstration Test - Carbon Capture from GT & RFCC

Demonstration test was made for KS-21™ solvent using Technology Centre Mongstad facility.

Facility Information

Site Location	**Technology Centre Mongstad, Norway**
Flue gas Source	**CCGT and RFCC**
CO_2 Source	**CCGT, RFCC flue gas**
Solvent	**KS-21™ Solvent** **KS-1™ Solvent**
Period	**Beginning of May 2021 – End of August 2021**

Photograph courtesy of Technology Centre Mongstad

Summary

1. **KM CDR Process™** has **World's largest delivery** of Carbon Capture Plants for over 100 tpd capacity since 1999
   *- 13 plants under commercial operation including **World's largest Carbon capture plant** (Petra Nova) and currently 2 under construction*

2. **Commercially proven** & used on **Natural gas, Heavy oil, and Coal** for many purpose such as Urea, Methanol, EOR and other general usage.

3. **Various project ongoing**
   - Expanding types of feed flue gas such as LNG plant, cement, and GT

4. **Advanced KM CDR Process™ & New KS-21™ solvent**
   - Commercialization is starting from new projects in the engineering stage

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GROUP