



We Care for a Better Future.



***CHP-Technology
for green produced hydrogen as fuel.***

2G. Cogeneration.



CHP as an enabler

Key Data.

- Founded 1995 - Headquarters in Heek in North West of Germany
- Solution provider: development, project engineering, production, service, financing
- Plants for biogas, natural gas and hydrogen applications
20 – 4,000 kW electrical power
- Strong focus on R&D
- 9 national and international subsidiaries
- Since 2007 listed at the German stock market
- 650 employees worldwide
- 6,000 CHP plants in more than 50 countries worldwide

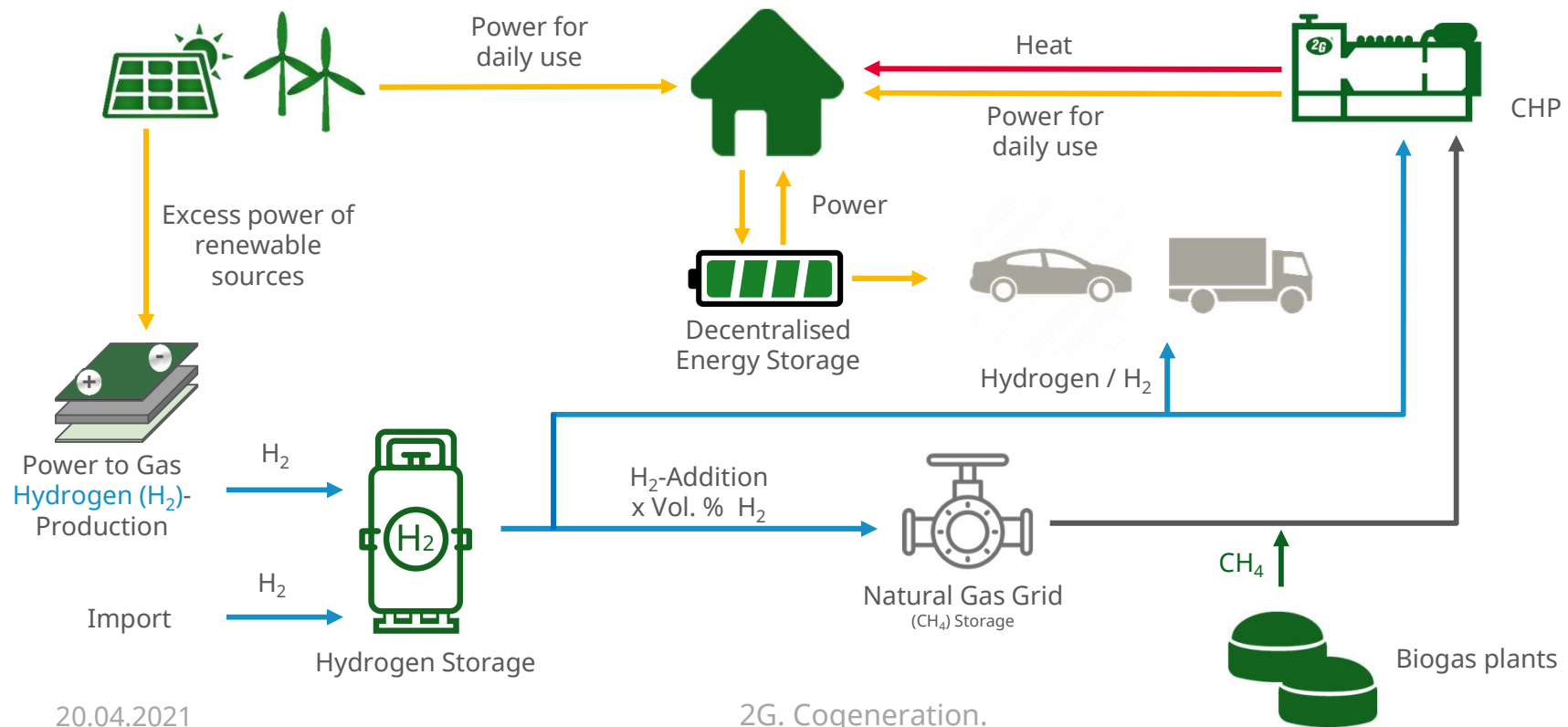


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Hydrogen CHP - The Enabler



Power to Gas.

