CHP-Technology for Green Hydrogen.

Andre Banken, Director of International Business Development.

2G. Cogeneration.

05.03.2019

2G Facts.

- Founding 1995 – Head Office in Heek / Northrhine-Westphalia
- One of the leading Cogeneration system manufacturer in Europe
- Total Solution Provider (Development, Manufacturing, Project Management, Service / Maintenance, Optimization)
- Power range: 20 to 2,000kW of electrical Output on various fuels
- Focus on technology = highest efficiency and realiability
- 10 subsidiaries in Germany and abroad
- Stocklisted in Frankfurt (Germany) since 2007
- 650 employees around the globe
- More than 5,300 Coegenration system installed in + 45 countries

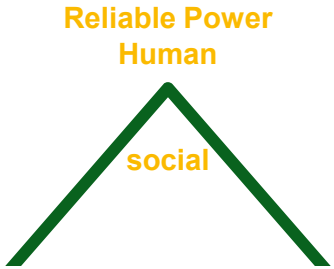
Have a look at our Homepage:
www.2-g.com

Goals of the „Energy Transition“.

Change from the usage of fossil and nuclear primary energy towards the utilization of sustainable and renewable Energy.

Goal	Status	Finish
Nuclear Phase-out	decided	till 2023
Coal (Lignite) Phase-out	recommended	till 2038
Extension of renewable Energy towards 80% of the total German power production	ongoing	till 2050
Total decarbonization of power industry (100% renewables)	planning	till 2080
Electrification of the total economy (Sector-coupling)	vision	till ????

The three pillars of Sustainability.



§ 1 (1) Energiewirtschaftsgesetz (EnWG):

The purpose of this law is to achieve a reliable, affordable, consumer friendly, efficient and environmental friendly supply of Electricity and Gas to the general public, which increasingly shall rely on renewable energy.

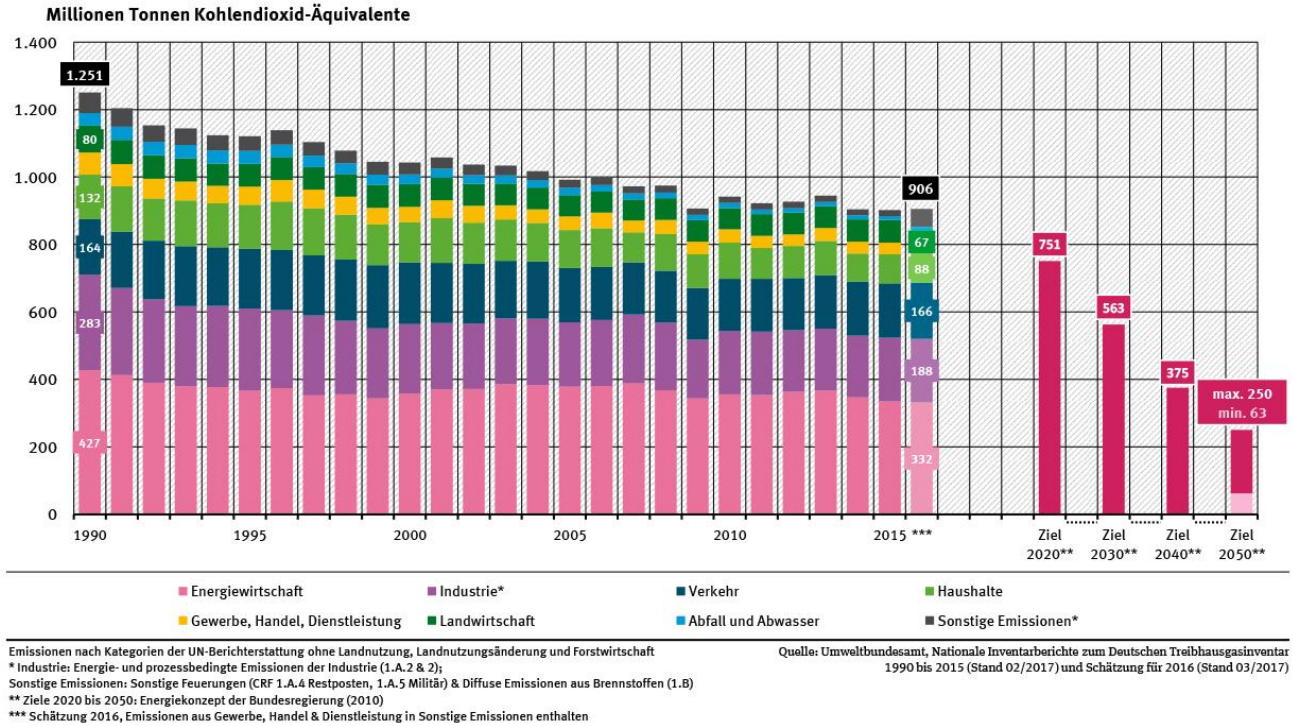
Blackout in Italy.

