Picture courtesy of Gerd Altmann, Pixabay

Welcome to IMIA´s Insight Webinar

The Webinar will start soon...

The International Association of Engineering Insurers

Insuring Hydrogen Infrastructure

IMIA: Our Mission

Matia Cazzaniga
Global Leader Engineering, Zurich Insurance plc
Member of IMIA EC / Project Sponsor

Prologue: Why Hydrogen?

Carl Dill
Lead Underwriter Engineering & Construction
Swiss Re Corporate Solutions

Picture courtesy of Gerd Altmann, Pixabay

The International Association of Engineering Insurers

Insights Webinar

- Why Hydrogen?
- Hydrogen Production
- Industrial Applications
- Transport & Storage
- Underwriting
- Coverage, Claims

Prologue: Why Hydrogen?

The Dilemma of the Hydrogen Economy

Green lights

- Unprecedented political momentum
- Strong pipeline and technological advances
- Positive outlook for green/blue H2 costs
- New industry players and capital

Roadblocks

- Lack of regulation and investment to meet Paris targets
- False sense of complacency
- New risks: complex business models and value chains
- Lack of standards and best practices

How to secure bankability and insurability?

- IMIA mission: time to talk risk and improve risk management in the H_2 industry
- Engage community beyond insurance! Risk managers, investors and other professionals dealing with H_2 risks

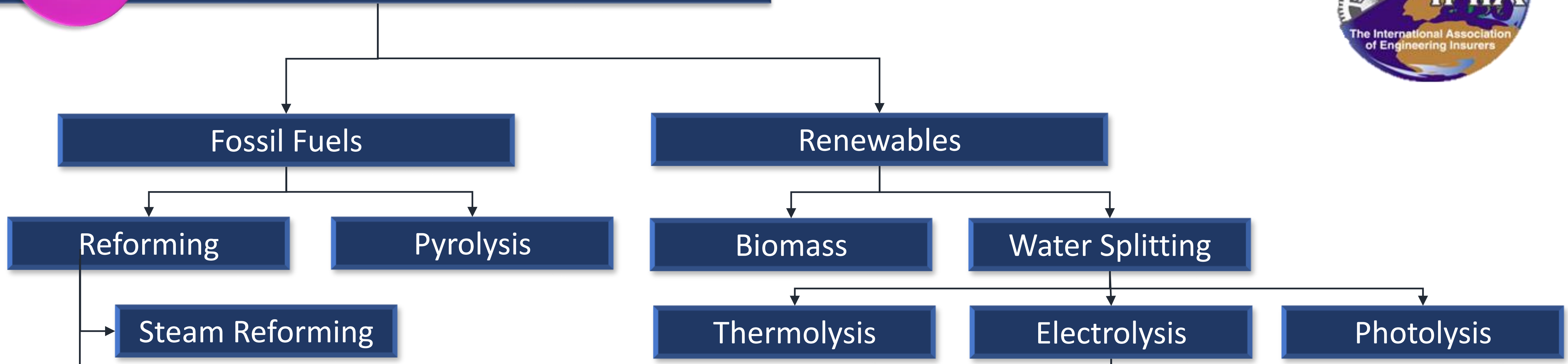
Geopolitical tensions = A new energy world

- Geopolitics as game changer: Hydrogen will play a key role to secure energy independence

