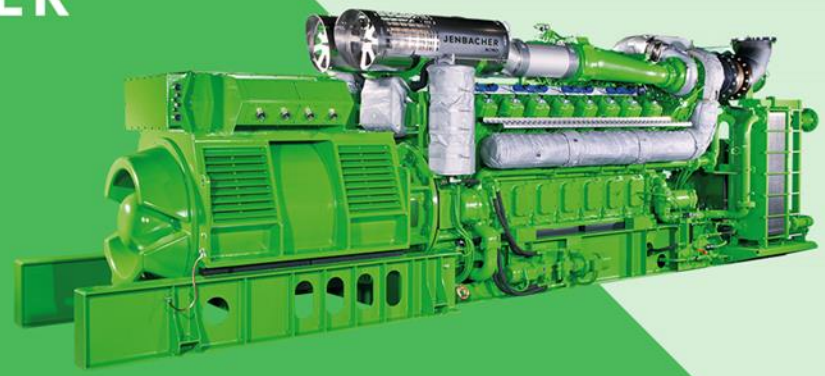
H2 as a future fuel for CHP

H2 (Water) stof tot nadenken, 2021

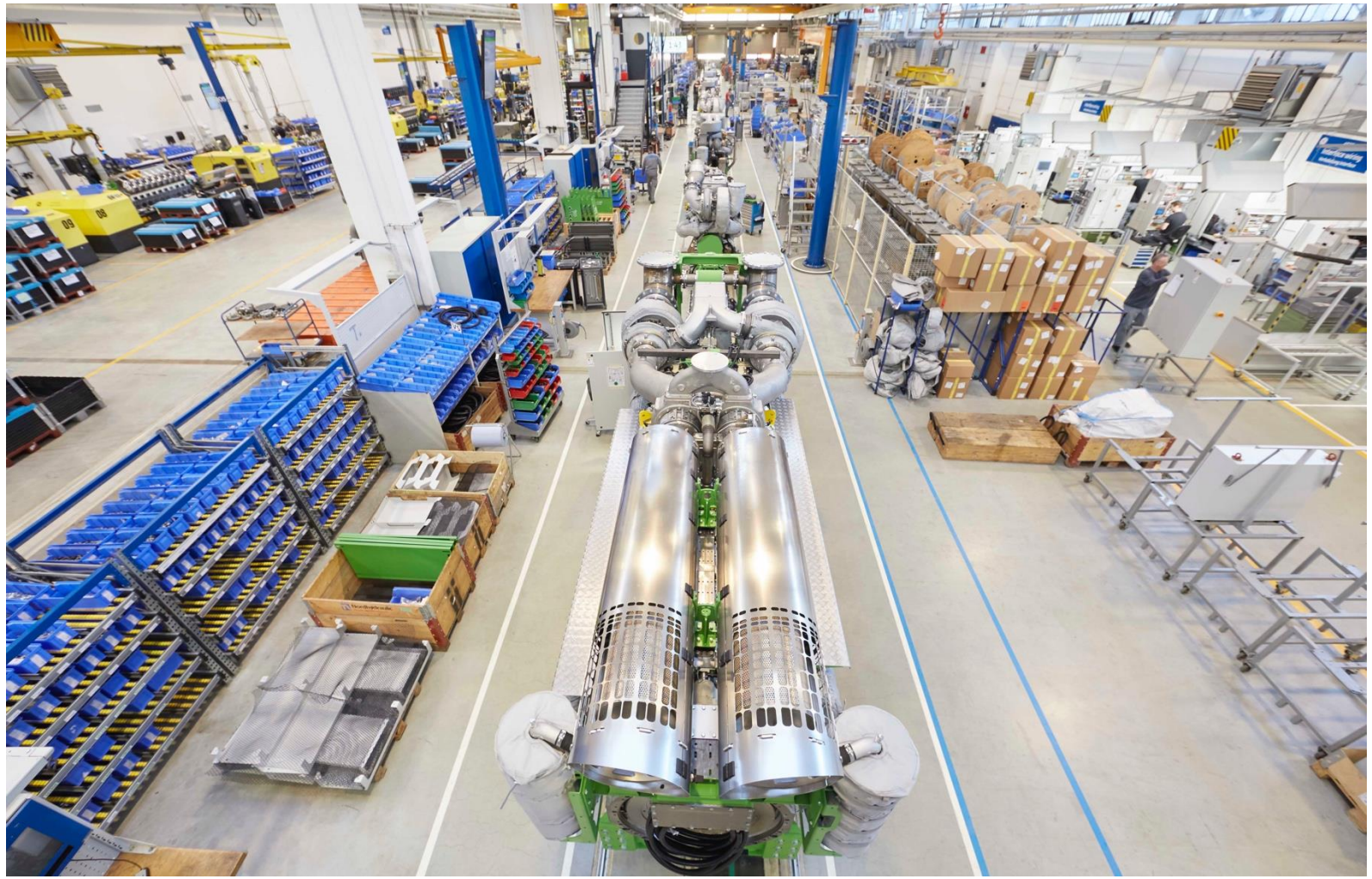


INNIO Jenbacher GmbH & Co OG
Jenbach, Austria
www.innio.com

Dr. Klaus Payrhuber

June 21st, 2021

Pushing beyond the impossible and looking boldly toward tomorrow



INNIO* is...

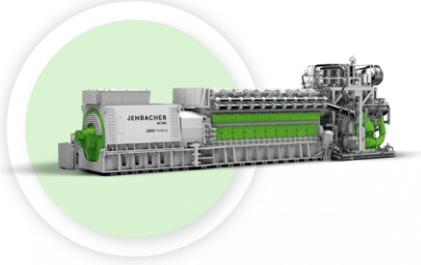
- A leading technology provider of gas engines, power equipment, a digital platform, Headquartered in Jenbach, Austria, with additional primary and related services for power generation and gas compression at or near the point of use.
- Renowned for our proven Jenbacher* and Waukesha* product brands.

  Gas engines from 200 to 10,400 kW
- Operations in Welland, Ontario, Canada, and Waukesha, Wisconsin, USA.

Power generation – Delivering fuel flexibility, long service life, outstanding durability & reliability

Jenbacher* gas engine platforms

Jenbacher J920 FleXtra

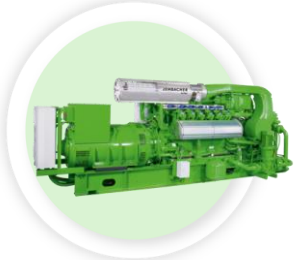


- V20 cylinder; 1,000/900 rpm (50/60 Hz)
- **Electrical output: 10.4 MWe (50 Hz)**, 9.3 MWe (60 Hz)
- **Electrical/total efficiency:** 49.1/>90% (50 Hz), 49.9/>90% (60 Hz)
- Fast start: 2-minute startup capability
- Delivered engines: ~40
- Launch date: 2013

Jenbacher Type 6

- V12, V16, V20 cylinder; 1,500 rpm (50/60 Hz)
- V24 2-stage turbocharged
- **Electrical output: 1.8 – 4.5 MWe (50 Hz)**
- **Electrical efficiency:** up to 47%
- Fast start version: 45-sec (J620)
- Delivered engines: ~5,500
- Launch date: 1989 (J624 in 2007)

