KAWASAKI GAS TURBINE EUROPE GMBH

Gas Turbines Ready For Future Requirements

ENERGY EFFICIENCY IN THE INDUSTRIAL SECTOR

Combined Heat and Power Plants
with H_2-ready Gas Turbines.

Bratislava, 03rd December 2024

Author: **Alexander Lecheler**
Dipl.-Ing. (FH) I MBA
Business Development

MITTELSTAND GLOBAL
EXPORTINITIATIVE ENERGIE

Das Geschäftsreise-programm wird mitorganisiert von

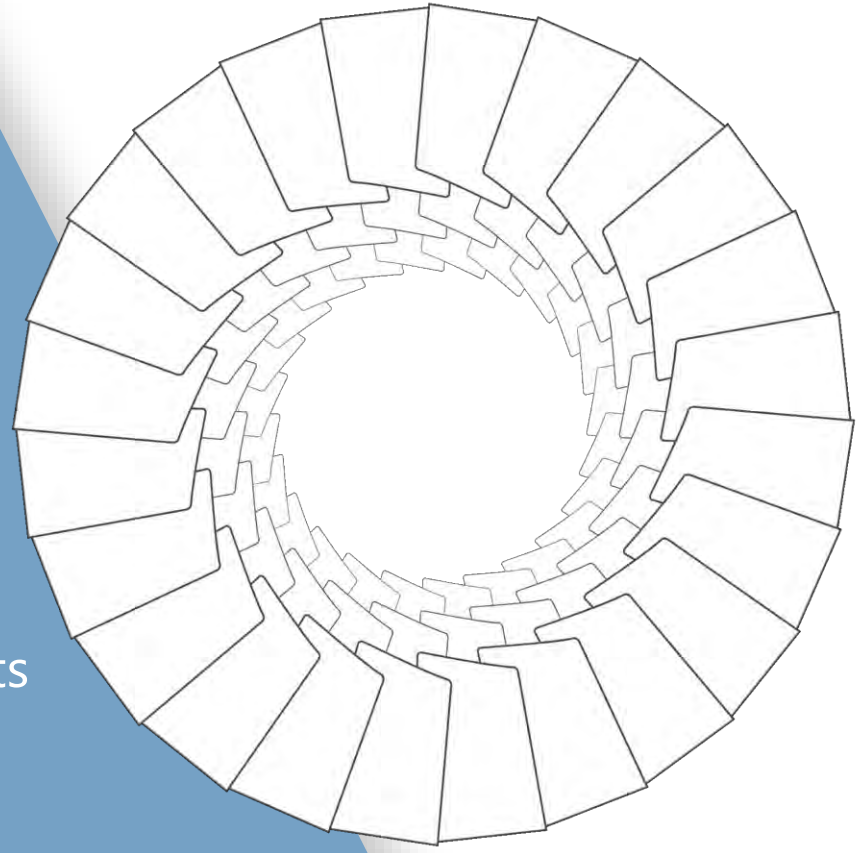
Agenda

I Kawasaki Heavy Industries (KHI)

II Kawasaki Gas Turbine Europe (KGE)

III Kawasaki Energy Efficiency, Products & Services

IIII Hydrogen Approach and Applications of Generator Sets

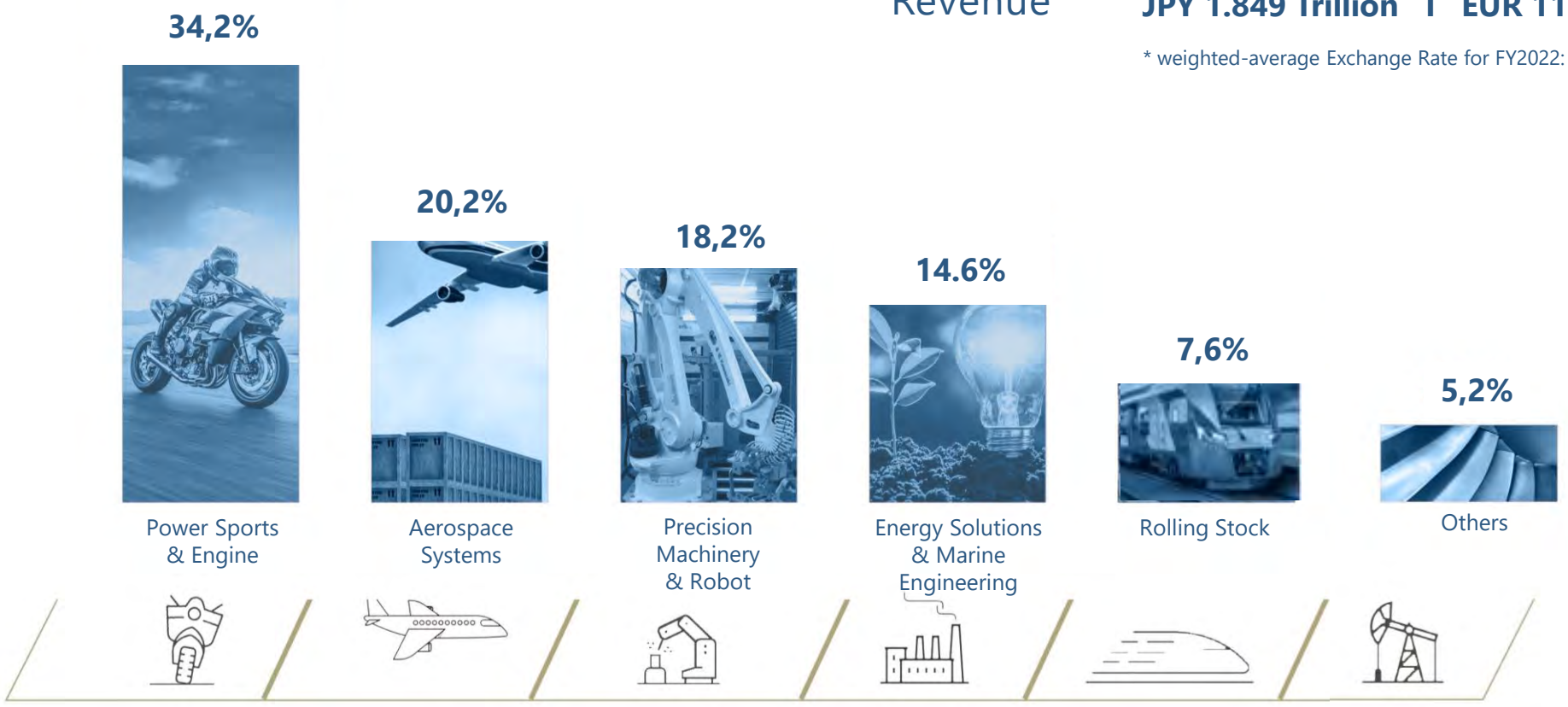


KAWASAKI HEAVY INDUSTRIES, LTD. (KHI)

FY2023 Business year started from April 1, 2023 and ended on March 31, 2024

Revenue **JPY 1.849 Trillion I EUR 11.7 Billion***

* weighted-average Exchange Rate for FY2022: 157,09 ¥/€



KAWASAKI HEAVY INDUSTRIES, LTD. (KHI)

