

Hydrogen Energy Supply Chain for Decarbonization

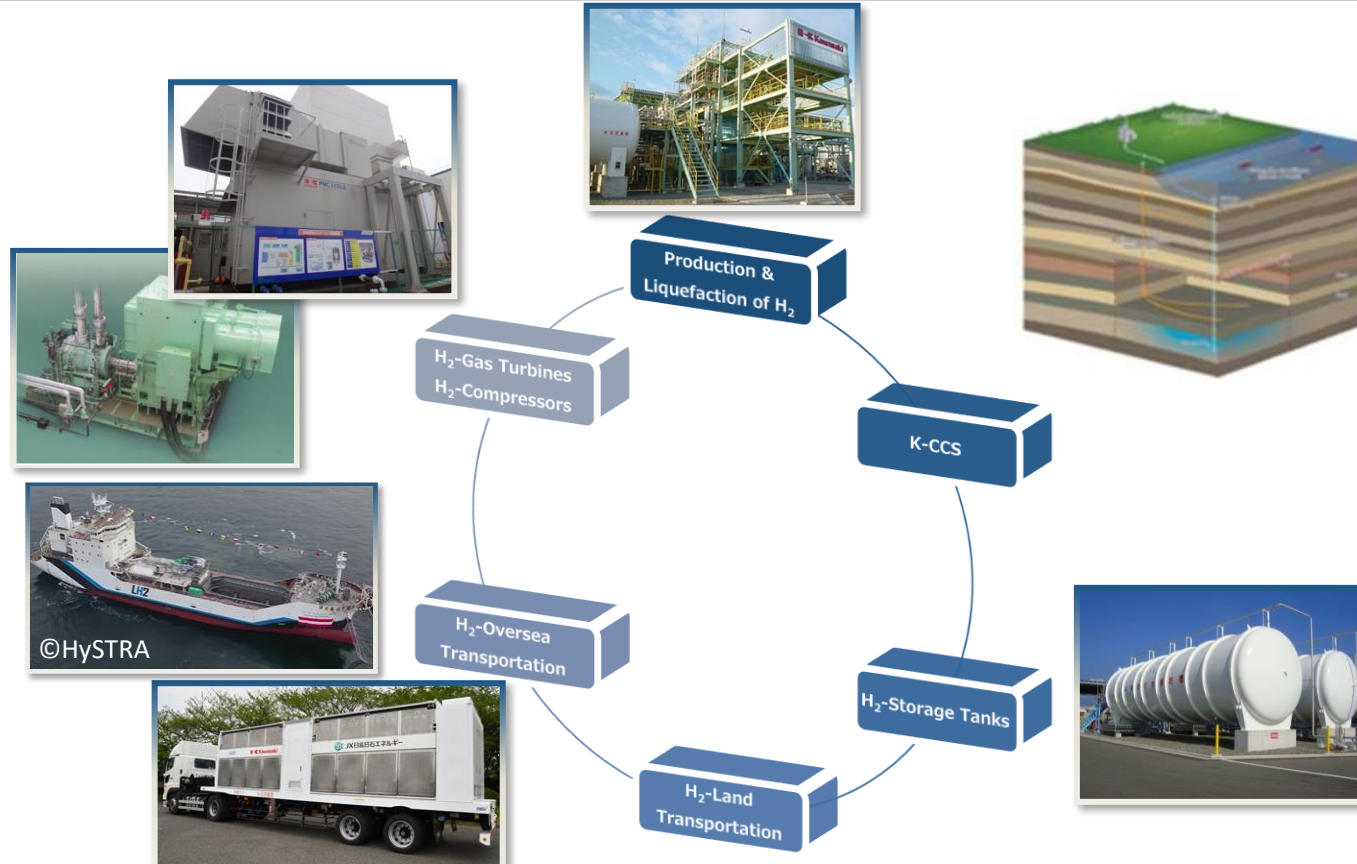
KAWASAKI HYDROGEN ROAD

Development of Innovative Hydrogen Technologies
for Future Hydrogen Society

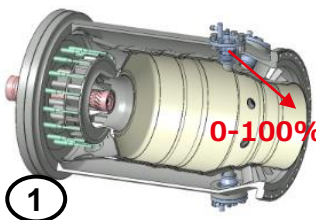
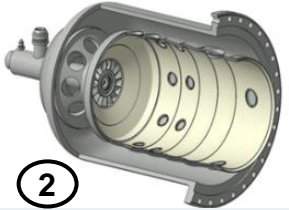
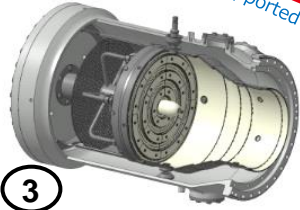