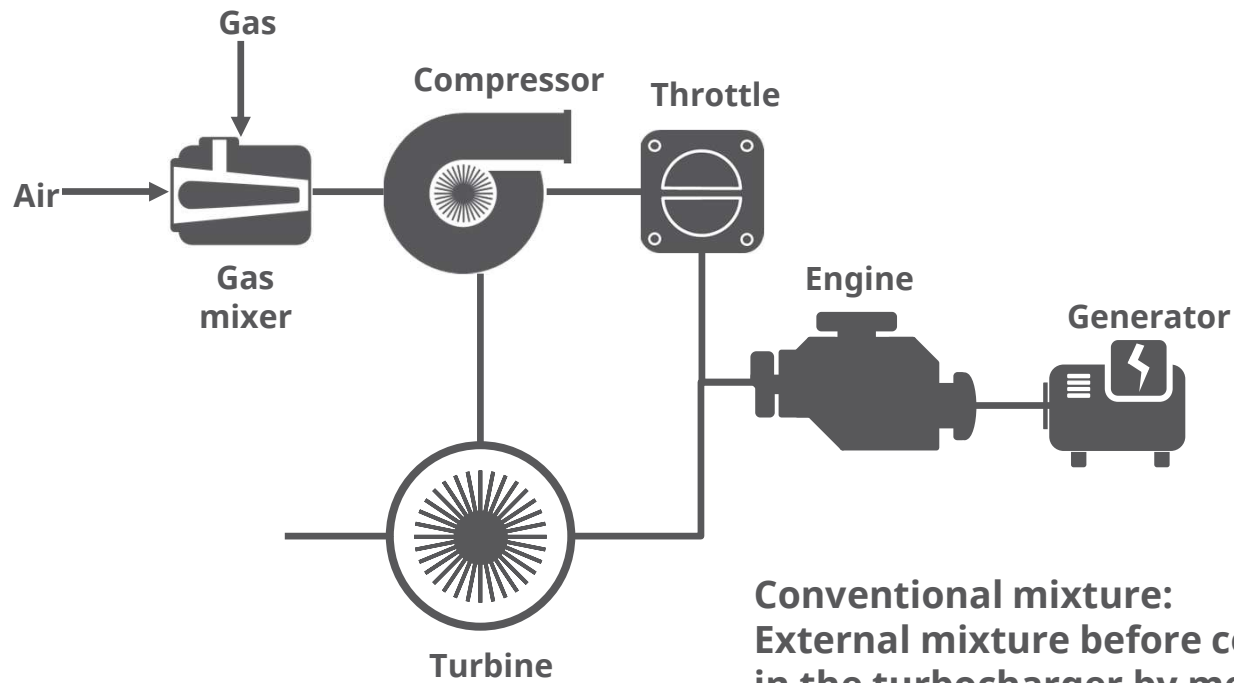


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2G. Cogeneration.



Comparison of mixture formation – Conventional.



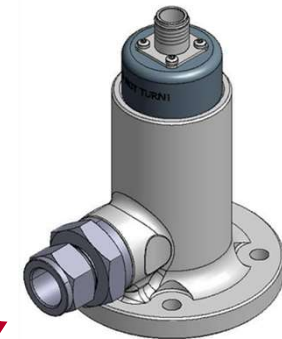
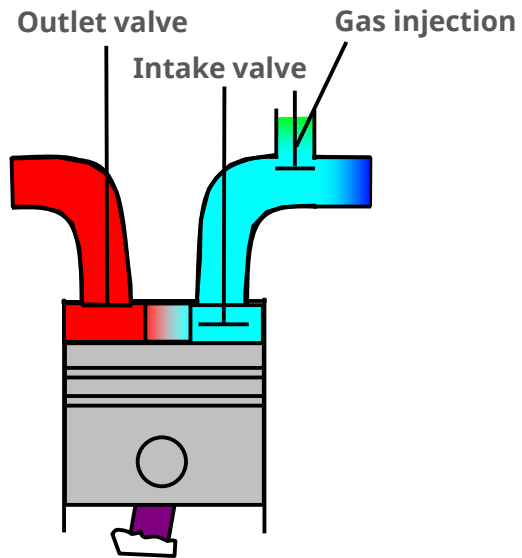
Conventional mixture:
External mixture before compression
in the turbocharger by means of a
controllable Venturi gas mixer



