

Understanding the risks of Hydrogen

The insurance perspective

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Risk Engineering Services



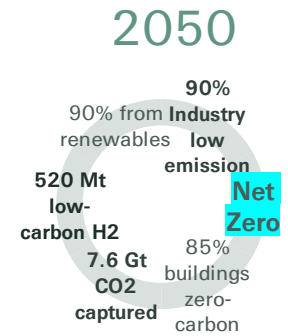
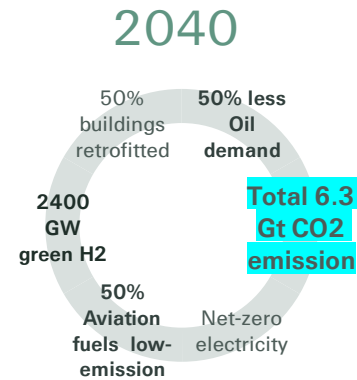
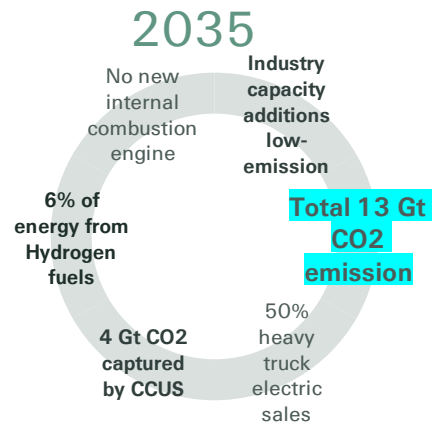
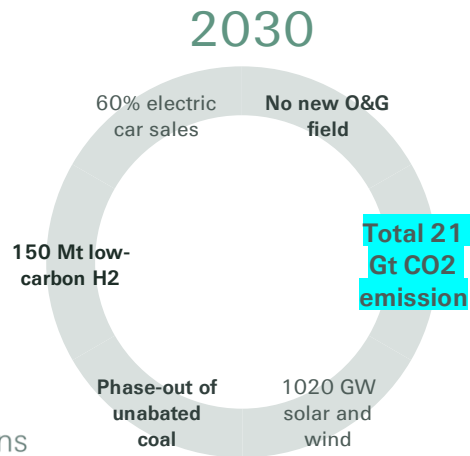
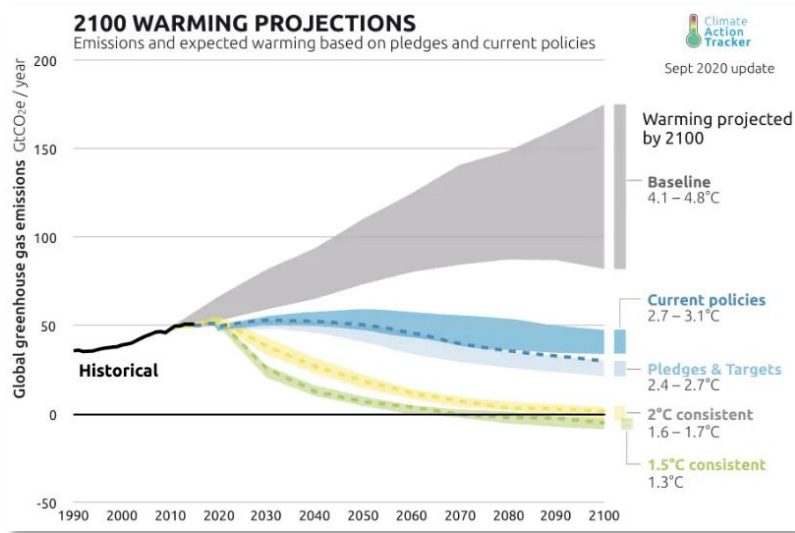
Understanding the risks of Hydrogen

A small molecule with a big potential



Understanding the risks of Hydrogen

A small molecule with a big potential



Understanding the risks of Hydrogen Hydrogen reputation

False starts prejudiced our confidence



...and still influence people opinion



Norway, 2019
Hydrogen fuelling station explosion



South Korea, 2019
Hydrogen tank explosion



Illinois, USA, 2019
Hydrogen blast at AB Specialty Silicones factory



Hastings, Australia, 2022
Hydrogen gas combustion system fire

[YouTube - Incompatible Chemicals: Explosion at AB Specialty Silicones](#)

Understanding the risks of Hydrogen

A safety moment



88 μ s 713 μ s 1338 μ s

1963 μ s 2588 μ s 5088 μ s

Unique molecular properties increase the risk of a leak. !

Low ignition energy increases the risk of ignition when a flammable mixture is present. !