DENA-Praxisworkshop Chemieindustrie:
Perspektiven für eine energieeffiziente und CO₂-arme Produktion
22th November 2021

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Kawasaki Gas Turbine Europe

Hydrogen Road of Kawasaki Heavy Industries (KHI)



Developments for Hydrogen Gas Turbines @ KHI

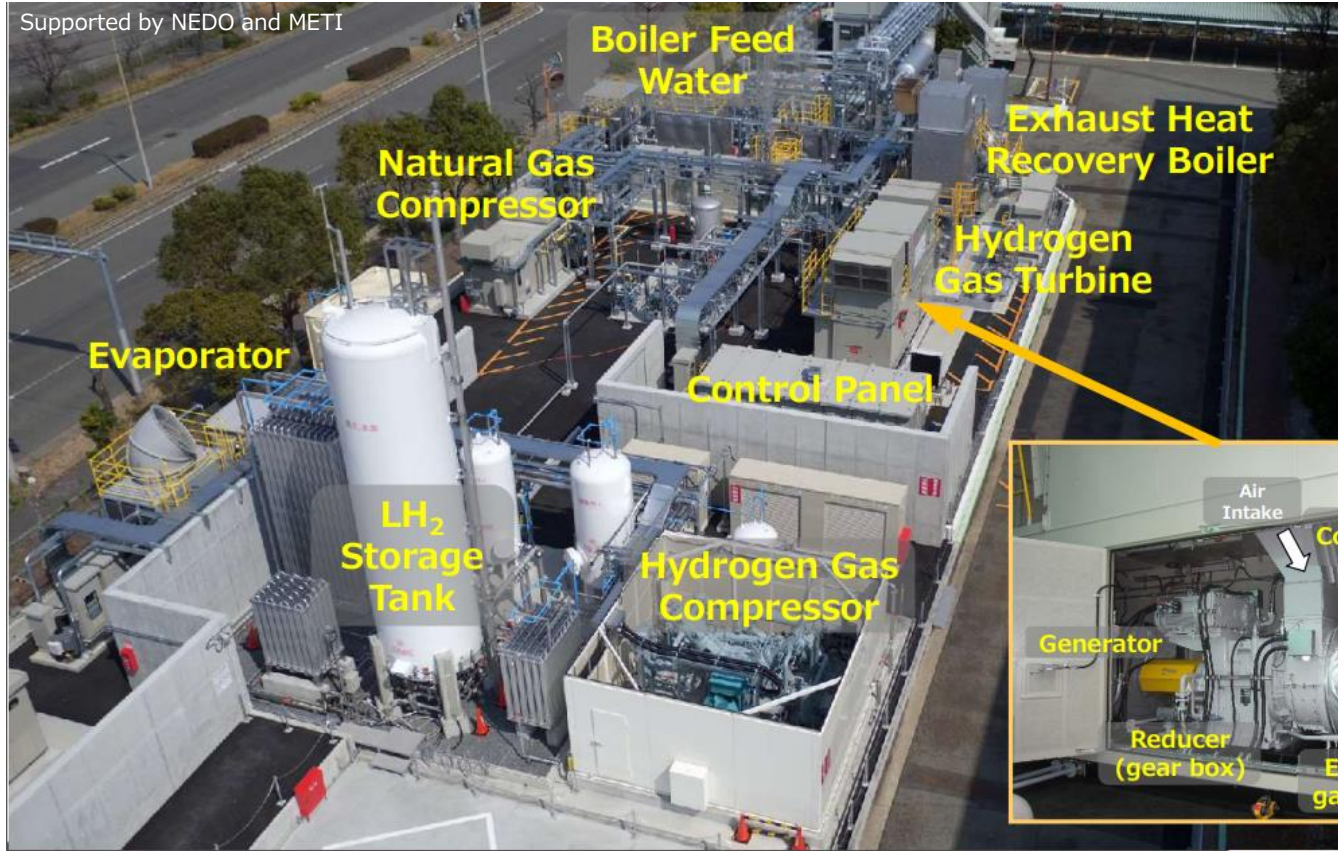
Combustor Overview	DLE - H2 Supplemental	Diffusion	DLE Micro-Mix
NOx Reduction	"Dry"	"Wet" Water/Steam	"Dry"
Combustor Model	 <p>① 0-100% H₂</p>	 <p>②</p>	 <p>③</p>
H2 Content	0-60vol%	0-100vol%	100vol%
Status	Applied to Akashi Works Demonstration, 2014 	Applied to KOBE Demonstration Plant, 2018 	Applied to KOBE Demonstration Plant, 2020 

