Hydrogen Energy Supply Chain for Decarbonization

KAWASAKI HYDROGEN ROAD

Development of Innovative Hydrogen Technologies for Future Hydrogen Society

Company name, Location
Date

Shahrad Adjili
Head of Sales Europe

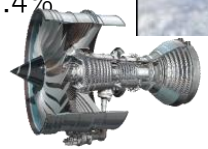
Kawasaki
Powering your potential

Kawasaki Heavy Industries - Sections

Motorcycle & Engine 20.6%

Others 6.2%

Aerospace Systems 32.4%



Rolling Stock 8.3%

Ship & Offshore Structure 4.4%

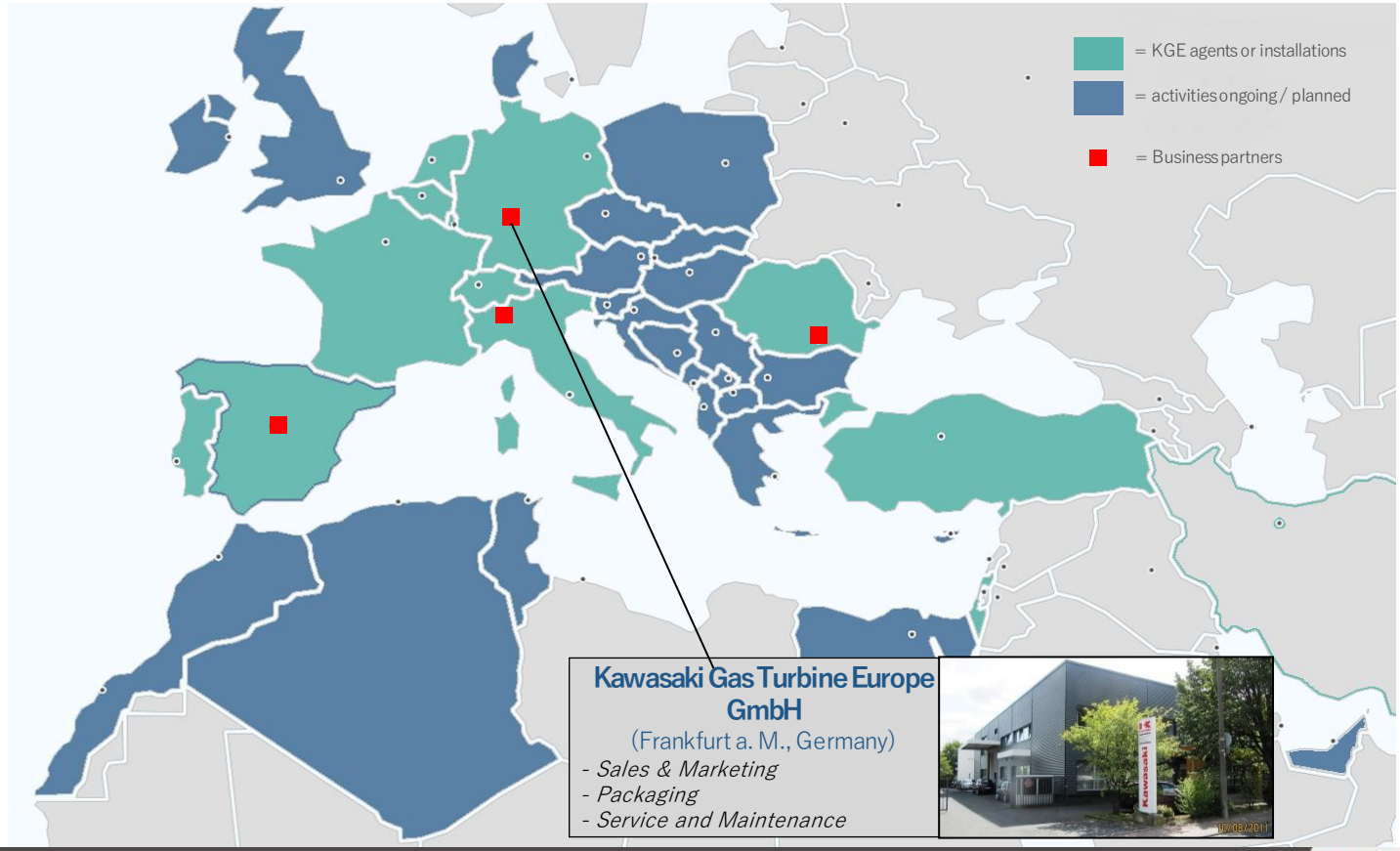
FY'19 Total Sales JPY1.64 Trillion (EUR 12.8 Billion)