Wide flammability range increases the risk of fire when mixed with an oxidizer. !

hydrogen **oxidizer** **ignition**

Property	Hydrogen
Density (gaseous)	0.089 kg/m ³ (0°C, 1 bar)
Density (liquid)	70.79 kg/m ³ (-253°C, 1 bar)
Boiling point	-252.76°C (1 bar)
Energy per unit of mass (LHV)	120.1 MJ/kg
Energy density (ambient cond. LHV)	0.01 MJ/L
Specific energy (liquefied, LHV)	8.5 MJ/L
Flame velocity	346 cm/s
Ignition range	4-77% in air by volume
Autoignition temperature	585°C
Ignition energy	0.02 MJ

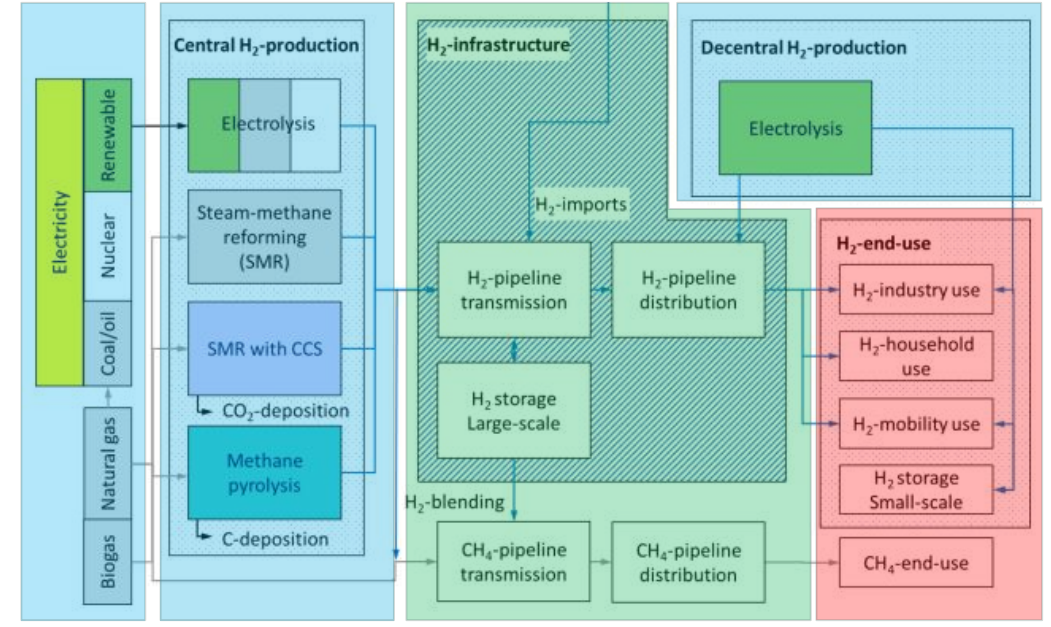
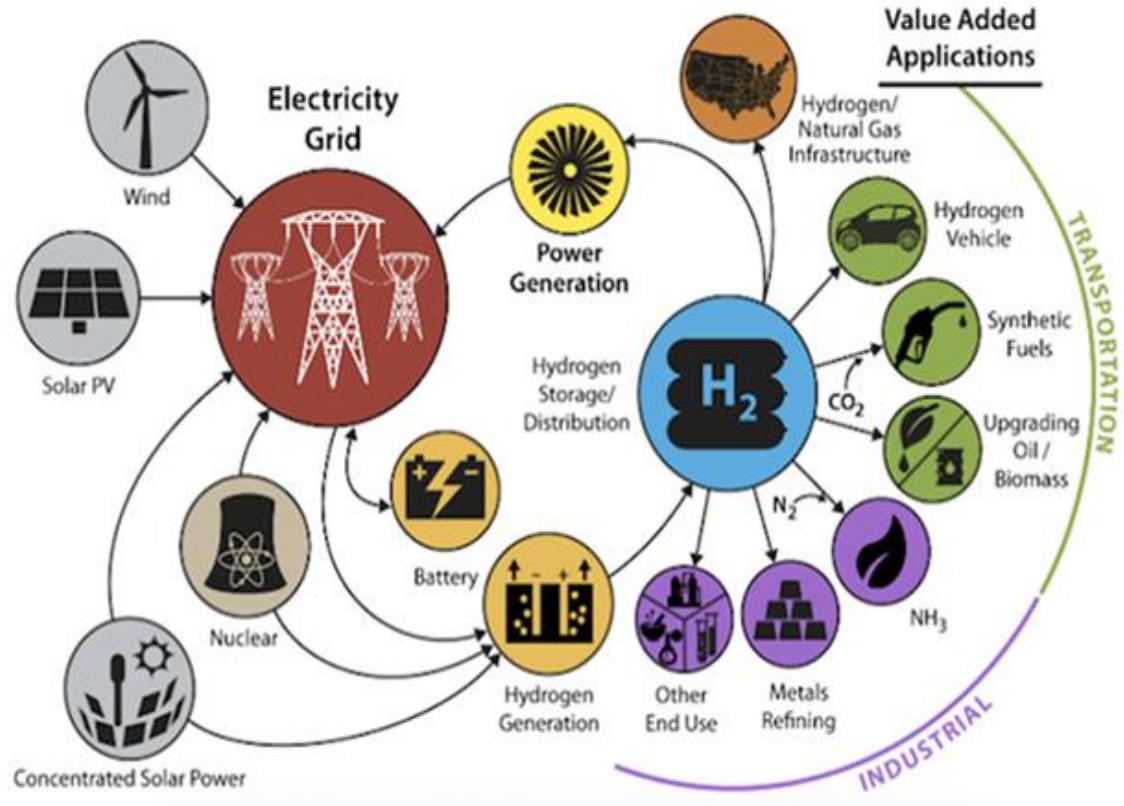
Notes

