

A worker in a yellow high-visibility jacket and safety gear is working on a blue industrial machine. The worker is wearing a hard hat, safety glasses, and a respirator mask. The background shows a complex industrial structure with blue metal beams and pipes.

FINNING[®]

HYDROGEN OVERVIEW - ELECTRIC POWER UK&I

Kelly Cole | March 2023



Agenda

- Overview of Finning
- Hydrogen's role in a net-zero economy
- Hydrogens today and future outlook
- Hydrogen for power generation
- Our Hydrogen experience
- Questions



About Finning.

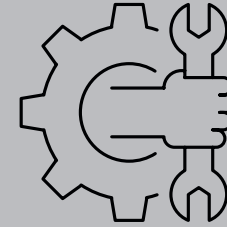
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SELL, LEASE AND
PROVIDE PARTS

12,000

PEOPLE ACROSS
7 COUNTRIES

INDUSTRIES INCLUDE



MINING



CONSTRUCTION &
INDUSTRIAL POWER



OIL & GAS



MARINE



ELECTRIC POWER

UK overview.

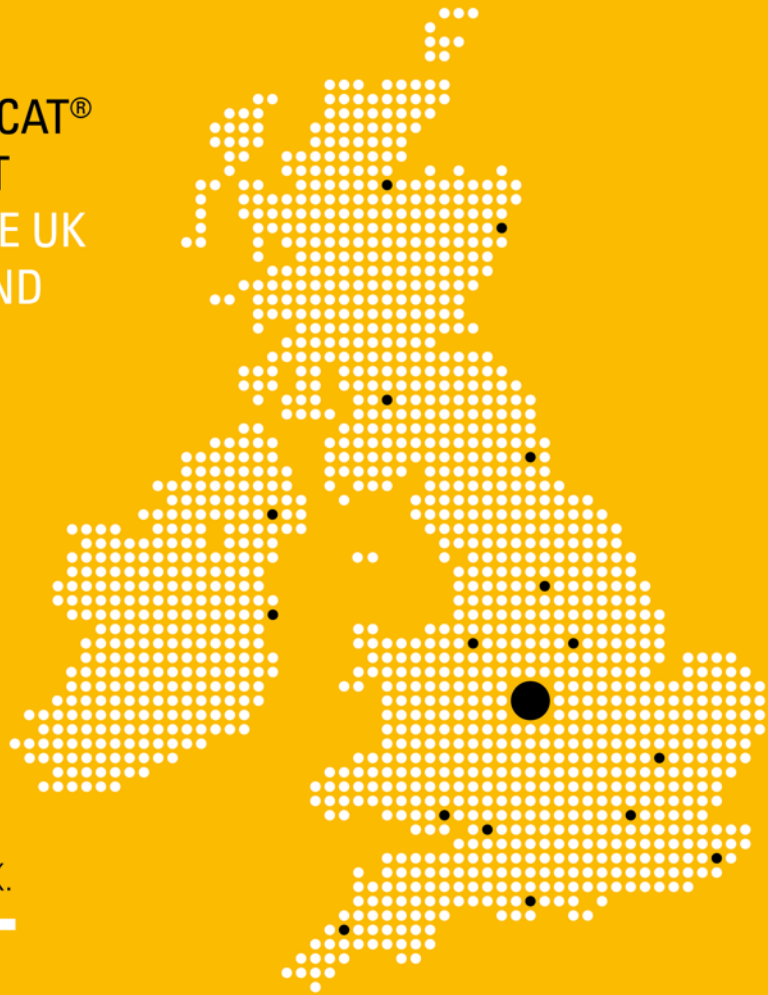
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Full range of Caterpillar® products, machinery, equipment and services. Powering productivity in sectors such as agriculture, building and construction, landscaping, quarrying and waste.

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17

UK LOCATIONS,
HQ IN CANNOCK.

