Hydrogen in CHP application

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Hydrogen

Rationale

- Hydrogen may become major energy carrier in sustainable and climate neutral energy supply
- Combustion of hydrogen only emits water
- (potentially) easy to store and transport, short fuelling times (compared to charging), high energy density compared to other fuels and batteries
- Decarbonising natural gas using industrial sectors

Important notice

- Hydrogen is not an energy source!
- Carbon neutrality depends on the underlying energy source

Key technologies need further development :

- **Electrolysis** technology requires increasing flexibility, lower capex, longer lifetimes, larger capacity
- For economic application in transport sector **fuel cells** requires still significant process innovation

[European Commission 2020]

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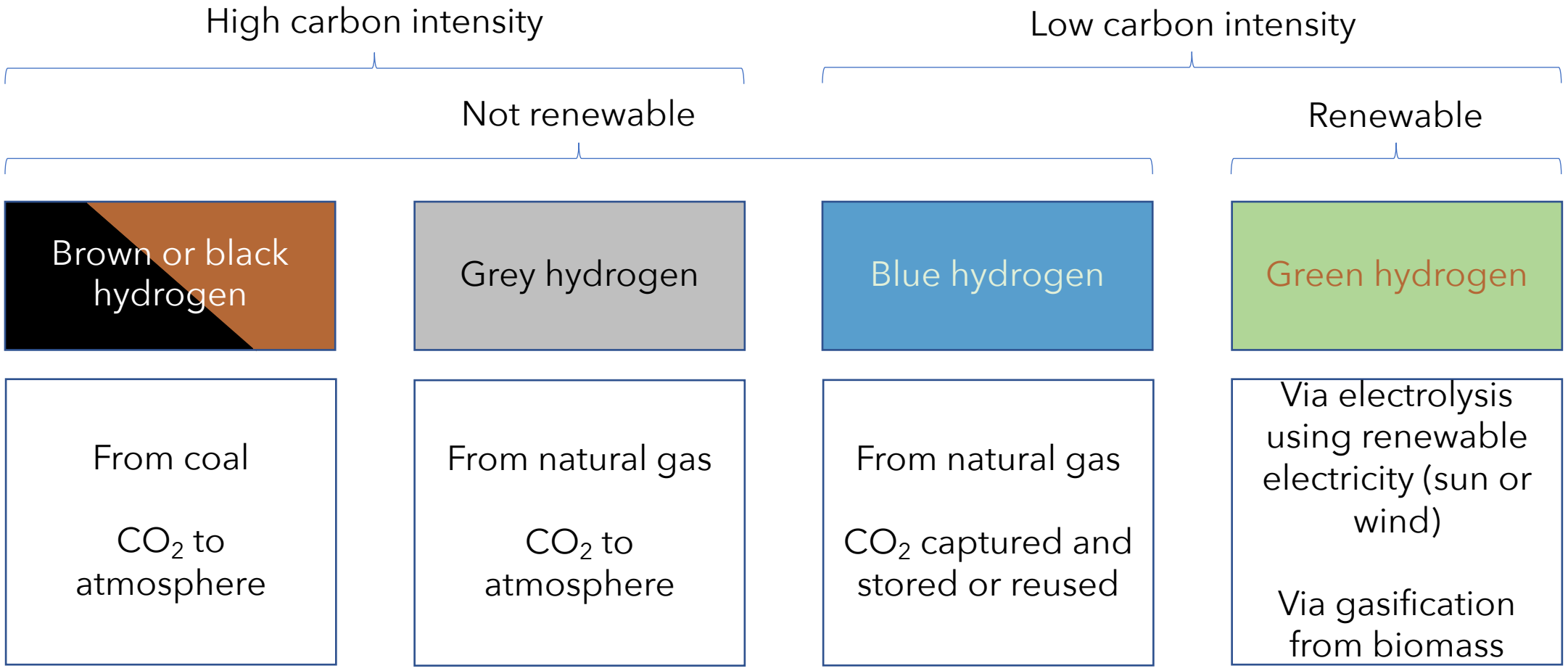
Types of hydrogen in low carbon transition

Today about 95% of hydrogen production has high CO_2 emissions



[Based on Sintef 2020]

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Hydrogen applications

Mobility

- Directly as hydrogen in fuel cell vehicles or ICEVs
- Via e-fuels: methanol, ammonia, synthetic diesel