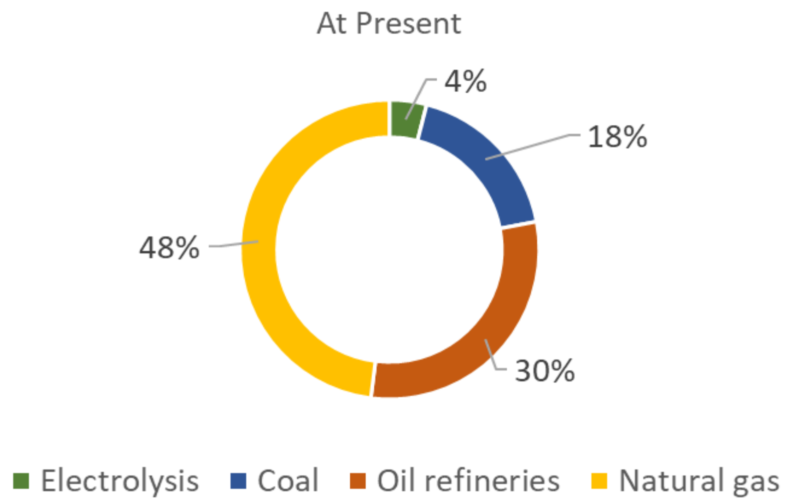
Hydrogen Production

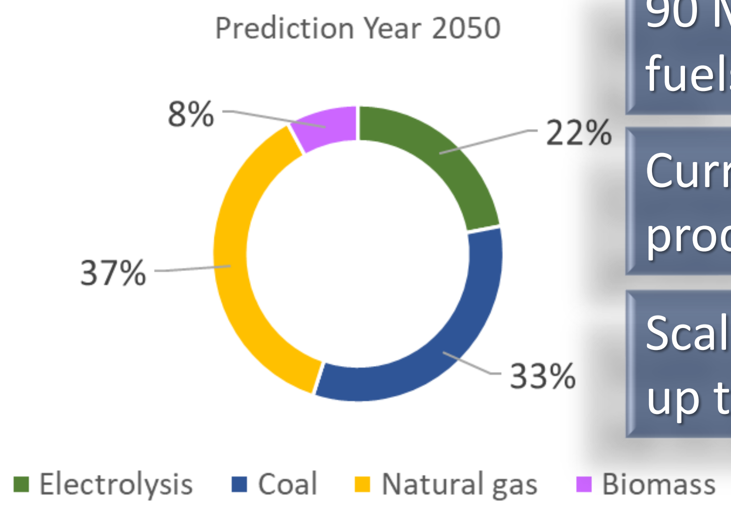
Dr. Isabel Escobar-Stanislowski
Risk Engineer
HDI Global

Hydrogen Production



Breakdown of hydrogen production by energy source. Data from IRENA, International Energy Agency





90 MMT hydrogen in 2020 from fossil fuels

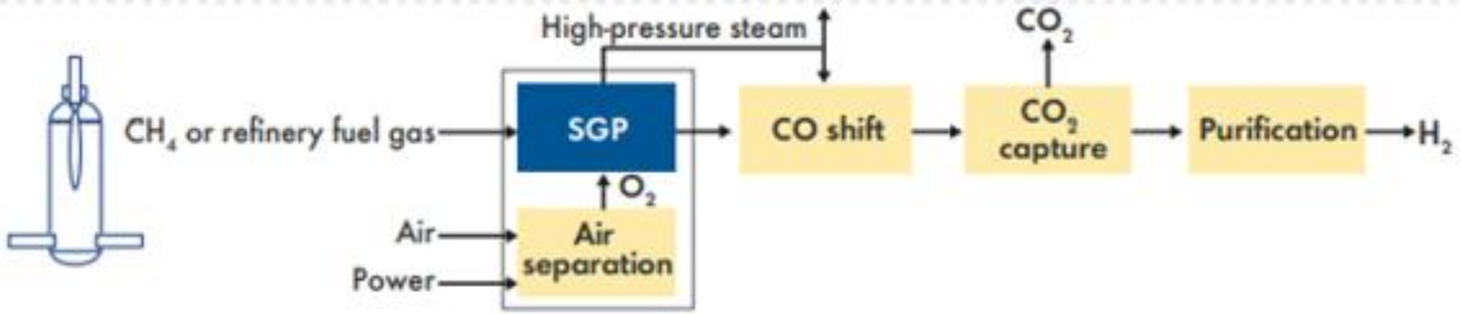
Currently, only 4% of the globally produced hydrogen from electrolysis