Energy System & Plant Engineering 14.8%

Precision Machinery & Robot 13.2%

*Business year starts from Apr. 1 and ends on Mar. 31
**As of the business year ending Mar. 31 2020
***On a consolidated basis
****Ex. Rate: 1 ¥ =0,0078 €

Kawasaki Gas Turbine Europe



Kawasaki Products & Services

Kawasaki Gas Turbine Europe

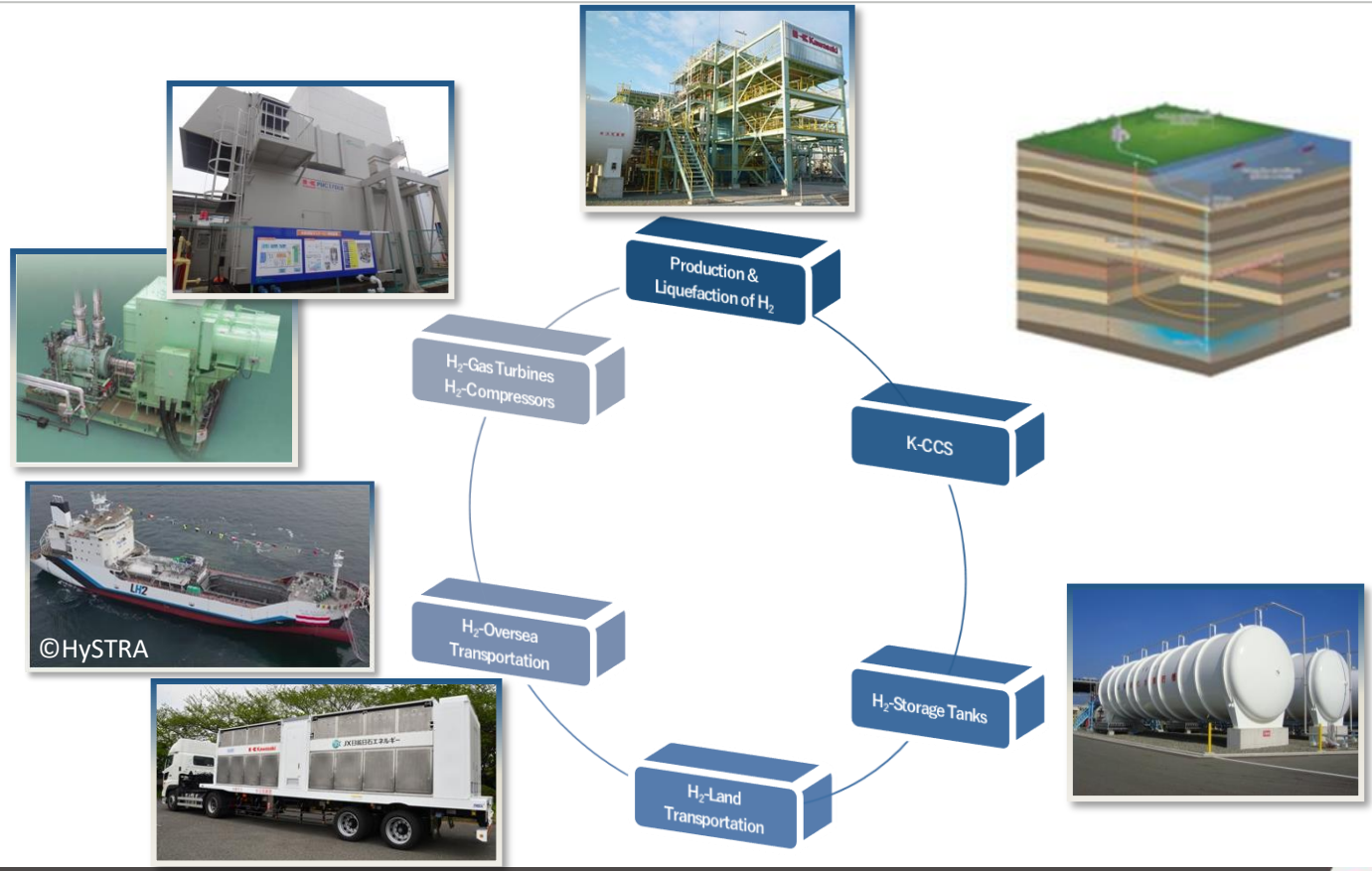
Products

Gas Turbines	Gas Engines
M1A-17D 1,800 kWel η = 28.1 %	KG12 5,200 kWel η = 49.0 %
M5A-01D 4,700 kWel η = 32.6 %	KG12-V 5,200 kWel η = 49.5 %
M7A-03D 7,800 kWel η = 33.6 %	KG18 7,800 kWel η = 49.0 %
L20A-01D 18,500 kWel η = 34.3 %	KG18-V 7,800 kWel η = 49.5 %
L30A-01D 34,300 kWel η = 40,3 %	KG18-T 7,800 kWel η = 51,0 %

Services

Engineering	Implementation	Maintenance
Preliminary Engineering	Project Planning	Custommers support
Detailed Engineering	Customized Packaging	Spare Parts & Comsumables
	Erection Commissioning	General Overhaul
		Remote Monitoring

Hydrogen Road of Kawasaki Heavy Industries (KHI)



Liquefied Hydrogen Carrier "Suiso Frontier"

Journey for commercialization

2020
Pilot Demo

1,250m^3 Ship x1

Mid 2020s
Commercial Demo

2030
Full Commercial

160,000m^3 Ship x2

Commercial Supply chain

Commercial scale
Technology confirmation

Technical & social
demonstration

Length(L.O.A)	約 315m
Breadth(Moulded)	約 56m
Cargo Tank Capacity (at -253℃、100%full)	40000 ㎥ / 基 x 4 基
Depth(Moulded)	28.0m
Designed Draught(Moulded)	11.0m