In industry and refineries

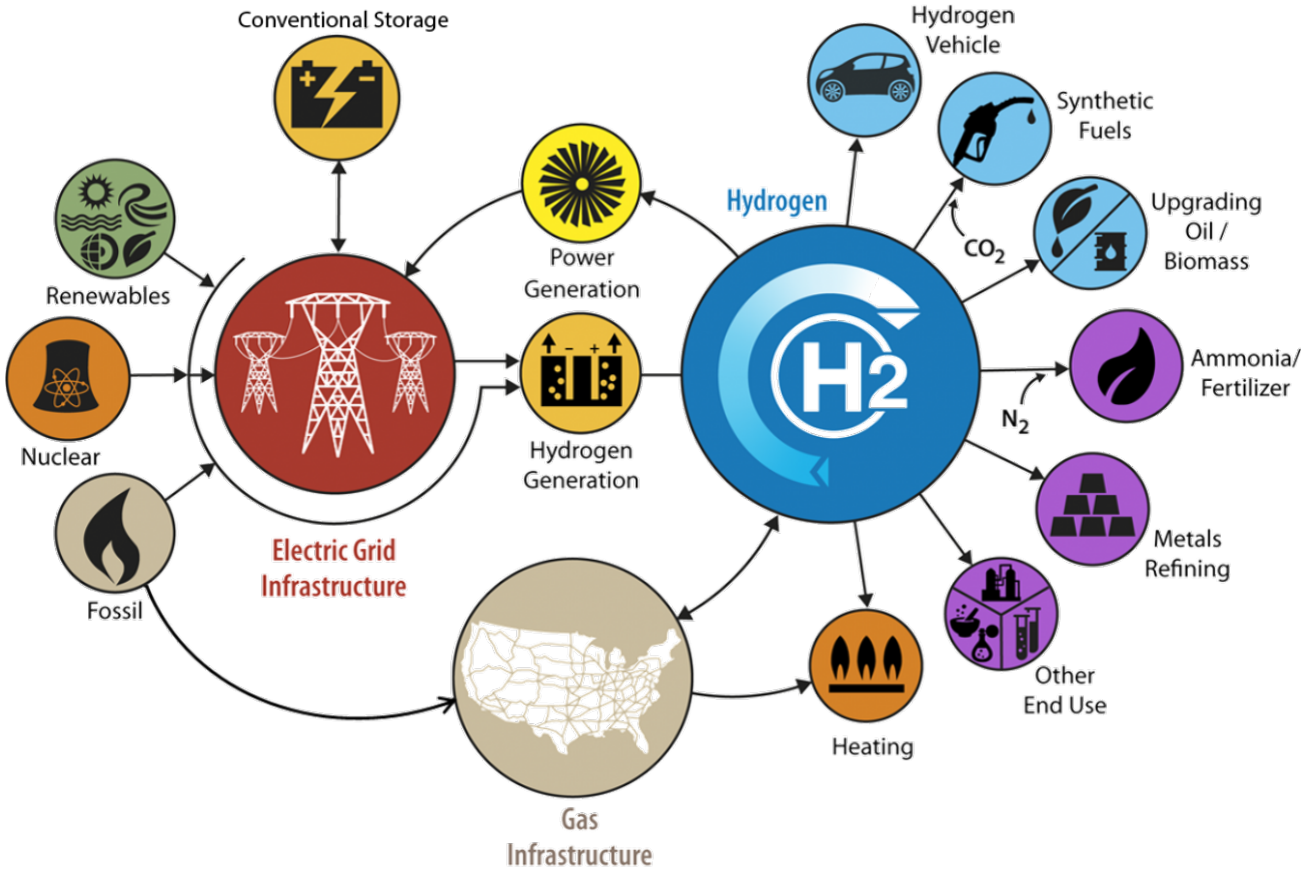
- Replacing fossil hydrogen in hydrocracking
- In metal processing

In energy generation

- To time-balance renewable energy with demand
- As hydrogen based energy storage

Hydrogen connects

- Various energy sectors
- Energy transport and distribution networks
- Increases operational flexibility of future low carbon energy system



[US Department of Energy, H2@Scale program]

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Hydrogen in the gas grid

Research

- Several decades of R&D on hydrogen in gas grids
- Urgency increases steeply in recent years