cm/s = centimetre per second, kg/m³ = kilograms per cubic metre, LHV = Lower heating value, MJ = Megajoule, MJ/kg = Megajoule per kilogram, MJ/L = Megajoule per litre

→ Hydrogen is unforgiving 

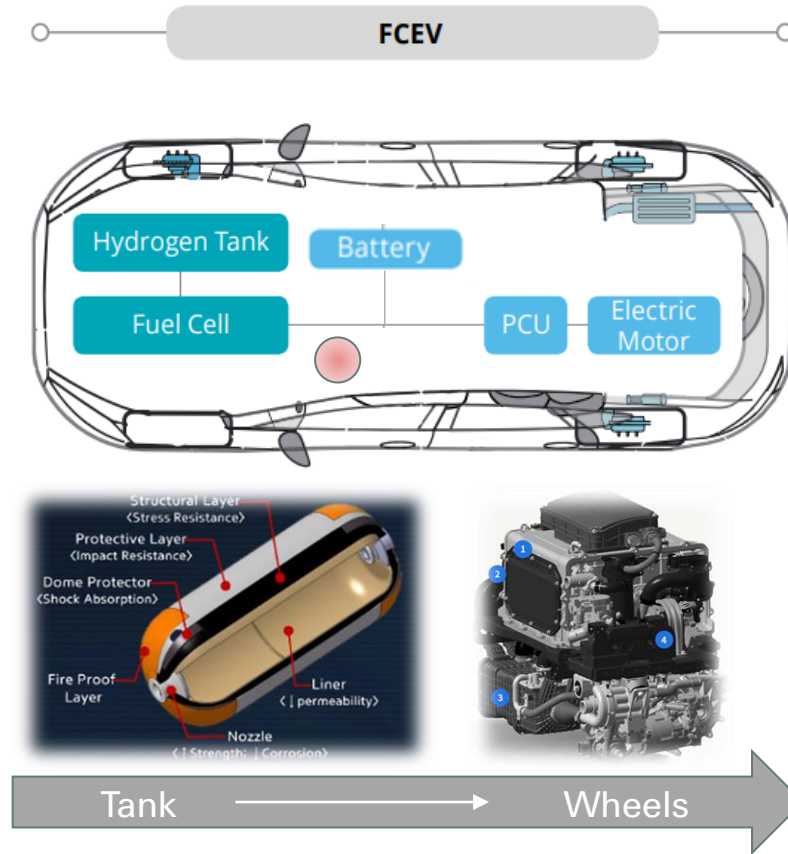
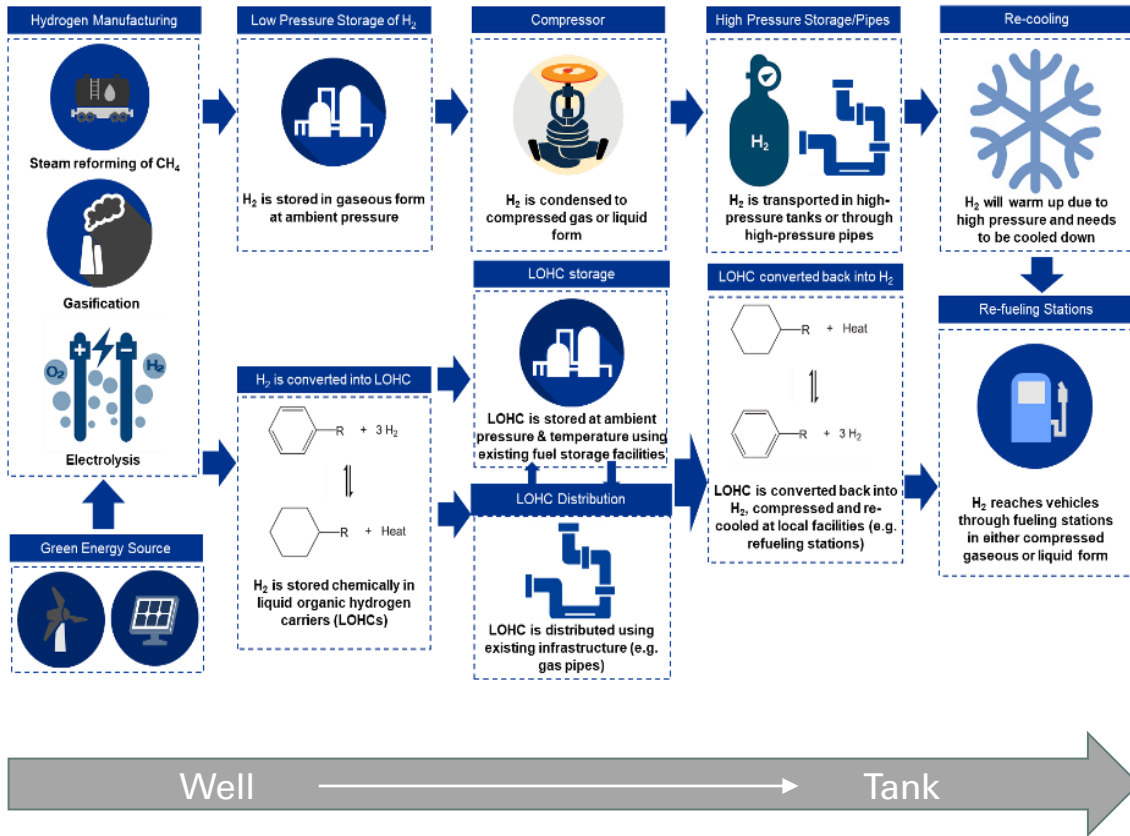
Understanding the risks of Hydrogen