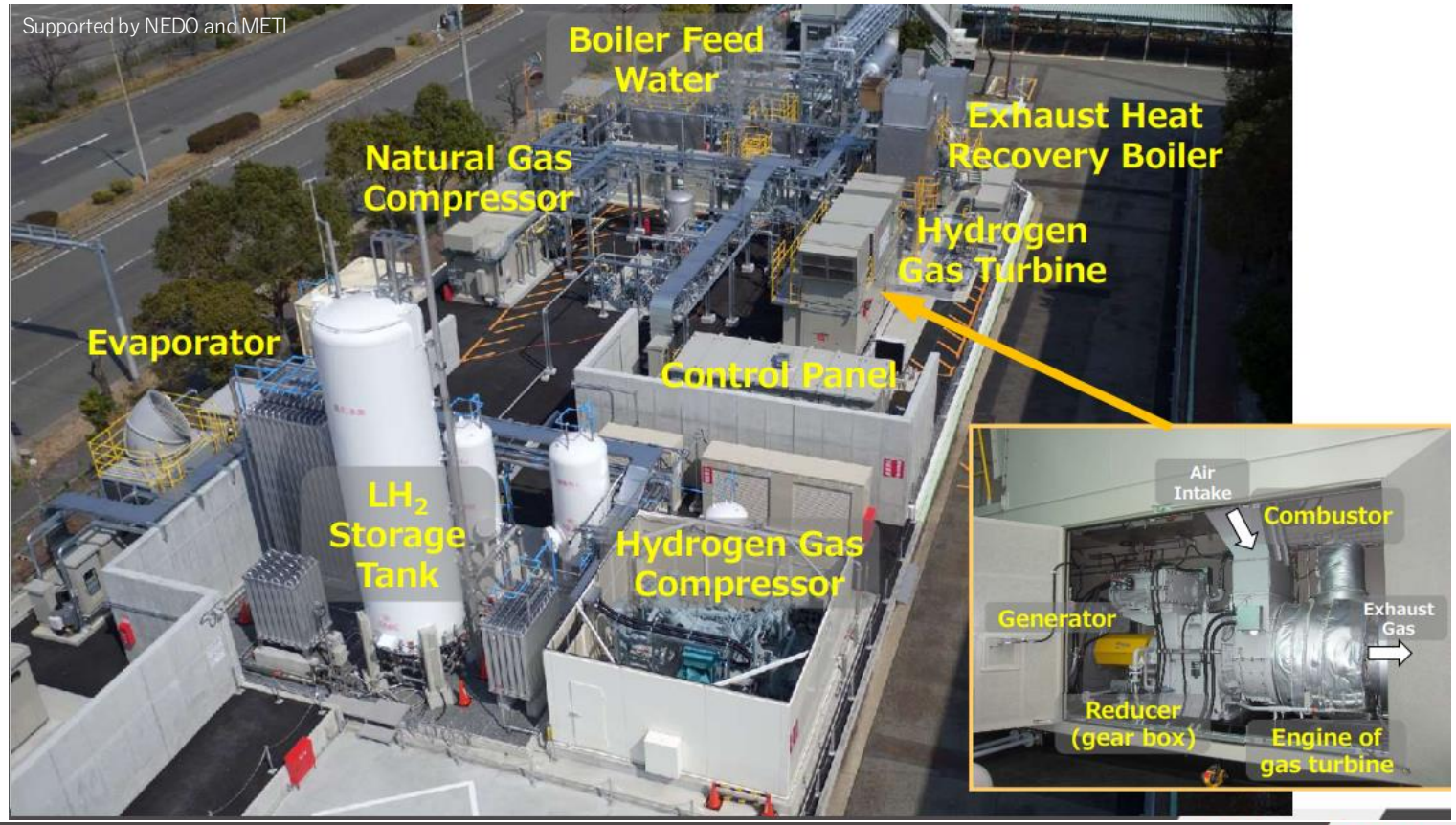
Liquefied Hydrogen Carrier "Suiso Frontier"

Launch ceremony (11 December 2019)
at KHI Kobe Shipyard

Cargo Tank Installation (7 March 2020)
at KHI Harima Works

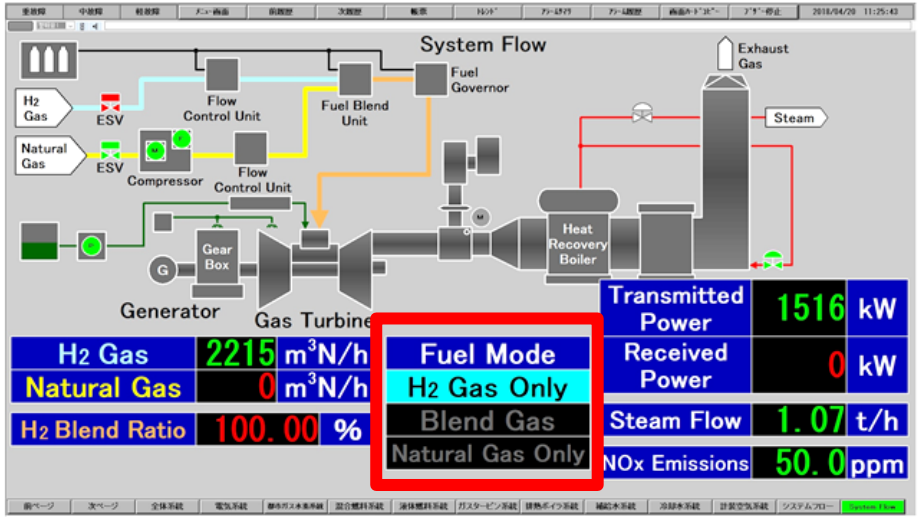
LH2 Receiving Terminal construction completed