Gas mixer:
Flowmix 65

CHP as an enabler

2G hydrogen engine technology.

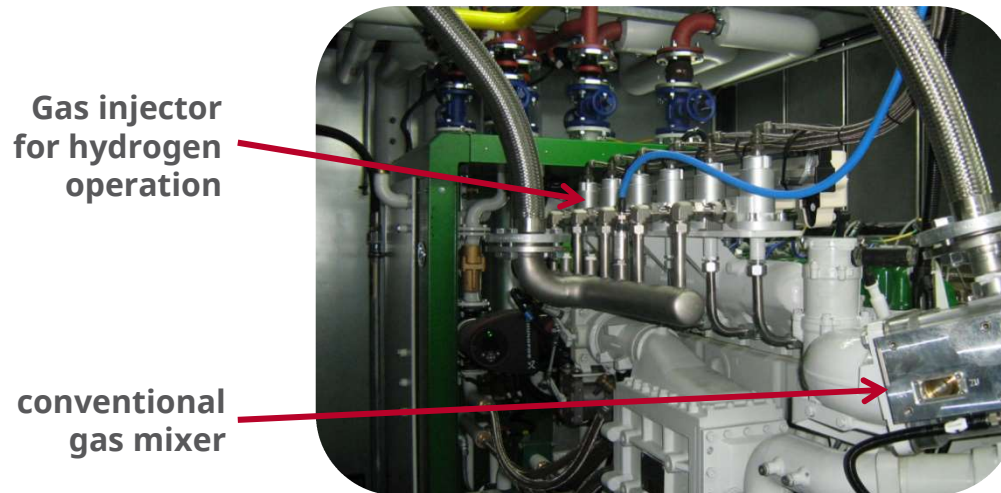


Gas injector

CHP as an enabler



Variable operation with hydrogen and conventional gases.



The 2G hydrogen engines can be operated with 100% hydrogen as well as natural or biogas. This significantly increases their operational capability for current peak coverage

CHP as an enabler



Part of the road map to carbon zero.



