IDEA2021

Powering the Future: District Energy/CHP/Microgrids

Sept. 27-29 | Austin Convention Center | Austin, Texas

Using Hydrogen-Fueled Gas Engine Generators to Reduce the Carbon Footprint of District Energy Power Plants and Systems

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JENBACHER
INNIO

INTERNATIONAL DISTRICT ENERGY ASSOCIATION

Transitioning to 100% Renewable fuels

Today

Natural Gas CHP

Biogas

Today's mix of fossil natural gas and renewable gas

Tomorrow

Biomethane or Synthetic Methane CHP

Biomethane & CO_2 usage

Hydrogen CHP

Biogas

Carbon neutral fuels & green hydrogen

Hydrogen is not a new fuel

Coke gas (Profusa)
COD 1998

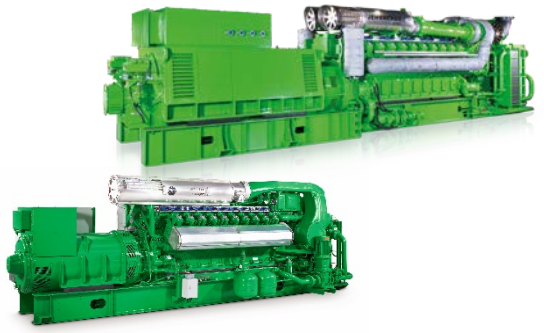
H_2: ~50-70Vol%
CH_4: ~20-25Vol%
LHV: ~5 kWh/m^3

Process gas (Krems)
COD 1996

H_2: ~15-17 Vol%
CH_4: ~1.5 Vol%
LHV: ~0.5 kWh/m^3

Syngas (Mutsu)
COD 2003

H_2: ~30-40 Vol%
CO: ~25-30 Vol%
LHV: ~2.5 kWh/m^3



Pure Hydrogen
2021+

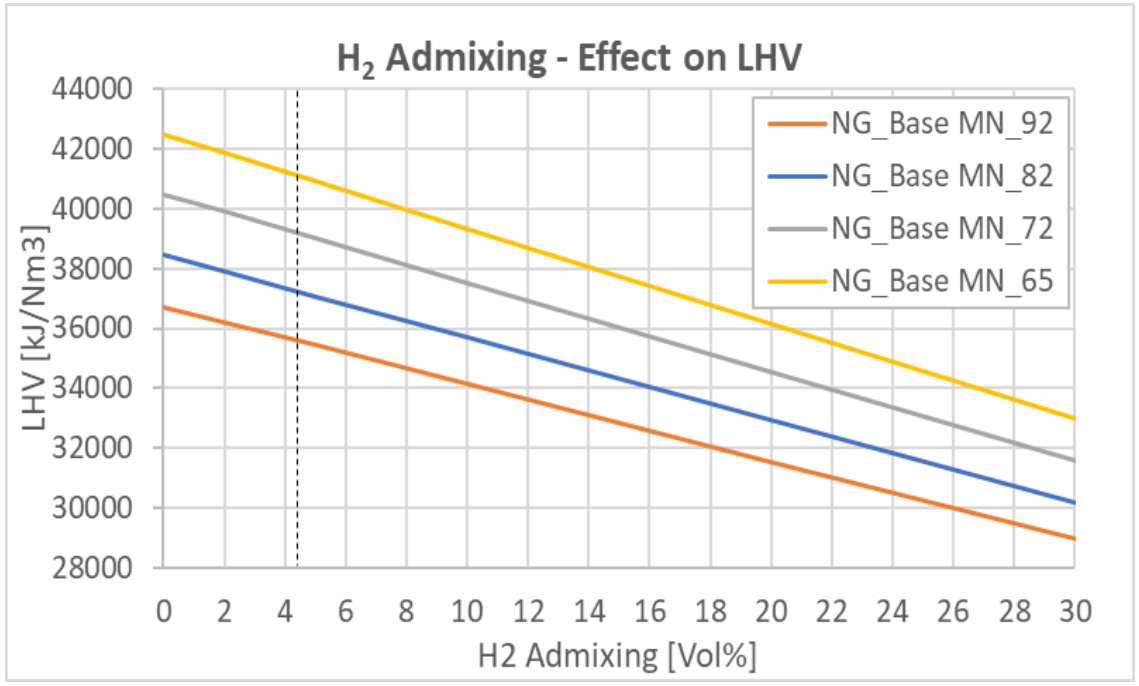
H_2: … 100 Vol%
Nat. Gas or Inerts
LHV: ~3 kWh/m^3