World's First 100% H2-CHP Plant at Kobe Port



World's First H2-Power Plant at Kobe Port

User Control Interface



Comparison between NG & H_2

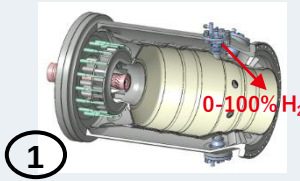
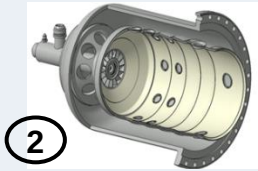
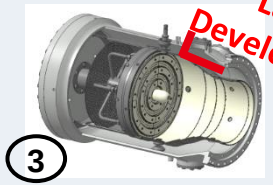
Gas Turbine Type		M1A-17	M1A-17
Fuel type		Natural Gas	Hydrogen
Electrical power	kW	1,848	1,902
Fuel input	kW	6,845	6,907
Efficiency	%	27.0	27.5
Exhaust gas mass flow	kg/s	7.98	7.89
Exhaust gas temperature	°C	529	528
Generator voltage	kV	0.4 / 6.3 / 10.5	0.4 / 6.3 / 10.5
Steam mass flow 8 bar(g) saturated	t/h	5.2	5.2
NOx Reduction method		Water injection	Water injection
Emissions (NOx)	ppm	37	73
Emissions (CO2)	%	3	**0.0**

Performance at 15°C, 60% RH, at Generator Terminal,
Inlet Pressure Loss 0,98 kPa, Exhaust Pressure Loss 2,45 kPa

Supported by NEDO and METI

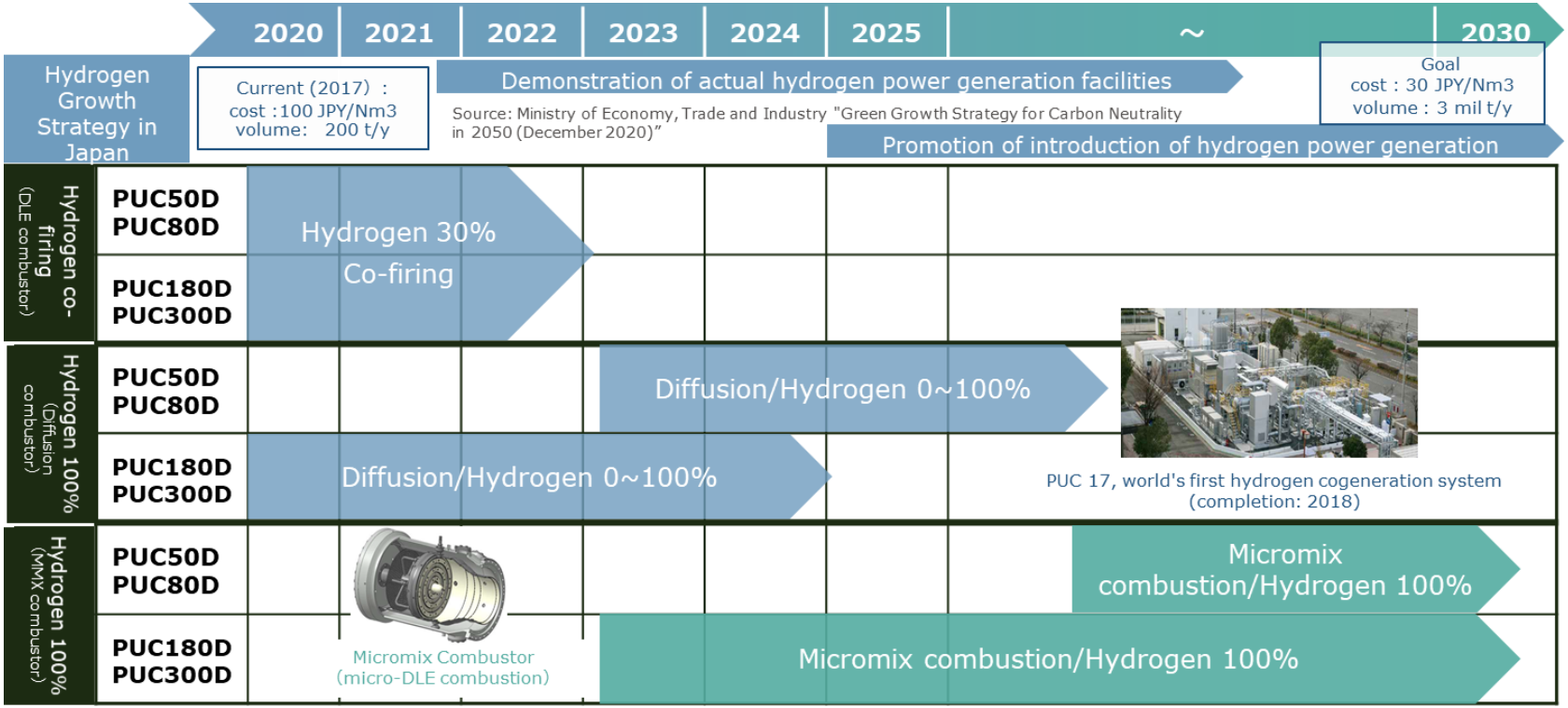
Developments for Hydrogen Gas Turbines @ KHI