Natural gas

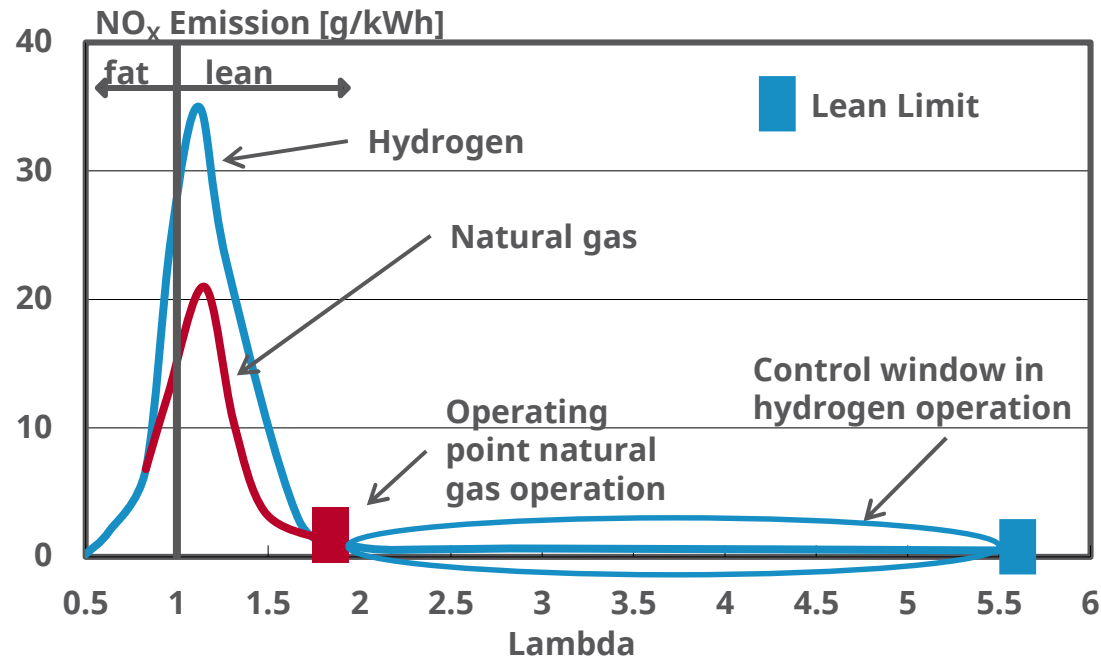


Hydrogen

The 2G engines can be retrofitted to the hydrogen injection on site. Run on natural gas now and convert once the hydrogen is available



Control windows and emissions during hydrogen operation.



Nitrogen oxide emissions (NO_x) are at the detection limit in hydrogen operation. In addition, there are no CO₂ emissions

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2G Hydrogen Portfolio.

Type	Output		Efficiency Rate		
	Electrical	Thermal	Electrical	Thermal	Total
agenitor 404c H₂	115 kW	129 kW	37.7 %	42.3 %	80.0 %
agenitor 406 H₂	170 kW	183 kW	39.0 %	41.9 %	80.9 %
agenitor 408 H₂	240 kW	250 kW	40.2 %	41.9 %	82.1 %
agenitor 412 H₂	360 kW	371 kW	40.5 %	41.7 %	82.2 %
agenitor 420 H₂	750 kW	747 kW	41.2 %	41.0 %	82.2 %