Risk exposures and engineering considerations from well-to-end-use



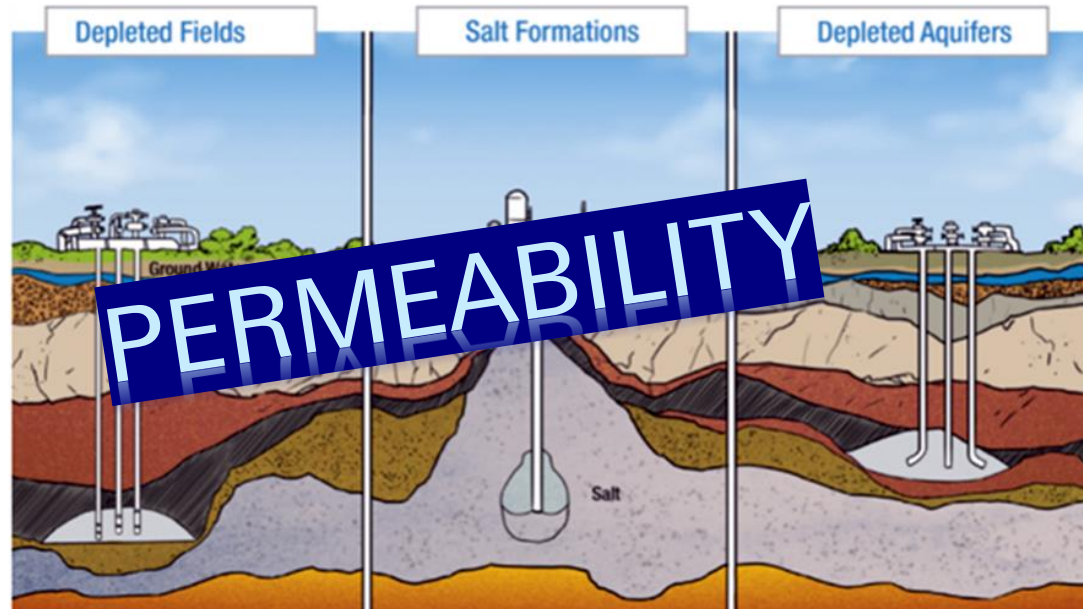
- Source of energy and production technologies
- Distribution and storage
- End users

Understanding the risks of Hydrogen Mobility: a well to wheel risk



Understanding the risks of Hydrogen

Hydrogen storage: risks against efficiency, security and resilience



Depleted reservoirs

Their imperviousness over geological time periods has already been proven and have already been very well researched (production activities). The suitability criteria include depth and adequate permeability and porosity of the reservoir rock.

- Seasonality
- Capacity

Salt caverns

Salt caverns are artificial cavities in underground salt formations, which are created by the controlled dissolution of rock salt. They are smaller and considered as one of the best ways to ensure hydrogen purity and tightness.

- Deliverability
- Cost per unit stored

Aquifers

Similar to depleted oil reservoirs in which originally there was a water-fille. Requirements: top sealed by a layer of rock, dome-shaped structure, high permeability with adequate pore space.