Commercial operation
(challenges: gas quality variations)

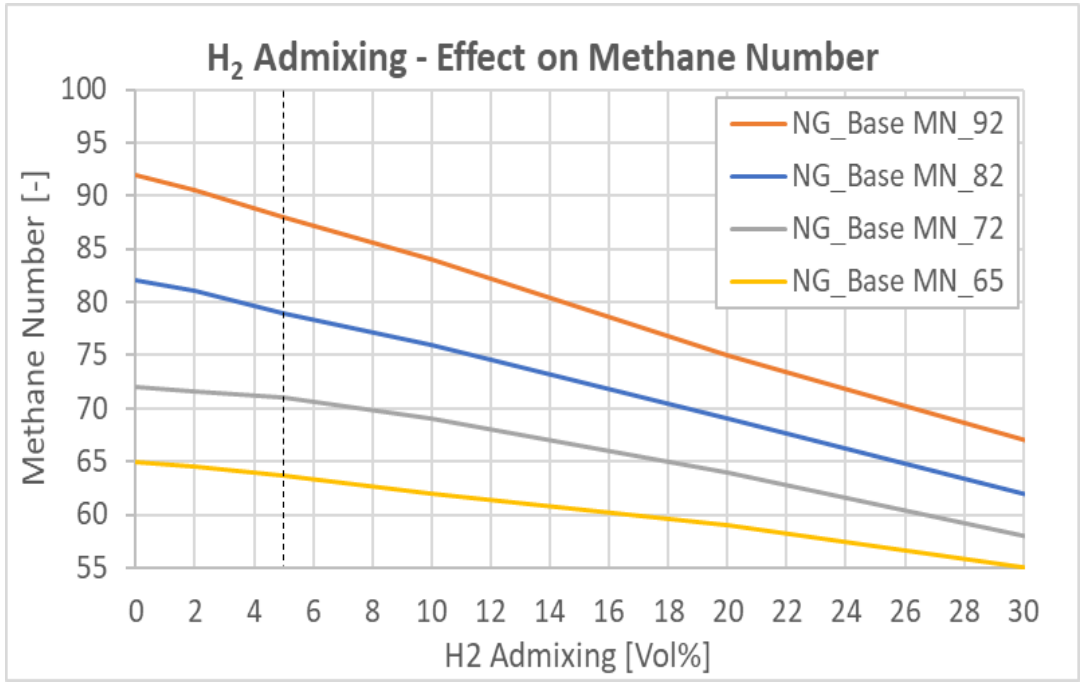
Future

Challenge 1: Combustion properties of Hydrogen

H2 Admixing-Effect on Heating Value



H2 Admixing-Effect on Methane Number



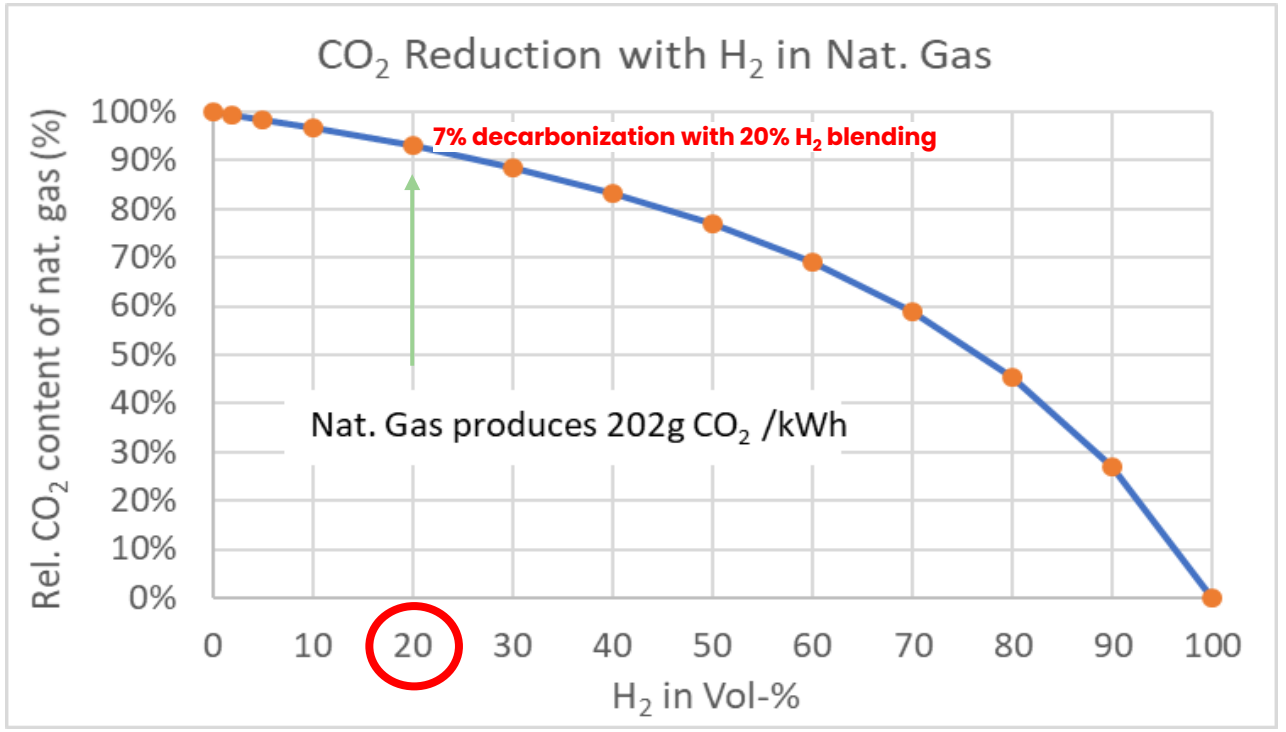
>5%(v) H_2 in pipeline gas … we recommend a signal to gas engines about H_2 content

Adding H_2 in pipeline gas changes the combustion properties substantially

Challenge 2: Decarbonizing with H2 / Natural Gas blends

		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
Stoichiom. air requ.	Nm³/Nm³	9.7	2.4
Laminar flame speed	cm/s	30	>100

Hydrogen added to pipeline Natural Gas



Solution: Not one size fits all

A

H_2 in natural gas pipeline

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

No modifications required

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

Limited optimizations required

B

H_2 local admixing

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

Limited optimizations required

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

Specialized engine required

C

Pure H_2

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

Specialized engine required

Case Studies: H_2 admixing projects with Jenbacher Engines (500-1800kW)