Kawasaki Heavy Industries, Ltd. (Tokyo Head Office)
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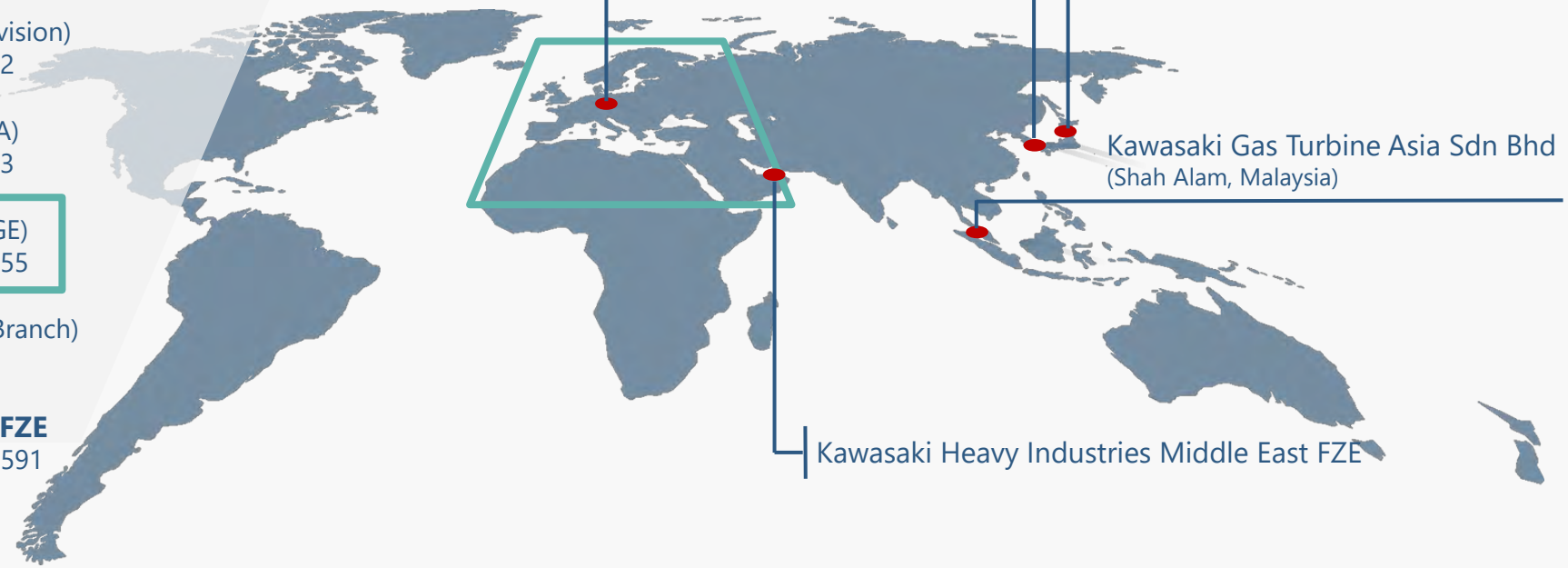


Energy System & Plant Engineering Company
global.kawasaki.com/en/energy/equipment/gas_turbines/index.html

Kawasaki
Powering your potential

KAWASAKI GAS TURBINE EUROPE GMBH (KGE)

Regions of Activity KGE

- **Kawasaki Gas Turbine Europe GmbH** (Frankfurt, Germany)
  - Sales & Marketing
  - Packaging
  - Service and Maintenance

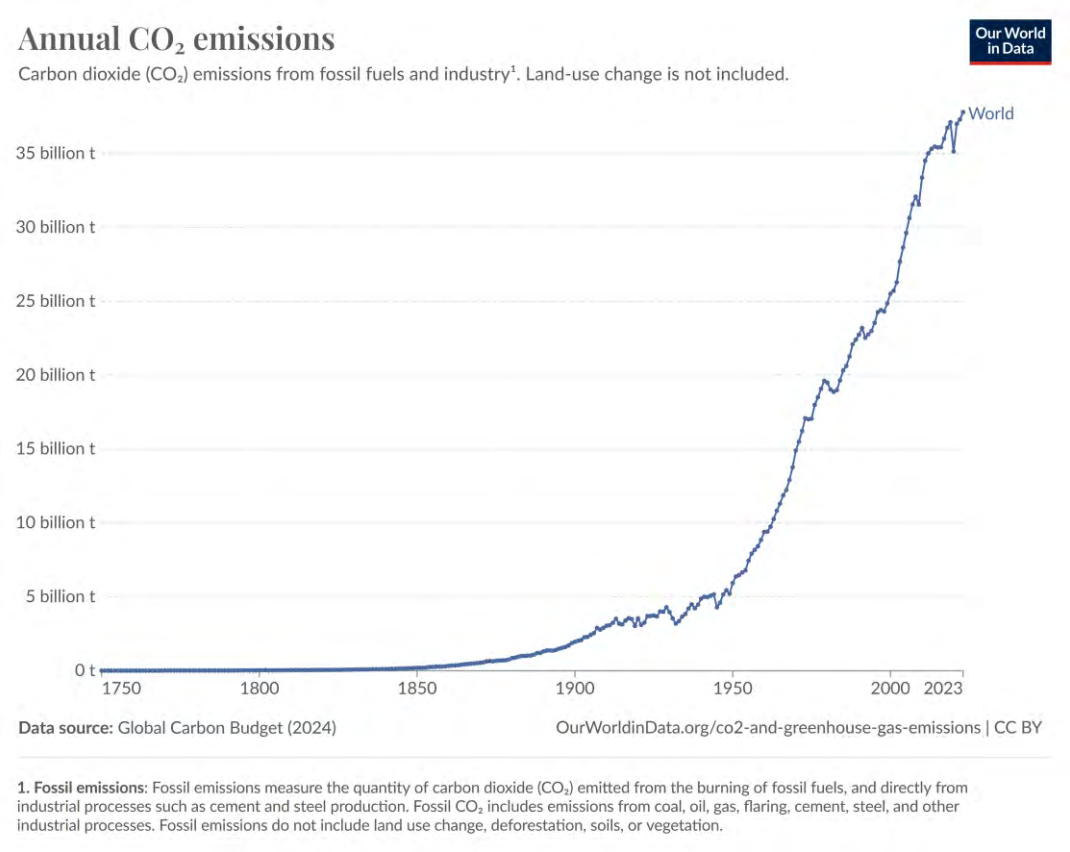
- **Kawasaki Gas Turbine Europe GmbH** (Bucharest, Romania)
  - Sales & Marketing

- **KGE Agents**

META Power Systems	(Tunis, Tunisia)
ENERGETUS S.A.	(Lisboa, Portugal)
ELEMONT Sp. z o.o.	(Wrocław, Poland)
MERCURIO S.r.l.	(Verbania, Italy)
NNG Enerji Teknoloji Ltd.	(Istanbul, Turkey)
SOLJET Energía S.A	(Madrid, Spain)

- **Kawasaki Heavy Industries Middle East FZE** (Dubai, UAE)

KAWASAKI GAS TURBINE EUROPE GMBH (KGE)