Scale-up of green hydrogen could reach up to 8 MMT in the next years

From Grey to Blue Hydrogen

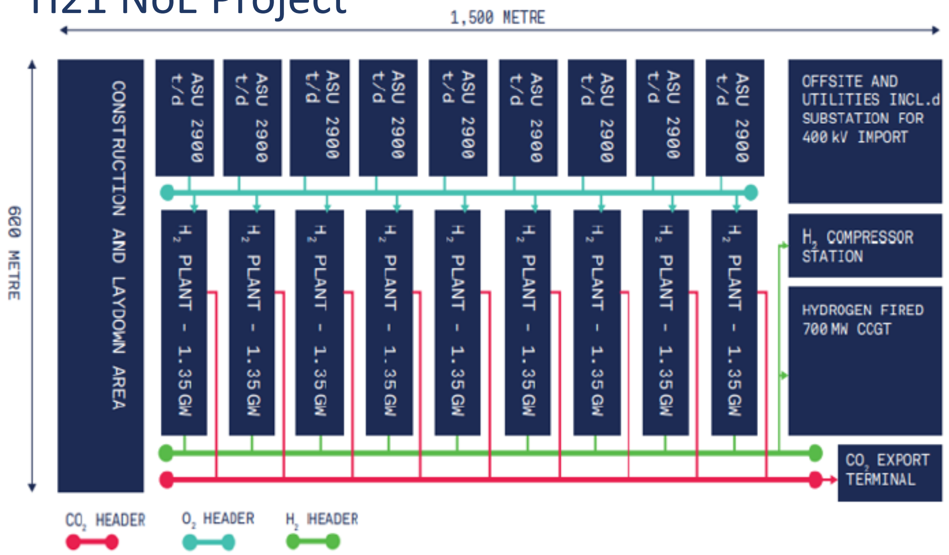
Steam Methane Reforming with Carbon Capture and Storage

Partial Oxidation with Carbon Capture and Storage



Autothermal Reforming with CCS

H21 NoE Project



Post-combustion carbon capture can be retrofitted to conventional methods in order to convert grey hydrogen production to blue

Sources:http://media.hydrocarbonengineering.com/whitepapers/files/The-Shell-Blue-Hydrogen-Process.pdf
https://together.northerngasnetworks.co.uk/wp-content/uploads/2019/03/H21-NoE-Exec-Sum-Print-Final.pdf