30%v H_2

Bozen - Italy
2017, Horizon 2020 Demo

J612, main fuel NG

30%v H_2

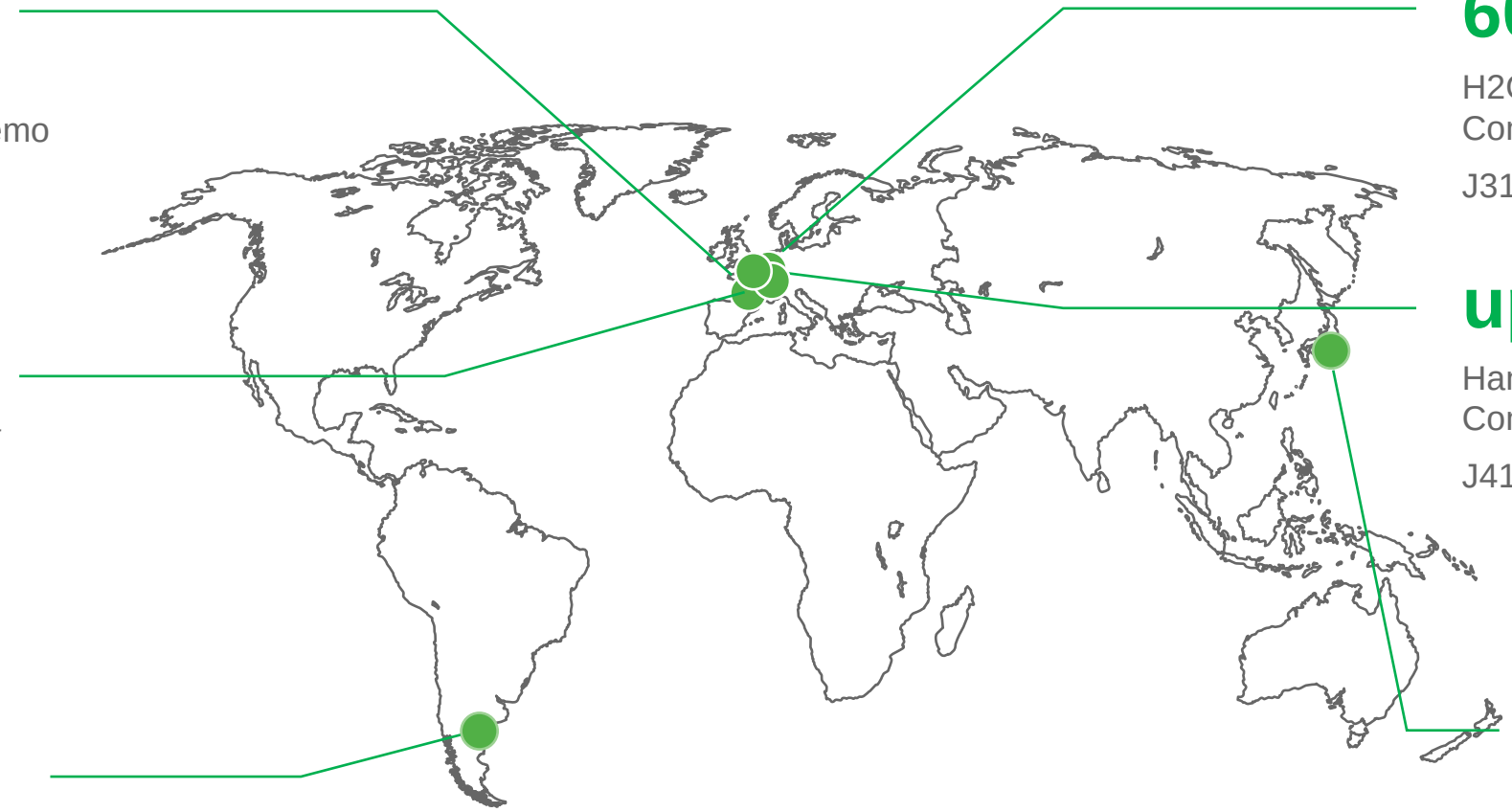
Biogas Stream- Austria
2008 Demo

J312, main fuel NG

42%v H_2

Hychico – Argentina
Operating since 2008

J420, main fuel NG



60%v H_2

H2ORIZON - Stuttgart
Commissioning 2020

J312, main fuel NG

up to 100% H_2

HanseWerk Natur - Hamburg
Commissioning 2020

J416, main fuel NG

