

# Contributing to Decarbonization of Industries

December 4<sup>th</sup>, 2020

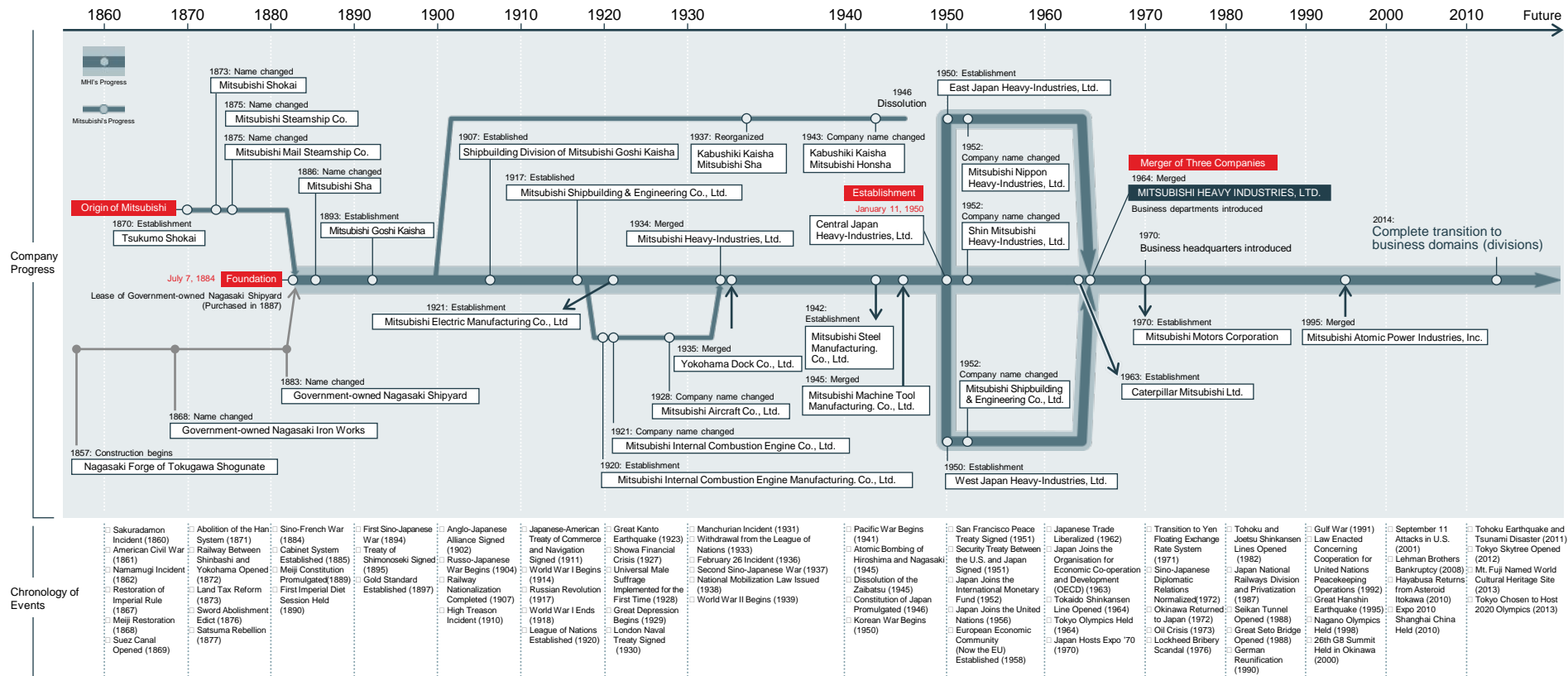
Fumiharu Shimamoto  
Chief Regional Officer, Europe  
Power & Energy Solutions  
Mitsubishi Heavy Industries Group

# HISTORY OF MHI GROUP

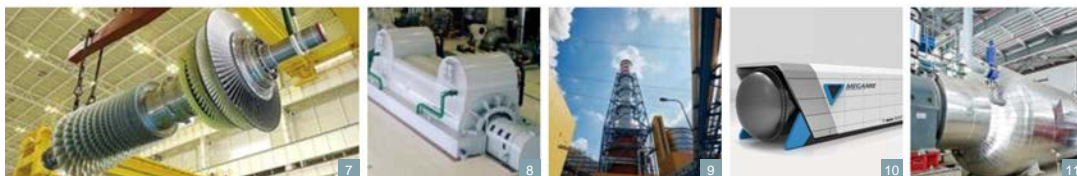
## Beyond 130 years of history, MHI Group technologies have supported Japan across rough seas.