Green Hydrogen - Electrolysis

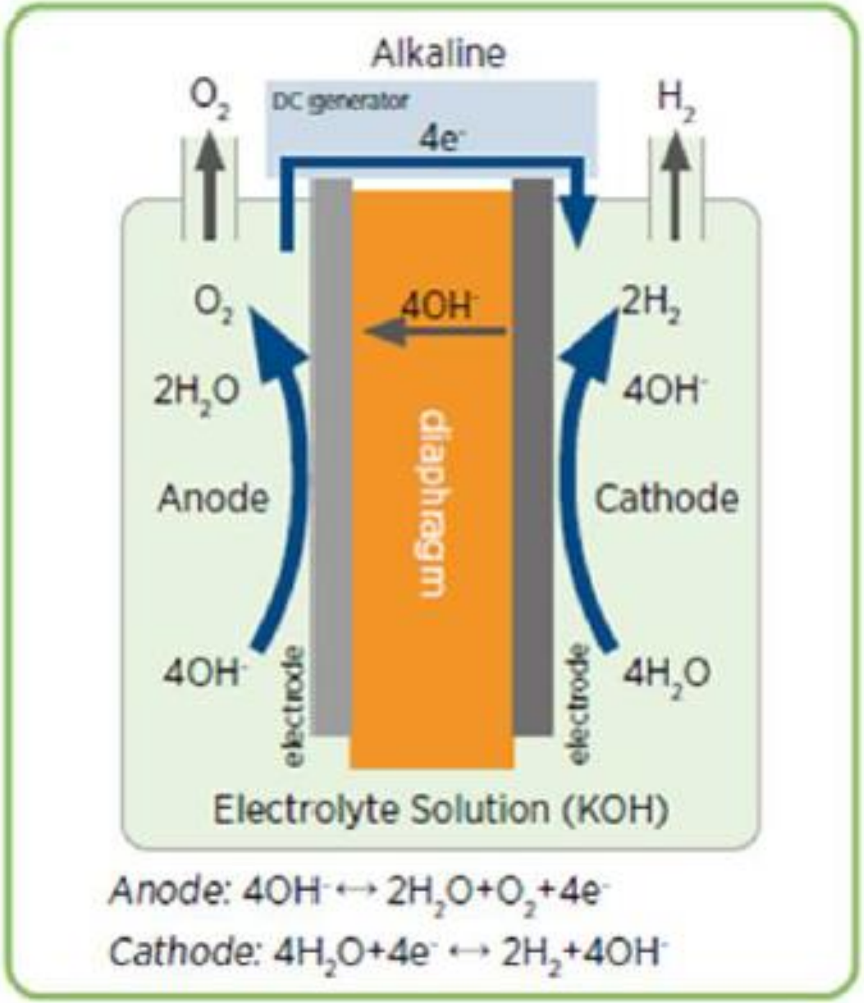
	Alkaline	PEM	AEM	Solid Oxide
Operating temperature	70-90 °C	50-80 °C	40-60 °C	700-850 °C
Operating pressure	1-30 bar	< 70 bar	< 35 bar	1 bar
Electrolyte	Potassium hydroxide (KOH) 5-7 $molL^{-1}$	PFSA membranes	DVB polymer support with KOH or NaHCO3 1$molL^{-1}$	Yttria-stabilized Zirconia (YSZ)
Separator	ZrO_2 stabilized with PPS mesh	Solid electrolyte (above)	Solid electrolyte (above)	Solid electrolyte (above)
Electrode / catalyst (oxygen side)	Nickel coated perforated stainless steel	Iridium oxide	High surface area Nickel or NiFeCo alloys	Perovskite-type (*e.g.* LSCF, LSM)
Electrode / catalyst (hydrogen side)	Nickel coated perforated stainless steel	Platinum nanoparticles on carbon black	High surface area nickel	Ni/YSZ
Porous transport layer anode	Nickel mesh (not always present)	Platinum coated sintered porous titanium	Nickel foam	Coarse Nickel-mesh or foam
Porous transport layer cathode	Nickel mesh	Sintered porous titanium or carbon cloth	Nickel foam or carbon Cloth	None
Bipolar plate anode	Nickel-coated stainless steel	Platinum-coated titanium	Nickel-coated stainless steel	None
Bipolar plate cathode	Nickel-coated stainless steel	Gold-coated titanium	Nickel-coated Stainless steel	Cobalt-coated stainless steel
Frames and sealing	PSU, PTFE, EPDM	PTFE, PSU, ETFE	PTFE, Silicon	Ceramic glass

Source:IRENA (2020), Green Hydrogen Cost Reduction: Scaling up Electrolysers to Meet the 1.5°C Climate Goal

Electrolysis is a surprisingly old technology, with the first units in operation already more than 100 years ago

Further electrolyser technologies are under development, e.g. the membrane less electrolyser, microbial electrolysis or electrolyser operating with salt water