KAWASAKI TARGET MARKETS

Industries with Continuous High Temperature Heat Demand

Pulp and Paper

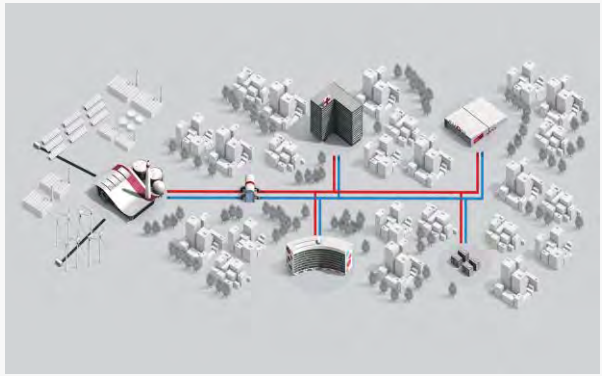
Pharma / Cosmetics

Refinery / Chemistry

Automotive / Tires

Food – Beverage - Dairy

District Heating

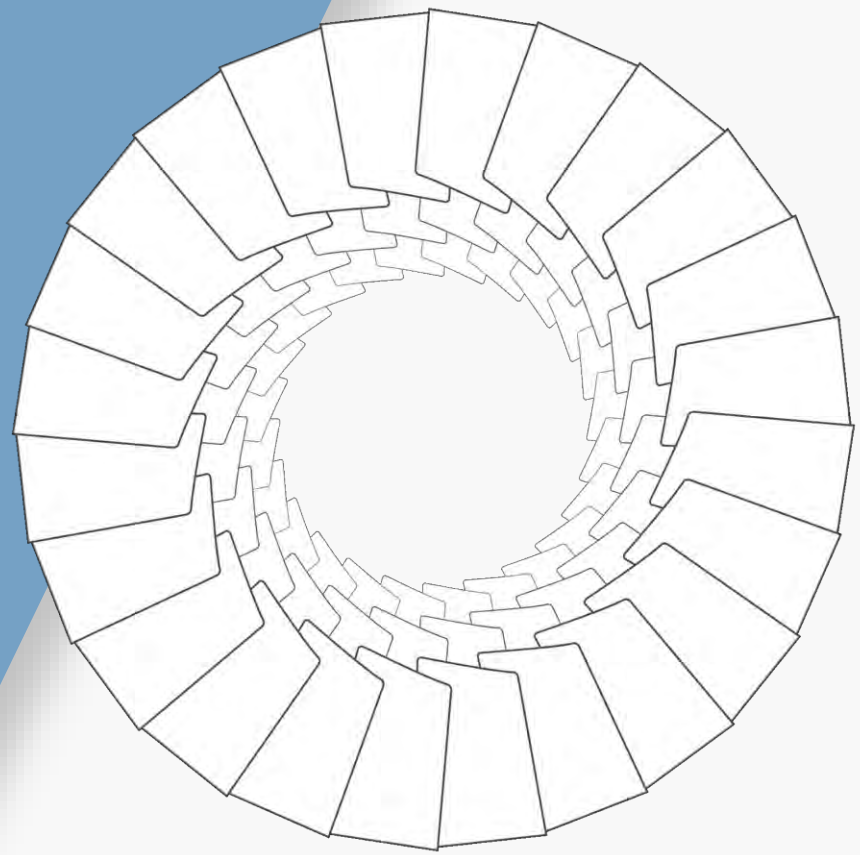


Universities
Hotels
Hospitals
Airports

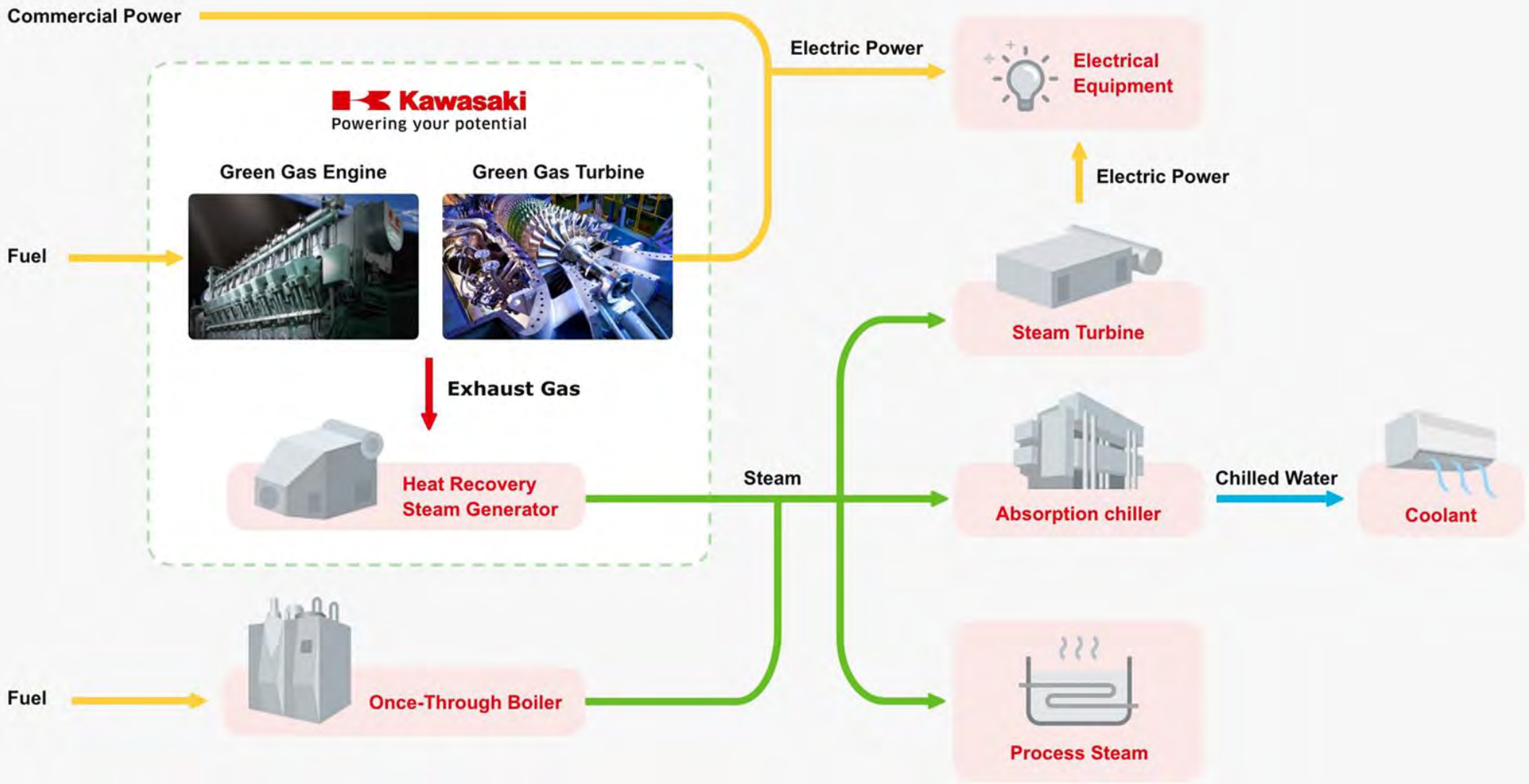
Ceramics

Fertilizers

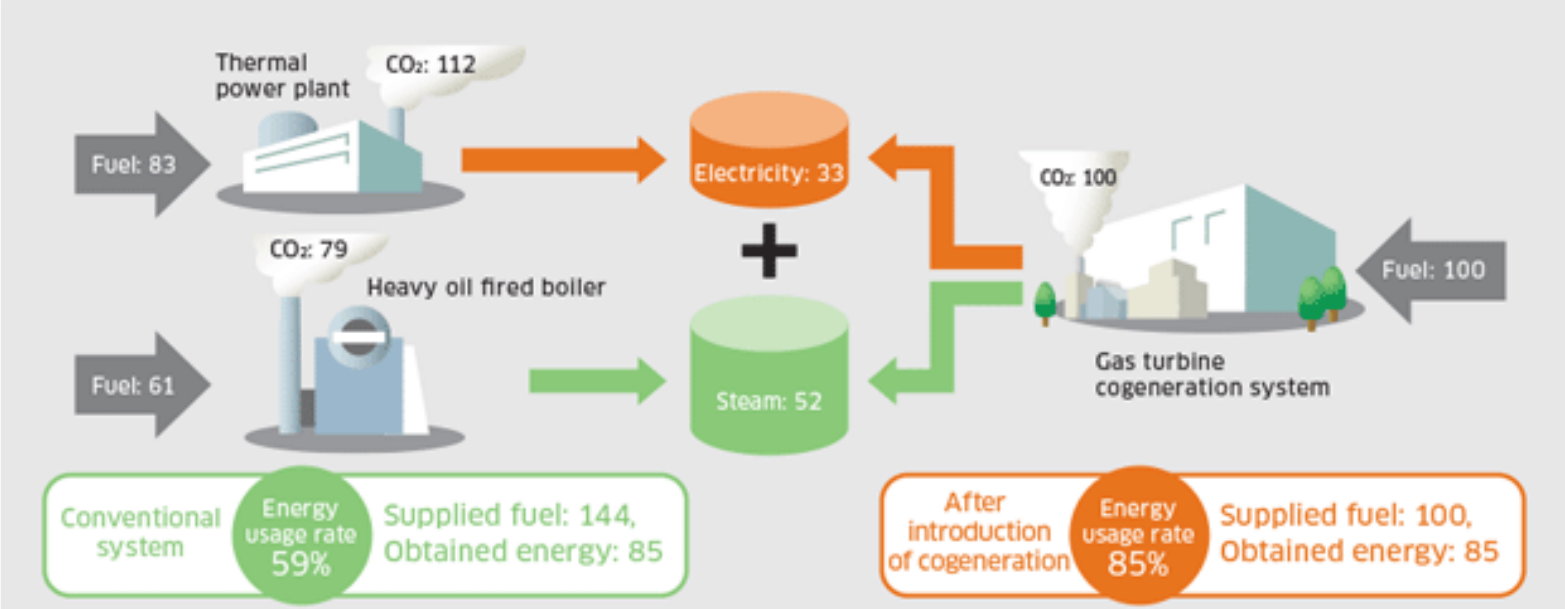
KAWASAKI'S PRODUCTS &SERVICES



ENERGY EFFICIENCY IN THE INDUSTRY



ENERGY EFFICIENCY IN THE INDUSTRY



Comparison table

	Conventional system	After introduction of cogeneration	Reduction rate	
Fuel	144	100	30%	Fuel reduction rate = Amount of reduction after introduction of cogeneration ÷ Conventional system x 100 = (144-100) ÷ 144 x 100 = 30(%)
CO_2 emissions	191	100	48%	CO_2 reduction rate = Amount of reduction after introduction of cogeneration ÷ Conventional system x 100 = (191-100) ÷ 191 x 100 = 48(%)

Sources for figures:
Greenhouse Gas Emission Calculation and Reporting Manual (2012), Enforcement Regulations for the Act on the Rational Use of Energy (2012), Medium-term Report of the Target Achievement Scenario Subcommittee, Global Environment Committee, Central Environment Council (2001).
These figures are used for calculating numerical values in Japan.