Latest Development
Supported by NEDO and METI

Main Difference between NG & H2 Gas Turbines is the Combustor

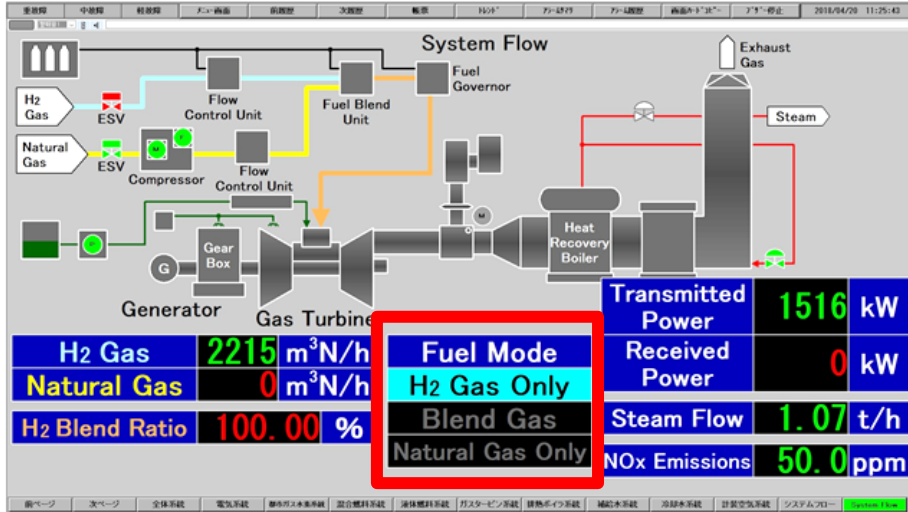
World's First 100% H2-CHP Plant at Kobe Port

Supported by NEDO and METI



World's First H2-Power Plant at Kobe Port

User Control Interface



Comparison between NG & H₂

Gas Turbine Type		M1A-17	M1A-17
		Natural Gas	Hydrogen
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