60%v H_2

Ando Hasama - Japan
Commissioning 2020

J312, main fuel NG

Hychico Project, Argentina

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

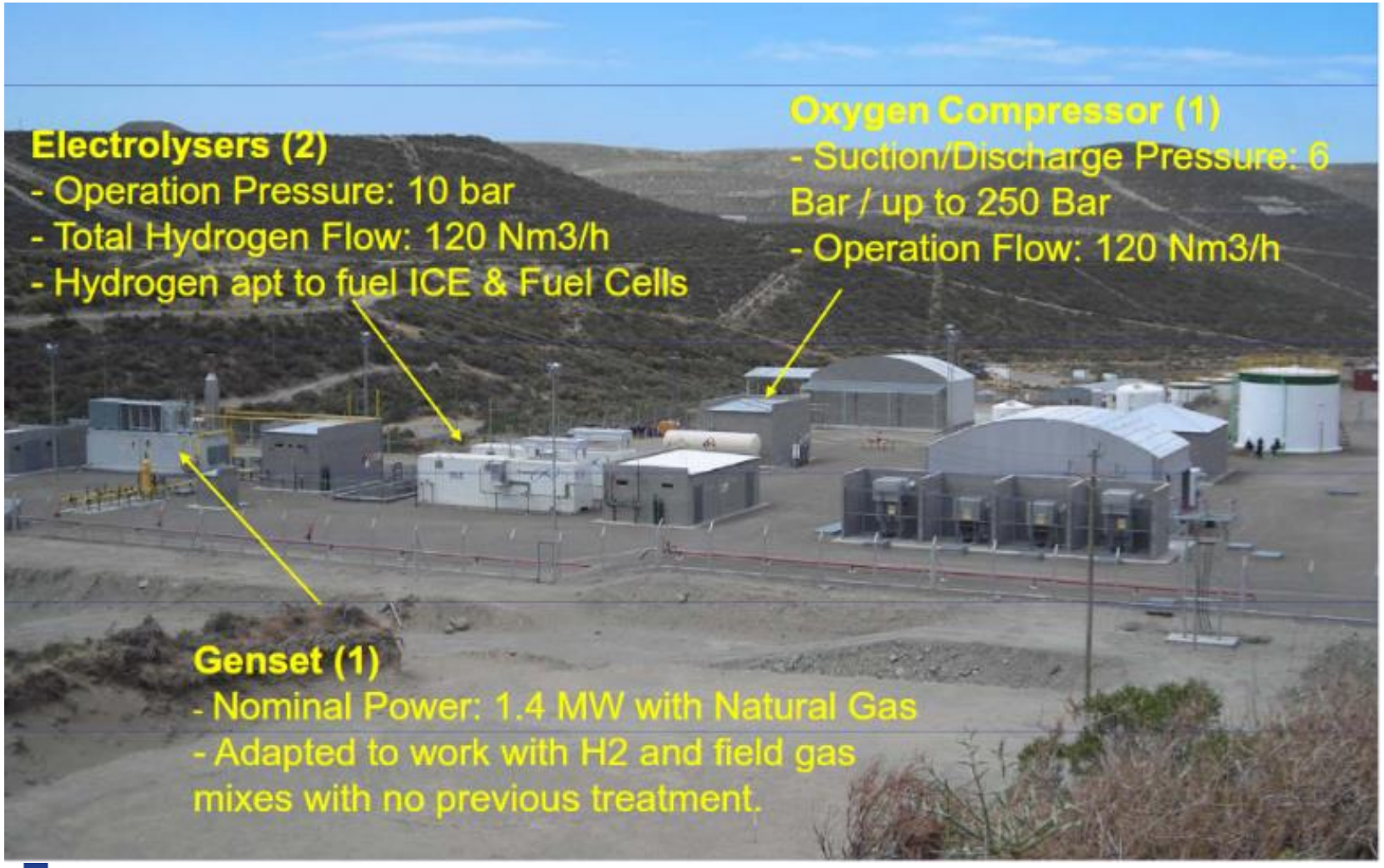
About the region:
Currently large oil & gas fields
2,000 GW wind power potential, compared to 600 GW global installations today
Ideal place for exporting green H_2 and e-fuels in the future