Limited fraction in existing natural gas grids

- 5-10% hydrogen allowed in natural gas grids
- Depends on grid characteristics:
  both pipeline structure, and natural gas quality (wobbe index)
- Gas appliances have limited tolerance for hydrogen
  (gas turbines, gas engines, CNG-tanks in vehicles, gas chromatographs in industry and laboratories)

Transition to higher fractions

- Until about 10% of EU transport sector could be fuelled via gas grid if limit at 5%
- Thereafter, development of dedicated hydrogen grids would be required

UK TINA report identifies key technologies that require innovation strategy

- Major infrastructure investment decisions need to be taken between 2020 and 2030 to achieve 2050 climate targets
- Development of hydrogen infrastructure should start now

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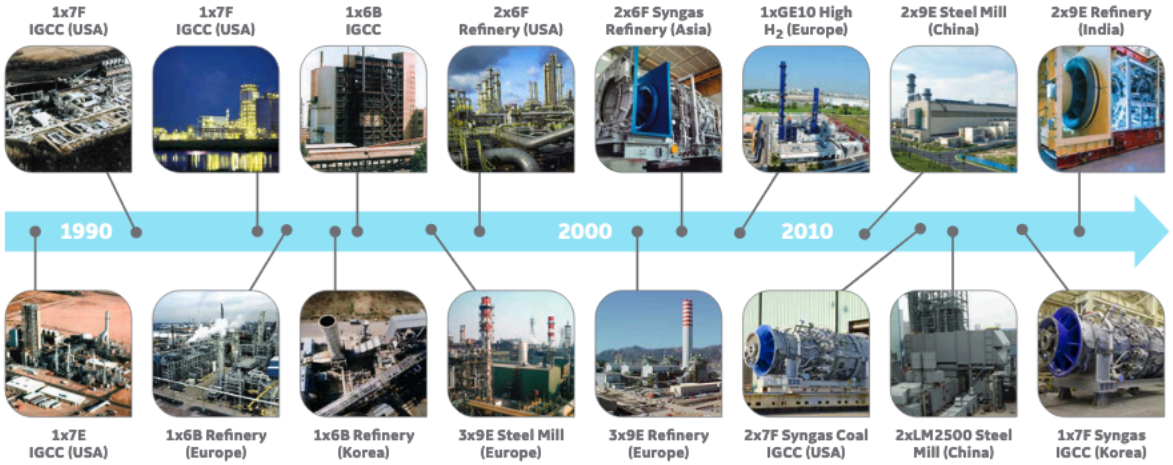
Hydrogen in gas engines

Existing experience

- Significant experience with up to 70% hydrogen in CHP
- Coke oven gases and byproduct gases from chemical processes
- Used in various types of Jenbacher gas engines
- > 1 million operating hours.

Relevance

- Hydrogen in CHP can assist transition towards hydrogen to natural gas grids
- Hydrogen distribution via existing grids facilitates hydrogen transition
- Gas grids by nature provide seasonal and daily energy storage capacity
- To balance intermittent renewable energy production



Gas engine and gas turbine projects that used various levels of hydrogen over past 20 years [GE Power 2018]