28.9.2003, 01:00 Uhr

28.9.2003, 03:20 Uhr

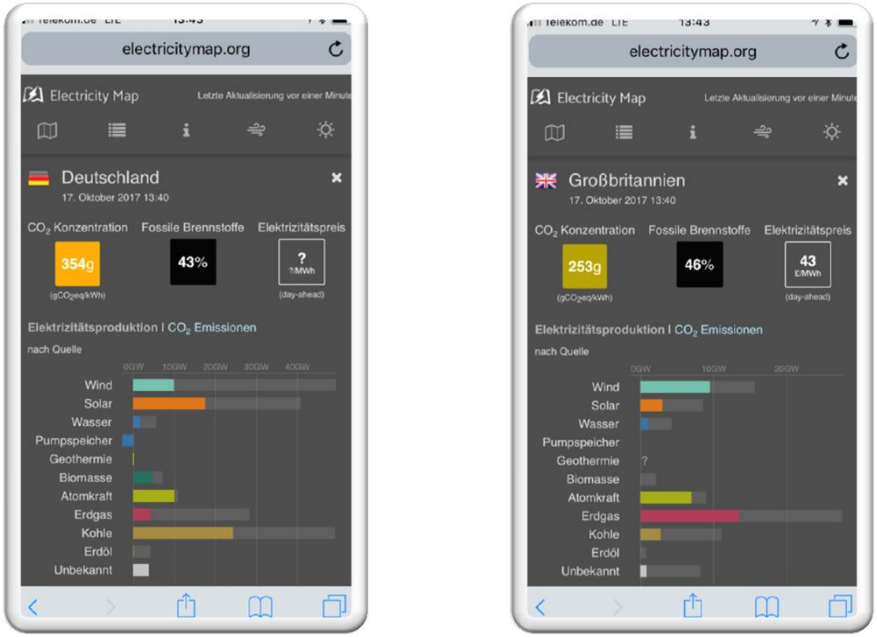
Quelle: Leipniz Universität Hannover

GHG emissions Germany.



Source: http://www.umweltbundesamt.de/daten/klimawandel/klimaschutzziele-deutschlands#textpart-1

Comparison of CO2 emission in between Germany and UK.



Source: www.electricitymap.org, 17.10.2017 um 13:43Uhr

Coal power causes a bad CO2 spread sheet, even though the amount of renewable energy in the grid is quite high.

CO2 emissions – Comparison of Coal and Natural Gas.

Lignite-fired Power Station

1150g CO2 /kWh Power*

* at power generation incl. Thermal energy = 730g CO2 per kWh

Natural gas CHP

250g CO2 /kWh Power and Heat**

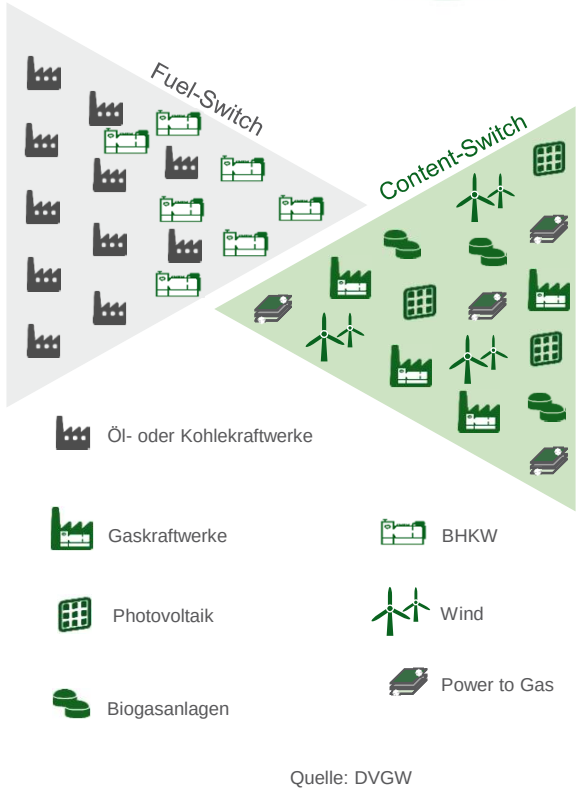
** at sole power production without thermal energy = 350g CO2 per kWh

Fuel-Switch und Content-Switch.

Fuel-Switch:
The switch from Coal towards Natural gas

Content-Switch:
The switch towards utilization of „green“ gases and renewable energy