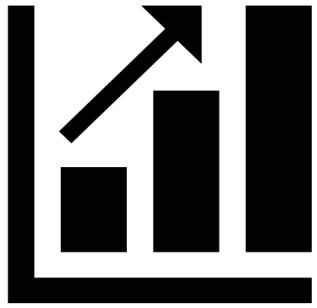
SUBSIDIARY BRANDS INCLUDE



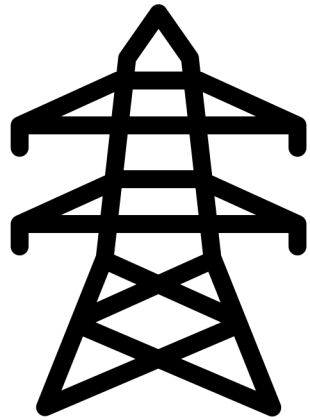


Hydrogen's role in a net-zero economy

Trends driving the energy transition



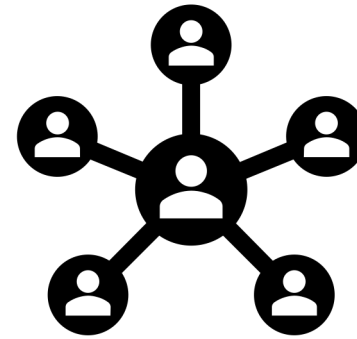
Demand



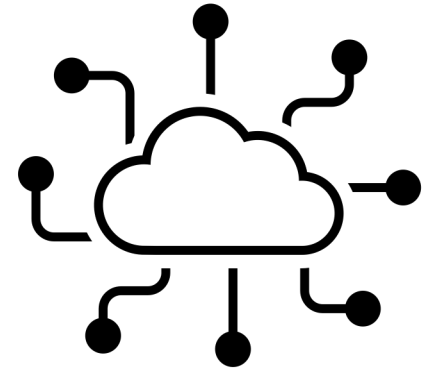
Electrification



Decarbonization

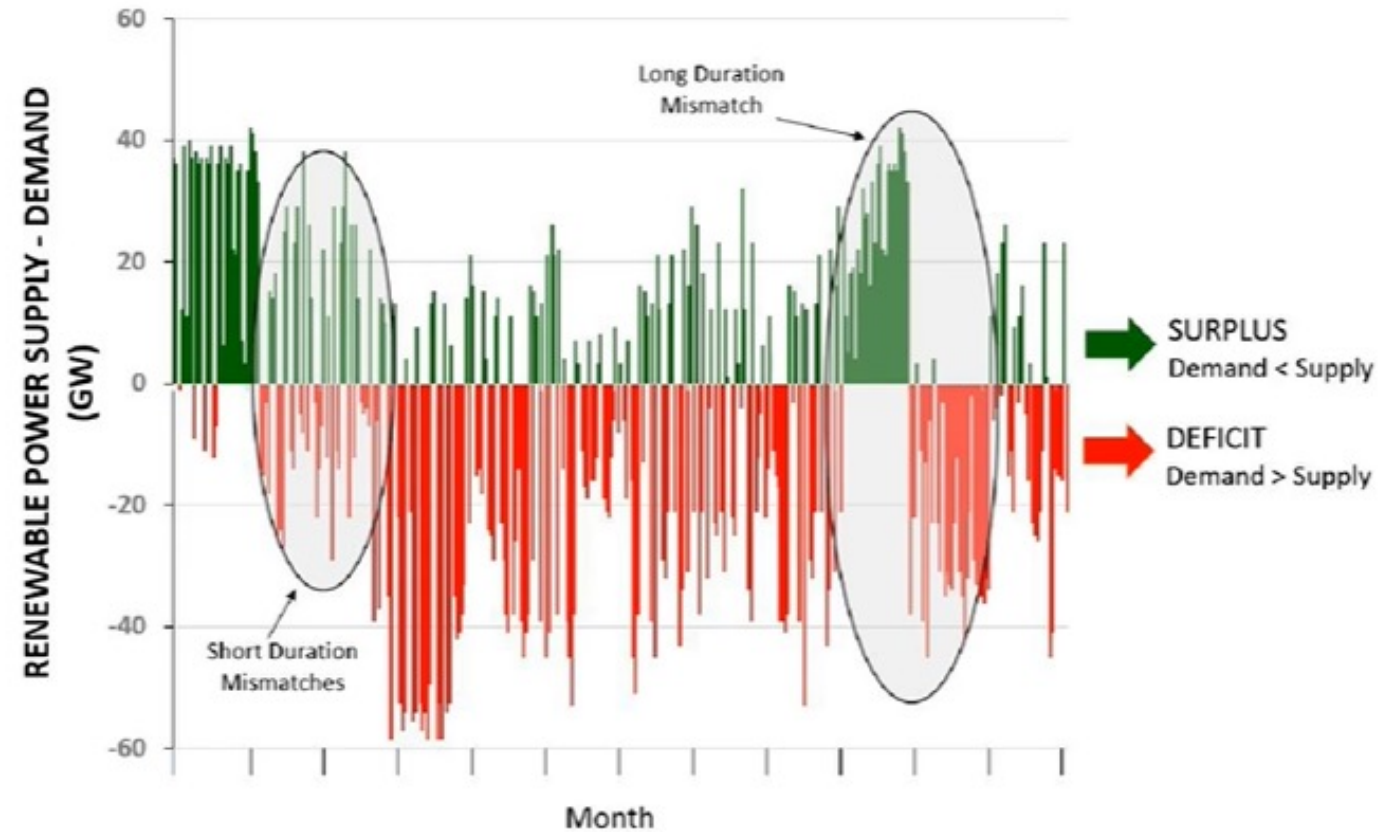


Decentralisation



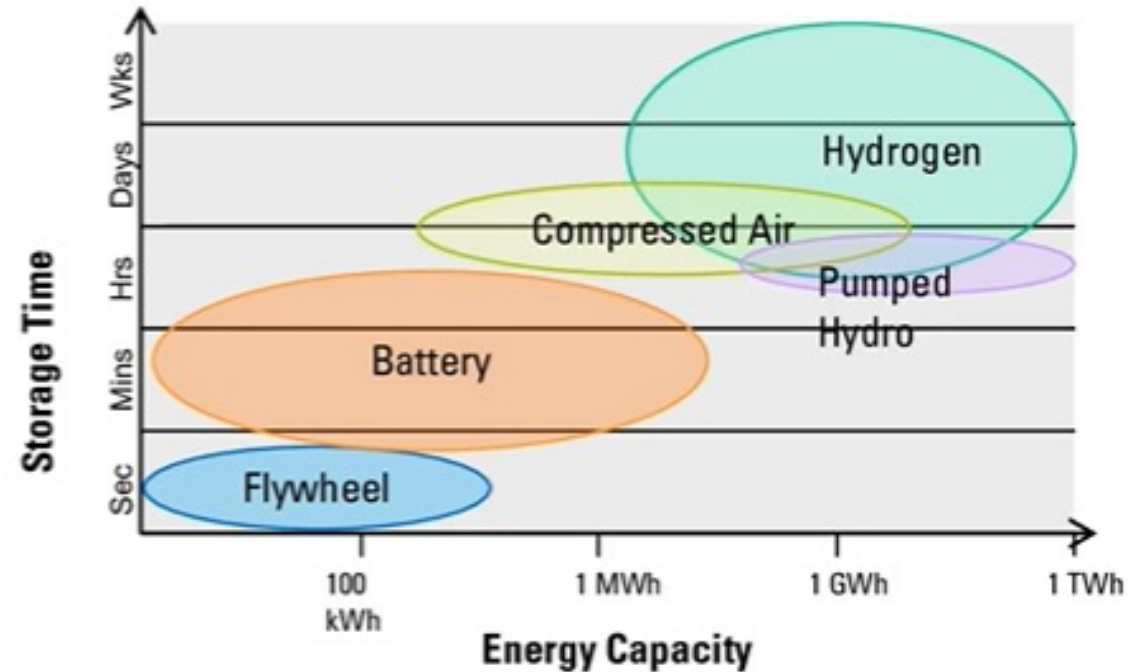
Digitalisation

Grid stability challenges



The Role of Hydrogen

- Energy storage medium which can provide grid stability
- Intermittent output, mismatch between peak output and peak demand
- Fit within distributed grid model



The Role of Hydrogen

- Clean burning* fuel for hard-to-decarbonize sectors...
- Attractive for areas where electrification is difficult, e.g. quarry's, steel manufacturing cement,....
- Versatility as liquid or gaseous, suitable for various modes of transport
- High energy per unit mass



*In a reciprocating engine hydrogen combustion generates near zero GHG emissions and significantly reduced NOx when compared to fossil fuels. In a fuel cell, only water is emitted. In both cases, emissions are measured at the “tail pipe.”