Jenbacher Type 4

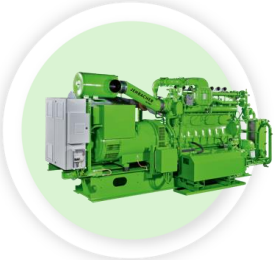


- V12, V16 and V20 cylinder: 1,500/1,800 rpm (50/60 Hz)
- **Electrical output: 0.8 – 1.5 MWe (50 Hz)**
- **Electrical efficiency:** up to 44%
- Delivered engines: ~4,900
- Launch date: 2002

Jenbacher Type 3

- V12, V16 ,V20 cylinder; 1,500/1,800 rpm (50/60 Hz)
- **Electrical output: 0.5 - 1 MWe (50 Hz)**
- **Electrical efficiency:** up to 41.7%
- Delivered engines: ~10,100
- Launch date: 1988

Jenbacher Type 2



- L8 cylinder; 1,500/1,800 rpm (50/60 Hz)
- **Electrical output: 250 - 330 kWe (50 Hz)**
- **Electrical efficiency:** 39.5%
- Delivered engines: ~1,200
- Launch date: 1976

Transitioning to 100% Renewable fuels

Today

45% ⬅ EU ➡ 55%

Natural Gas CHP

Biogas

Today's mix of fossil natural gas and renewable gases

Tomorrow

Biomethane or Synthetic Methane CHP

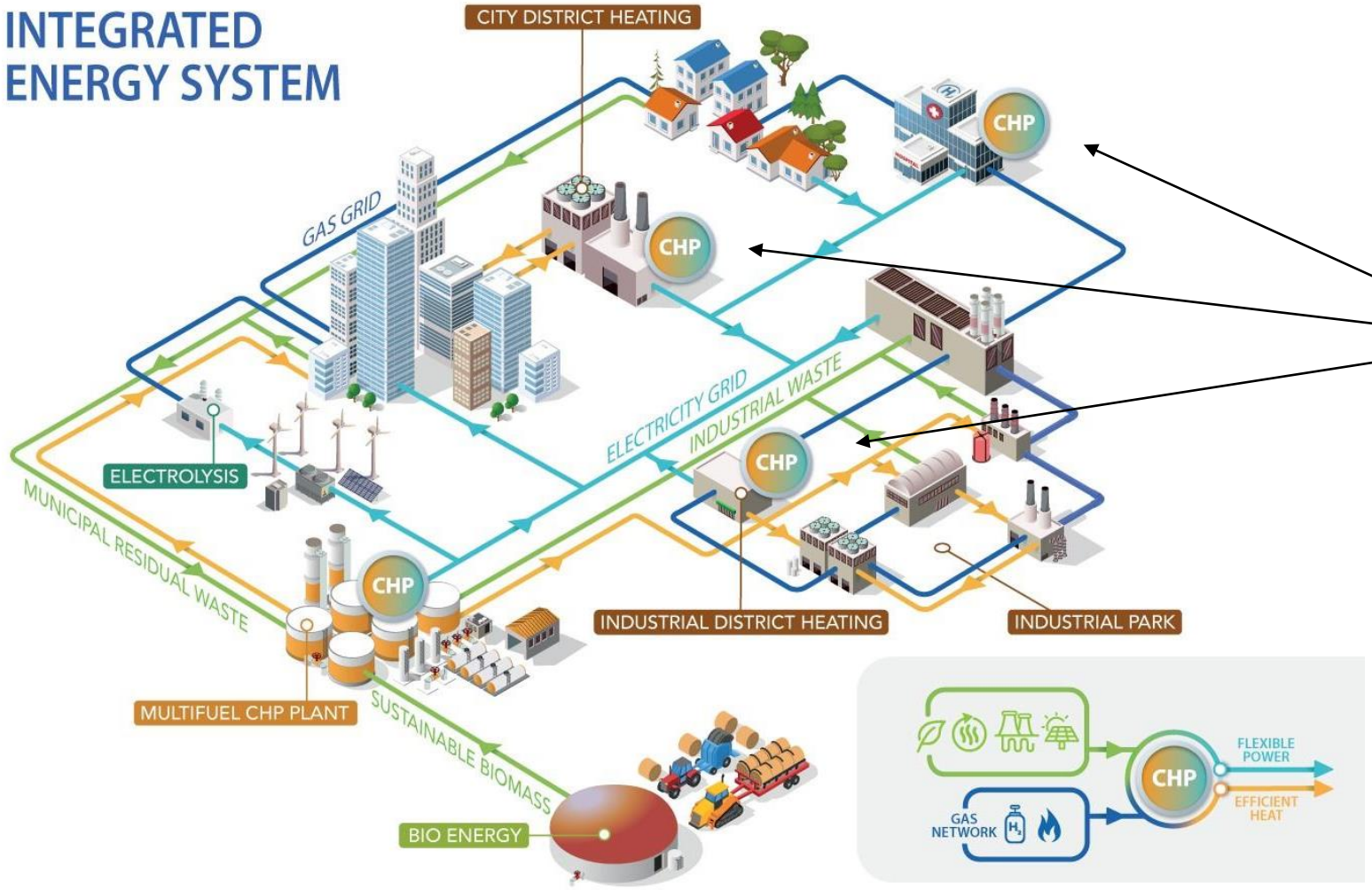
Biomethane & CO_2 usage or Hydrogen CHP

Hydrogen CHP

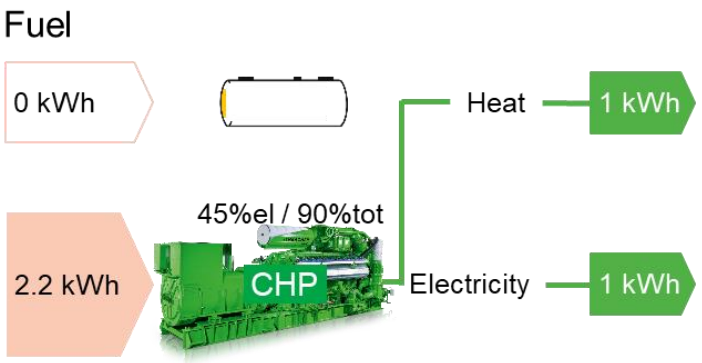
Biogas

Carbon neutral fuels & green hydrogen

Integrated energy system



Decentralized CHP



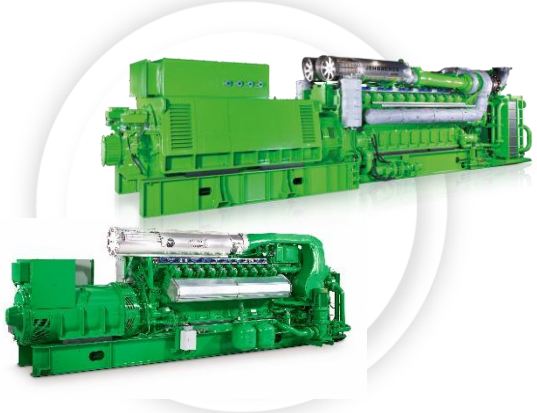
Primary energy savings	~33%
CO_2 savings	~33%

Source: Illustration von CogenEurope, © COGEN Europe

Jenbacher gas engines with hydrogen operation

MW scale

Jenbacher's experience with Hydrogen & Hydrogen mixtures



Coke gas (Profusa) COD 1994	Process gas (Krems) COD 1996	Syngas (Mutsu) COD 2003	Pure Hydrogen 2021+
H_2: ~50-70Vol% CH_4: ~20-25Vol% LHV: ~5 kWh/m^3	H_2: ~15-17 Vol% CH_4: ~1.5 Vol% LHV: ~0.5 kWh/m^3	H_2: ~30-40 Vol% CO: ~25-30 Vol% LHV: ~2.5 kWh/m^3	H_2: … 100 Vol% Nat. Gas or Inerts LHV: ~3 kWh/m^3