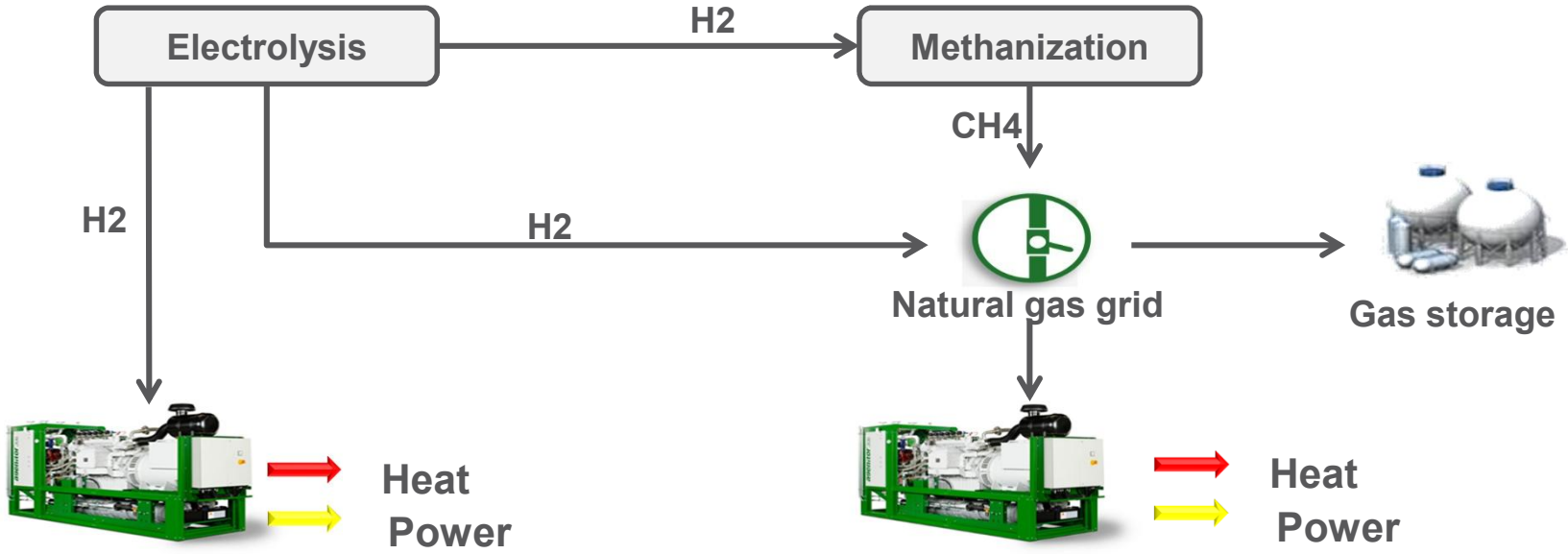
By undertaking a complete fuel-switch from Lignite to Natural Gas, it would be possible to reduce Germany´s CO2 emissions by 108.7 Million tons or alternatively 12% of the overall GHG emissions of every sector which have been 906 Million tons per annum in 2016/2017 at a very short time period.



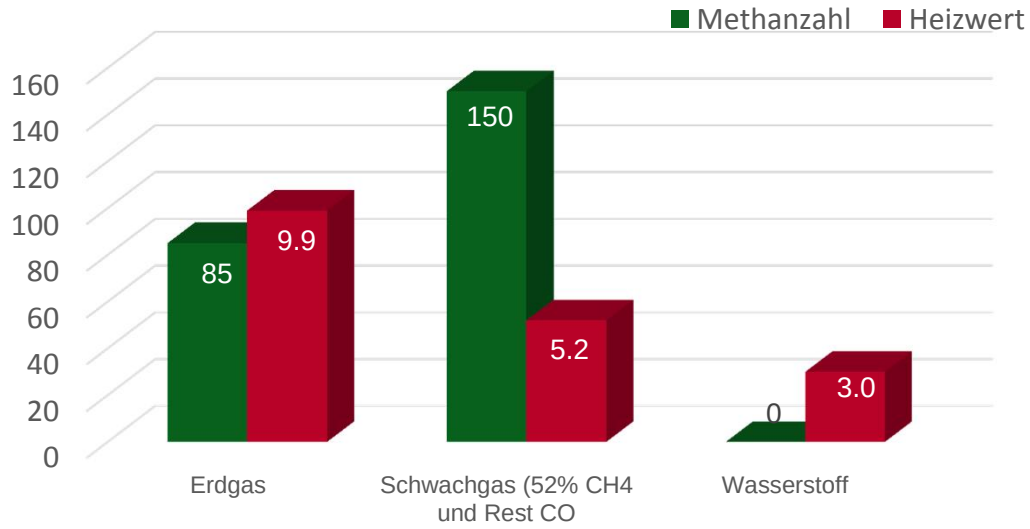
Quelle: DVGW

Power to Gas / Future utilization of Hydrogen.

Volatile power production from renewable sources



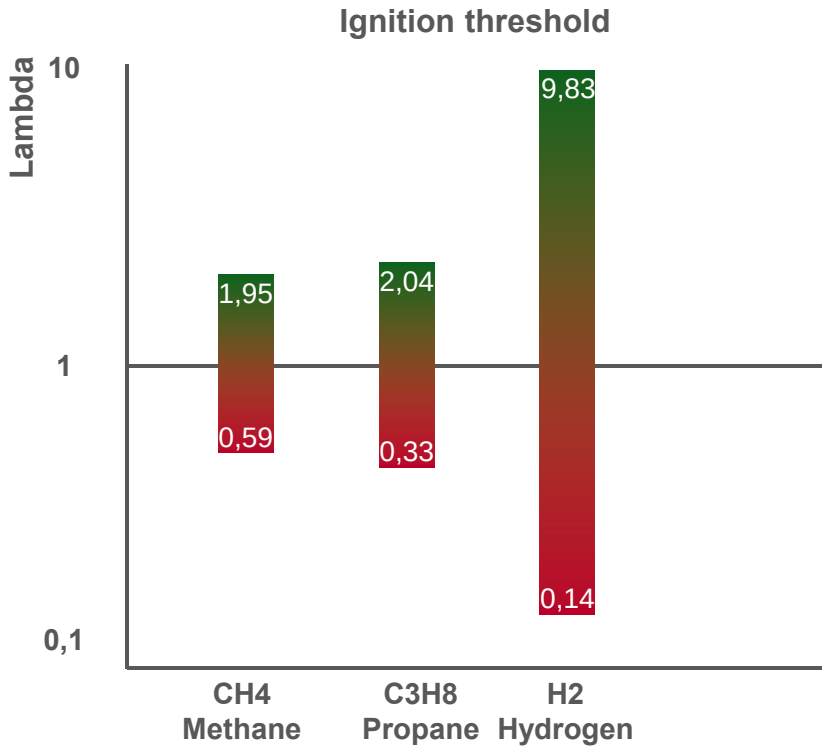
Comparison of Gas types.