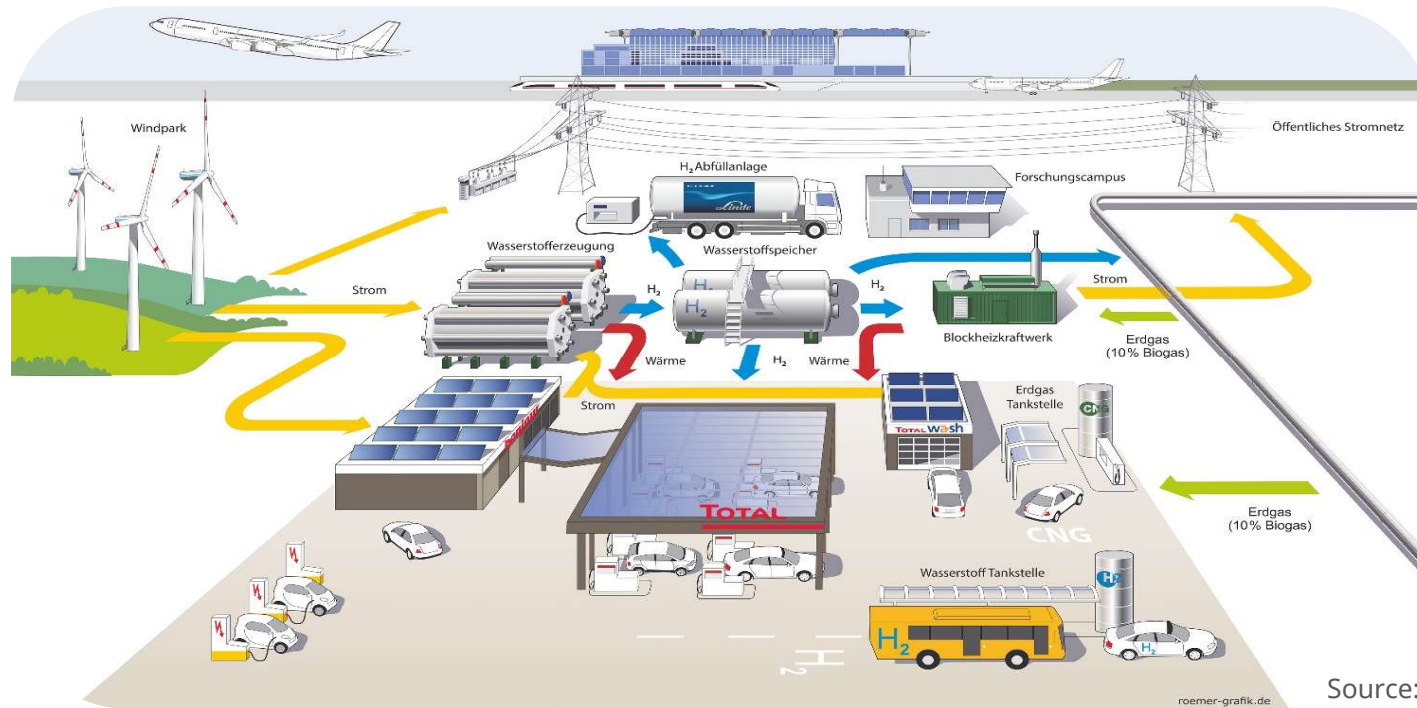
Examples

- **TOTAL Hydrogen Service Station at BER Airport**
agenitor 306 SG with 2G hydrogen technology
- **APEX in Rostock**
agenitor 404c with 2G hydrogen technology
- **Haßfurt Municipal works**
agenitor 406 SG with 2G hydrogen technology
- **Esslingen residential buildings**
agenitor 408 with 2G hydrogen technology
- **Siemens project in Dubai**
agenitor 412 SG with 2G hydrogen technology



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Case Study Berlin Airport.



Source: Enertrag / Total

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Reference.



agenitor 306 SG in a Container



Project: TOTAL Hydrogen Service Station at the BER Airport in Berlin

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Hydrogen project in Dubai.

The Worlds largest solar parks
(1000MW in 2020 / 5,000MW in 2030)
the Mohammed bin Rashid Al Maktoum (MBR)
in Dubai.

Siemens and the DEWA are building up the
hydrogen economy in 2020.



CHP as an enabler



Power to Gas - Case Study Utility Haßfurt.