CHP on hydrogen / methane mix

Chubut province Argentina

Context

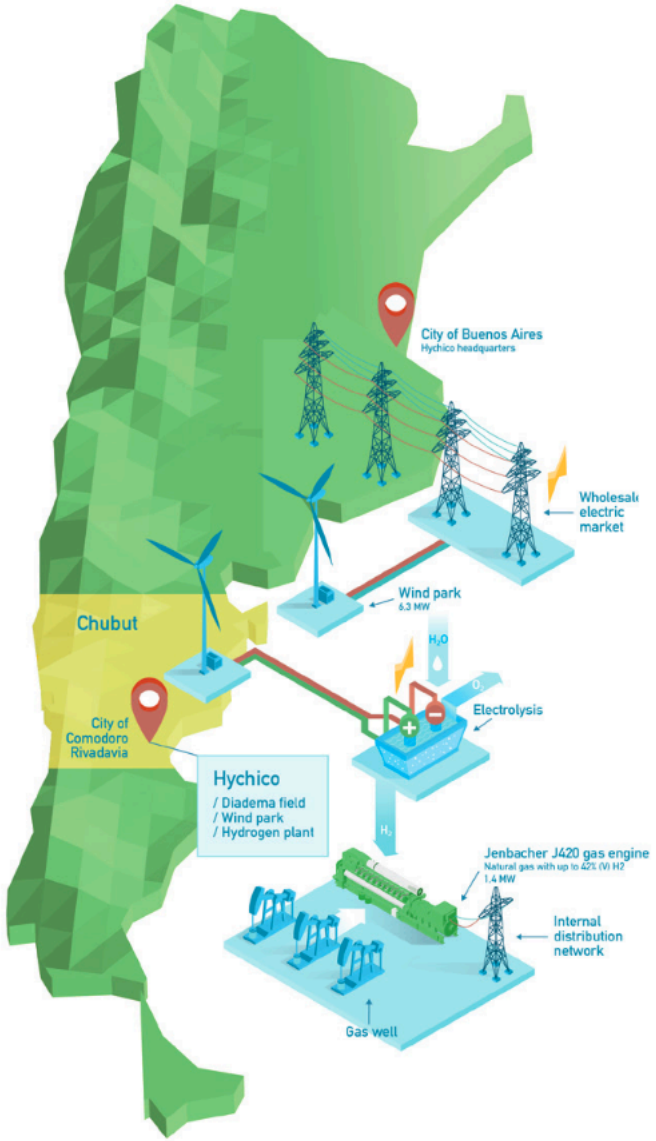
- Hychico is a subsidiary of the Argentinean energy company Capex
- In 2008, Hychico developed a wind park along with a green hydrogen production plant that uses water electrolysis
- The pilot project in Argentinean Patagonia produces power from the 6.3 MW wind park with an average capacity factor of approximately 50%

Hydrogen production

- Hydrogen produced from excess wind power
- 120 Nm^3/h of high purity hydrogen (99.998%)
- Hydrogen is stored in underground reservoir.

CHP set-up

- Jenbacher J420 gas engine (1.4 MW)
- Mix of 40% H_2 and 60% Natural gas
- Slight derating in power
- In operation for about 10 years and still running



[INNIO 2019]

Stadtwerke Hassfurt

Hassfurt Germany

Context

- Public utility of the small city Hassfurt in the north of Germany
- Nearby windfarm often produces surplus electricity

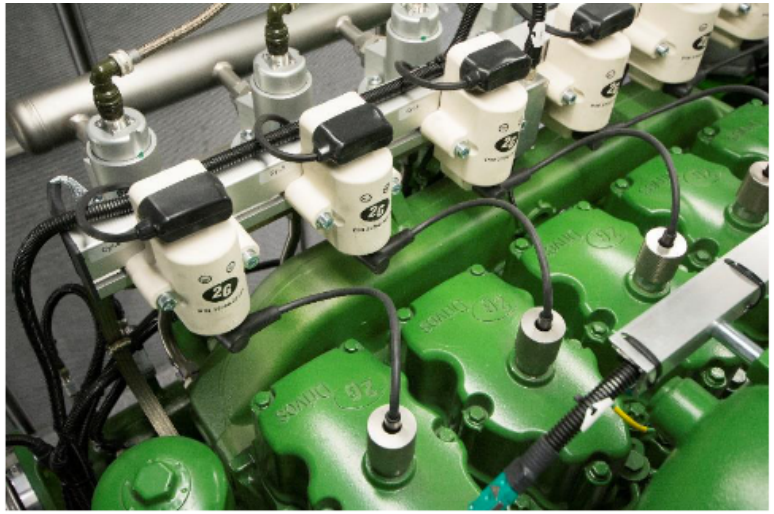
CHP project (2019)

- Hydrogen production (electrolysis) from surplus local wind farm electricity
- The hydrogen is then stored in a storage facility
- Gas engine cogeneration unit transforms the hydrogen into heat and electricity
- Electricity to local users via existing grid
- Heat via (new built) local heat network to a school, kindergarten, and a brewery malting plant

Performance

- CHP efficiency well over 80% (efficient and cost-effective way of using hydrogen)
- Only small adjustmens to a standard natural gas module, with “standard components”
- Therefore only slightly more expensive than comparable gas-driven system
- Electric output of 168 kW in hydrogen operation, compared to 210 kW for natural gas

The “H_2CHP agenitor 406 SG” from 2G Energy, based on standard CHP adapted for optional use of pure hydrogen [2G 2019]