Overview of Combustor Developments

Combustor Configuration	DLE Combustor for Natural Gas	Diffusion Flame Combustor	DLE Micro-Mix Combustor
NOx Reduction	"Dry"	"Wet" Water/Steam	"Dry"
			 Latest Development
Max. H2 Content	60vol%	100vol%	100vol%
Status	Engine Demonstration in Akashi Works, 2014 	Final Combustor Test, 2016 Applied to KOBE Demonstration Plant, 2018 	Final Combustor Test, 2018 Applied to KOBE Demonstration Plant, 2020  Supported by NEDO and METI

Main Difference between NG & H2 Gas Turbines is the Combustor

Hydrogen Capability of Gas Turbines @ KHI



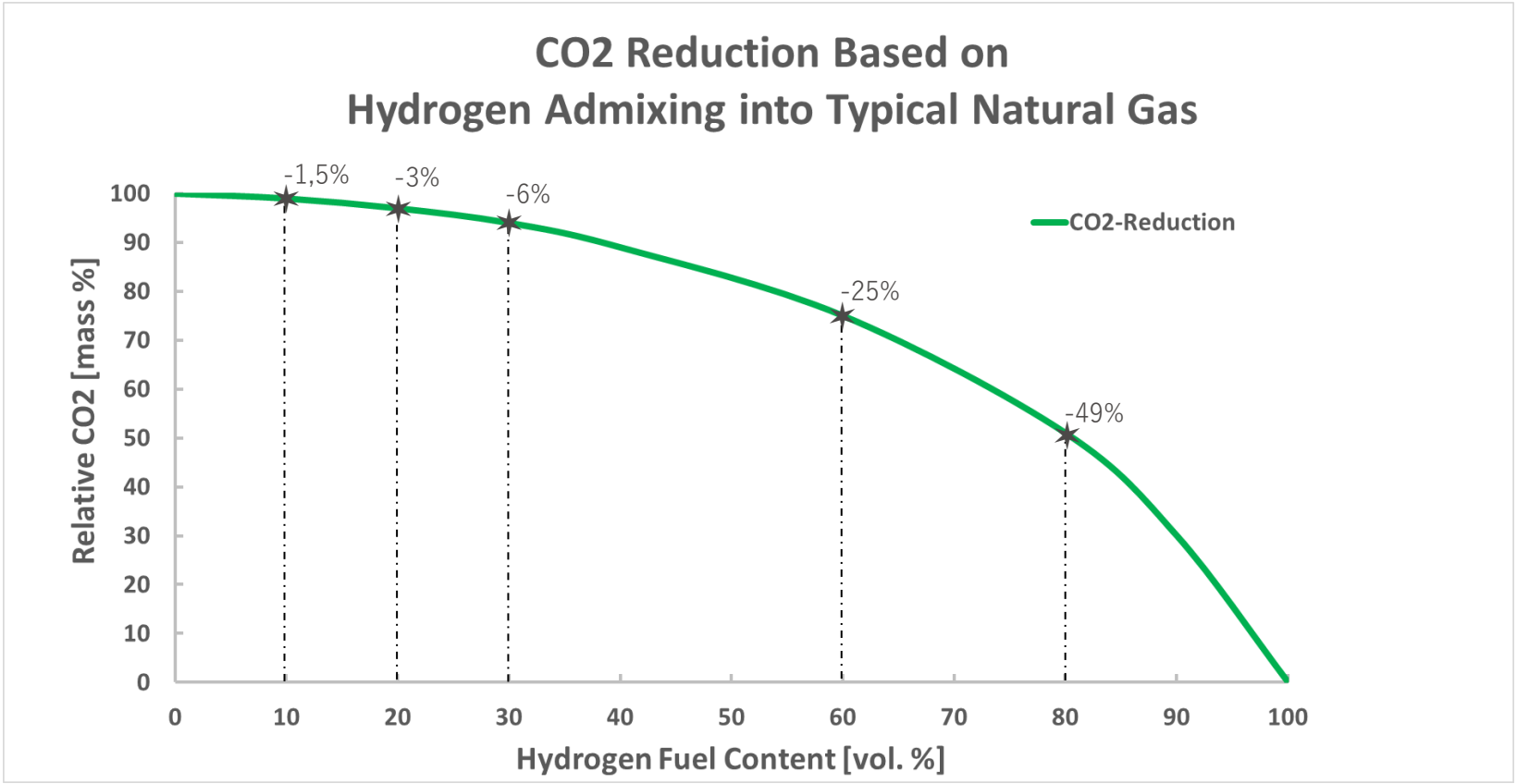
Joint undertaking of Kawasaki & RWE

RWE and Kawasaki plan to build one of the world's first 100% hydrogen-capable gas turbines on industrial scale in Lingen, Germany