AUS WIND WIRD WASSERSTOFF!
pro Windgas, unser Speicher
für erneuerbare Energie

städtebetriebe
haßfurt

windgas
haßfurt

GREENPEACE
ENERGY

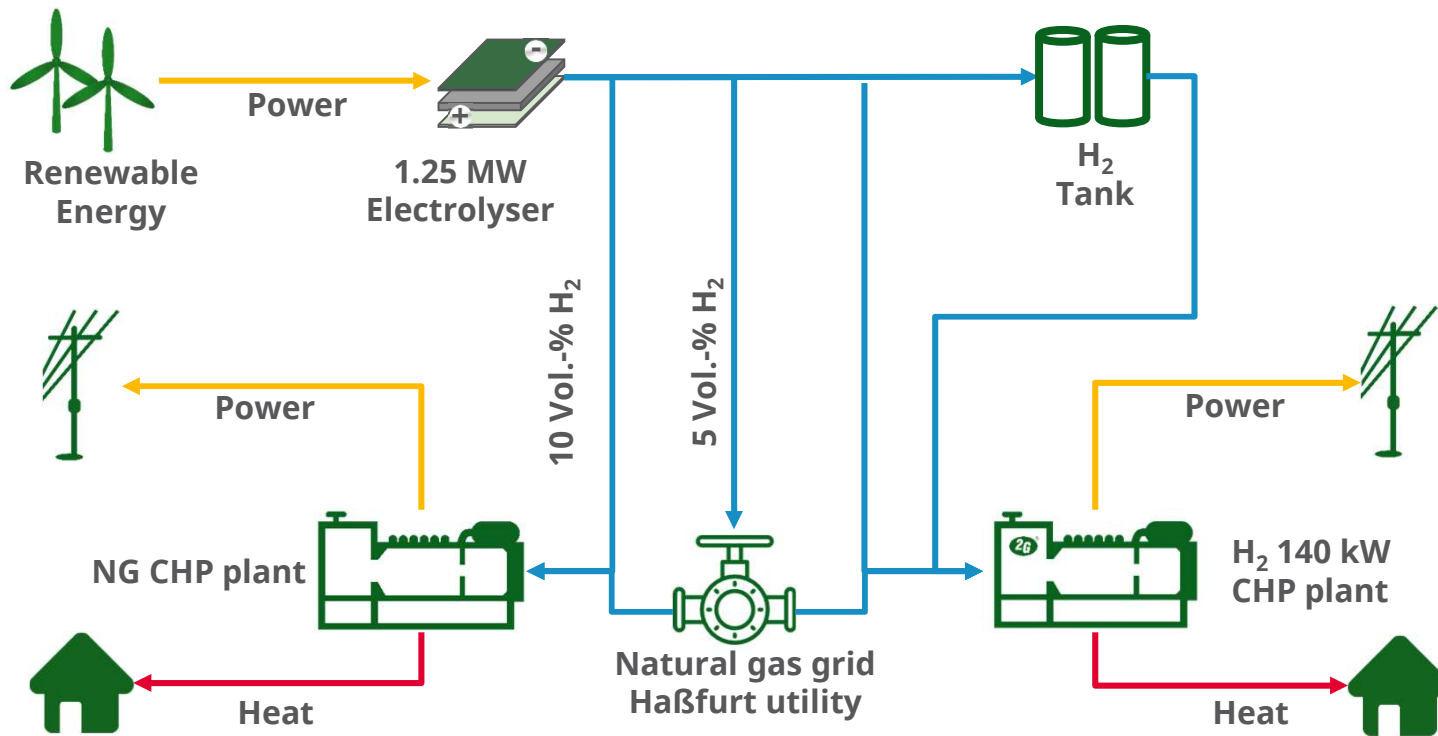
The image is a promotional poster for 'Power to Gas' in Haßfurt. It features a landscape illustration with a dirt road leading towards a horizon with several wind turbines under a cloudy sky. The text is overlaid on the lower portion of the image. At the bottom, there are three logos: 'städtebetriebe haßfurt' on the left, 'windgas haßfurt' in the center (with a circular icon of a wind turbine and a gas tap), and 'GREENPEACE ENERGY' on the right.

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Source: Stadtwerk Haßfurt

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Power to Gas - Case Study Utility Haßfurt.



Source: Stadtwerk Haßfurt

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District Energy Esslingen.

500 apartments, shops, 12 story office block and campus for 1800 students.

Concept design to act as a blueprint for ecological and economic city district supply.



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Hydrogen Airport.

The European Marine Energy Centre (EMEC) is collaborating with Highlands and Islands Airports Limited (HIAL) to decarbonise heat and power at Kirkwall Airport through green hydrogen technology.

The hydrogen is being delivered to the site in containerised storage tanks.