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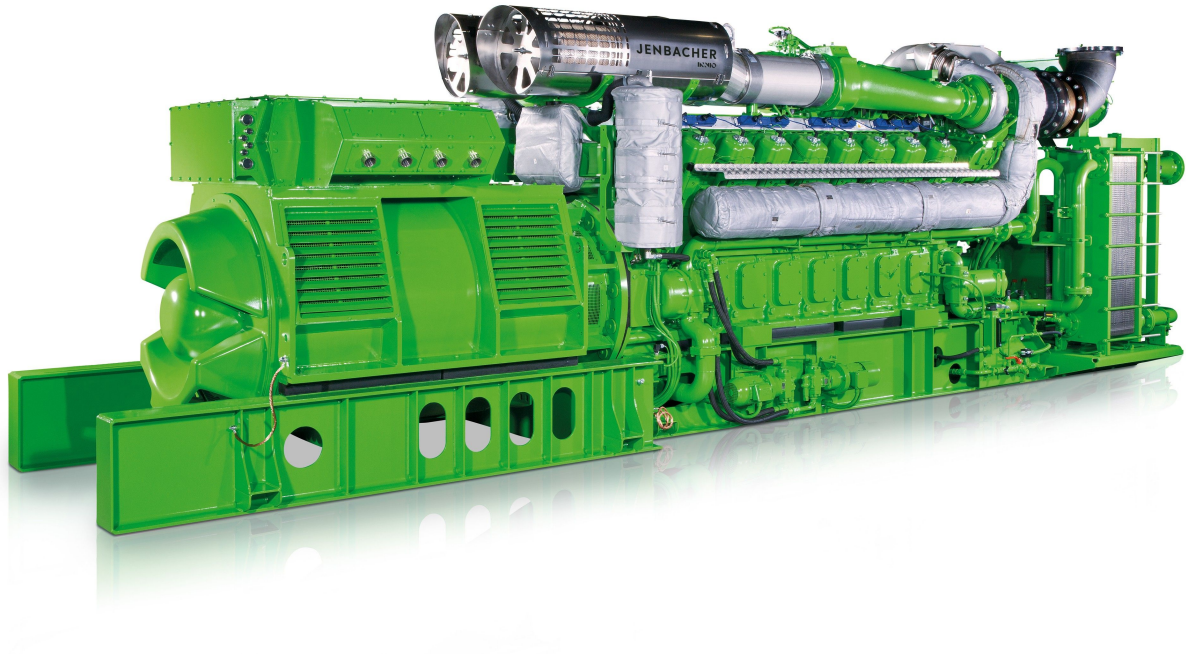
HanseWerk Natur
Hamburg Germany

Context

- City of Hamburg and public utility HanseWerk Natur want to kick-sta hydrogen transition
- Larger goal is to supply interested customers in power, heat and transportation sectors almost entirely with green hydrogen by 2035
- Project to support hydrogen development
- Building on INNIO's experience in Argentina

Set-up

- Jenbacher gas engine CHP system
- Flexibility between 100% natural gas, 100% hydrogen or any mix
- Heat generated will be fed into HanseWerk AG's local heating network
- Electricity for recharging electric vehicles at the site
- Gas engine capacity 1 MW (e+h) at >95% efficiency
- Scheduled commission 2020 Q1



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HARI : Hydrogen and Renewables Integration
Leicester UK

Context

- Existing project site demonstrates several renewable energy options : household / farm scale
- West Beacon Farm (WBF) and neighboring Whittle Hill Farm (WHF)
- Focus on the intregration and balancing of demand and supply
- Goal is to demonstrate and gain experience

HARI project (2002 – recent)

- Integration of hydrogen energy storage with renewable energy systems
- Develop software models for the design of future systems
- Combines several sources of renewable electricity to locally produce H_2 via electrolyser
- Storage of hydrogen
- Use in PEM fuel cell to convert back to electricity

CHP functionality

- PEM fuel cells produce waste heat : slightly less than its electric power output
- Operation in 60-80 °C range
- Heat exchanger to produce usable heat

Left: Intelligent Energy 2 kW fuel cell. Initially with hot water tank, later replaced by heat exchanger

Right: Plug Power Gencore 5kW fuel cell – later converted to CHP functionality

[http://ieahydrogen.org/pdfs/HARI.aspx]
[http://westbeaconfarm.co.uk/renewables/index.html##]