Commercial operation

Future

More than 250MW installed with syngas / process gases

90 projects in 28 countries and experience with all engine types

Jenbacher gas engine solutions for H_2

A

H_2 in natural gas pipeline

A-1: Low H_2 blending
Optimized for NG
<5%v H_2

A-2: Medium H_2 blending
broadband product
5-20 (30)%v H_2

B

H_2 local admixing

B-1: Special gas engine
operational optimized
up to ~60%v H_2

B-2: NG / H_2 engine
dual gas engine 100%v
NG / H_2

C

Pure H_2

C: H_2 engine
hydrogen engine (H_2)
100%v H_2

Conventional NG+H2 fuel mixture boosted system

H2 fuel injection system

no modifications required	existing versions available	existing versions available	pilots available (pre-serial engines)	pilots available (pre-serial engines)

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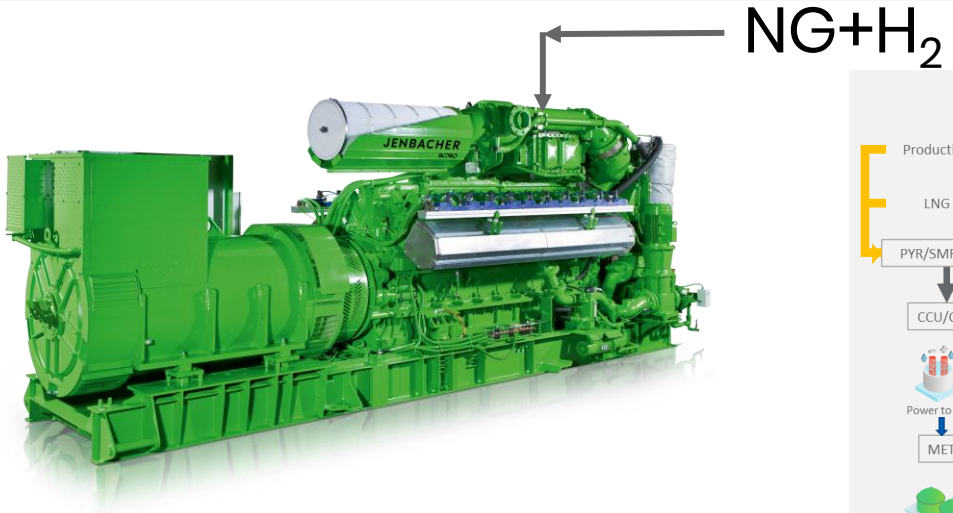
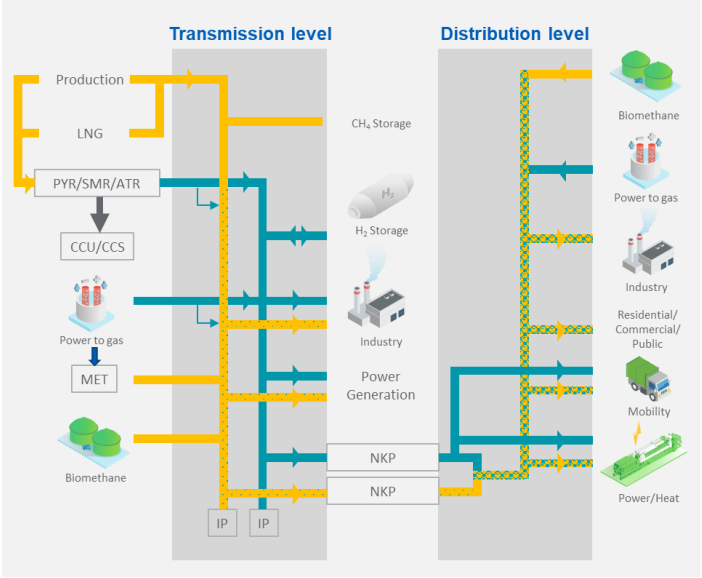
H_2 mixed in pipeline natural gas (typically up to 20%vol)





Important fuel properties to consider

- Heating Value
- Methane Number
- Laminar Flame Speed

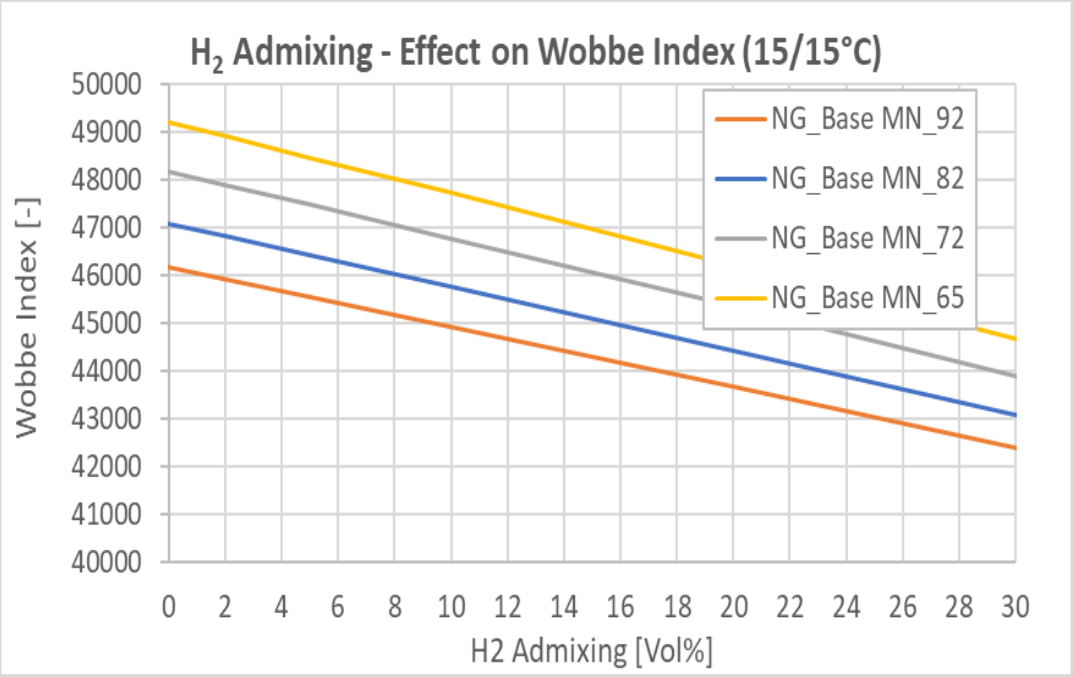
	Characteristic	Limits	Unit
LHV	Fluctuation	≤ 4	%/min
MN	RoC	≤ 10	MN/min
H_2 content in NG	RoC	≤ 4	Vol%/min
100% H_2	H_2 purity	not relevant	% H_2