What is Hydrogen

- Colorless and an odorless gas
- Stored as a cryogenic liquid
- Most abundant chemical substance in the universe
- Very reactive and not found freely in nature
- Requires extraction from naturally occurring compounds - energy intensive
- Main uses today:
 - Refineries for upgradation of fossil fuels, hydrodesulfurization and hydrocracking
 - Ammonia and methanol production
 - Steel production

Comparison to other fuels

	Hydrogen	Natural Gas	Diesel
Color	No	No	No
Toxicity	No	Some	High
Odor	Odorless	Mercaptan	Yes
Buoyancy Relative to air	14x Lighter	2x Lighter	4x Heavier
Energy By Weight	2.8x > Diesel	~1.2x > Diesel	43 MJ/kg
Energy By Volume	4.5x < Diesel	1.6x < Diesel	35 MJ/L

Hydrogen storage

Gas



Compressed gas



Cryo-Compressed



Underground

Liquid



Liquid

Material-Based



Hydride



Absorption



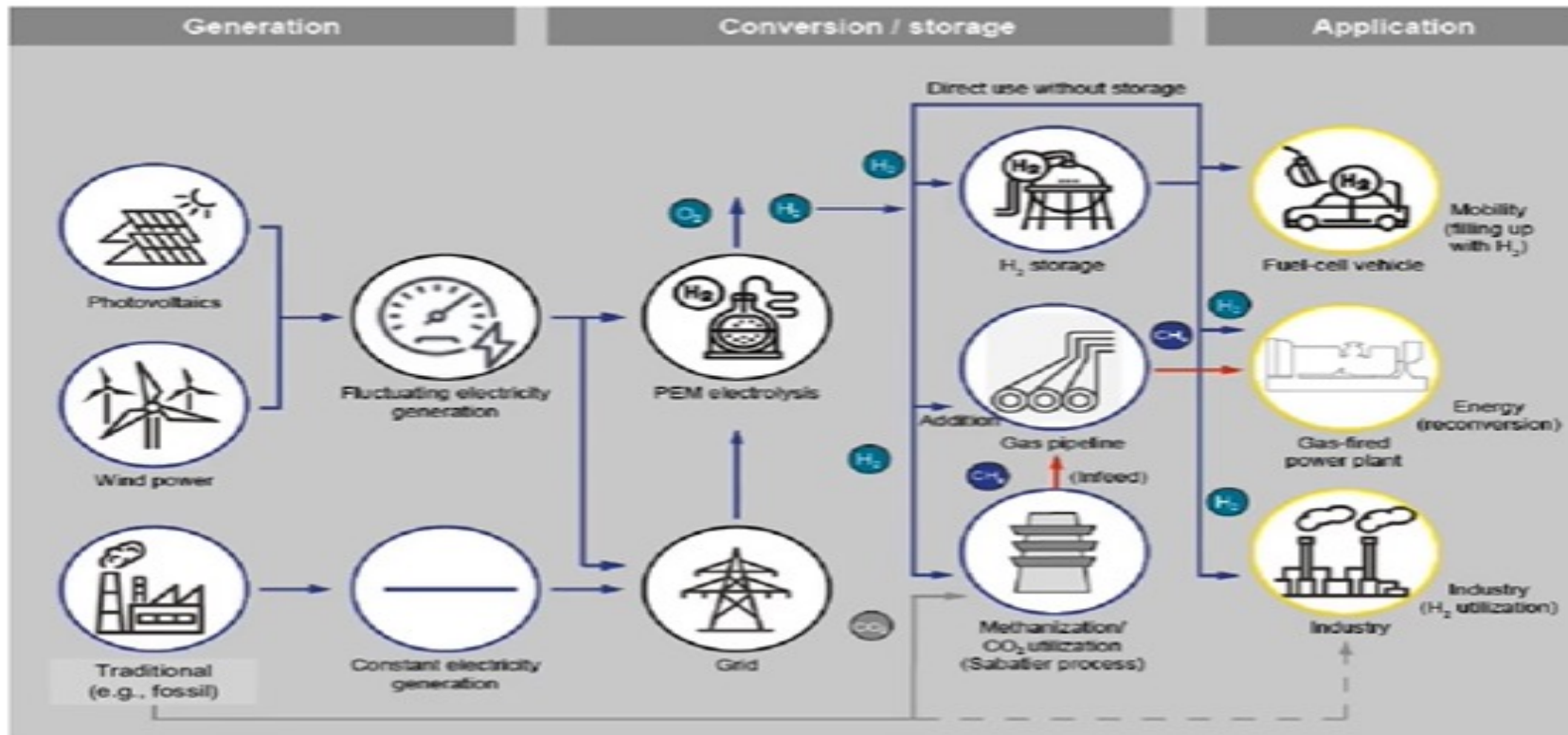
Chemical

Hydrogen “Colours” by Origin

Type	Fuel Source	Process	Relative Cost in 2020 USD/kg H ₂	GHG emission intensity kgCO ₂ e / kgH ₂
Grey	Natural Gas	Steam methane reforming		8 – 12
Blue	Natural Gas	SMR with CCUS		0.6 – 1
Green	Renewable electricity	Electrolysis		~0
Brown	Coal	Gasification		18 – 20
Turquoise	Natural Gas	Pyrolysis		5 – 11
Yellow	Grid electricity	Electrolysis		0 – 9
Pink	Nuclear electricity	Electrolysis		0 – 0.4