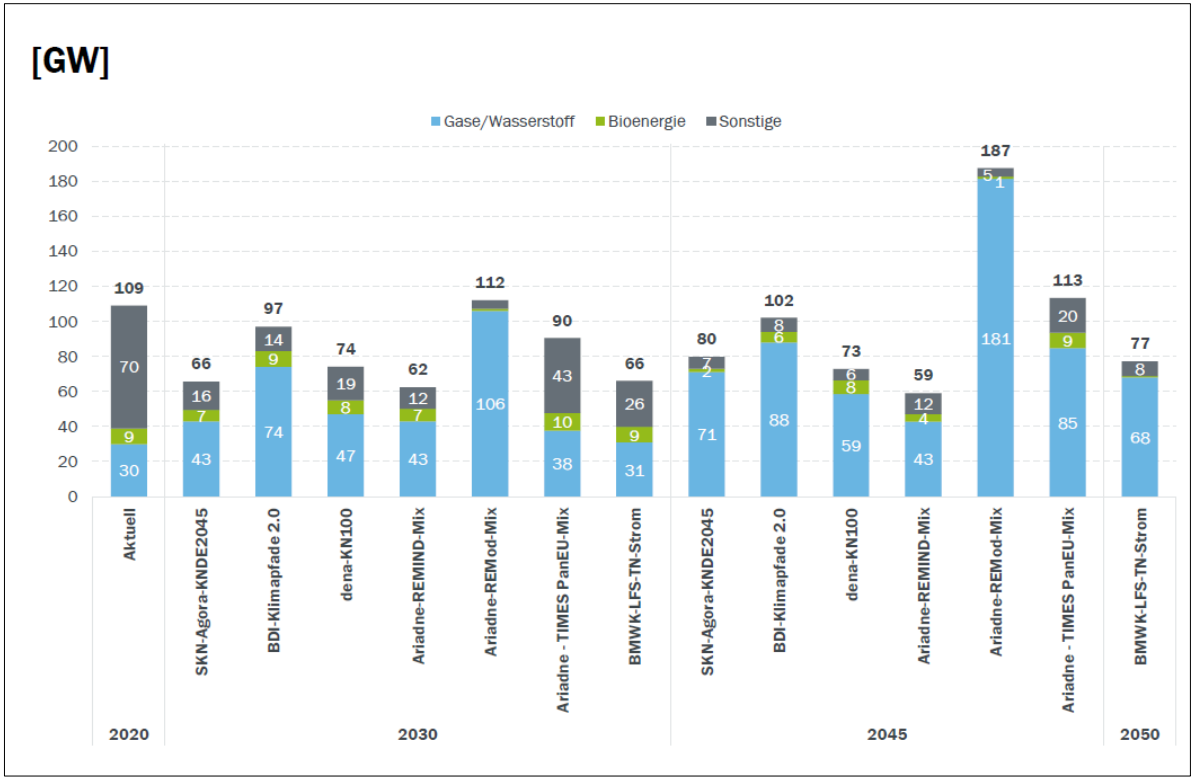
GETH2 Nukleus

- From 2024 onwards 34 megawatt plant could reconvert green hydrogen to power
- In future, H2-fuelled power plants will contribute significantly to green security of supply

Impact of Hydrogen Admixing on CO2 Reduction



Installed capacity of power plants - scenarios



Installed capacity gas/H2 power plants

- All scenarios show an increase in installed capacity of gas-fired power plants until 2030
- The range is very wide, from 31 GW to 106 GW in 2030

✓ GREEN Environmentally Friendly Technology for Industrial Applications by De-Carbonization of the Energy Production

✓ World's 1st Hydrogen Dry Low NOx Emission (DLE) System