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

Hychico Project, Argentina



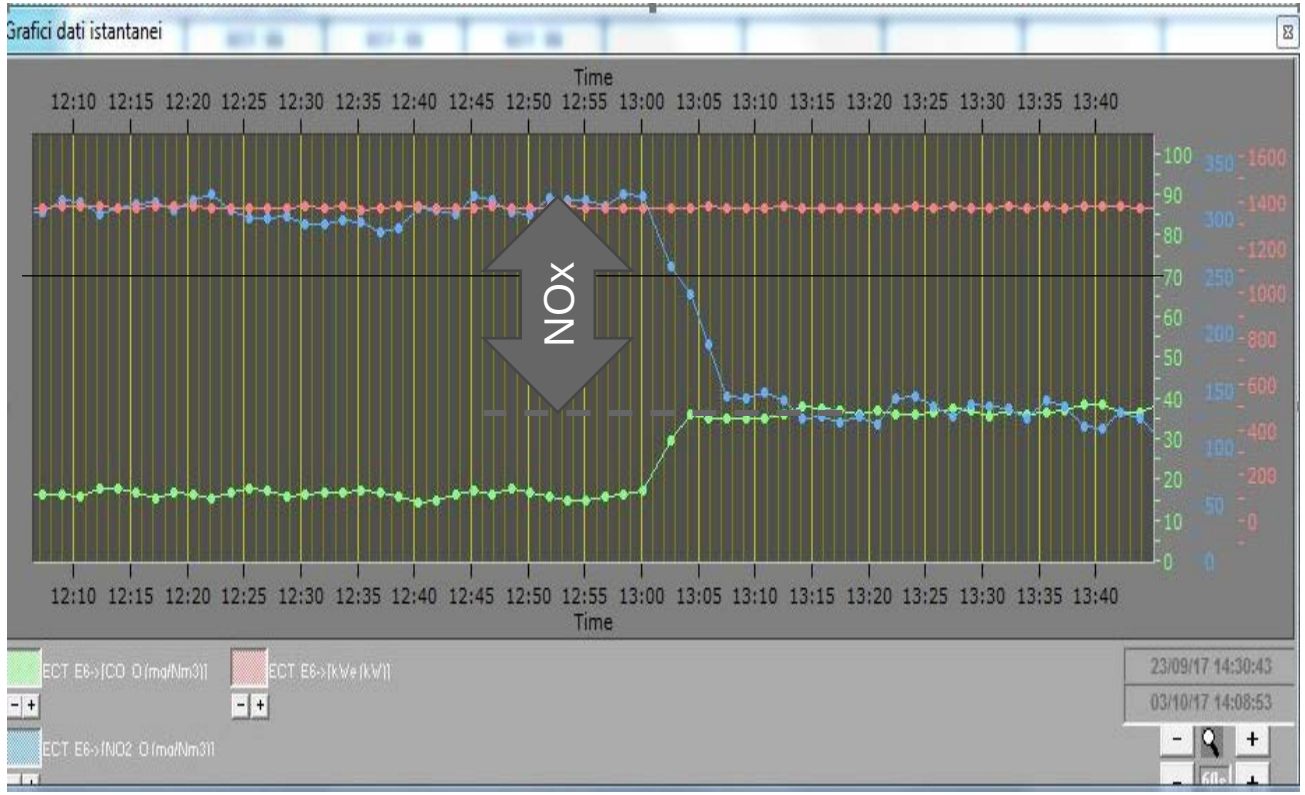
Sinfonia Project, Italy

Project Sinfonia: controlled H_2 blending to existing NG CHP engine

- J612 Pel=1824kWe
- Base gas: Natural gas (MN~90)
- Up to 30Vol% H2 controlled blending possible by engine specific parameter setting
- Up to 50% NOx reduction possible w/o exhaust gas aftertreatment @ >20Vol%H2 blending

Intended & controlled H_2 blending can improve combustion of gas engines
Uncontrolled blending can cause emission challenges and knocking

Sinfonia Project, Italy – NOx and H_2 combustion



H_2-signal not available

H_2-signal available

+20% NO_x with 30% H_2 (without H_2 signal)

~250 mg/Nm^3 NO_x @5%O_2 with 100% NG

-50% NO_x with 30% H_2 (with H_2 signal)

J612 (2010)	100% NG (MN90)	70%v NG & 30%v H_2
El. Output (kW)	1.824	1.824
El. Efficiency (%)	43.5	~43.8
NO_x (mg/Nm^3 @5%O_2)	250 (~0.5g/bhprhr)	~125 (~0.25g/bhprhr)

30Vol% H_2 blending with parameter adjustments reduce NO_x by ~50%.

Hamburg Project, Germany – 100% H_2

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)