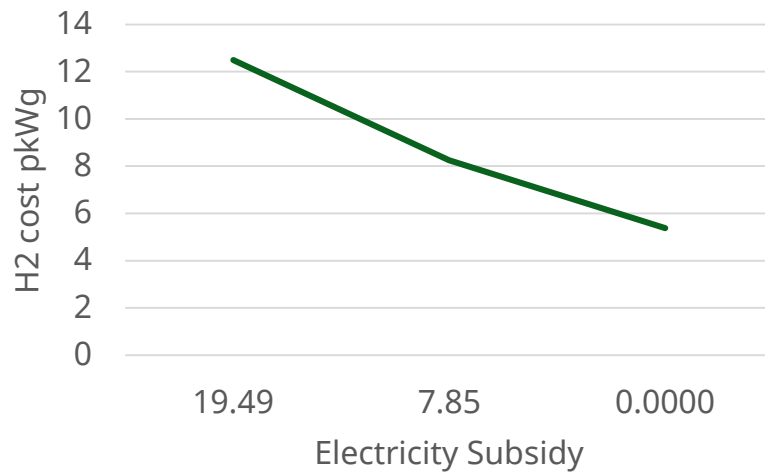


CHP as an enabler

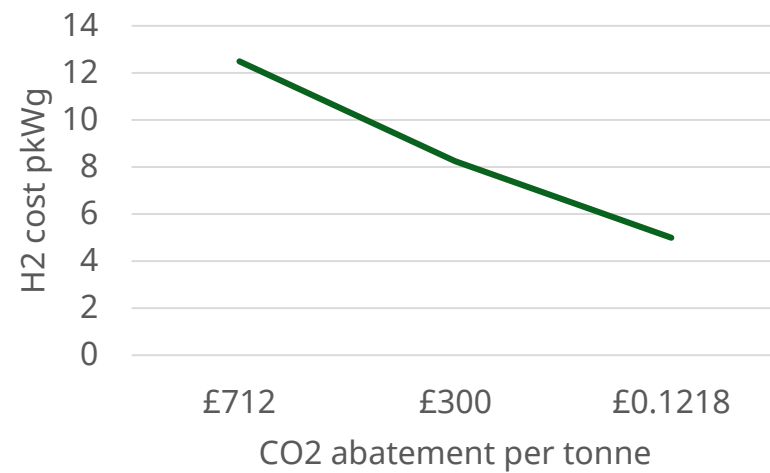


Hydrogen costs.

H2 cost vs Electricity Subsidy



H2 cost vs £t CO2 abatement

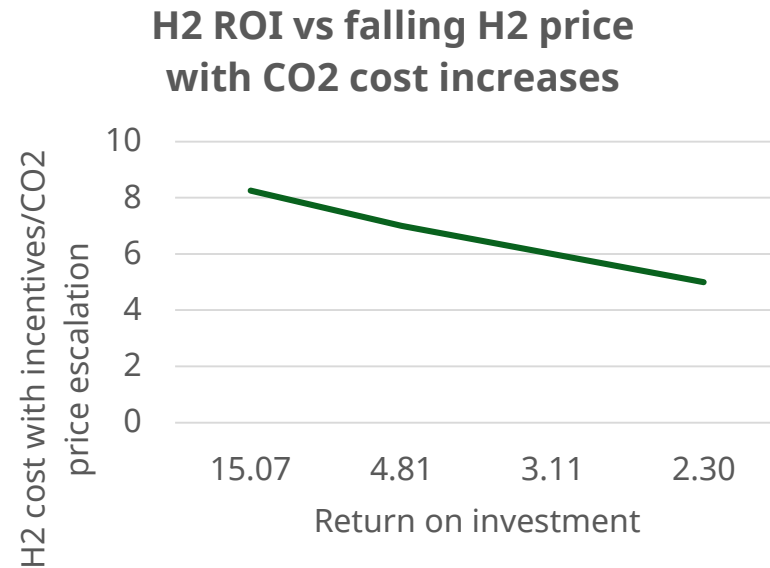
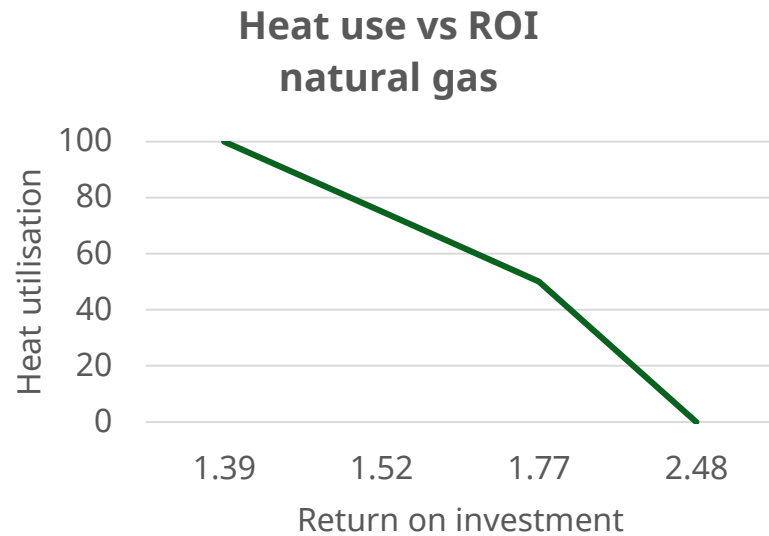