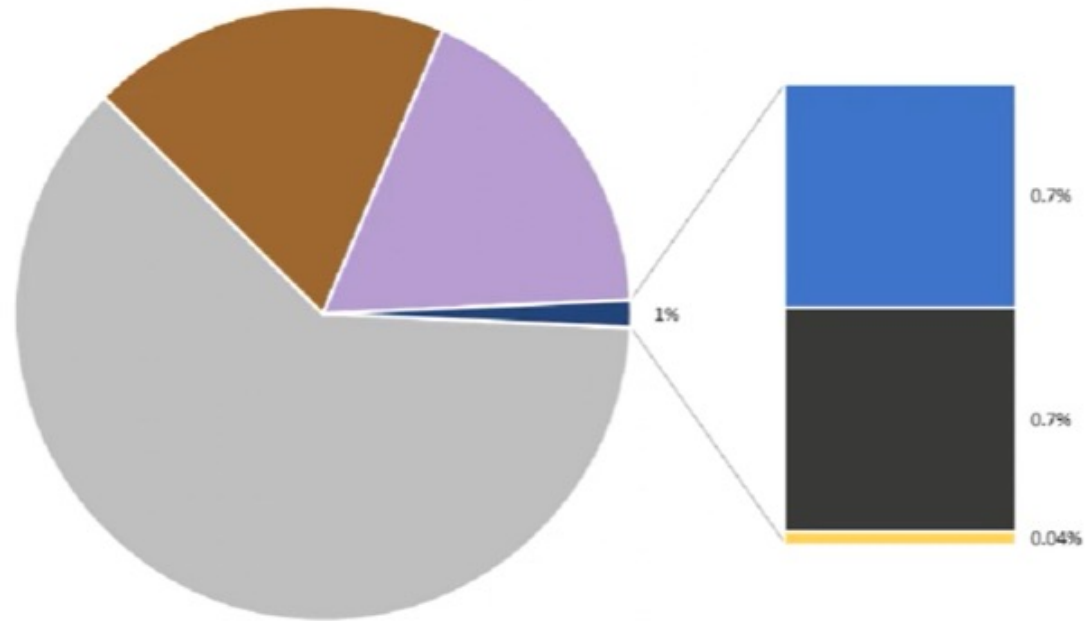
*Sources: IHS Markit, "Can batteries play a role in green hydrogen production?," 2001., Iberdrola, NREL.

Low carbon intensity gas is critical to net-zero economy



Hydrogen production today

Global Hydrogen Production 94 Mt
Percent by Source (2021)



- Natural Gas SMR (unabated)
- Coal
- Byproduct
- Fossil fuel w/ CCUS
- Oil
- Electricity

Mt = mega tons (million metric tons)

Data source: International Energy Agency. Global Hydrogen Review 2022. September 2022.