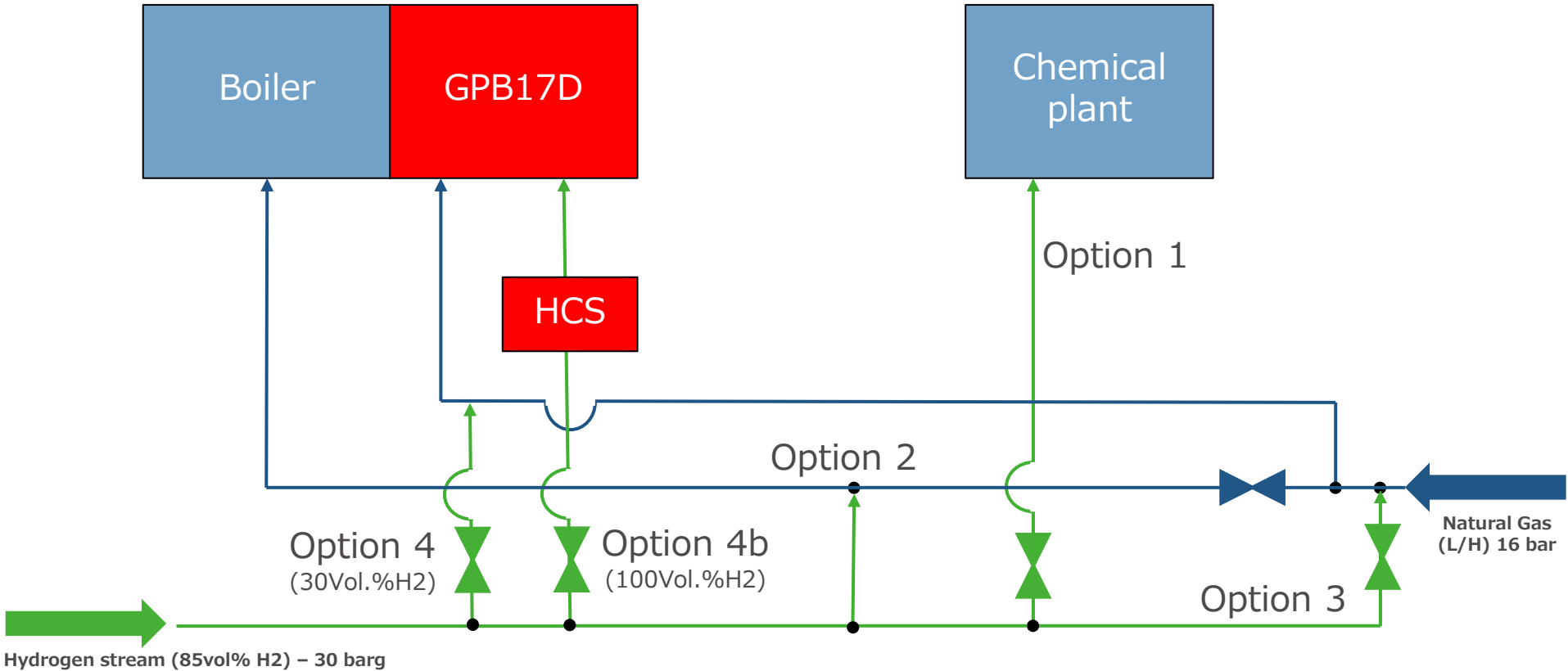
Composition of Gas Stream

Hydrogen stream		
mol%	H2 purge - avg	H2 purge - max
N ₂	2.05	1.19
CO ₂	0	0
C1 (CH ₄)	4.03	9.05
C2 (C ₂ H ₆)	7.54	2.98
C3 (C ₃ H ₈)	0.82	2.72
iC4	1	0.41
nC4	0.1	0.01
iC5	0	0
nC5	0	0
C6+	0.0459	0.01
O ₂	0	0
H ₂ O	0.3	0.4
H ₂	84.1141	83.23
Total	100	100

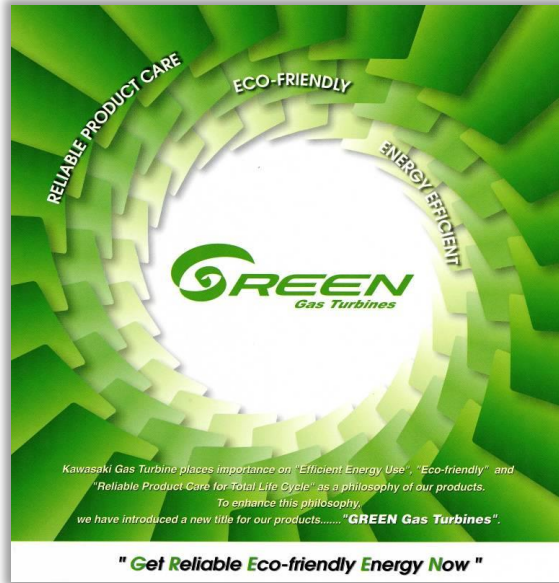
The characteristics of the H₂ stream are as followed:

- 40°C and 30 barg
- Saturated with water (@ 50°C, 30 barg) but can conditioned to KGE's requirements
- Maximum flow of 80 kg/h from which 25 kg/h of hydrogen, other component are hydrocarbons C1-C4 and water
- H₂S content is below 5 ppm

World's First H2-Power Plant at Kobe Port



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