Over one hundred and thirty years have elapsed since Mitsubishi first leased the government-owned Nagasaki Shipyard from the Ministry of Industry in 1884. MHI Group technologies have been instrumental in steering Japan's modernization and globalization.

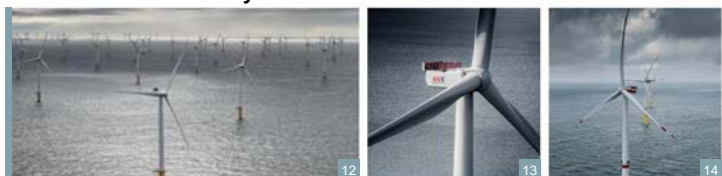
The history of Japan's development is etched into MHI Group technologies, products and services that underpin contemporary society.



## Thermal Power Systems



## Offshore Wind Power Systems



## Marine Machinery



## Aero Engines



## Compressors



## Thermal Power Systems

### ■ MITSUBISHI POWER, LTD.

1. Gas Turbine Combined Cycle (GTCC) Power Plant/Tohoku Electric Power Co., Inc. Sendai Thermal Power Plant No. 4 (Japan)
2. Steam Power Plant/JERA Co., Inc. Hitachinaka Thermal Power Station No. 1, No. 2 (Japan)
3. Integrated coal Gasification Combined Cycle (IGCC) Power Plant/Joban Joint Power Co., Ltd. Nakoso Power Plant No. 10 (Japan)
4. Geothermal Power Plant/Reykjavik Energy Hellisheidi Geothermal Power Plant (Iceland)
5. Aero-derivative Gas Turbine FT8® MOBILEPAC®
6. LP Steam Turbine Rotor with 54-Inch Blades for Nuclear Power Plant
7. M501J Gas Turbine
8. 1,120 MVA Turbine Generator
9. Flue Gas Desulfurization Plant/Kozienice Power Plant (Poland)
10. Solid Oxide Fuel Cell (SOFC)/Micro Gas Turbine (MGT) Hybrid System

### ■ TURBODEN S.P.A.

11. Organic Rankine Cycle (ORC) Power System

## Offshore Wind Power Systems

### ■ MHI VESTAS OFFSHORE WIND A/S

12. MVOW Platform! Off shore Wind Turbine (Belgium)
13. MVOW Platform! Off shore Wind Turbine (Denmark)
14. MVOW Platform! Off shore Wind Turbine (Germany)

## Marine Machinery

### ■ MITSUBISHI HEAVY INDUSTRIES MARINE MACHINERY & EQUIPMENT CO., LTD.

15. MET Turbocharger
16. Ultra Steam Turbine (UST) Plant
17. Auxiliary Boiler
18. Fin Stabilizers
19. Steering Gear

## Aero Engines

### ■ MITSUBISHI HEAVY INDUSTRIES AERO ENGINES, LTD.

20. V2500 Series (Turbofan)
21. Trent Series (Turbofan)
22. PW1000G Series (Turbofan)
23. MRO: Maintenance, Repair and Overhaul
24. TS1 (Turboshaft) Engine, Output Power: 884 SHP [Observation Helicopter OH-1]

## Compressors

### ■ MITSUBISHI HEAVY INDUSTRIES COMPRESSOR CORPORATION

25. Cracked Gas Compressors and Steam Turbines for Ethylene Plant
26. Main Gas Compressor Trains for FPSO
27. Product Gas Compressors and Steam Turbines for PDH Plant
28. Rotor of Steam Turbines



## Commercial Ships



## Commercial Ships

### ■ MITSUBISHI SHIPBUILDING CO., LTD.

1. Ferry, SETTSU
2. Cargo-passenger Ship, OGASAWARA MARU
3. RO/RO Ship, HIMAWARI 8
4. Marine Resources Survey Ship, HAKUREI
5. Patrol Vessel, SHUNKO
6. LPG Carrier, FUTURE ENERGY
7. SOx Scrubber Systems for Large Output Engines
8. SOx Scrubber Systems for Small to Medium Output Engines
9. LNG Fuel Gas Supply System (FGSS)