- Time to market
- Discharge duration

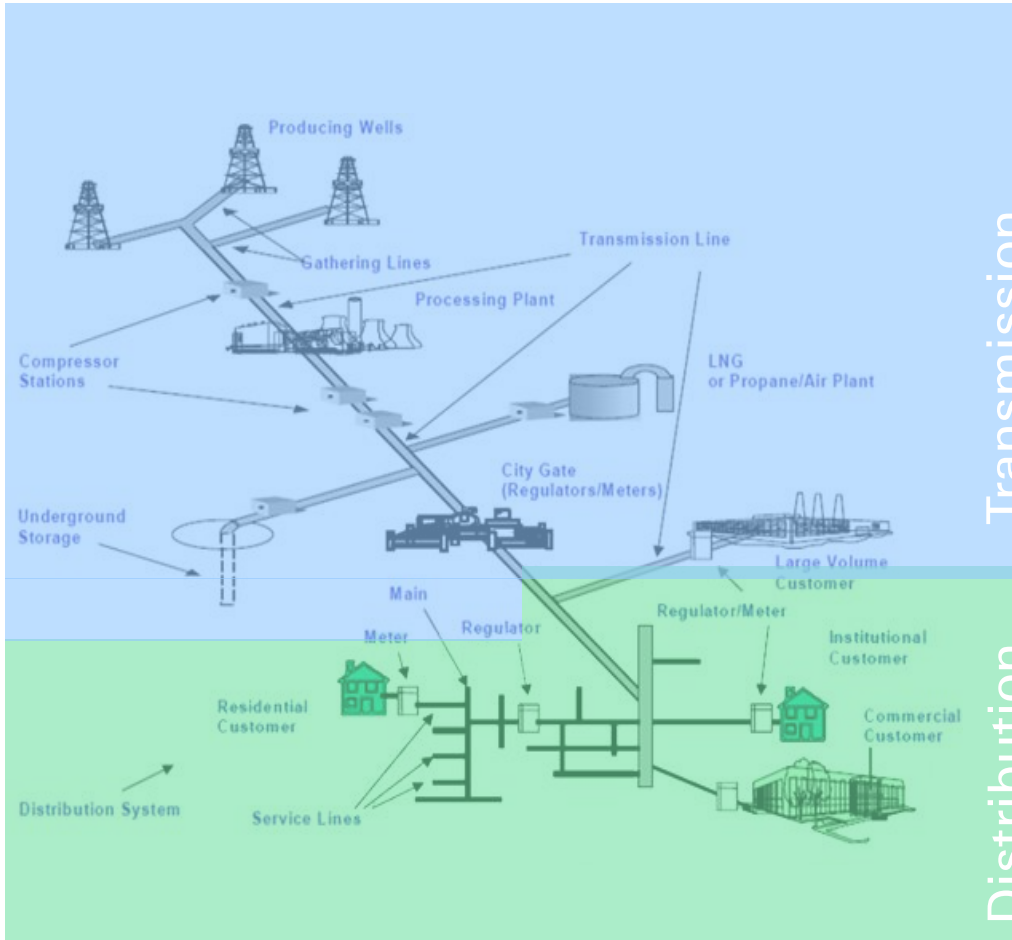
- Energy intensity
- Transportation

- Buoyancy
- Cooling down

- Boil off
- Ignition mechanisms

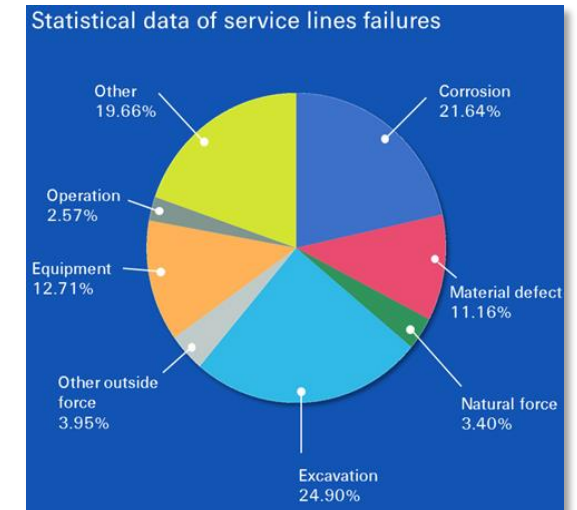
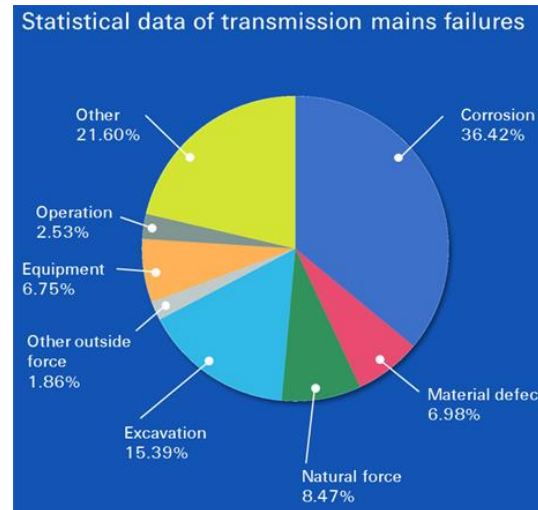