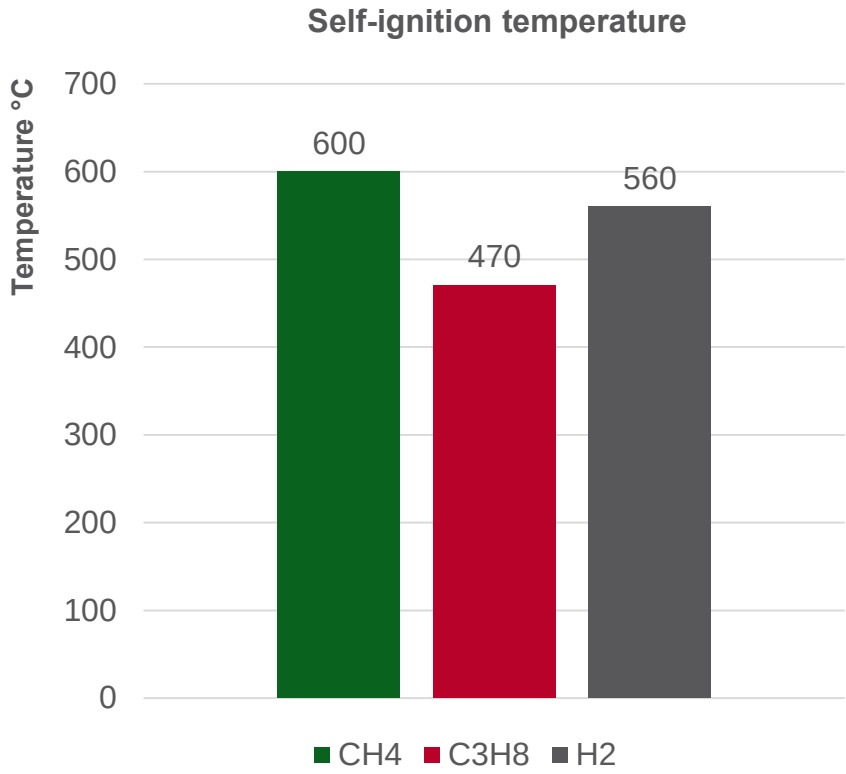


Target: Maximizing the compression ratio within the cylinder

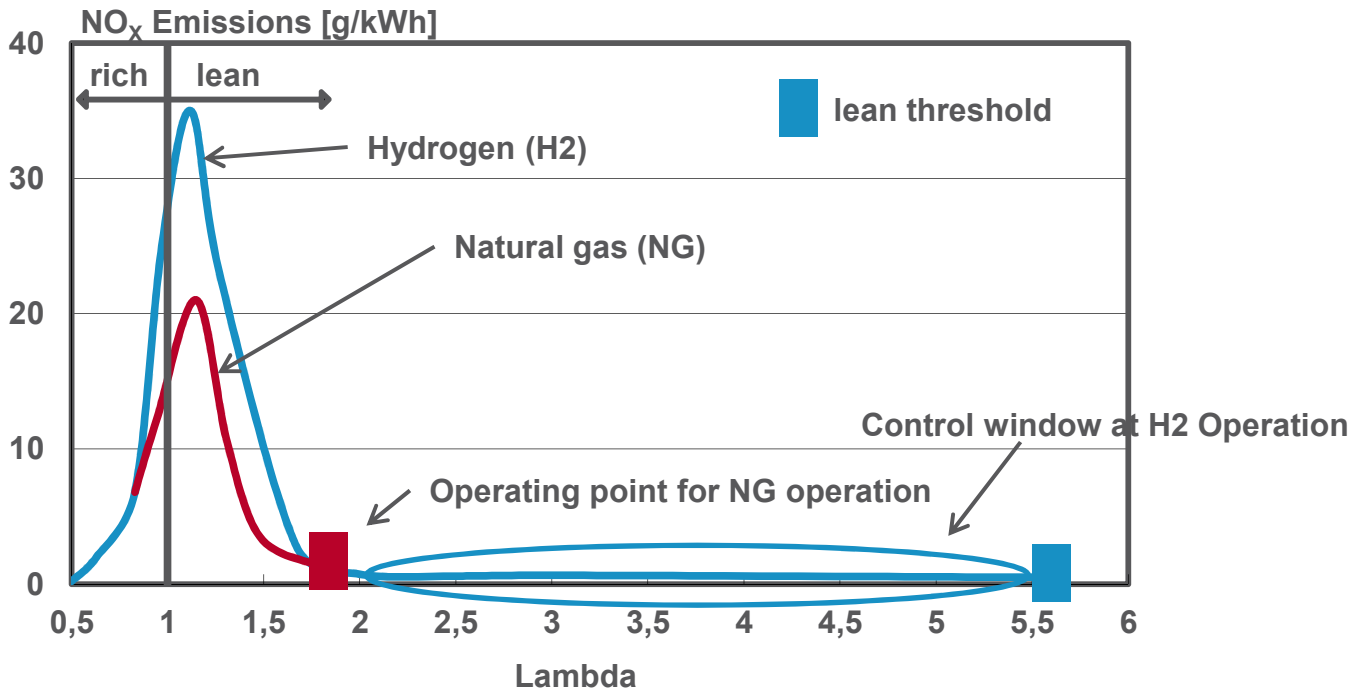
The piston geometry developed by 2G for the agenitor engine series allows for a efficient, individual Adjustment of the compression ratio matching the individual type of gas used as the primary fuel source.