## Marine Structures



## Marine Structures

### ■ MITSUBISHI HEAVY INDUSTRIES MARINE STRUCTURE CO., LTD.

10. KAMI-GOTO National Oil Stockpiling Site

## Chemical Plants



## Chemical Plants

### ■ MITSUBISHI HEAVY INDUSTRIES ENGINEERING, LTD.

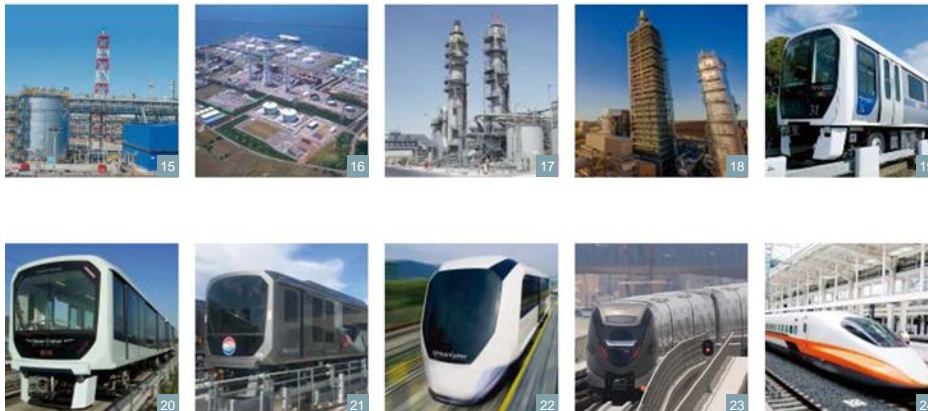
11. Ammonia and Methanol Co-production Plant (Tatarstan/Russia)
12. Ammonia/Urea Plant (Malaysia)
13. Methanol Plant (Venezuela)
14. Polyethylene Plant (Mexico)
15. Acrylic Acid Plant (Bashkortostan/Russia)
16. LNG Receiving Terminal (Niigata, Japan)
17. CO<sub>2</sub> Capture Plant (Qatar)
18. CO<sub>2</sub> Capture Plant for EOR (U.S.)

## Transportation Systems

### ■ MITSUBISHI HEAVY INDUSTRIES ENGINEERING, LTD.

19. AGT for Tokyo Yurikamome
20. Macau LRT
21. Tampa International Airport APM (U.S.)
22. Super AGT
23. Urban Transportation System (Doha Metro)
24. High-speed Rail (Taiwan)