Mixture

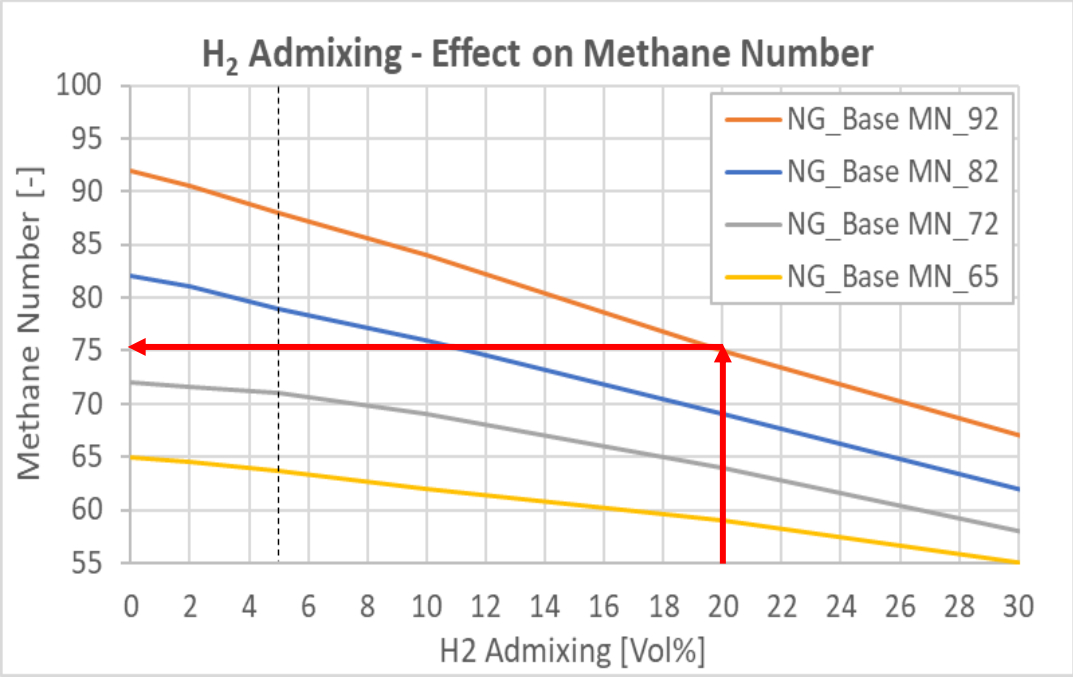
		NG example	Hydrogen
CH4	Vol-%	97.6	0
C2H6	Vol-%	2	0
C3H8	Vol-%	0.4	0
H2	Vol-%	0	100
LHV	kJ/Nm³	36 730	10 800
WI	kJ/Nm³	48 704	41 000
MN	-	92	0
Laminar flame speed	cm/s	38	>300

Hydrogen added to pipeline Natural Gas

H2 Admixing-Effect on Wobbe Index



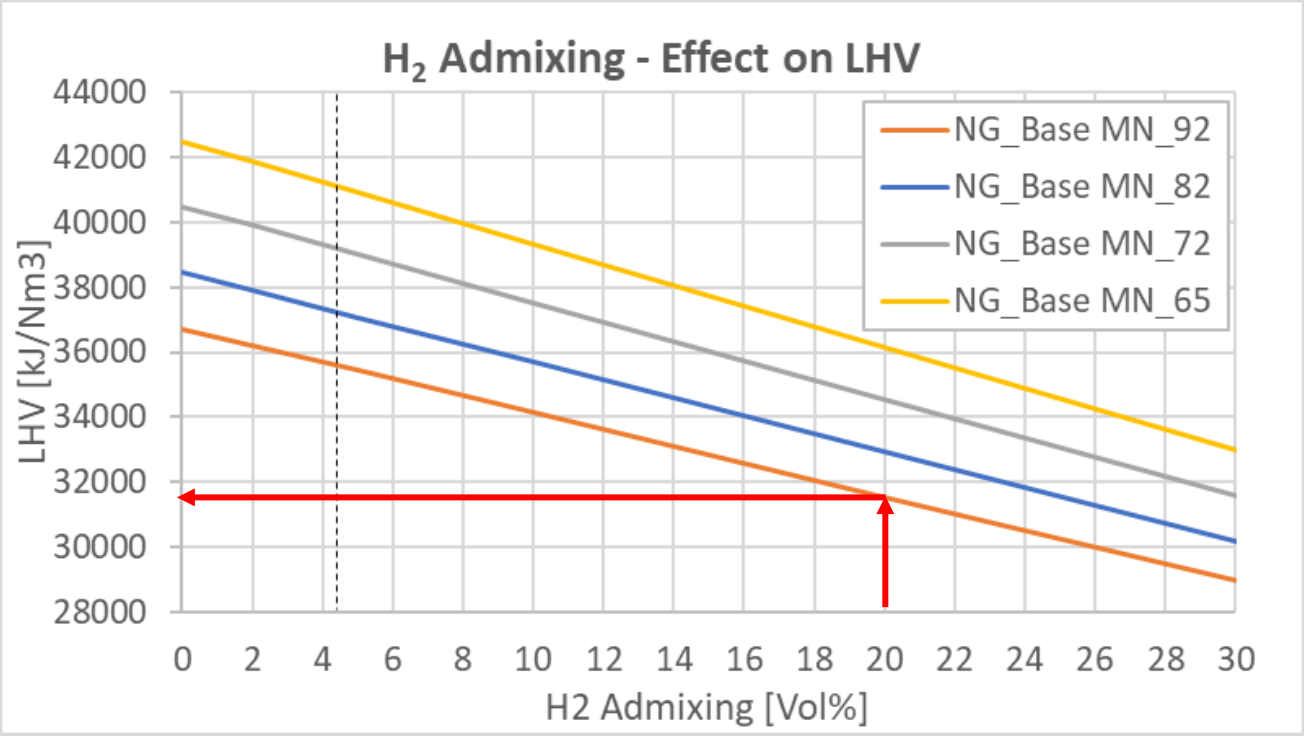
H2 Admixing-Effect on Methane Number



>5%(v) H_2 in pipeline gas … we recommend a signal to gas engines about H_2 content

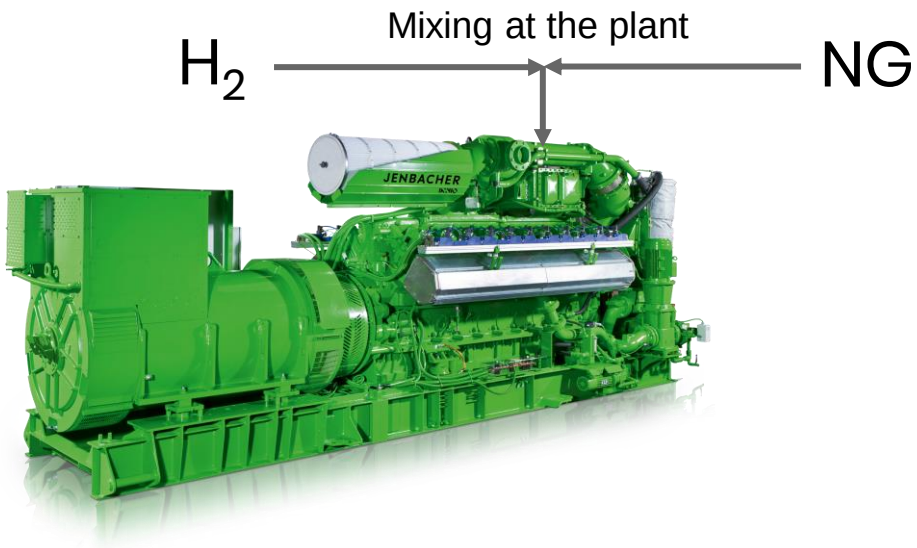
Hydrogen added to pipeline Natural Gas

H2 Admixing-Effect on LHV



>5%(v) H_2 in pipeline gas … we recommend a signal to gas engines about H_2 content