Comparison of Gas types.

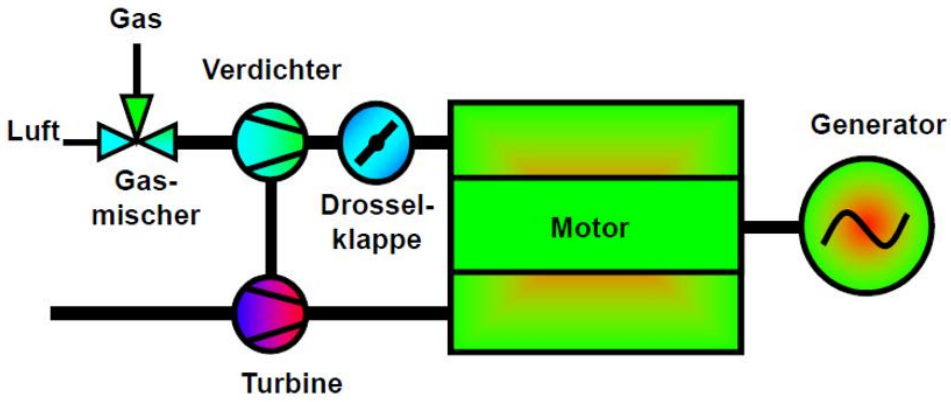




NO_X generation of various fuels.



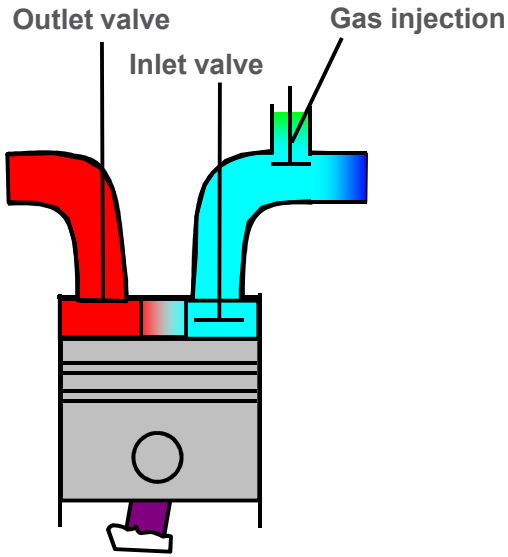
Comparison of fuel-mixture generation – Conventional.



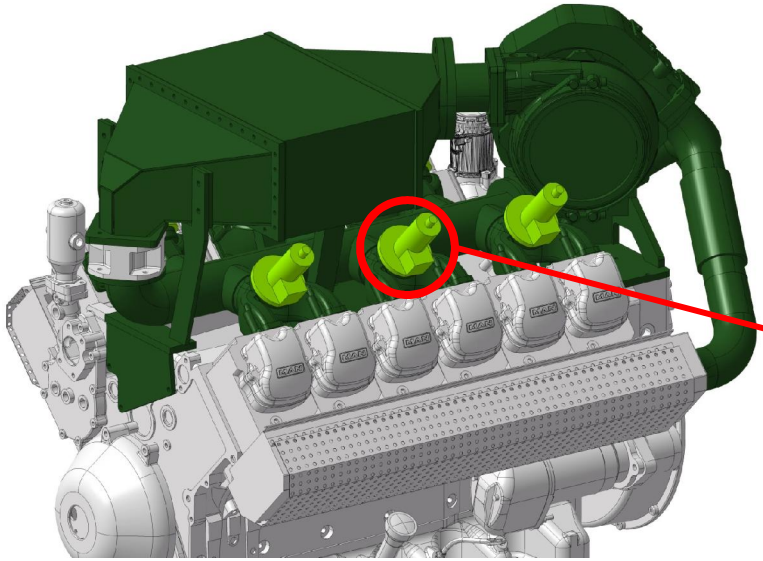
Conventional fuel-mixture generation:
External gas / air fuel-mixture generation prior to compression via the turbo charger utilizing an adjustable Venturi type - Gasmixer

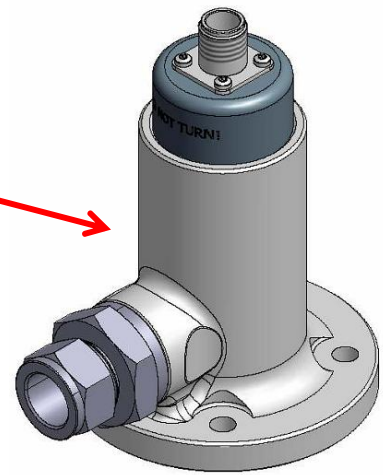
Gaxmixer:
Flowmix 65

Fuel-mixture generation using Port Injection for fuels with low methane number.