## Transportation Systems




# Decarbonization – An Integrated Solution

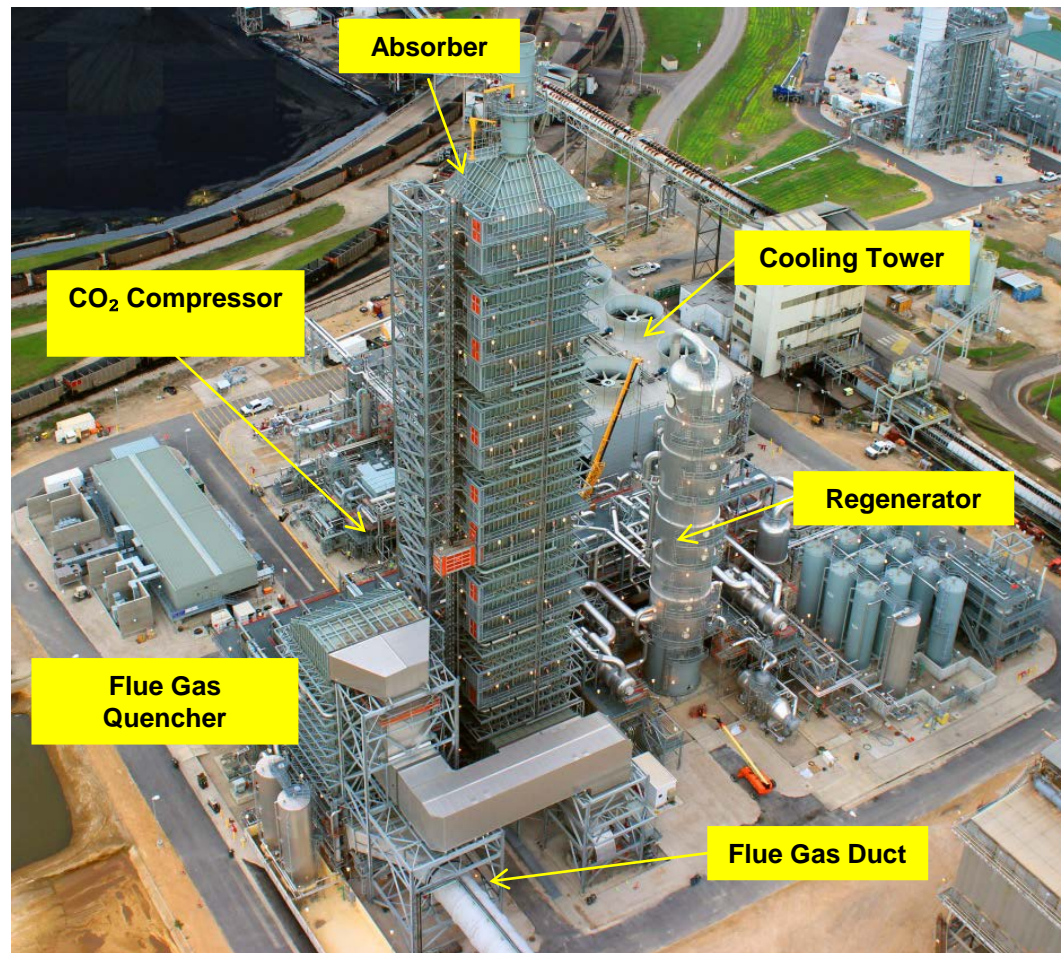




# Petra Nova – The World's Largest CO<sub>2</sub> Capture

- ✓ **The world's largest CO<sub>2</sub> capture plant** on coal-fired flue gas has been under commercial operation since December 2016
- ✓ Supported by DOE (U.S. Department of Energy) grant program (CCPI 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 <sub>eq</sub>
CO <sub>2</sub> capacity	4,776 TPD (1.4 MMtonne/year)
CO <sub>2</sub> conc.	11.5 mol%-wet
CO <sub>2</sub> removal	90%



*\*U.S. Department of Energy "W.A. Parish Post-Combustion CO<sub>2</sub> Capture and Sequestration Project Final Environmental Impact Statement Volume I" (Feb, 2013), DOE/EIS-0473*

## Creating Green Hydrogen Value Chain



### Leading position in floating offshore wind

- **Under Operation:**

- **Windfloat Atlantic**

V164-8.4 MW x 3 (25.2 MW) Portugal, 2020



- **Under Construction:**

- **Kincardine Offshore Windfarm**

V164-9.5MW x 5 (47.5MW) / UK, 2020



- **Preferred Supplier:**

- **Groix & Belle-Ile /**

V164-9.5 MW x 3 (28.5 MW) France

- **EFGL**

V164-10.0 MW x 3 (30.0 MW) France

- **EolMed**

V164-10.0 MW x 3 (30.0 MW) France,





## Creating Green Hydrogen Value Chain



Site: Velika Ciglena, Croatia  
Customer: MB Holding  
Start-up: 2018  
Configuration: power only  
ORC power: 17.5 MWe  
Liquid brine + steam: 171 °C