H_2 local admixing to natural gas



		Hydrogen
CH4	Vol-%	0
C2H6	Vol-%	0
C3H8	Vol-%	0
H2	Vol-%	100
LHV	kJ/Nm³	10 800
WI	kJ/Nm³	41 000
MN	-	0
Laminar flame speed	cm/s	>300

Important fuel properties to consider

- Heating Value
- Methane Number
- Laminar Flame Speed
- ✓ H2 content to control system available

		NG example
CH4	Vol-%	97.6
C2H6	Vol-%	2
C3H8	Vol-%	0.4
H2	Vol-%	0
LHV	kJ/Nm³	36 730
WI	kJ/Nm³	48 704
MN	-	92
Laminar flame speed	cm/s	38

H_2 local admixing demo projects

30%v H_2

Bozen - Italy
2017, Horizon 2020 Demo

J612, main fuel NG

Sinfonia

30%v H_2

Biogas Stream- Austria
2008 Demo

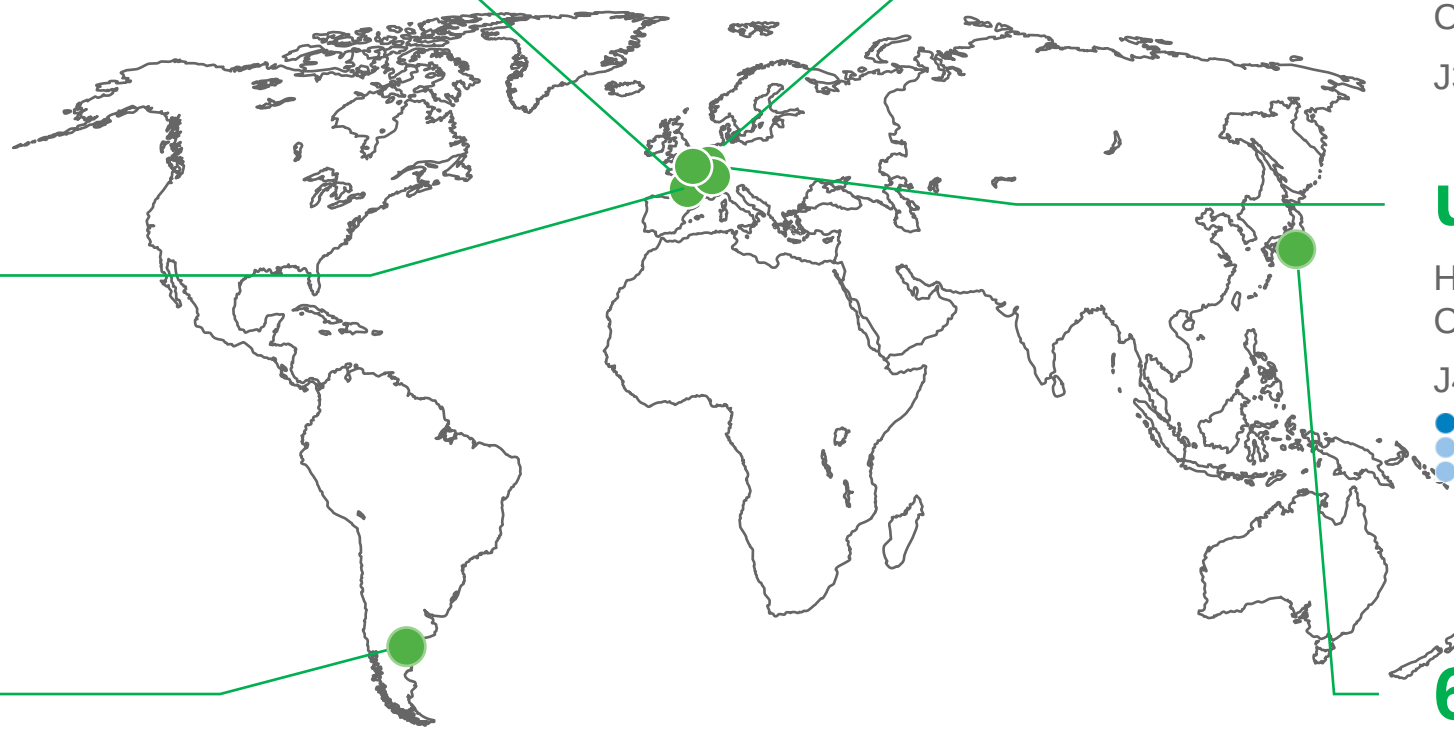
J312, main fuel NG

42%v H_2

Hychico – Argentina
Operating since 2008

J420, main fuel NG

HYCHICO



60%v H_2

DLR

H2ORIZON - Stuttgart
Commissioning 2020

J312, main fuel NG

up to 100% H_2

HanseWerk Natur - Hamburg
Commissioning 11/2020

J416, main fuel NG

Hanse Werk

60%v H_2

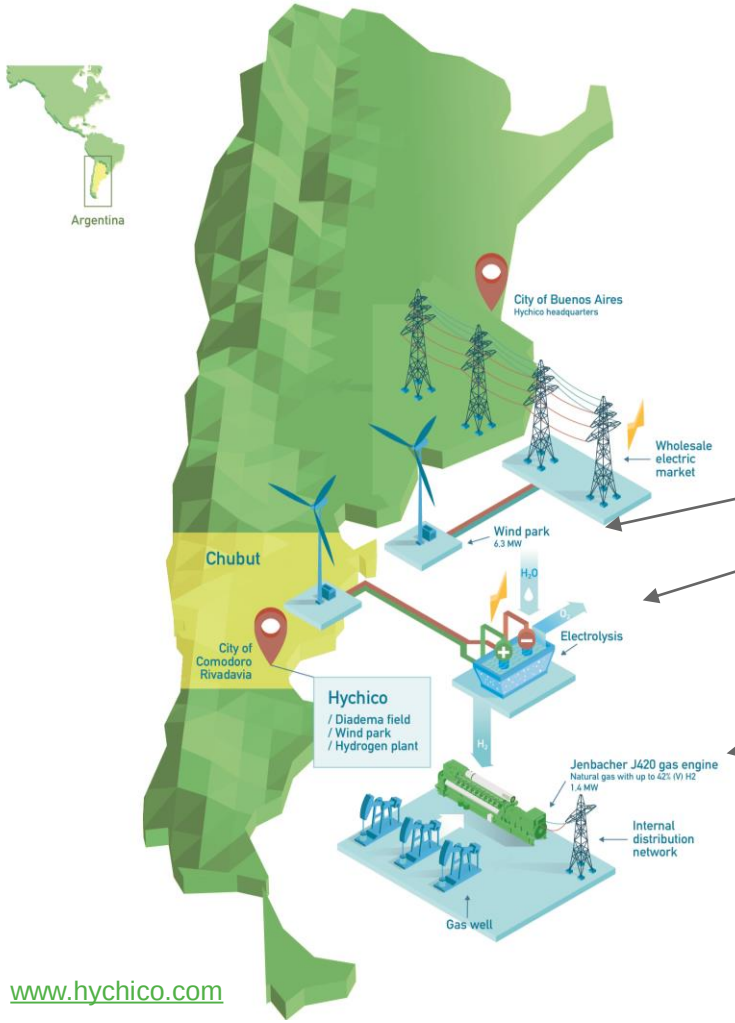
Ando Hasama - Japan
Commissioning 01/2020

J312, main fuel NG

HAZAMA ANDO CORPORATION

JENBACHER
INNIO

Hychico, Argentina site



www.hychico.com

Hychico, Diadema Wind Park and Hydrogen Plant, Chubut Province, Argentina

About the region:

Currently large oil & gas fields

2,000 GW wind power potential, compared to 600 GW global installations today

Ideal place for exporting green H_2 and e-fuels in the future

Green H_2 demo :

6.3 MW wind park with **54.9% CF (2017), avg. >50%**

0.8 MW of electrolyser (2 units), 120 Nm^3/hr H_2

H_2 with high purity (99.998%), O_2 for local market

Underground H_2 storage research

J420 converts H_2 back to power

Output 1,415 kW_{el}

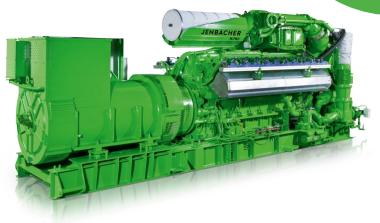
Main Fuel: NG MN >90

Operation with **controlled H_2 blending**

0-27 v% H_2 1,415 kW

28-42 v% H_2 1,415 to 1,180 kW

~70,000 oh
since 2008



JENBACHER

First 100% Hydrogen pilot engine with ~1MW HanseWerk Natur (E.on), GER

Engine type and version	J416 C202	J416 C202
Fuel	Natural gas	**Hydrogen**
Nom. output Pel*	999 kWel	>600 kWel
Elec./total eff. @ nom. output	~42%/~93.5%	40+%/~93%
Expected H_2 content w/o derating*	-	~20 Vol%
Max H_2 content (w/ derating)*	-	100 Vol%

* Controlled H_2 blending, base gas quality MN~80

CHP Othmarschen, Hamburg/GER

Engine designed and optimized for operation with natural gas fuel,
Engine capable to run on 100% hydrogen and any mixture of natural gas and hydrogen (Dual-Fuel engine)

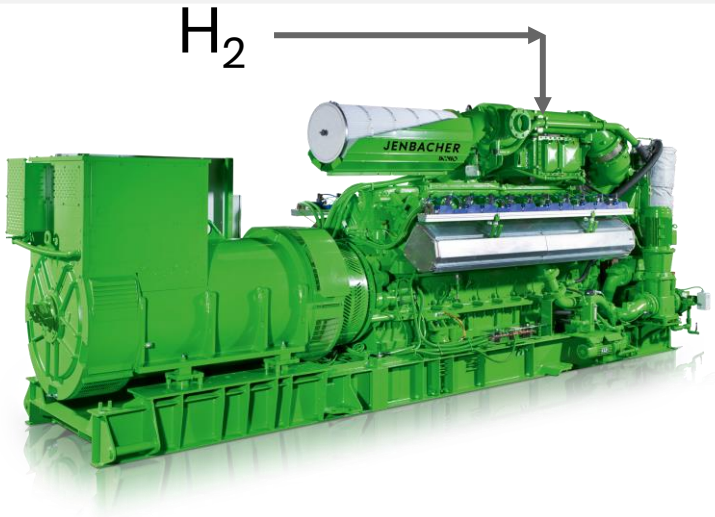
- 100% NG as commercial fuel achieving max. total efficiency
- Up to 100% H_2 operation possible (H_2 as demonstration fuel)

Milestones

- ✓ Factory test successful in Aug., 2020
- ✓ Site demonstration in Nov. 2020
- ✓ PR about site demonstration by INNIO and E.ON in Q4, 2020

With hydrogen becoming a commercial fuel, INNIO Jenbacher will invest in optimizing gas engine performance

100% H_2



		Hydrogen
CH4	Vol-%	0
C2H6	Vol-%	0
C3H8	Vol-%	0
H2	Vol-%	100
LHV	kJ/Nm³	10 800
WI	kJ/Nm³	41 000
MN	-	0
Laminar flame speed	cm/s	>300

Important fuel properties to consider

- Heating Value
- Methane Number
- Laminar Flame Speed

✓ First 100% H2 demo in 2001

Illustration 19: Hydrogen test engine JGS 156 GS S.L

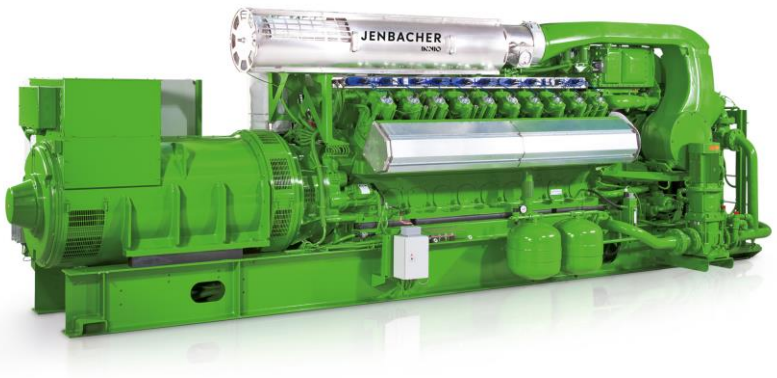
H2 engine offerings

H2 engine – Type 4 – 50Hz (pre-serial engine)

H2: <100mg NOx @5%O2	J412-H2	J416-H2	J420-H2
Electrical Output (kW)	531	710	889
Thermal Output (kW)	630	838	1,049
Electrical Efficiency (%)	39.4	39.5	39.5
Total Efficiency (%)	86.1	86.1	86.2
H2 consumption (kg/h)	40	54	67
H2 consumption (Nm^3/h)	450	599	749

Technology

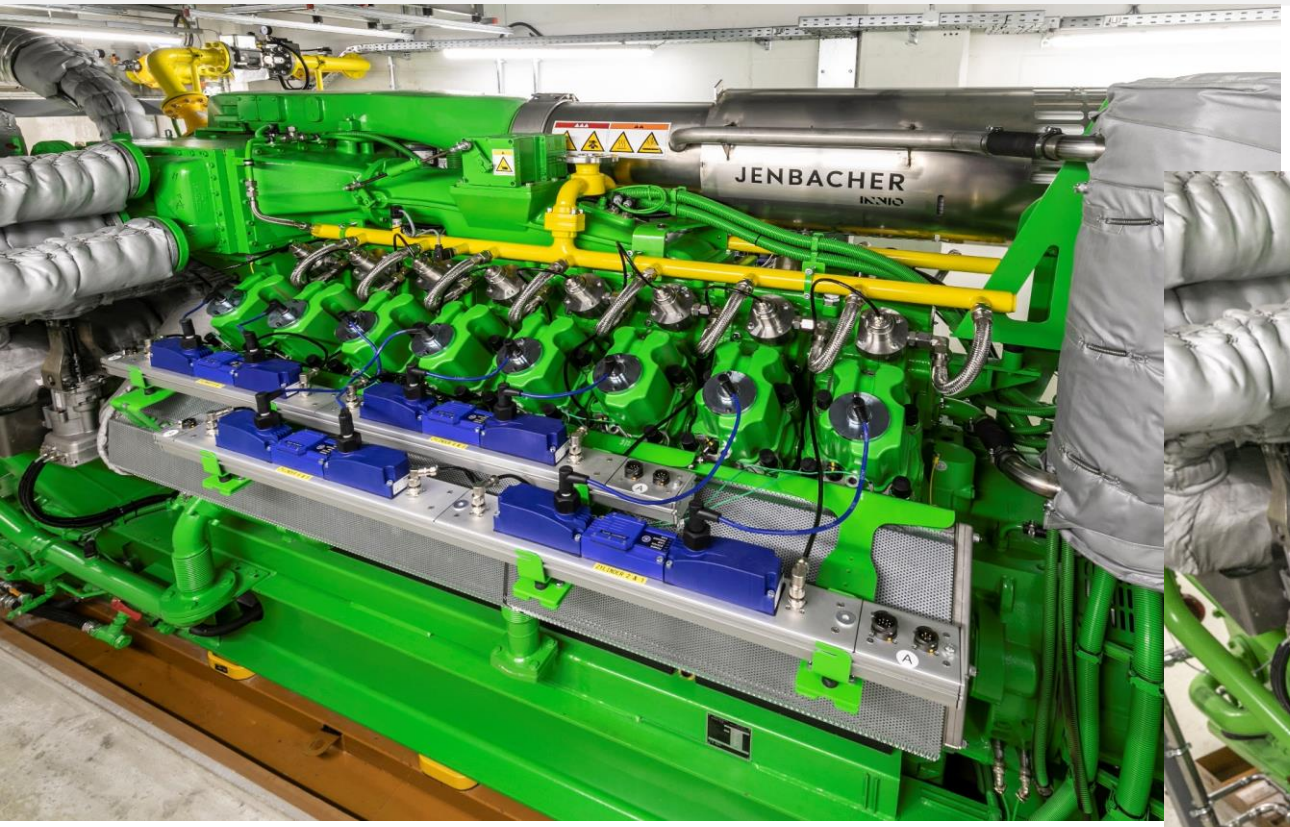
- Port injection (gas pressure 8+bar)
- Cylinder selective combustion control
- Wastegate for turbo charger