Hydrogen is not yet economic without subsidies – but costs are falling

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Conversion point.

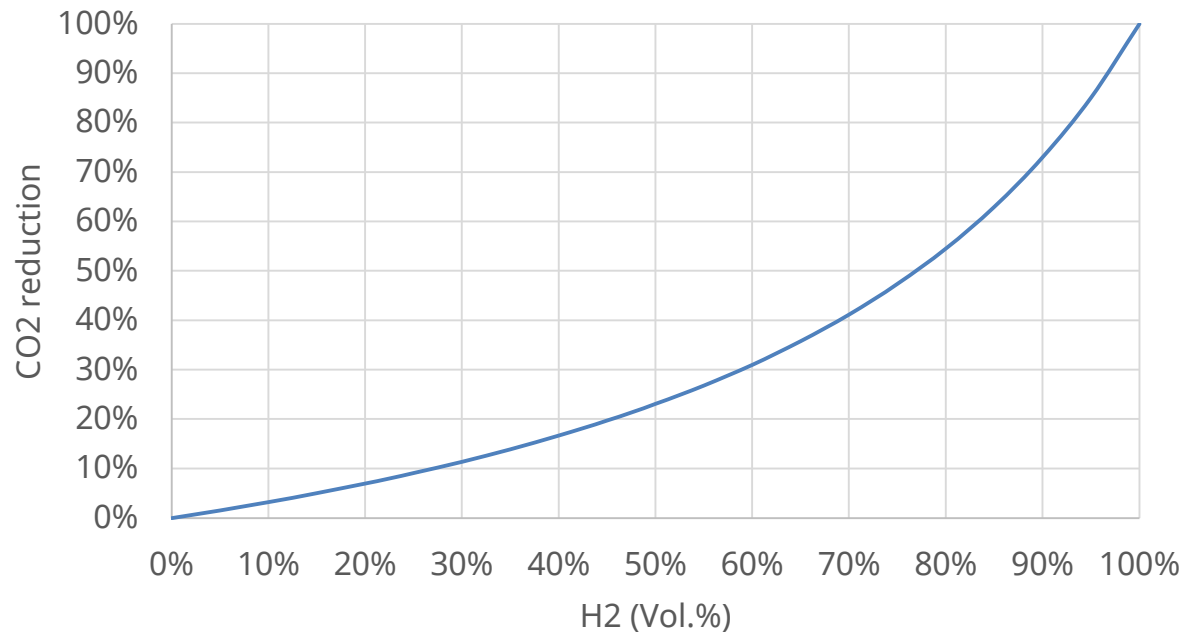


At some future point the economic conditions will be right to convert from natural gas to hydrogen operation

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CO2 reduction.



CO2 reduction is not linear to the percentage volume of hydrogen in the gas mix



Conclusions.

- Hydrogen engines unlike the fuel cell do not need pure Hydrogen, they can operate successfully with impurities in the gas flow. This hydrogen can be obtained as a by-product of industrial processes or syngas with high hydrogen contents can be used
- Increasing requirements for ensuring network stability are met – Decentralised approach!!!
- Partial load capability from at least 50 – 100 % nom. load
- Existing technologies for integration into virtual power plants
- Island operation with large load increases is possible
- Mixed gas operation possible with second gas control system (e.g. natural gas / biogas / landfill gas)

Thank you very much for your attention!



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