✓ 0-100% Hydrogen Gas Turbine Technology are Already Available

✓ Provides Highest Fuel Flexibility, Blend NG/H2 Gas

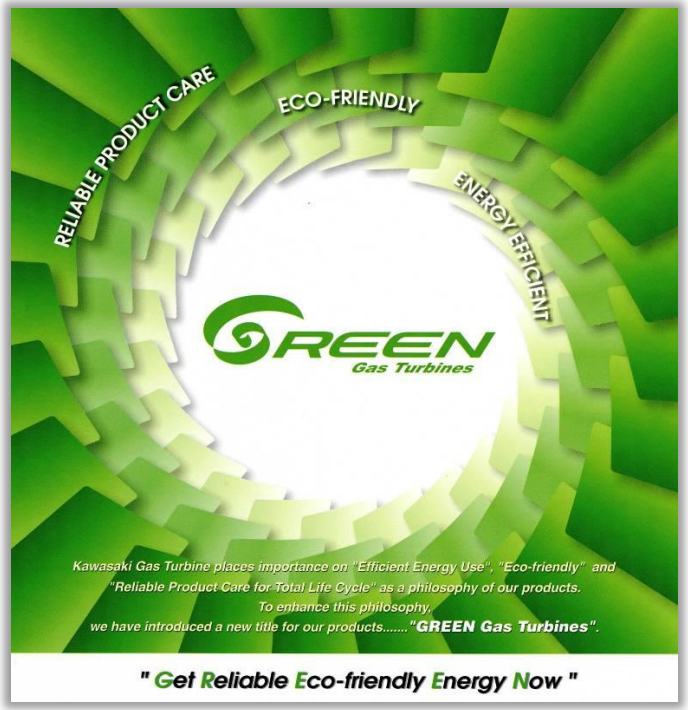
✓ Highest Efficiencies

✓ Lowest No_x-Emission

Why Hydrogen Technology of Kawasaki

- ✓ World‘s 1st Combined Heat and Power with Hydrogen
- ✓ GREEN Environmentally Friendly Technology for Industrial Applications by De-Carbonization of the Energy Production
- ✓ World‘s 1st Hydrogen Dry Low NOx Emission (DLE) System
- ✓ 0-100% Hydrogen Gas Turbine Technology is Already Available
- ✓ Provides Highest Fuel Flexibility, Blend NG/H2 Gas
- ✓ Highest Efficiencies
- ✓ Lowest NO_x-Emission

KAWASAKI Gas Turbine Europe – Contact details



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