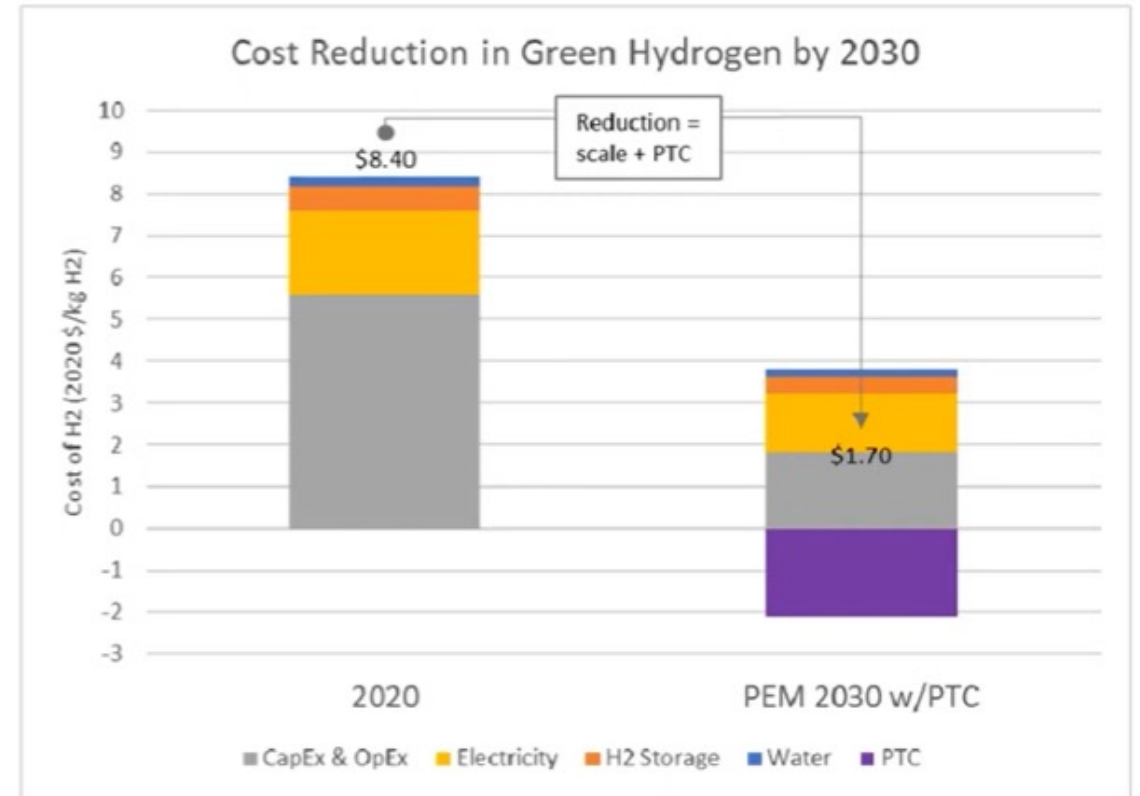
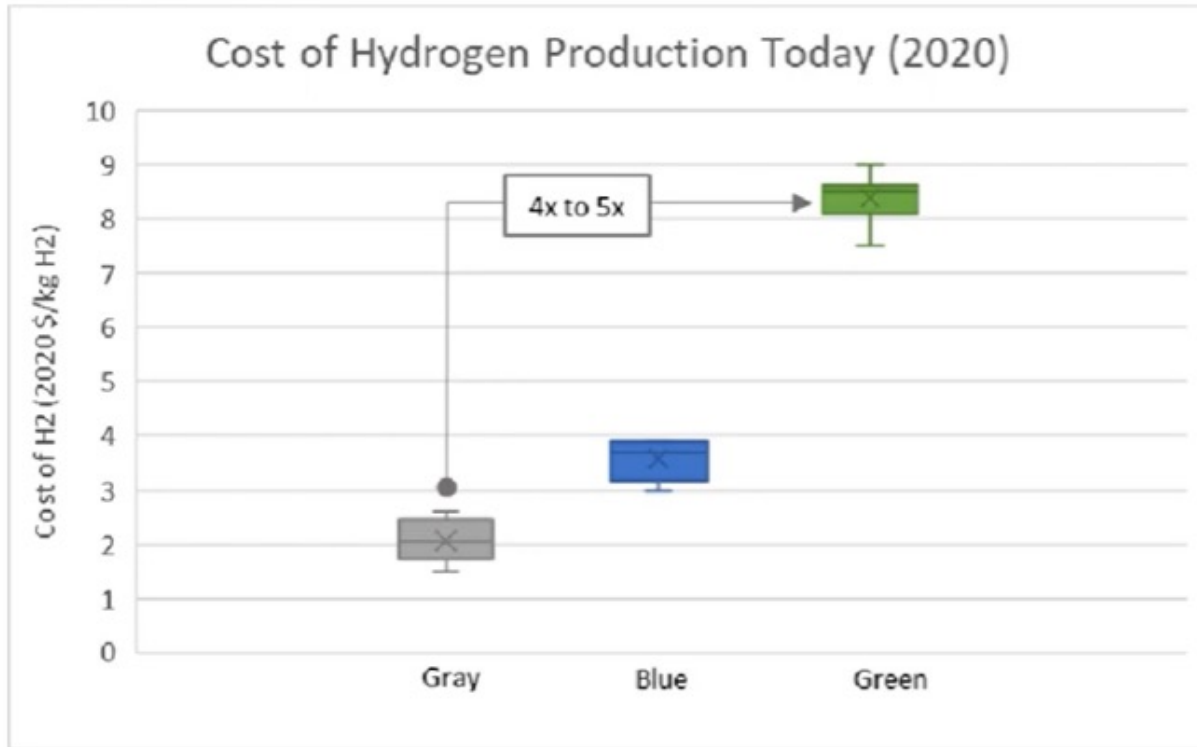
EU Proposals involving hydrogen



RFNBO = renewable fuels of nonbiological origin

Source: S&P Global Commodity Insights

Hydrogen production cost comparison



Costs based on on-site hydrogen production. Transportation costs are not included.