Port Injection:
external creation of fuel mixture shortly before the combustion chamber

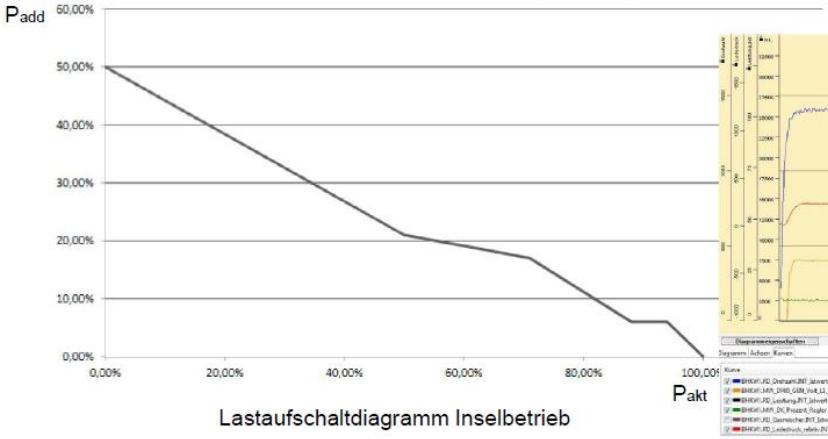




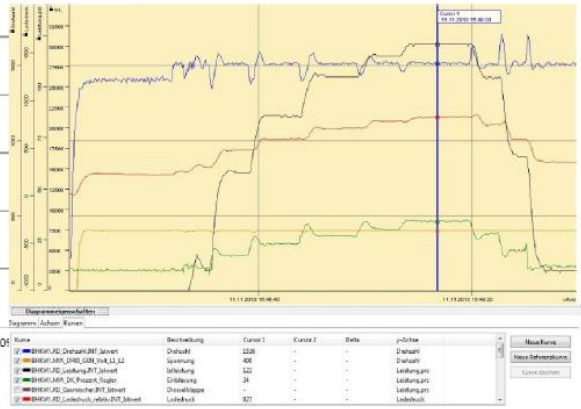
Gas-injection valve

Performance data of the 2G engine.

P_{add} von P_{nenn}	50,00%	21,00%	17,00%	6,00%	6,00%	0,00%	0,00%	0,00%
in [KW]	60KW	25KW	20KW	7KW	7KW	0KW	0KW	0KW
P_{akt} von P_{nenn}	0,00%	50,00%	71,00%	88,00%	94,00%	100,00%	100,00%	100,00%
in [KW]	0KW	60KW	85KW	106KW	113KW	120KW	120KW	120KW



Lastaufschaltdiagramm Inselbetrieb

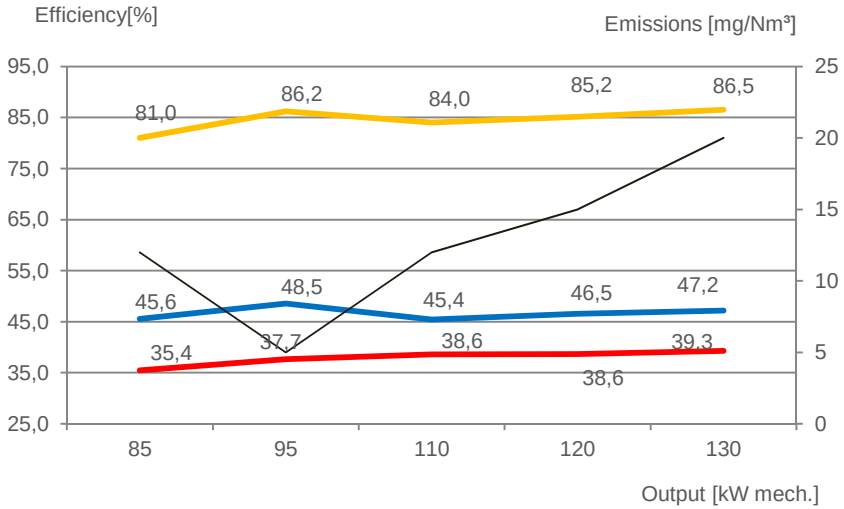


Lastaufschaltung im Inselbetrieb nach Toleranzklasse A2

Ausführung gemäß DIN ISO 8528, Teil 5	dynamische Frequenz-abweichung		Frequenz-ausregelzeit	dynamische Spannungs-abweichung		Spannungs-ausregelzeit
~~Klasse A1~~	~~10,00%~~	~~-25,00%~~	~~10 Sek~~	~~25,00%~~	~~-25,00%~~	~~10 Sek~~
Klasse A2	12,00%	-20,00%	5 Sek	25,00%	-20,00%	6 Sek
Klasse A3	10,00%	-15,00%	3 Sek	20,00%	-15,00%	4 Sek
Klasse A4	nach Vereinbarung					