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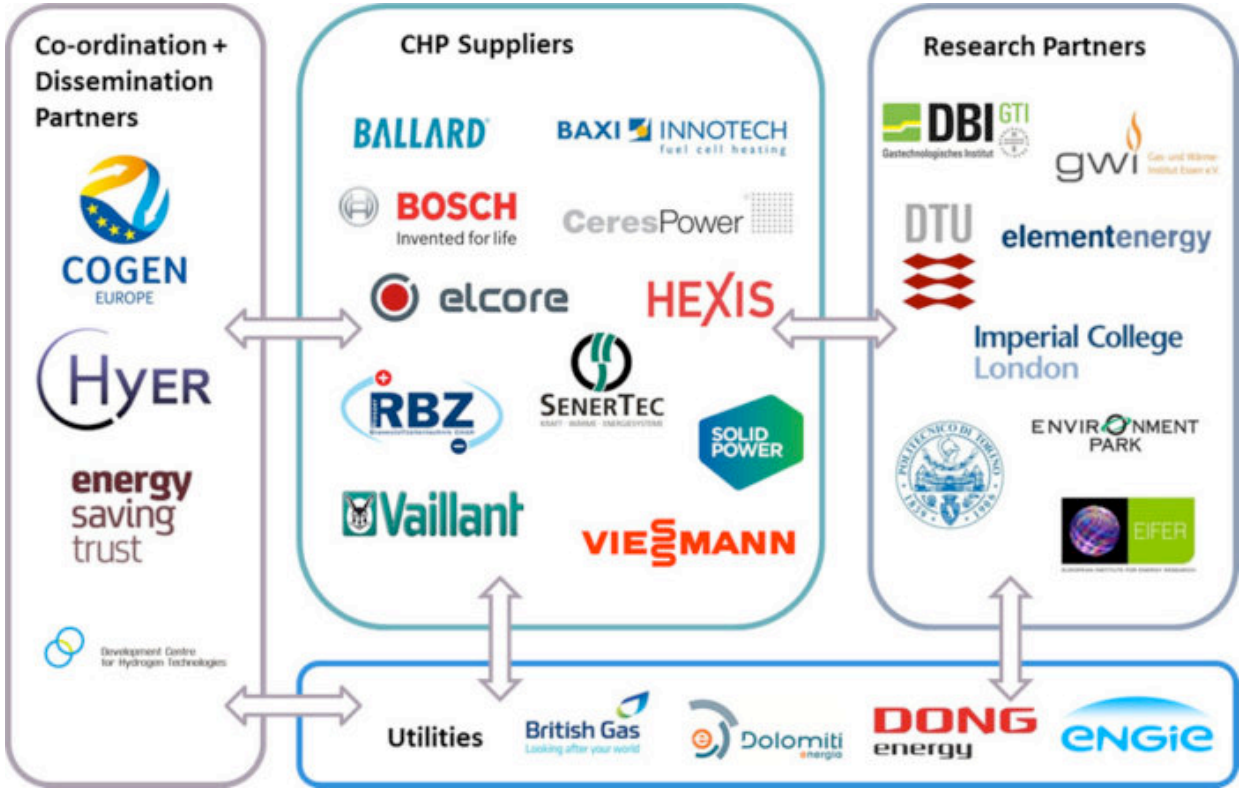
ene.field Across Europe

Context

- European Commission funded research and development project 2012-2017
- Brought together 10 mature European *micro* FC-CHP manufacturers
- Represent all available fuel cell CHP technologies
- 1000 residential fuel cell micro CHP units
- Across 11 EU Member States

Key results

- 1,046 units in real customer homes
- > 5,5 million hours of reliable operation
- generating > 4.5 GWh of electricity
- Follow-up in PACE project



Consortium ene.field project [http://enefield.eu/]

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Summary

Key options for CHP in hydrogen energy system

- Centralised CHP (feed into heat networks and power grid):
  Based on gas engines
  100% hydrogen at 1 MW achieved in 2020
- Residential: micro CHP
  PEM fuel cell based
  nearly 50% heat at 60-80 °C

Transition to hydrogen energy system

- Requires innovations related to all components in production-to-utilisation chains to increase scale and decrease costs
- Disruptive transition to full hydrogen system not yet economically viable
- Incremental transition via existing natural gas grid and plug-in demonstrations seems most attractive in short term
- RD&D of utilisation requires stable supply (grey hydrogen accepted for the time being)
- RD&D of production requires stable demand
- Hydrogen CHP can play role to create scale and awareness

Role of hydrogen in CHP

- Depends on developing demand in transport and industry

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More information

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