Data sources:

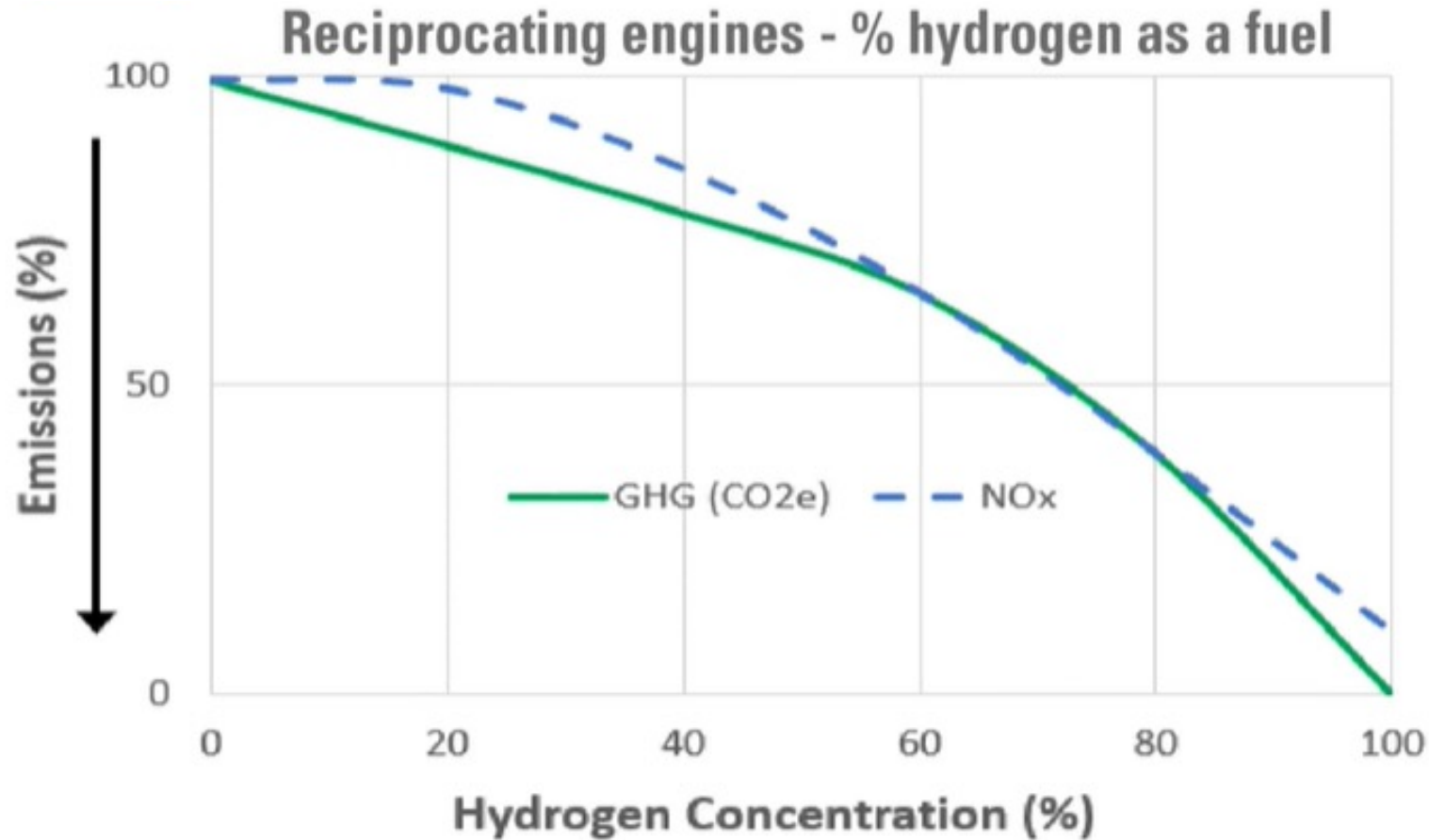
- S&P Global, "Firing the Starting Gun: The Inflation Reduction Act transforms hydrogen production in the United States", Aug. 2022.
- S&P Global, "Conflicting pressures: Evolution of the cost of electrolysis-based hydrogen", Sept. 2022.