COMBINED HEAT AND POWER GENERATION IS THE MOST EFFICIENT WAY OF USING FUELS TO GENERATE ENERGY.

CHP has made the use of fossil fuels such as coal and natural gas efficient and will do so tomorrow with renewable fuels: from biomass and with hydrogen.

What other technology is so flexible?

KAWASAKI GAS TURBINE EUROPE

PRODUCTS

Gas Turbine Generator Sets

GPB17D	GPB50D	GPB80D	GPB180D	GPB300D
1,800 kWel	4,700 kWel	7,800 kWel	18,500 kWel	34,300 kWel
η = 28.1 %	η = 32.6 %	η = 33.6 %	η = 34.3 %	η = 40.3 %

Gas Engines

KG12	KG18	KG18-V	KG18-T
5,200 kWel	7,800 kWel	7,800 kWel	7,800 kWel
η = 49.0 %	η = 49.0 %	η = 49.5 %	η = 51.0 %

@ ISO-conditions

SERVICES

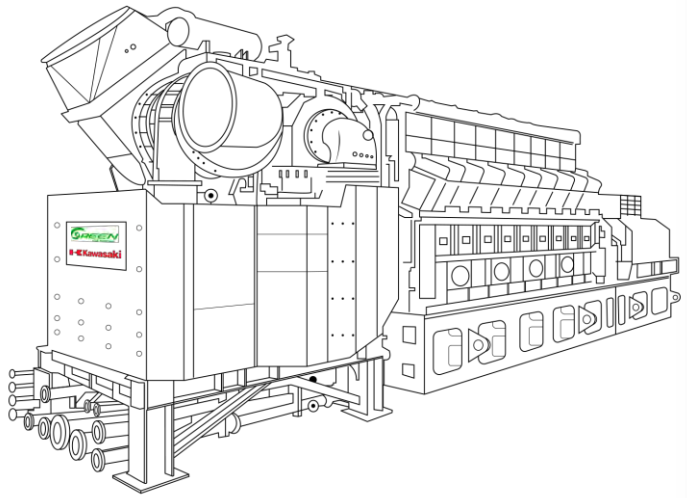
ENGINEERING
Preliminary Engineering
Detailed Engineering

IMPLEMENTATION
Project Planning
Customized Packaging
Erection Commissioning

MAINTENANCE
Scheduled Maintenance
Trouble Shooting
Spare Parts, Consumables
General Overhaul
Remote Monitoring

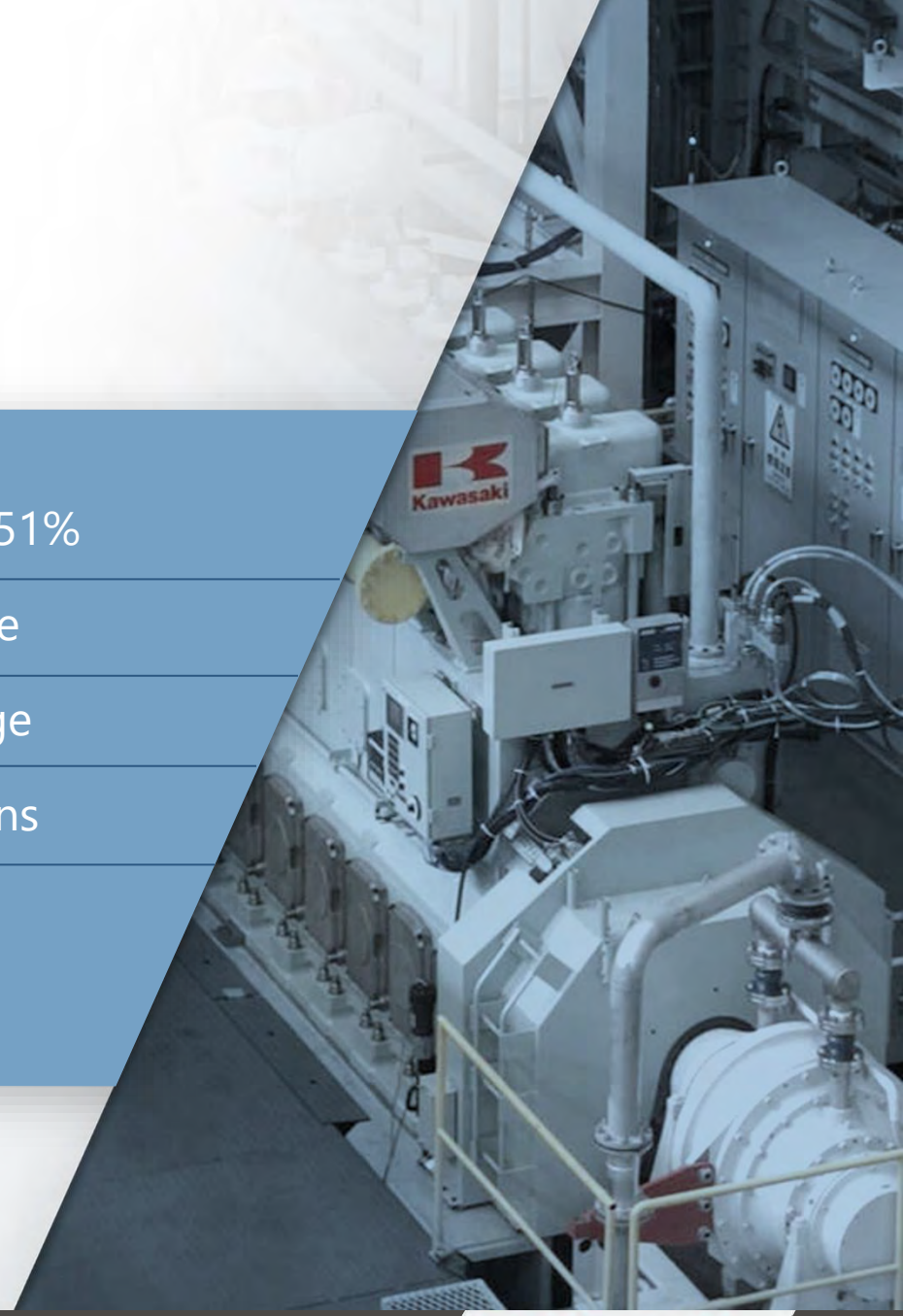
HYDROGEN
Preliminary engineering
Detailed engineering
Retrofit

GAS ENGINE GENERATOR SETS

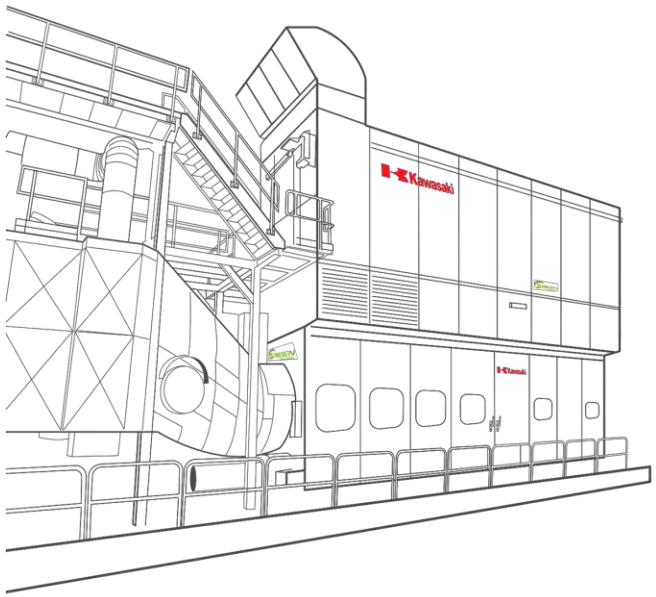


Main Features:

- High Electrical Efficiency 49.5% - 51%
- Excellent Partial Load Performance
- Wide Continuous Operating Range
- Less Impact by Ambient Conditions
- Quick Start-Up
  In 10 minutes to 100% Load



GAS TURBINE GENERATOR SETS



Main Features:

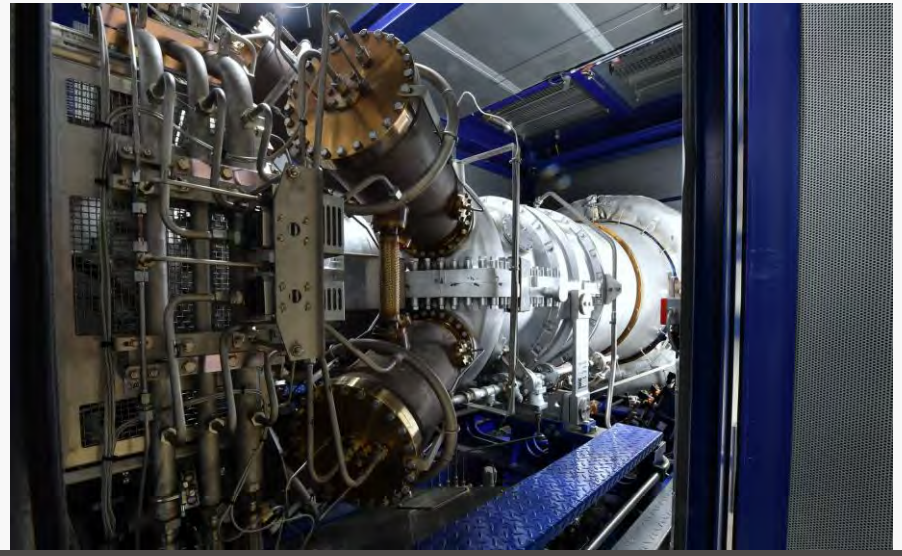
- High Exhaust Temperature >500°C
- Less amount of Low Temperature Heat
- Low Level Sound Enclosures
- Low Exhaust Gas Emissions
- Less Interfaces
- Long Maintenance Intervals

REFERENCE

Barilla (Parma, IT) – 2x GPB 80D in Trigeneration (CCHP-Plant)

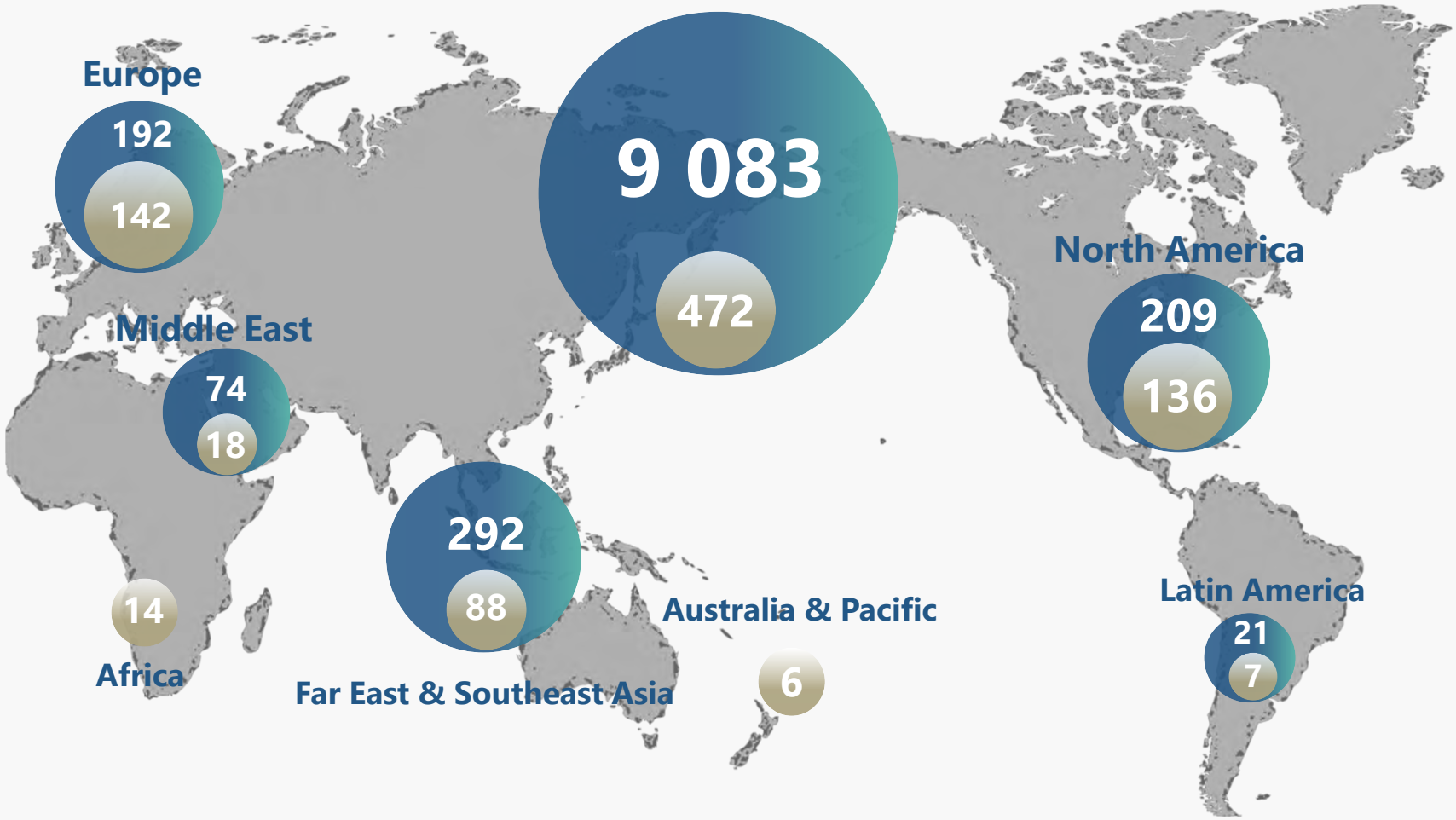
REFERENCE

Barilla (Parma, IT) – 2x GPB 80D in Trigeneration (CCHP-Plant)



KAWASAKI GAS TURBINES

Worldwide Installations

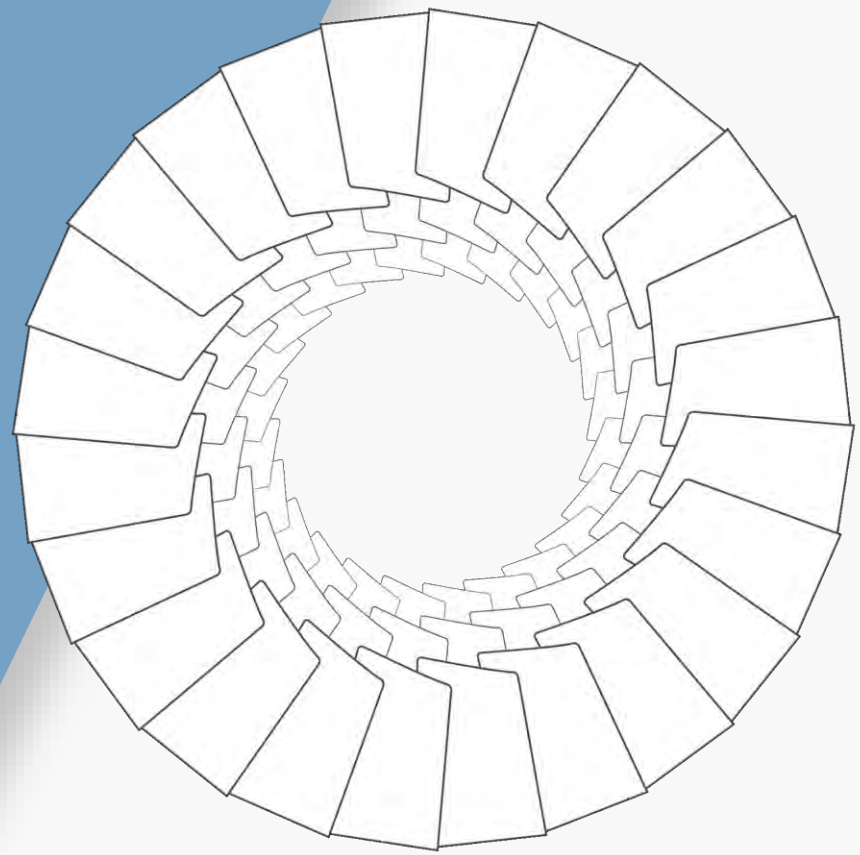


Base Load & Standby
Base Load only

	Int'l	Japan	Total
Base Load ＋Standby	827	9 083	9 910
Base Load	402	472	874
Standby	425	8 611	9 036

(As of April, 2023)

KAWASAKI'S HYDROGEN TECHNOLOGIES



HYDROGEN ROAD

H2-Production and Liquefaction | H2-Storage Tanks | H2-Oversea Transportation | H2-Land Transportation | H2-Gas Turbines H2-Compressors