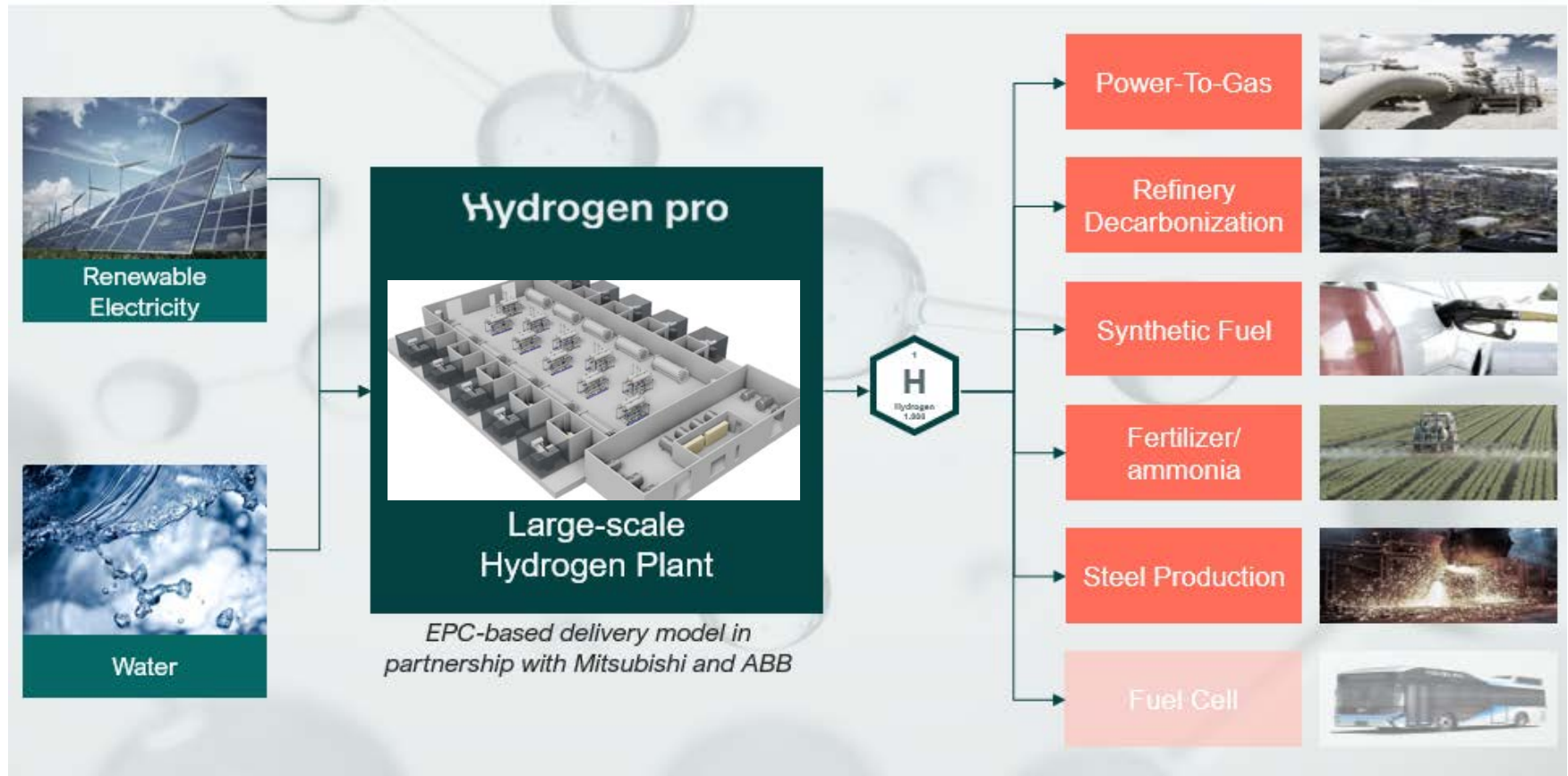
## Creating Green Hydrogen Value Chain

### Hydrogen pro

- HydrogenPro aims to be a world leading designer and supplier of alkaline electrolyser technology plants and solutions that meet the highest standards for safety, reliability and long lifetime
- HydrogenPro was established in 2013
- Headquarter in Porsgrunn, Norway
- Public listed company on Merkur Market at Oslo Stock Exchange
- Mitsubishi Heavy Industries acquired 9.6% of HydrogenPro in October, 2020



## Creating Green Hydrogen Value Chain





**Leading EPC Contractor for Ammonia Plant**  
**Authorized Licensee of Haldor Topsoe Ammonia Technology**  
**Business Development of Blue / Green Ammonia Projects**

**14.3% share world wide**

(2008-2018,  
contractors share  
for ammonia plant,  
Capacity-based)



**Leading EPC Contractor for Methanol Plant**  
**Mitsubishi Methanol Process & Haldor Topsoe Methanol Technology**  
**Business Development of Green Methanol Projects**

**14.0% share world wide**

(2000-2018,  
contractors share  
for methanol plant,  
Capacity-based)