Power generation from hydrogen

- Electrification: Increasing demand for power, not all of which is flexible
- Peak power demand projected to grow 20% by 2050.
- Gas is the prime back-up power today
- Electrification and decarbonization is driving demand for hydrogen in power generation



Hydrogen help address GHG in power generation



For 20% hydrogen blend – maintain NOx emissions and achieve reduction in greenhouse gas emissions

For 100% hydrogen – near-zero greenhouse gas emissions and significant NOx reduction

Emission data compared to natural gas operation, validated by 100% hydrogen testing on 1 MW engine.

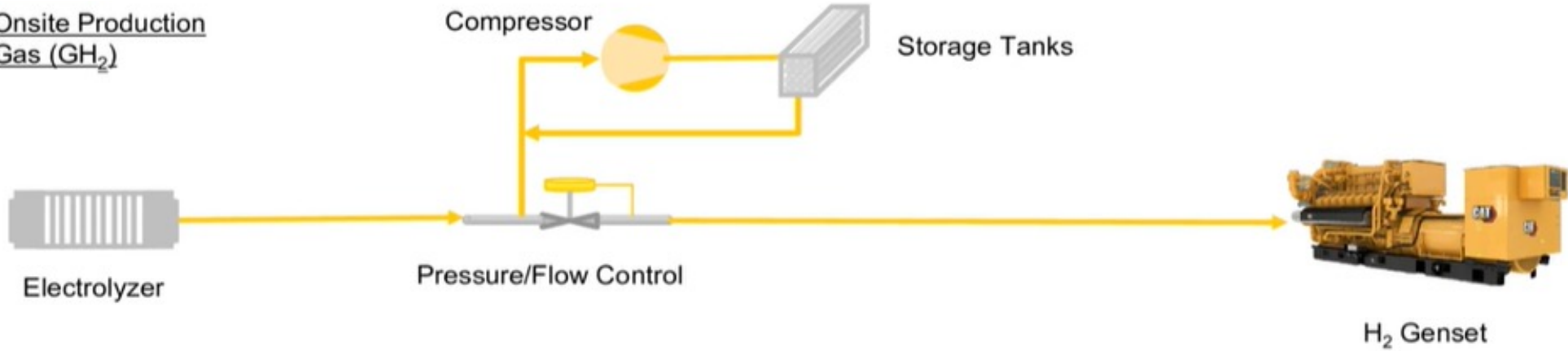
Development of hydrogen internal combustion engines

- Safety
 - Fuel supply and handling
- Durability
 - Material compatibility
- Performance
 - Emissions and power output
 - Fuel flexibility

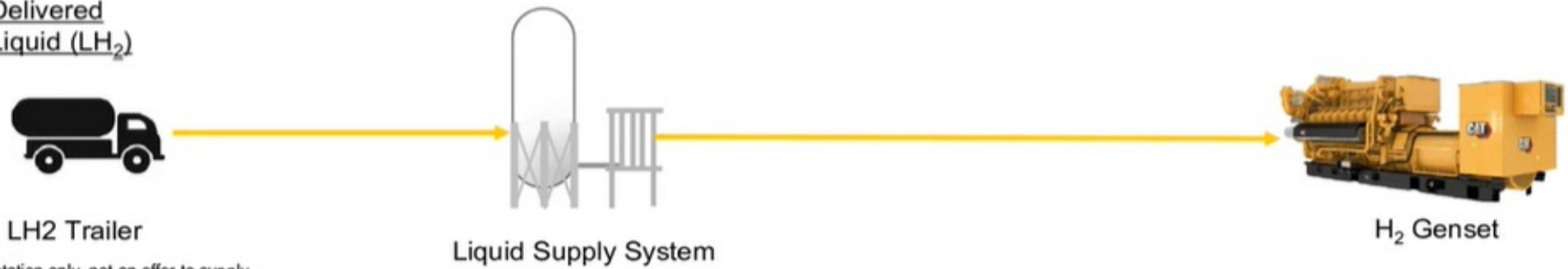


Hydrogen supply system examples

Onsite Production Gas (GH₂)



Delivered Liquid (LH₂)



**For representation only, not an offer to supply.

Summary

- Hydrogen is an alternative fuel, available today, to help you achieve your suitability targets through GHG reductions.
- Bringing hydrogen onsite requires careful evaluation of scope, scale, safety and space claim
- There are solutions today for power generation from hydrogen including reciprocating engines operation on 100% hydrogen fuel.

Thank you