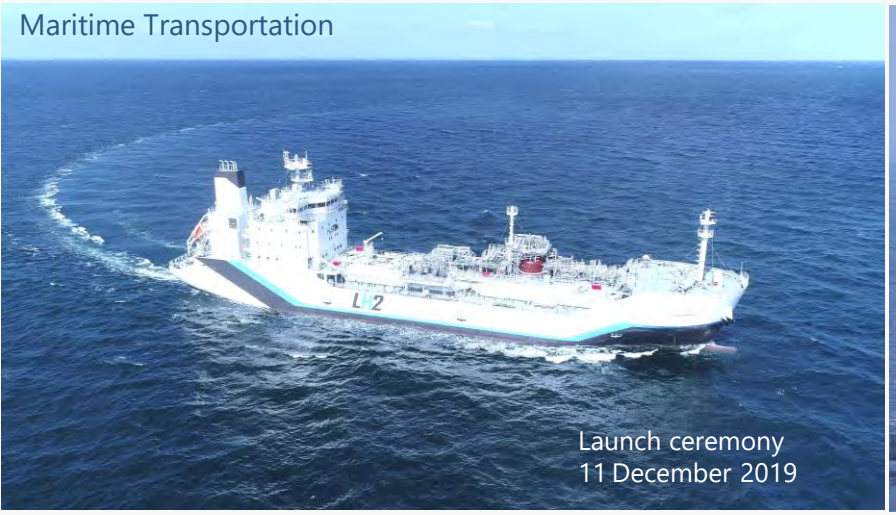
PILOT DEMONSTRATION PROJECT

Hydrogen Production (Australia)

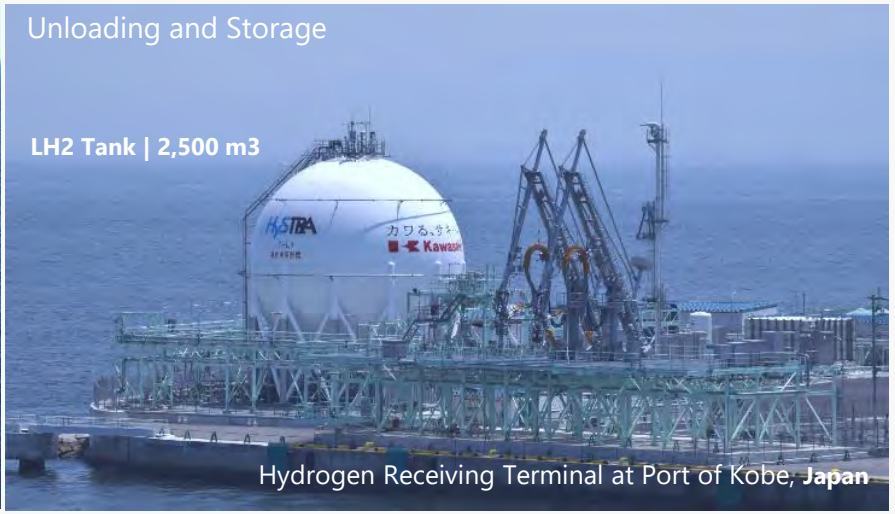
Land Transportation and Liquefaction(Australia)

Land Transportation (Japan)

Maritime Transportation



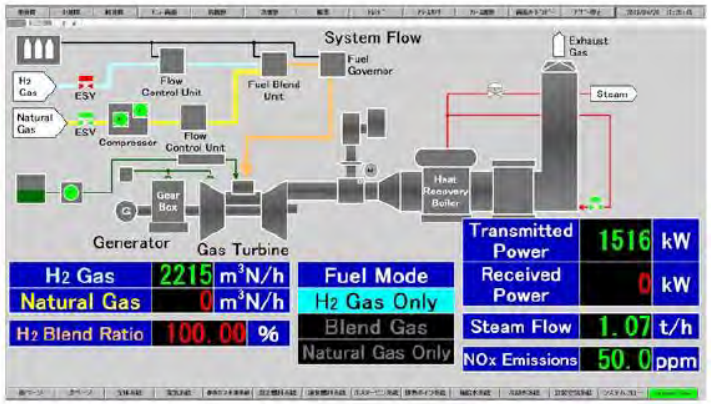
Unloading and Storage



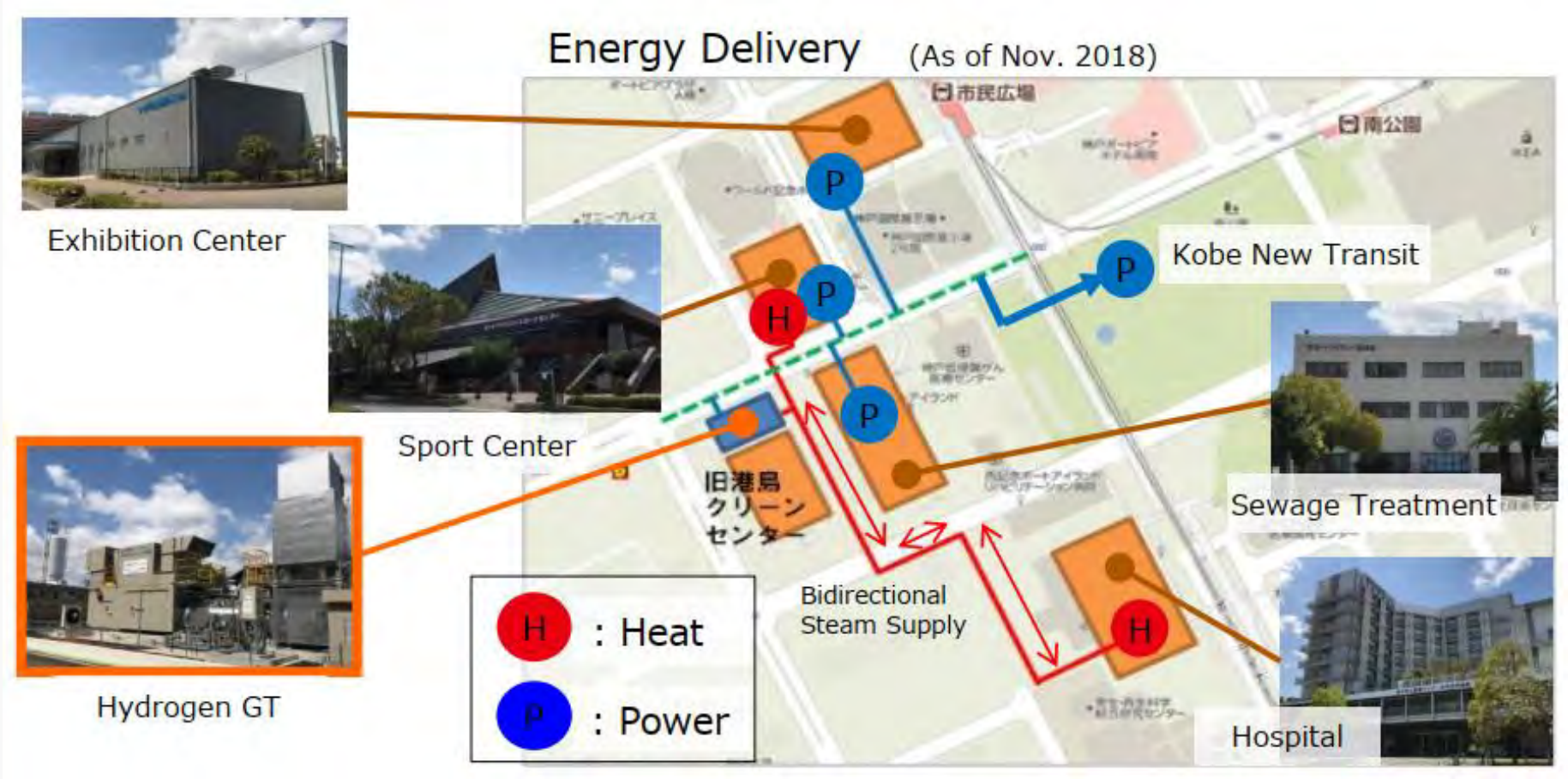
Utilization (Japan)

WORLD'S FIRST 100% H2-CHP PLANT

GPB17-H2



SCHEME OF HEAT & POWER SUPPLY

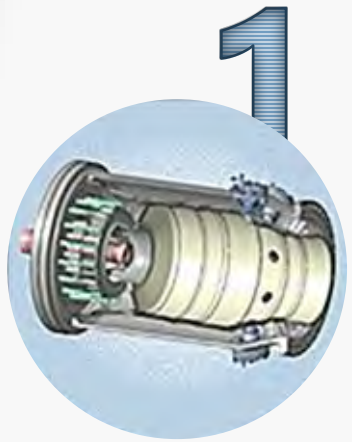


- Energy Delivery Capability
  Electricity: Approx. 1,100 kW
  Heat: Approx. 2,800 kW

- Heat and power supply at the urban area using a hydrogen fueles gas turbine has been accomplished in 2028 (World first!)