Understanding the risks of Hydrogen Infrastructure is the «heart»



- Almost consisting of steel pipelines
- Larger size with DN from 4-6 in up to 48 in
- Normal operating pressures in the range of 40-80 barg up to (in some cases) 140 barg
- Loss scenarios dominated by the rupture of the pipeline

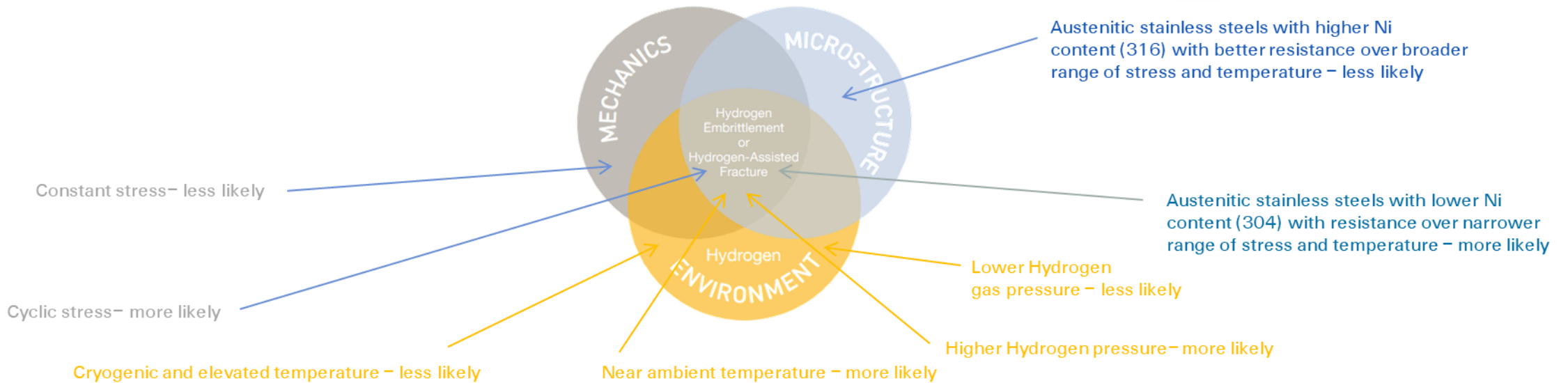
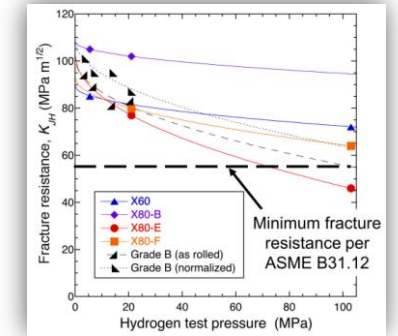
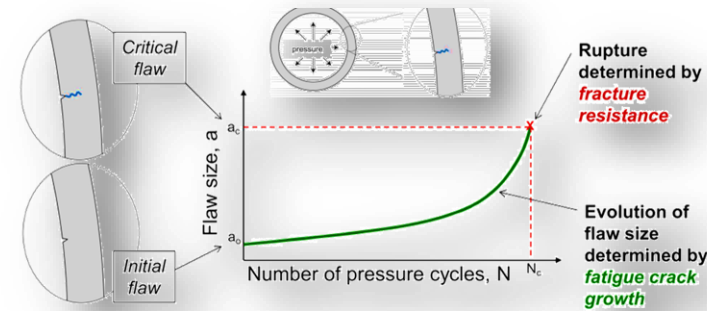
- Low alloy steel and polyethylene are the dominant materials
- Distribution and service lines are typically 1.5 – 4 in
- Normal operating pressures in the range of 1 - 5 barg up in some cases to 10 barg
- Distribution pipeline incidents typically result in leaks