# Direct Reduction - MIDREX<sup>®</sup> H<sub>2</sub>

## The World's Leading DRI Production Process

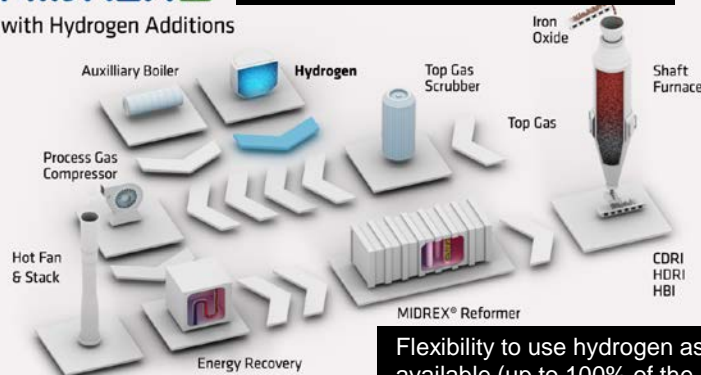


### NEAR FUTURE (TRANSITION): NG/H<sub>2</sub> based DRI + EAF

### FUTURE: H<sub>2</sub> DRI + EAF

**MIDREX<sup>NG</sup>**

with Hydrogen Additions

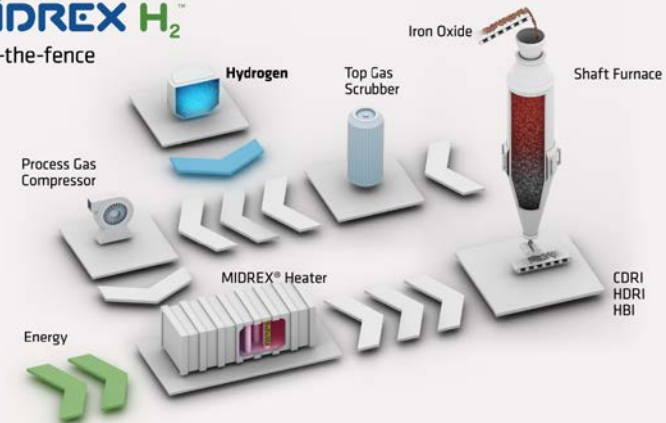


Proven technology available today  
**Immediate CO<sub>2</sub> reduction of ~50%  
vs. BF/BOF route**

Flexibility to use hydrogen as it becomes  
available (up to 100% of the reductant,  
source can be on-site or external)

**MIDREX<sup>H2</sup>**

over-the-fence



Feed Gas	Natural Gas	Natural gas + Hydrogen (as % of energy from external H <sub>2</sub> )			Hydrogen
		20%	50%	70%	
CO <sub>2</sub> emissions (kg <sub>CO2</sub> / t <sub>DRI</sub> )	500	400	250	150	From heater burners only

Hydrogen: 650 Nm<sup>3</sup>/t<sub>DRI</sub> (58 kg/t<sub>DRI</sub>)  
For 2.0 Mt/y MIDREX Plant:  
→ approx. 162,500 Nm<sup>3</sup>/h (14,625 kg/h)  
→ 800 MW electrolyzer capacity required

## The Next Generation DRI Production Process



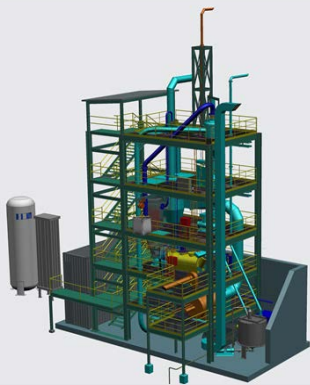
**HYFOR** is a new developed direct reduction process for **any type** of iron ore concentrate (hematite and magnetite)

*From lab scale via*

*pilot plant to*

*industrial scale*

### Hot Bench Scale Plant



### Pilot plant in Austria

Start up: Q1 2021

#### Testing phase:

- Test of different iron ore fines.
- Material tests of concentrates of customers interested in this new technology for iron ore reduction.