HYDROGEN TECHNOLOGY FOR GAS TURBINES (KHI)

OVERVIEW OF AVAILABLE TECHNOLOGIES



Combustor Configuration:	**H2 DLE**	**H2 Diffusion**	**H2 DLE MMX**
NO_x Reduction	"Dry"	"Wet" Water/Steam	"Dry"
H_2 Content	0 … 30 vol%	0 … 100 vol%	50% … 100 vol%
Technology Status	Demonstration at Akashi Works 2014	Applied to KOBE Demonstration Plant 2018	Applied to KOBE Demonstration Plant 2020

HYDROGEN TECHNOLOGY FOR GAS TURBINES (KHI)

OVERVIEW OF AVAILABLE TECHNOLOGIES

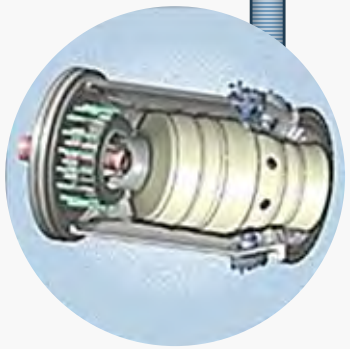
Combustor Configuration:

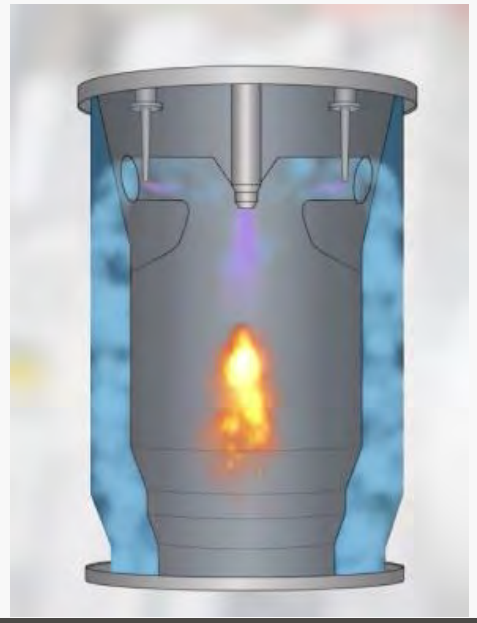
NO_x Reduction

H_2 Content

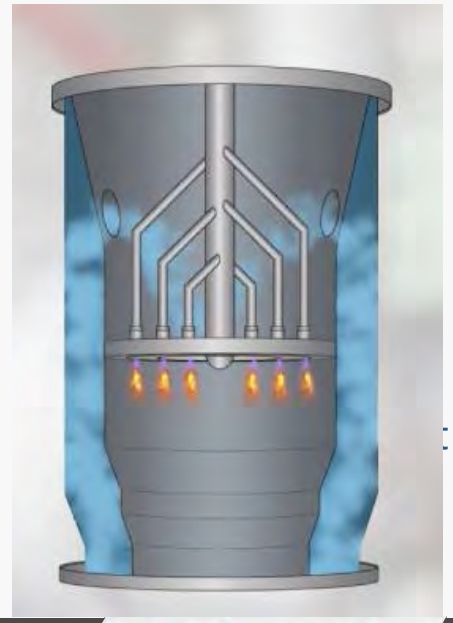
Technology Status

1

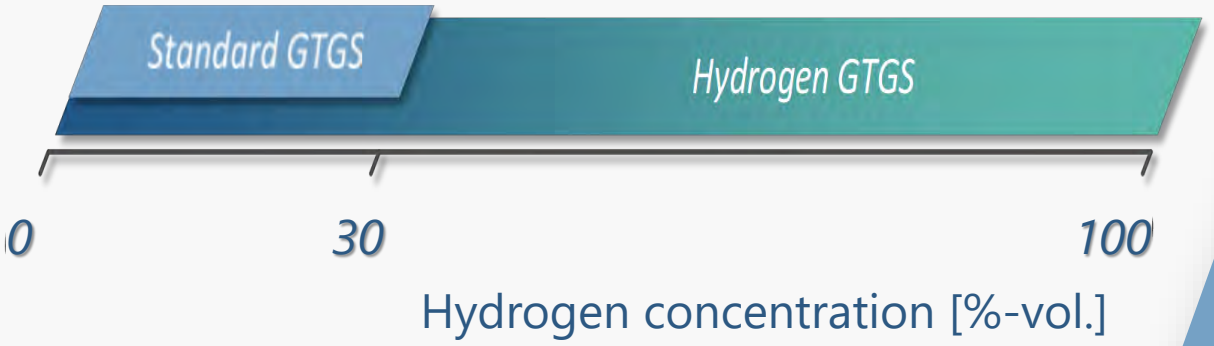




3



GAS TURBINE GENERATOR SET (GTGS)



GTGS types divided into two general categories

- Standard GTGS for applications with ≤ 30 %-Vol. H2
- Hydrogen GTGS for applications with ≤ 100 %-Vol. H2

All new GTGS are Standard type.

Standard GTGS can be upgraded to Hydrogen GTGS.

Depending on site requirements additional fuel gas equipment might be necessary.

WORLD'S FIRST H_2-POWER PLANT AT KOBE PORT

Interchangeable Combustor Equipment on the Gas Turbine Set

Tests & Demonstration
2018-2020

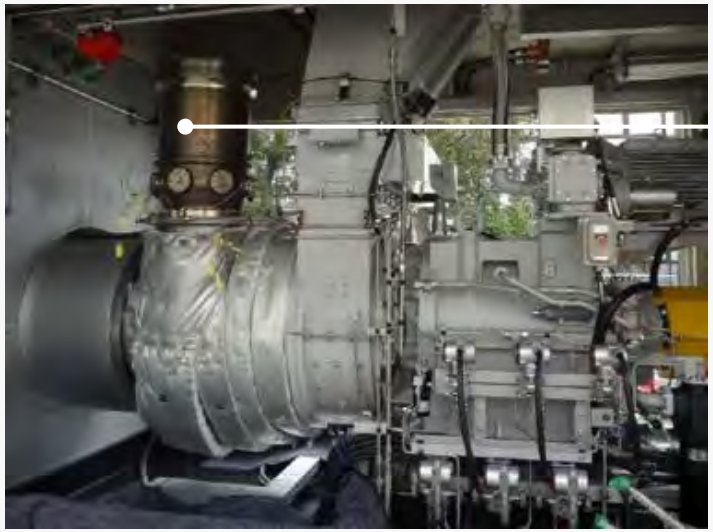
Diffusion Flame Combustor

Best Choice for Mixture

Highest Fuel Flexibility

Water/Steam Injection

Tests & Demonstration
2020-2022



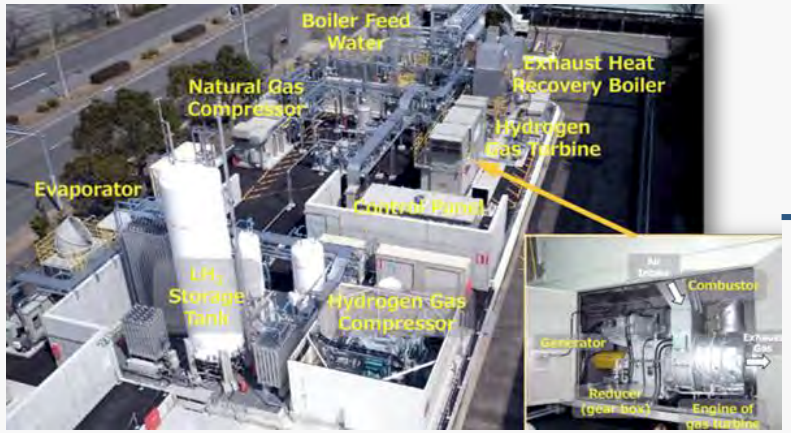
Micro-Mix (MMX) DLE Combustor

Up to 100% H_2-DLE

Technological Breakthrough

Dry Combustion

FIRST REFERENCES



World's First 100% H_2-CHP Plant at Kobe Port in 2018

Retrofit from diffusion to Micromix 2020

GPB17D-H_2 CPChem (Tessenderlo, Belgium)