Understanding the risks of Hydrogen

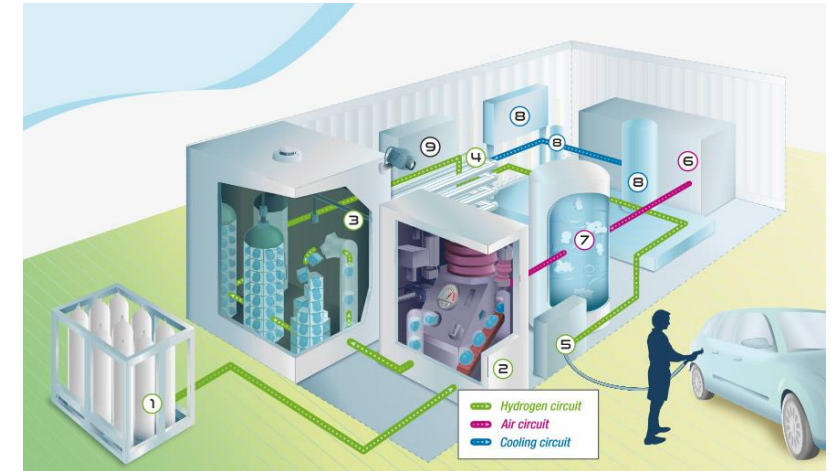
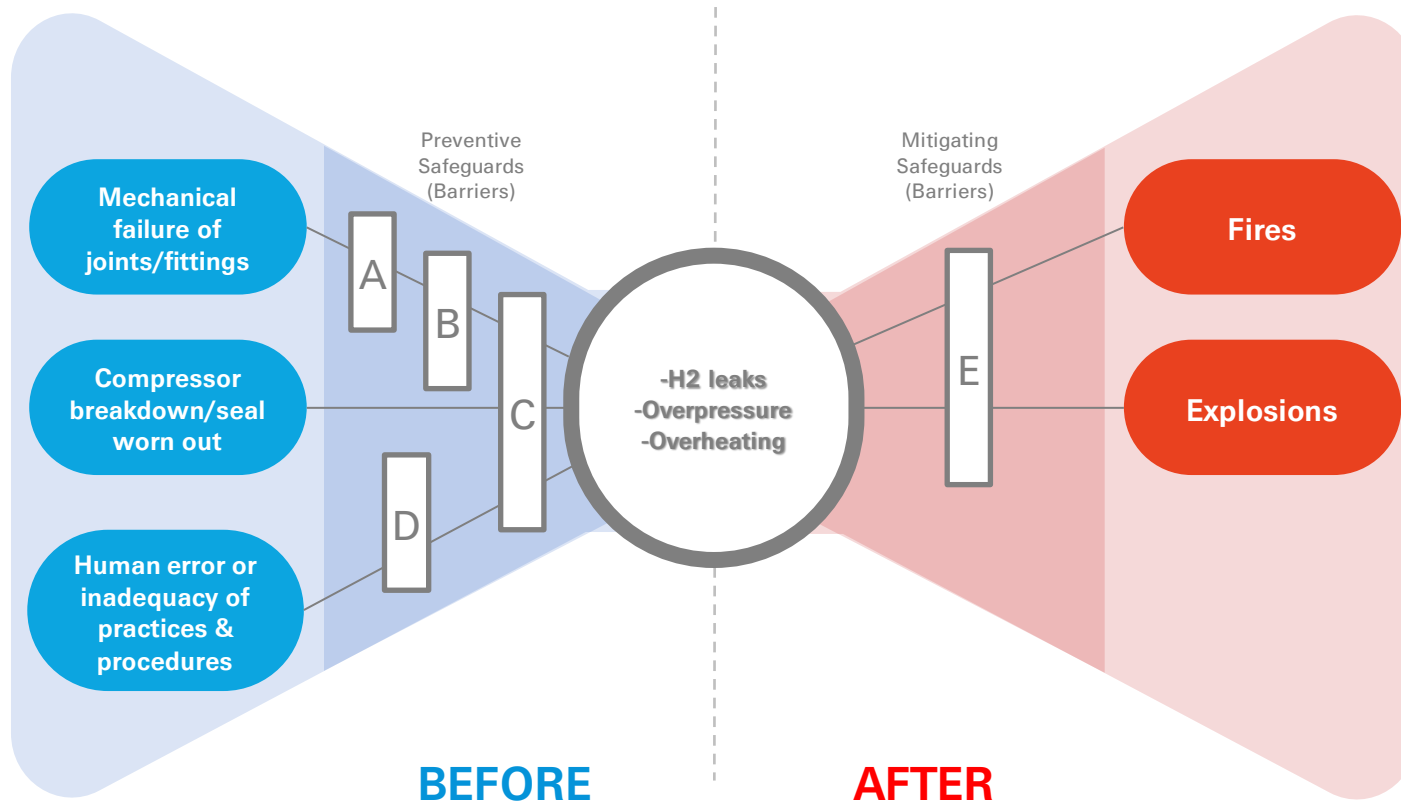
Hydrogen embrittlement: not only a material compatibility issue

- Hydrogen degradation is directly connected to its capability to be easily absorbed by metals coupled with the high mobility it has on the microstructural level
- Hydrogen can be a silent assassin, weakening the material slowly and without any clear signs of damage, often leading to critical failure