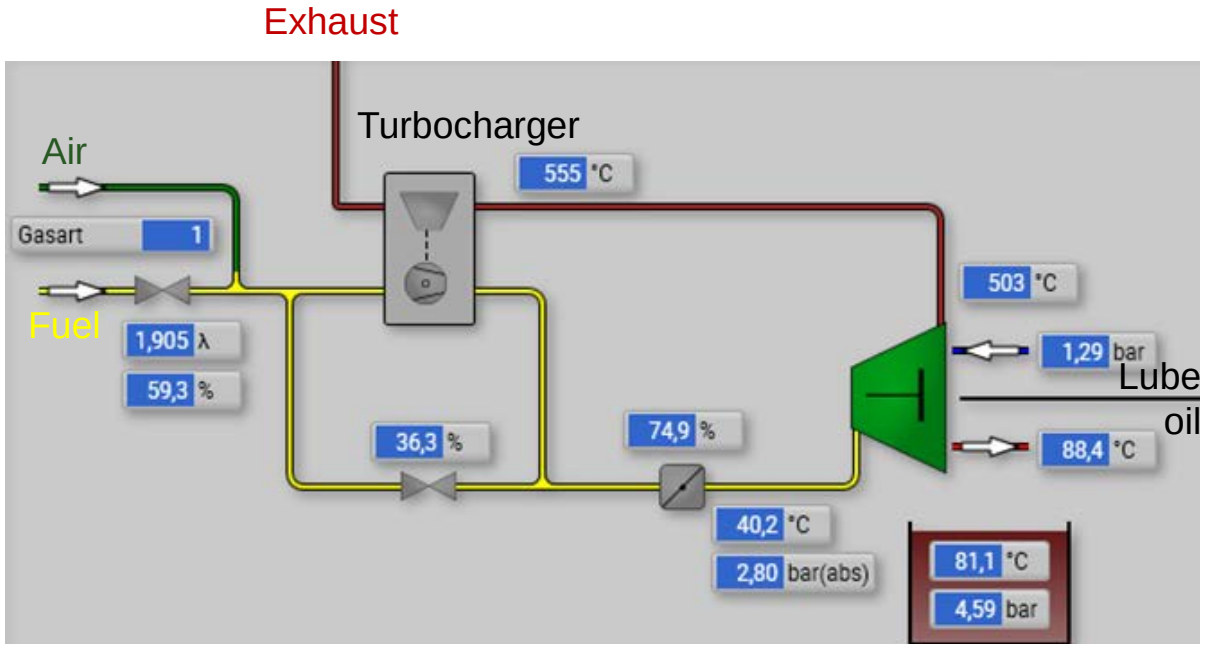
Milestones

- ✓ Factory test successful in Aug., 2020
- ✓ Site commissioning in Nov. 2020

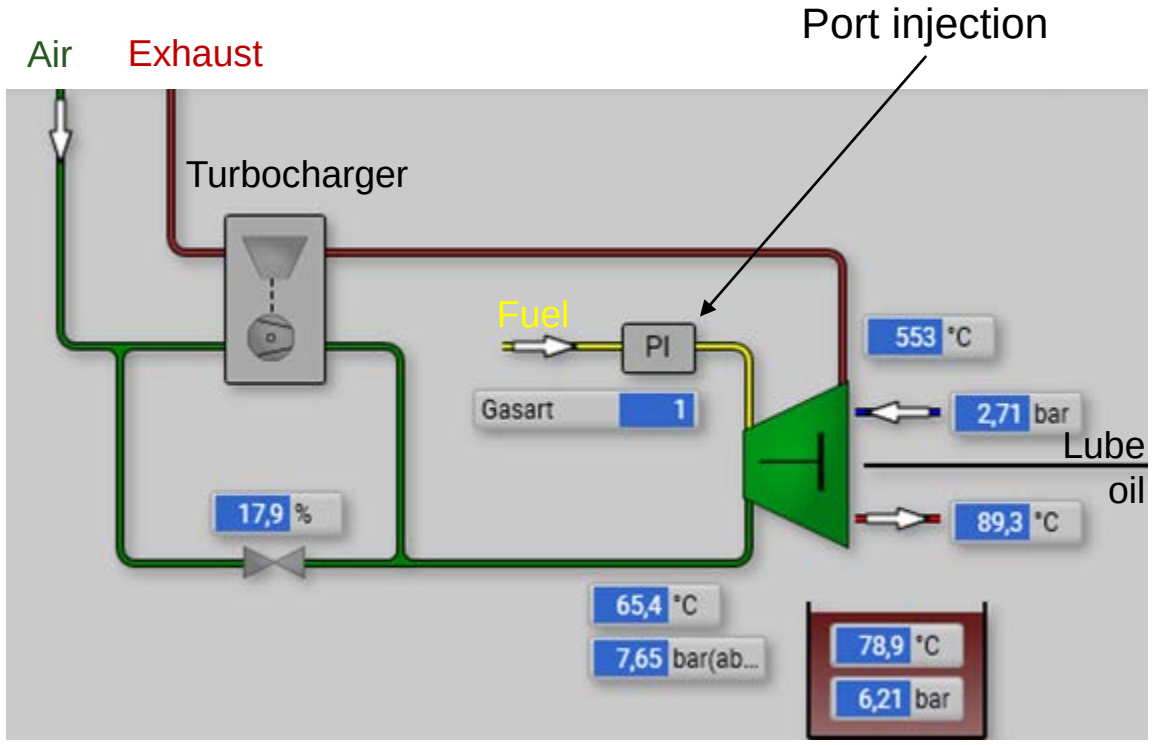
First 100% Hydrogen pilot engine in 1MW class