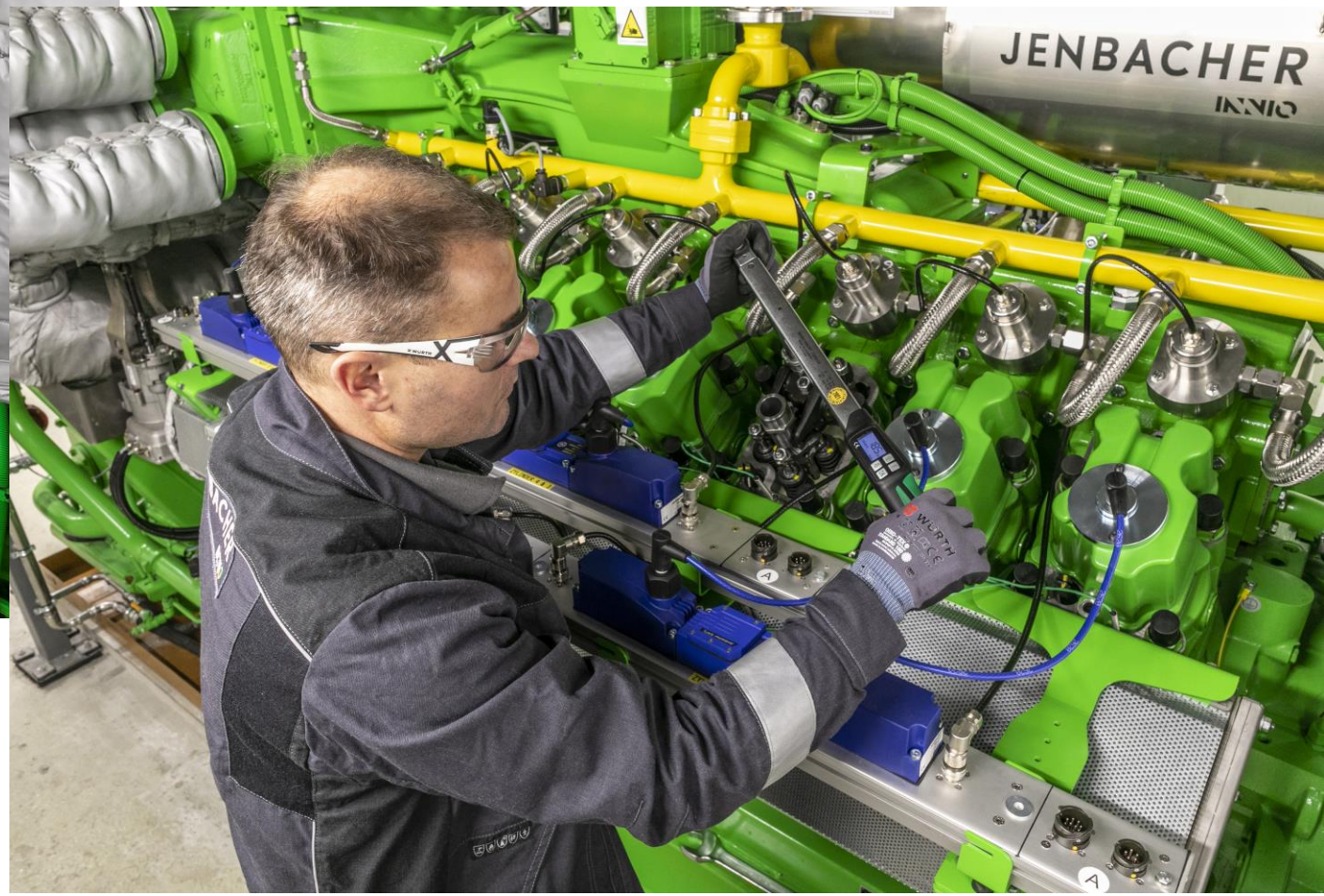


Best effort performance is about 10% higher in output

Alternatively, a “Dual Fuel Product” – 100% NG / 100% H2 – is available

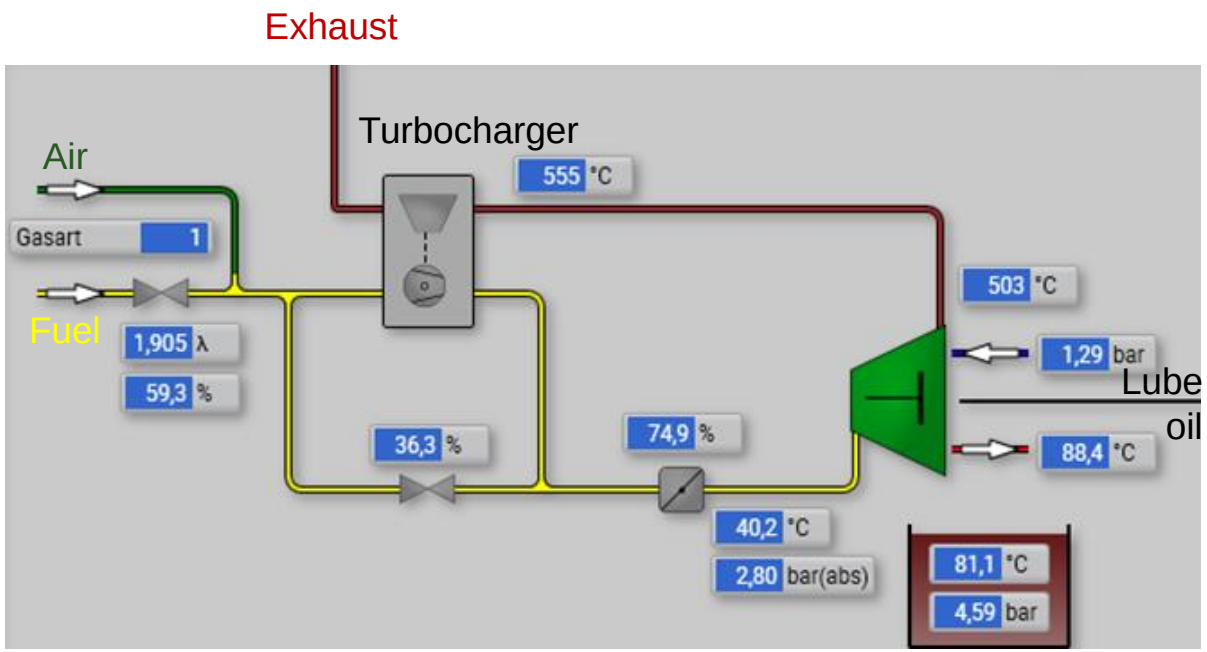
H2 engine – fuel supply system



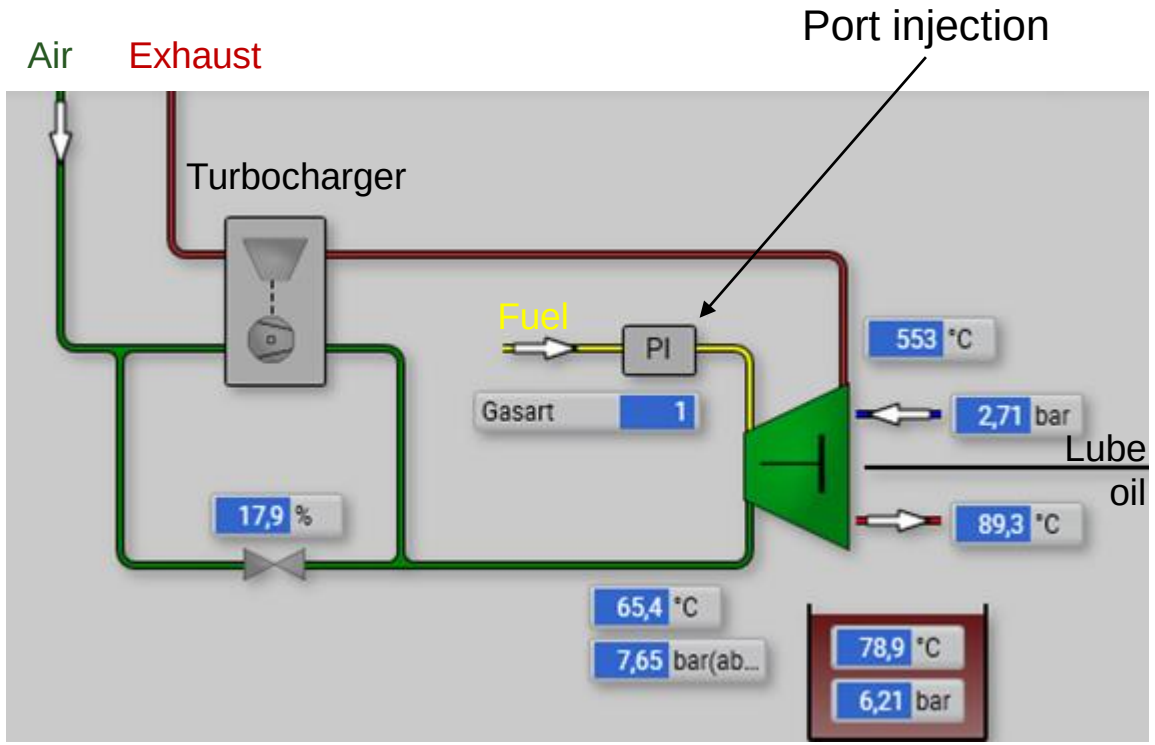


Main difference between a NG engine and a H2 engine

NG engine

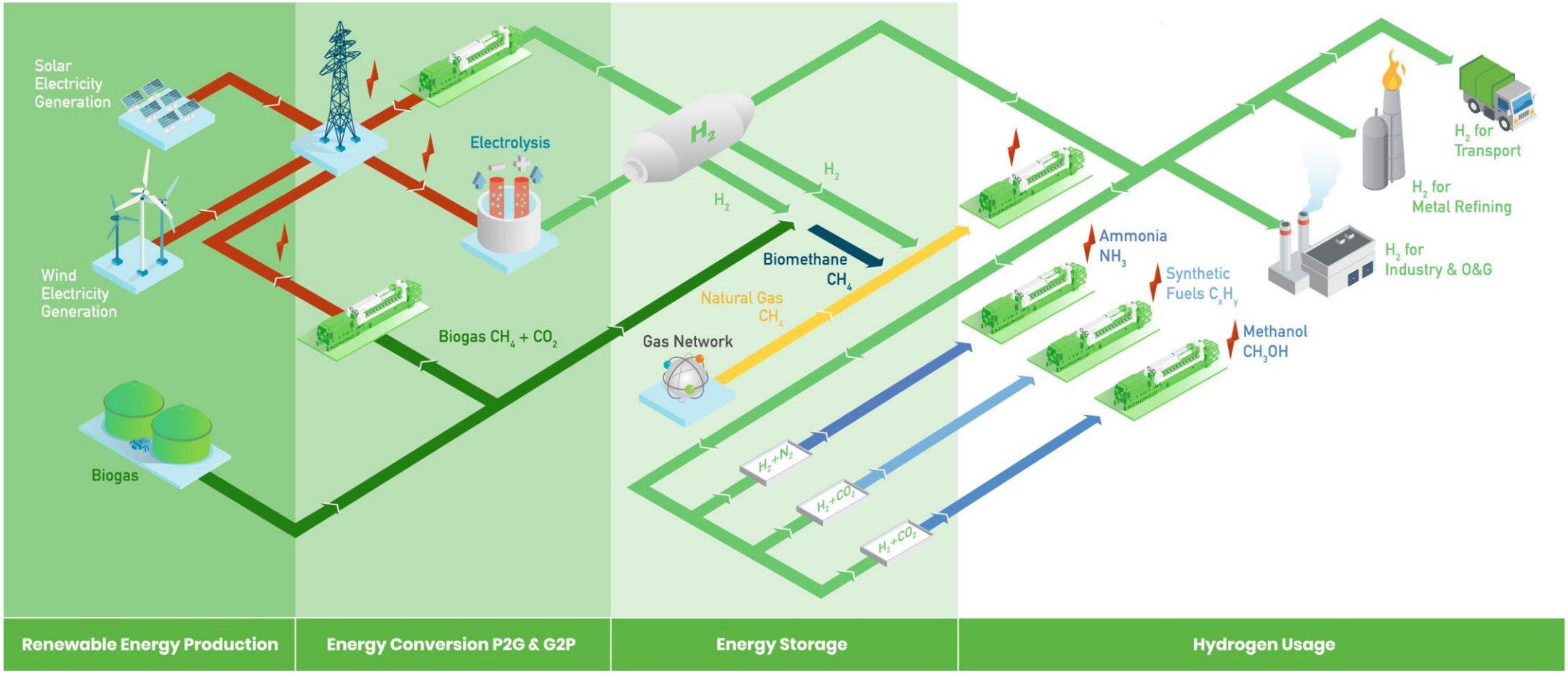


H2 engine



Intercooler on both pictures is not shown

Future role of Jenbacher gas engines in a renewable world



THE HYDROGEN ECONOMY CAN BECOME A REALITY ACROSS ALL SECTORS – IF WE USE THE EXISTING INFRASTRUCTURE!

H2 ready means the Jenbacher gas engines can operate with up to 20%(v) of hydrogen and can be converted to 100% H2 operation. A H2 ready designed power plant helps to reduce future H2 retrofit costs.

ready for H_2

INNIO JENBACHER Waukesha