**After successful testing**, industrial plants will be built for lead customers.

### Industrial plant



Module size: 250,000 t/a

#### Iron ore concentrate

- direct use of pellet feed concentrate
- Typical grain size: 100% < 150 µm

#### Reducing gas

- **Hydrogen** 58 kg/t<sub>DRI</sub>

MAIN INPUT

#### No pelletizing required



**High oxide yield** due to dry dedusting and recycling of oxide dust

**CO<sub>2</sub> free ironmaking** by use of hydrogen

**High reduction rate** due to high particle surface

MAIN BENEFITS



## Advanced Class Gas Turbines for Deep Decarbonization

### Mitsubishi Power “JAC” Gas Turbine



	GT/ CC	
M701JAC (50Hz)	574 MW	840 MW
M501JAC (60Hz)	435 MW	630 MW

#### High Efficiency

Achieved 64% CC efficiency

with

- High pressure compressor (25:1)
- Enhanced air-cooled combustor
- Advanced TBC/Aerodynamics

#### High Reliability

Achieved 99.5% reliability by

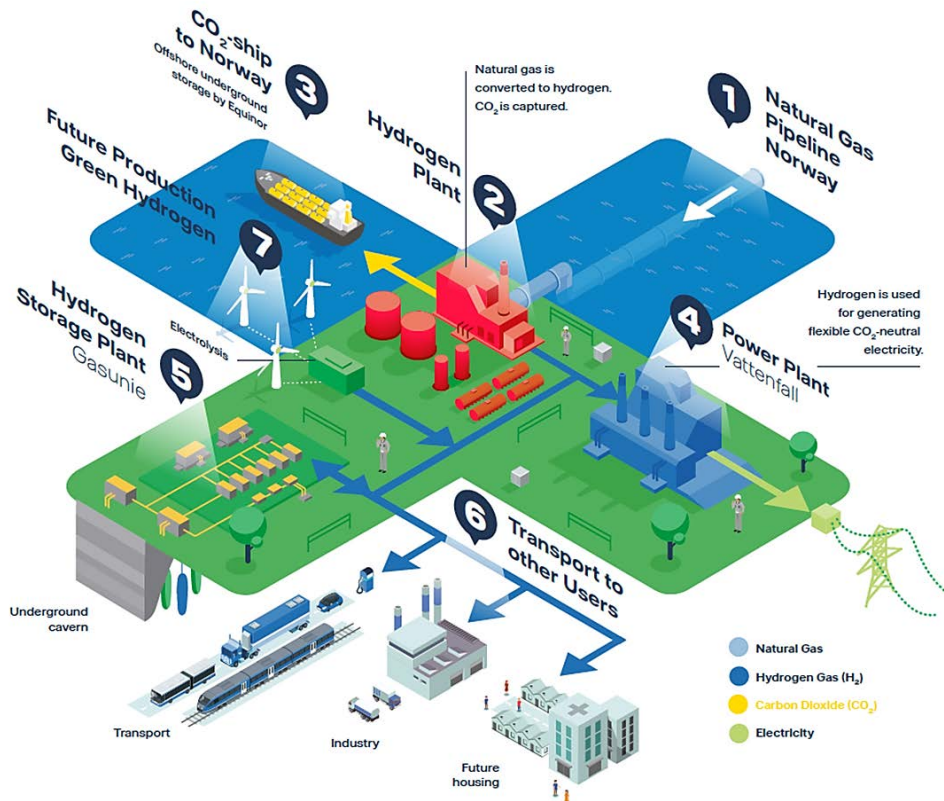
- Over 1070k operation hours
- Ordered: 76 GT units,  
Commercial operation: 45 GT  
units  
(J Series as of September 2020)

#### Fuel Flexibility

Gas Turbine can be fueled by

- Fossil fuel (Natural Gas, Oil)
- Clean fuel (Hydrogen)

## H2M Project - Towards clean and sustainable hydrogen economy



Turbine Model	M701F
Power Output	440 MW
CO <sub>2</sub> reduction	Up to 2 Mt/year*
Location	Eemshaven, The Netherlands

The goal is to Kick-start H<sub>2</sub> economy by using **Blue H<sub>2</sub>** for Hydrogen (100%) firing in CCGT by 2025, and gradual transition to **Green H<sub>2</sub>**.

Development of hydrogen demand by H2M will assist realization of hydrogen infrastructure.

\*Expected CO<sub>2</sub> emission reduction reaches up to 2Mt/year including use of Hydrogen in Transport, Industry and Housing.

Source and courtesy Vattenfall

**MOVE THE WORLD FORWARD**

**MITSUBISHI  
HEAVY  
INDUSTRIES  
GROUP**