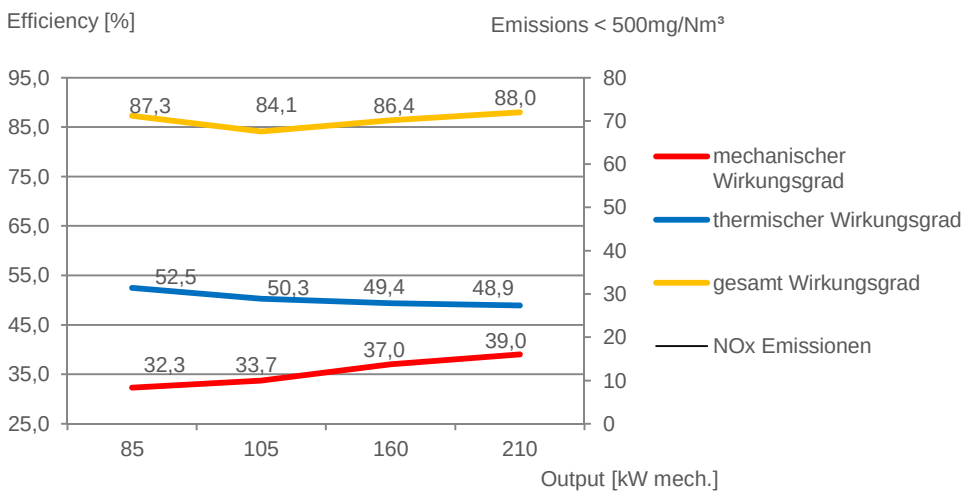
Performance data of the 2G technology.

Hydrogen operation



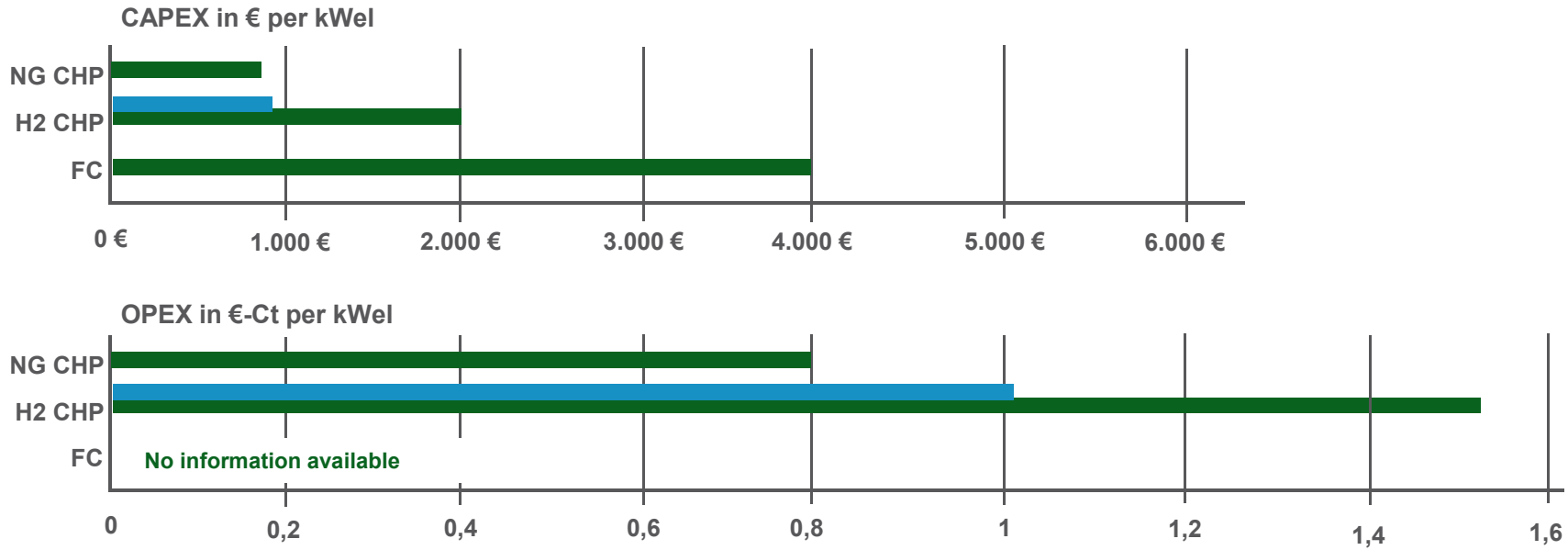
- Ignition timing: 14°vOT
- Lambda > 3
- Medium pressure max.: 8.1 bar
- Gas line pressure: 1.0 – 1.9 bar(g)
- Exhaust gas cooling: 120°C
- Heating circuit VL/RL: 90 / 70°C

Natural gas operation



- Ignition timing: 16°vOT
- Lambda 1,6
- Medium pressure max.: 13bar
- Gas line pressure: 20 – 100mbar
- Exhaust gas cooling : 120°C
- Heating circuit VL/RL: 90 / 70°C

Products for Hydrogen usage.