Understanding the risks of Hydrogen

Hydrogen re-fuelling: key bridgehead in commercializing FCEVs



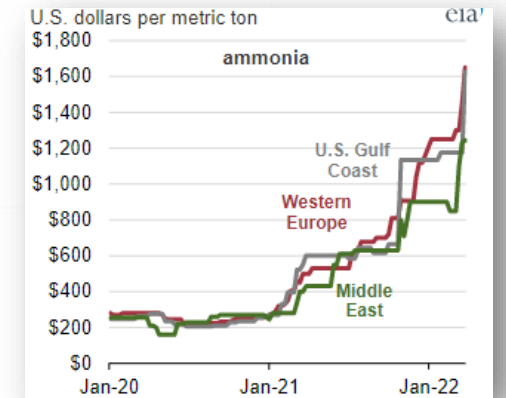
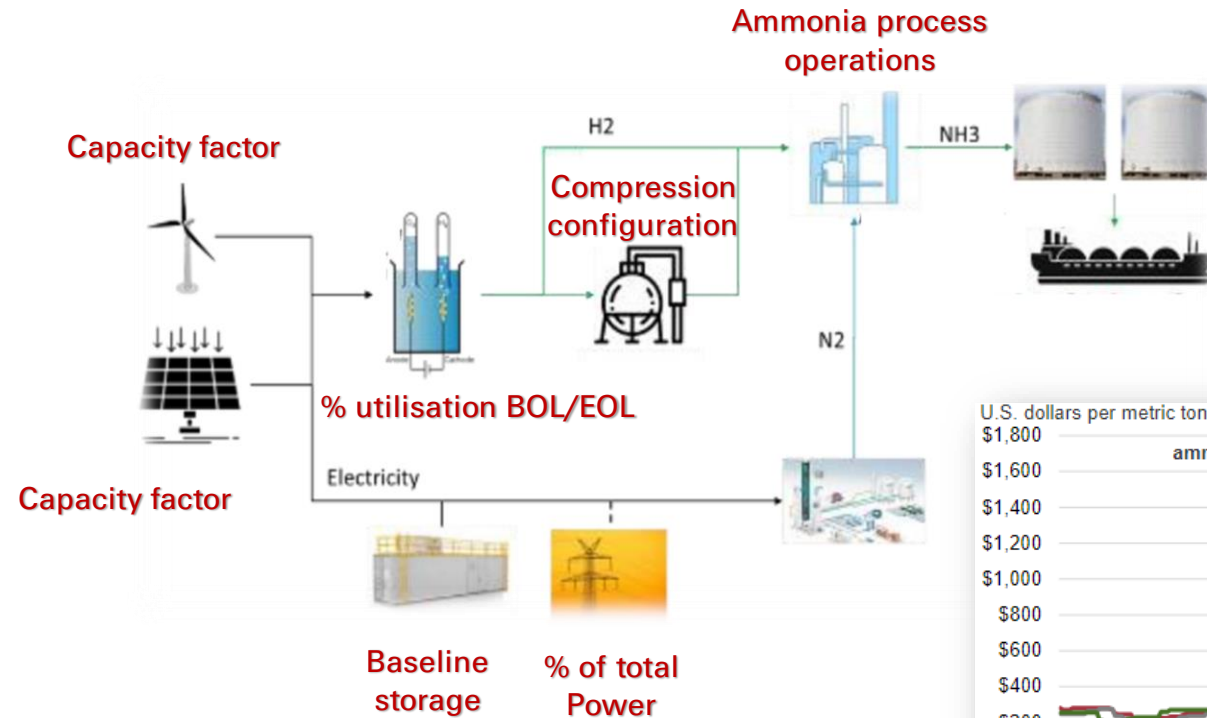
- Hydrogen buffer/storage
- Hydrogen compression
- Hydrogen pre-cooling
- Hydrogen dispenser

Understanding the risks of Hydrogen Business continuity & Mode of operations

Business Interruption exposures



Design Constraints



Understanding the risks of Hydrogen

Knowns and Unknowns

Known knowns

- Hydrogen production processes from fossils fuels (reforming and gasification)
- Carbon capture & storage
- Traditional electrolyzing technology
- HP (up to 300 bar) storage

Known unknowns

- Rotating equipment conversions and repurposing
- Upscaling of capacity – R&D in new electrolyzing technology
- Infrastructure retrofitting and high-high pressure storage (700 bar)

Unknown unknowns

- Cryogenic hydrogen
- Business continuity exposures for largest integrated projects



Risk

“Leading in a new economy means patterning our future on the understanding and management of unknown risks. Acting knowingly is better than reacting boldly.”



Massimo Giachino,
Manager Risk Engineering OPC

Thank you!

Contact us



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