Installation in 2021

Retrofit for hydrogen in October 2023

Joint undertaking of RWE & Kawasaki
(planned commissioning end of 2026)

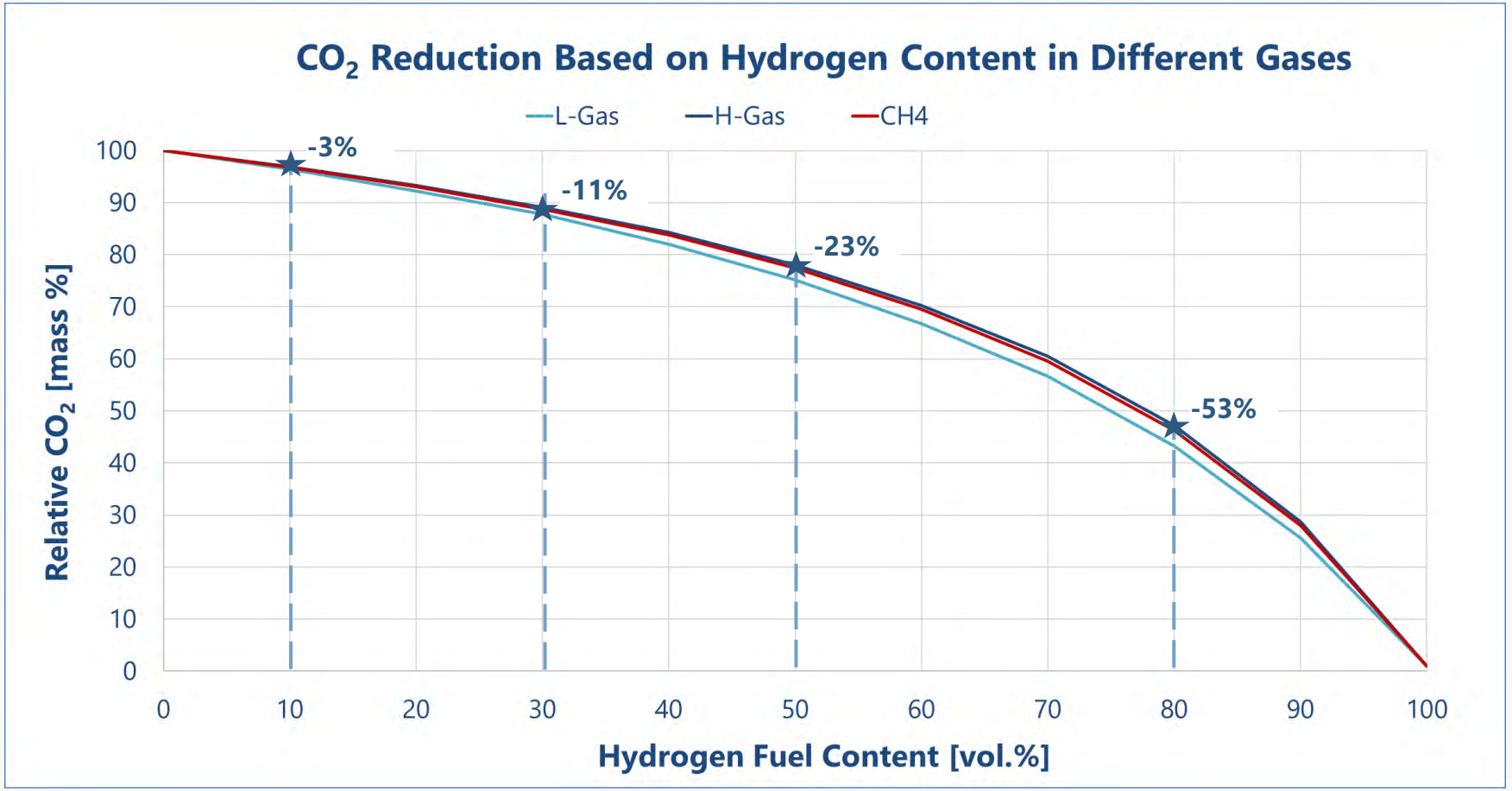
World's First 100% H_2 industrial size GTGS

From 2026 onwards 34 MW plant could reconvert green hydrogen to power

Power generation Output:
34,000 kW
Mixed combustion (20%-50% hydrogen)

Hydrogen power generation plant for Seibu Oil Co., Ltd.
(started operations in August 2021)

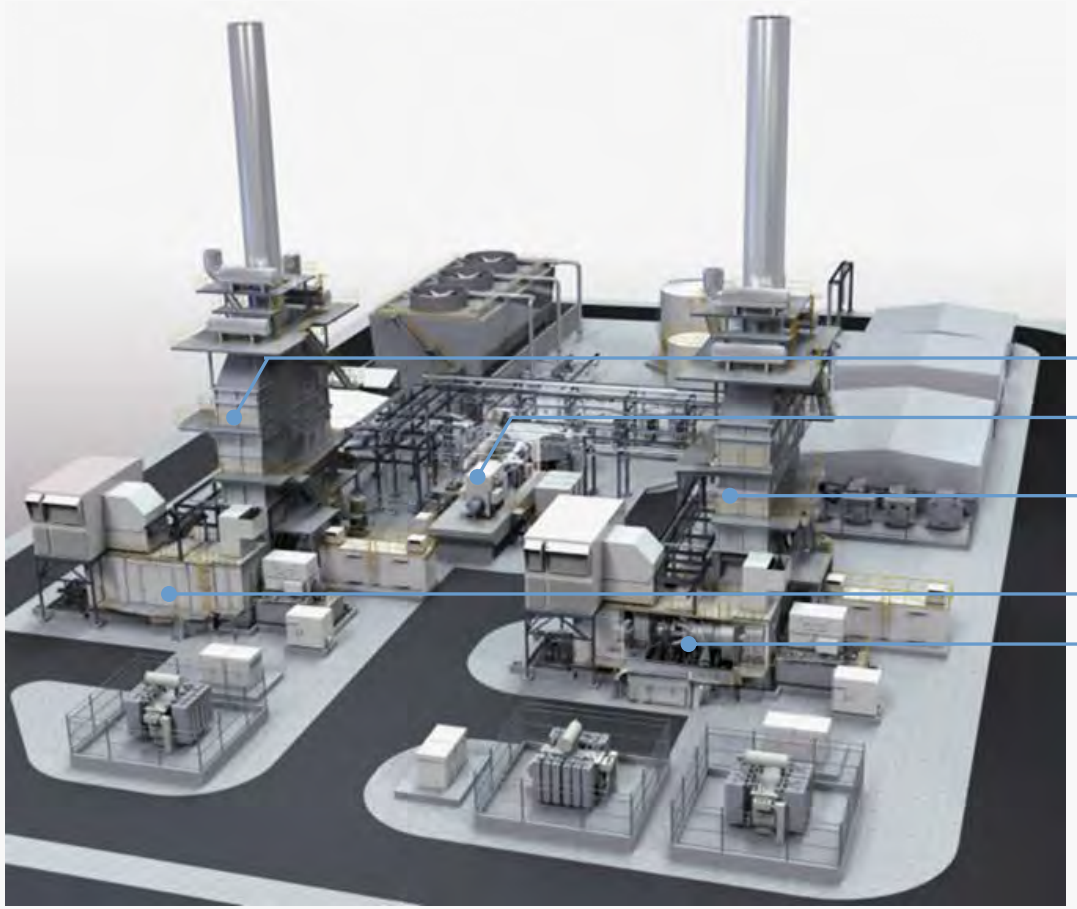
IMPACT OF HYDROGEN ADMIXING ON CO_2 REDUCTION



Gas Composition [vol%]			
	L-Gas	H-Gas	Methane
CH4	81.8	93.0	100
C2H6	2.8	3.0	-
C3H8	0.4	1.3	-
C4H10	0.2	0.6	-
CO2	0.8	1.0	-
N2	14.0	1.1	-

Author: Dr.-Ing. Nurettin Tekin, KGE

H_2-READY 100 MW COMBINED CYCLE POWER PLANT



Combined Cycle Configuration*	1 on 1	2 on 1	2 on 1 (Reheat)
Electric Output in [MWe]	44.7	89.9	101.5
Heat Rate in [kJ/kWh]	6,650	6,620	6,520
Electrical Efficiency [%]	54.1	54.4	55.2
Number of Gas Turbine(s)	1	2	2
Bottoming Cycle Type	2PNRH	2PNRH	3PRH

* Standard conditions for NG, 100% H2 capability

GLOBAL KAWASAKI

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