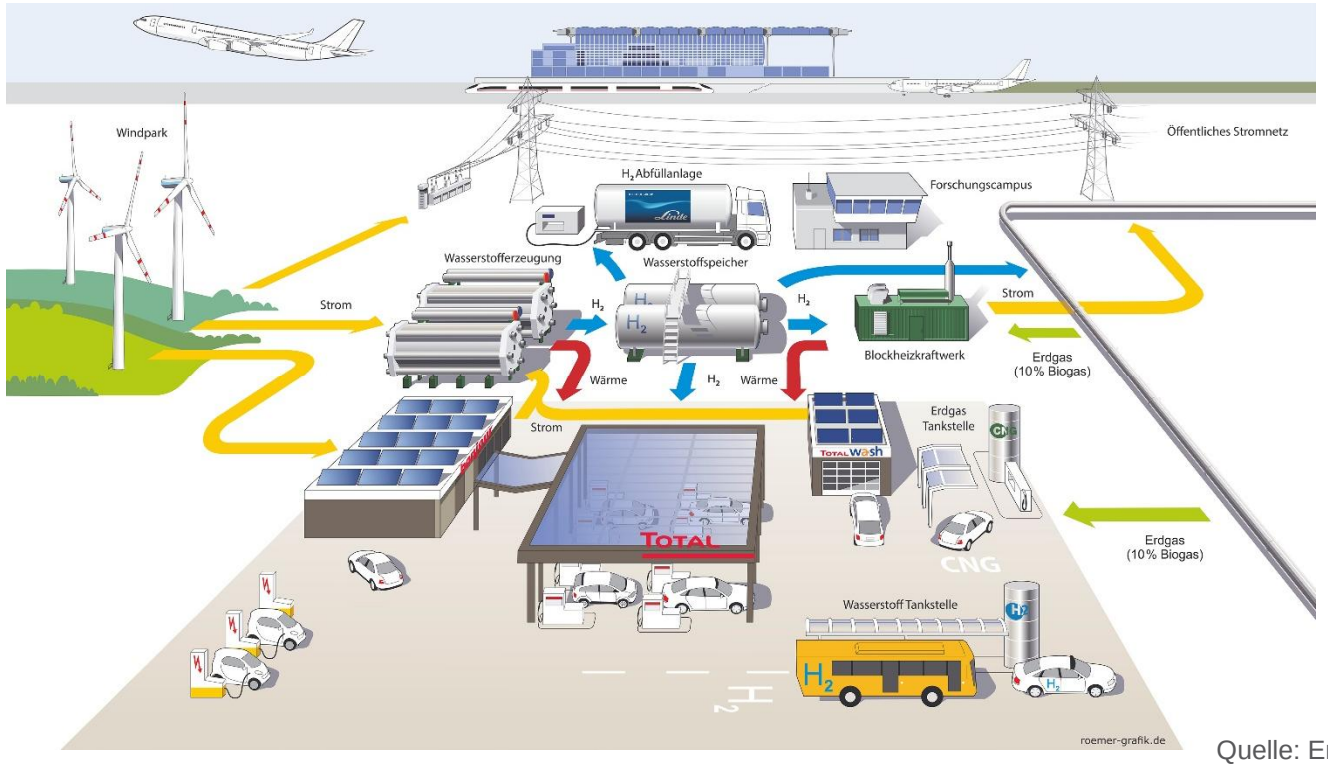
Low maintenance cost

- Standard spare parts are easily available, also in larger quantities, at the free market
- Lifetime of Engine ~ 60.000 operating hours

Products for Hydrogen usage.

Module	agenitor 406 Hydrogen	agenitor 412 Hydrogen
Electrical Output	120 kW	280 kW
Electrical Efficiency	38.5 %	39.5 %
Thermal Output	138 kW	293 kW
Thermal Efficiency	44.3 %	41.4 %

Reference #1.



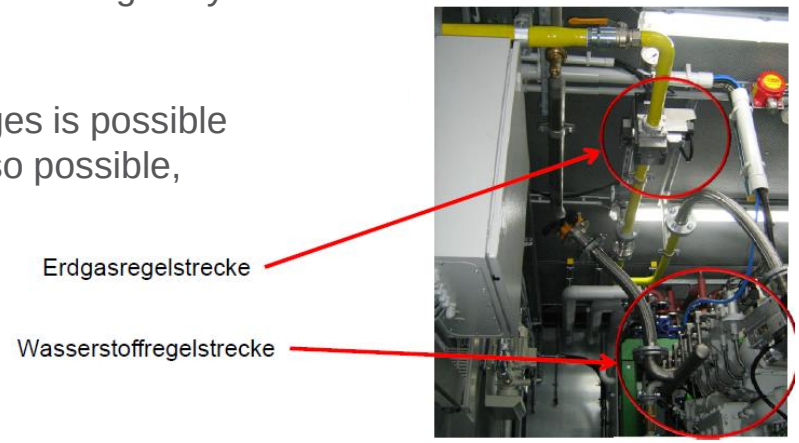
Quelle: Enertag / Total

Reference #2.

- Gas-to-Power Project in Haßfurt, Germany
- Collaboration with Stadtwerke Haßfurt and Greenpeace Energy
- Technical data of CHP unit:
  - Engine-based Cogeneration System
  - 120kWel on 100% Hydrogen with 38.5% electrical eff.
  - 200kWel on Natural gas (alternatively)
  - Lifetime: 60,000 Operating hours
  - Possibility of On-demand (Start / Stop) Operation

Summary.

- The engine is resistant to pollutants contained within the combustion fuel (e.g. Sulphur). Due to this Hydrogen, which originates as a byproduct from e.g. Industrial processes or also Synthetical gases with a high Hydrogen content, can be effectively utilized.
- Increasing technical demands towards supporting the stability of the public power grid can be matched as well due to the engine´s high flexibility towards operating modes and behavior.
- Low losses of overall efficiency over the course of a lifetime (60,000 hours = < 2% eff. loss).
- Existing technologies for the implementation of VPP or Smart grid systems can be easily applied as well.
- Low specific costs
- Island Mode / Off-grid operation with bigger load changes is possible
- A fuel-mix operation including a second Gas train is also possible, for instance with Natural gas, Biogas or Landfill gas.



Thank you very much for your kind Attention!

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