Hamburg Project, Germany – 100% H_2

NG engine

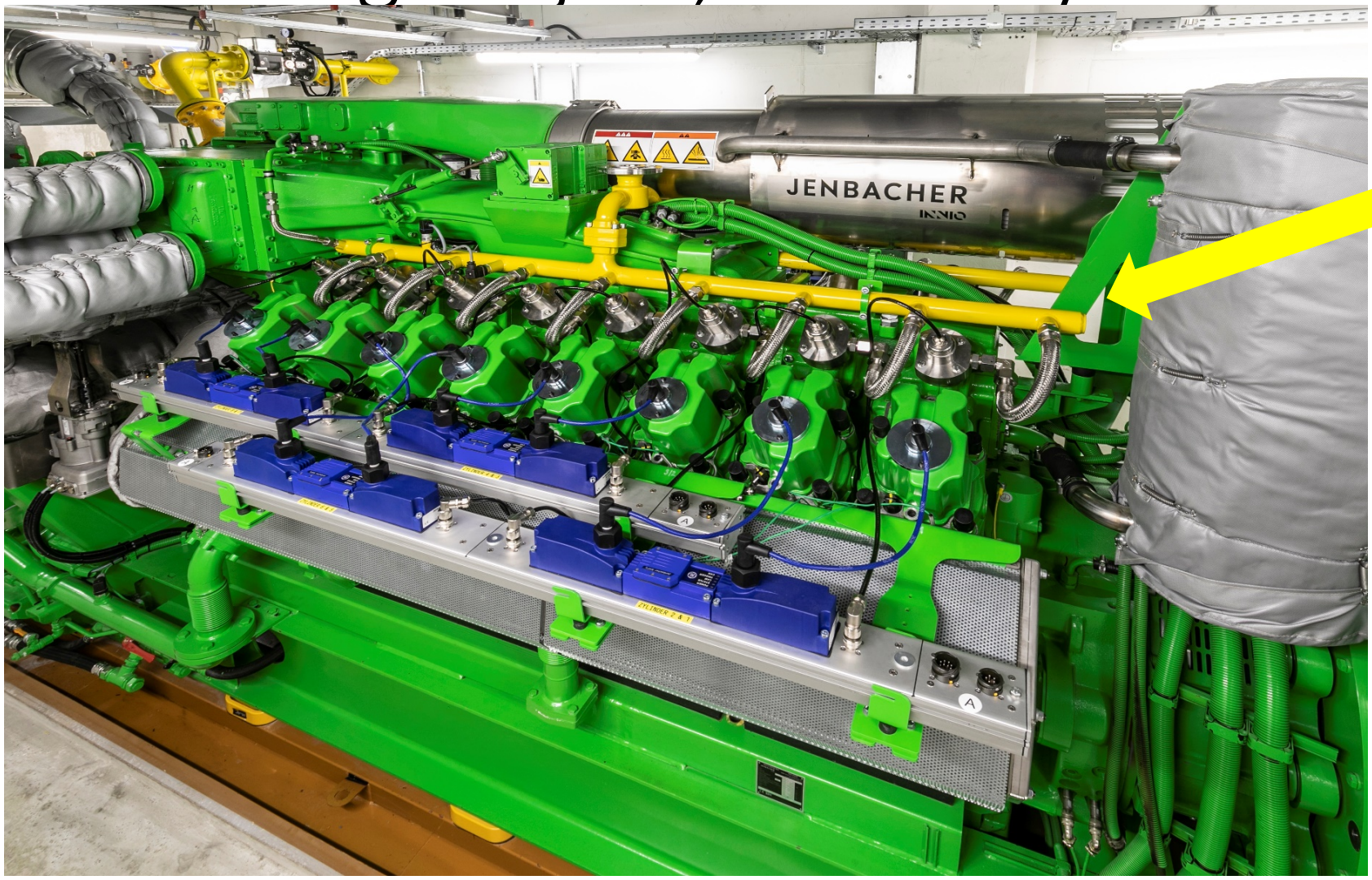


H2 engine



Intercooler on both pictures is not shown

Hamburg Project, Germany – 100% H_2



Hydrogen Fuel Supply

Proof of Technology

1. First to Market 1MW H2
2. On-site conversion of gas generator
3. Tested:
   - Energy efficiencies of engine & fuels
   - Variable H_2 & natural gas fuel ratios, up to 100% H_2
   - Conversion of engine hardware & software between H_2 & natural gas fuel supplies

Leasons Learned

1) Adding H2 to natural gas changes combustion properties and requires H2 signal for optimal performance of engine
2) Significant reduction of NOx emissions with increasing H2 content when engine is running with optimized controls technology such as Jenbacher LeanoxPlus
3) >60% H2 in fuel supply require specialized engine with port injection technology
4) On-site conversion of gas genset from natural gas to 100% H2 is possible. This offers flexibility to operators purchasing a natural gas genset today to convert later when H2 becomes available

Thank You!

Christian Mueller

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Q&A