Alkaline Electrolysis

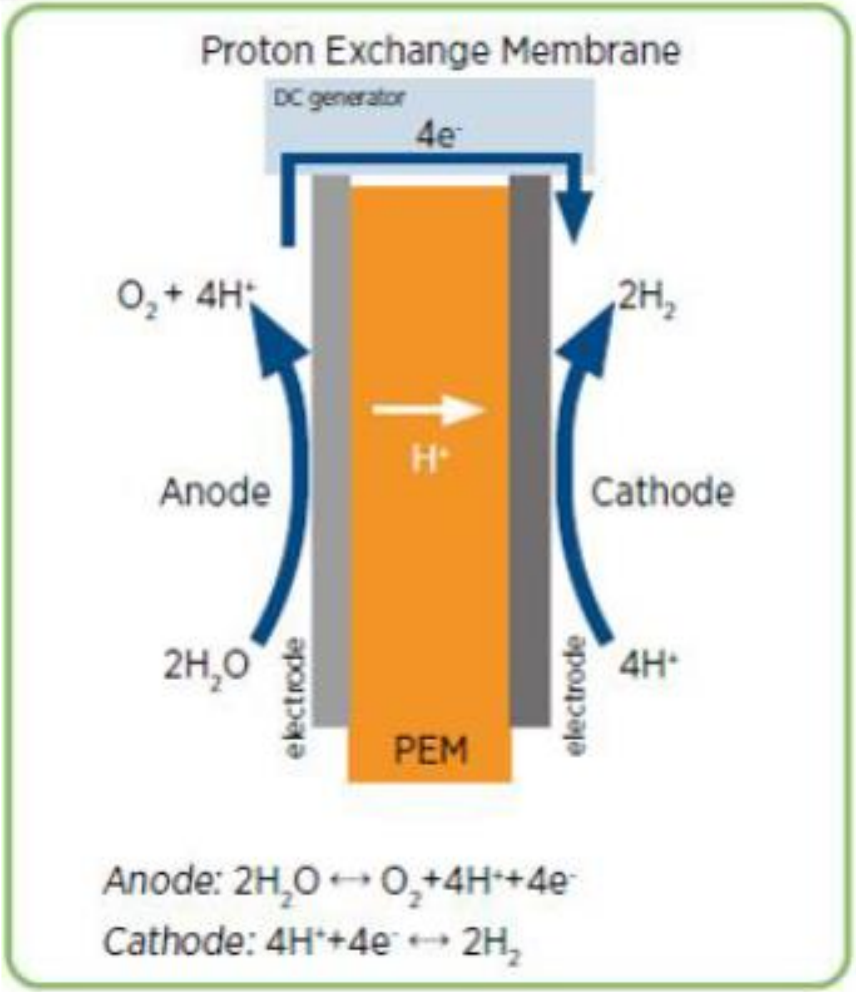


- Proven technology up to 4 MW per stack
- Current membrane development for cost reduction
- Process run-off risk: explosion protection limit varies between 4% to 2% hydrogen concentration
- Diaphragm durability influenced by operating regime

World's largest green hydrogen project (Ningxia Baofend Energy Group). 150 MW AE from 200 MW wind energy. Commissioned in 2021.

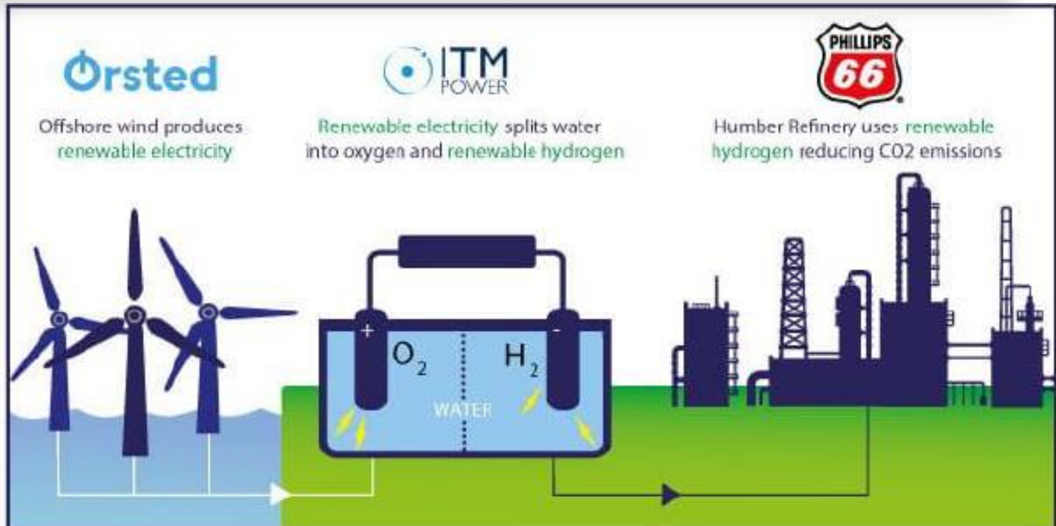
Sources:IRENA (2020), Green Hydrogen Cost Reduction: Scaling up Electrolysers to Meet the 1.5ºC Climate Goal
https://fuelcellsworks.com/news/the-worlds-largest-green-hydrogen-project-with-a-150mw-electrolyser-comes-online-in-china-el-periodico-de-la-energia/

Proton Exchange Membrane (PEM)



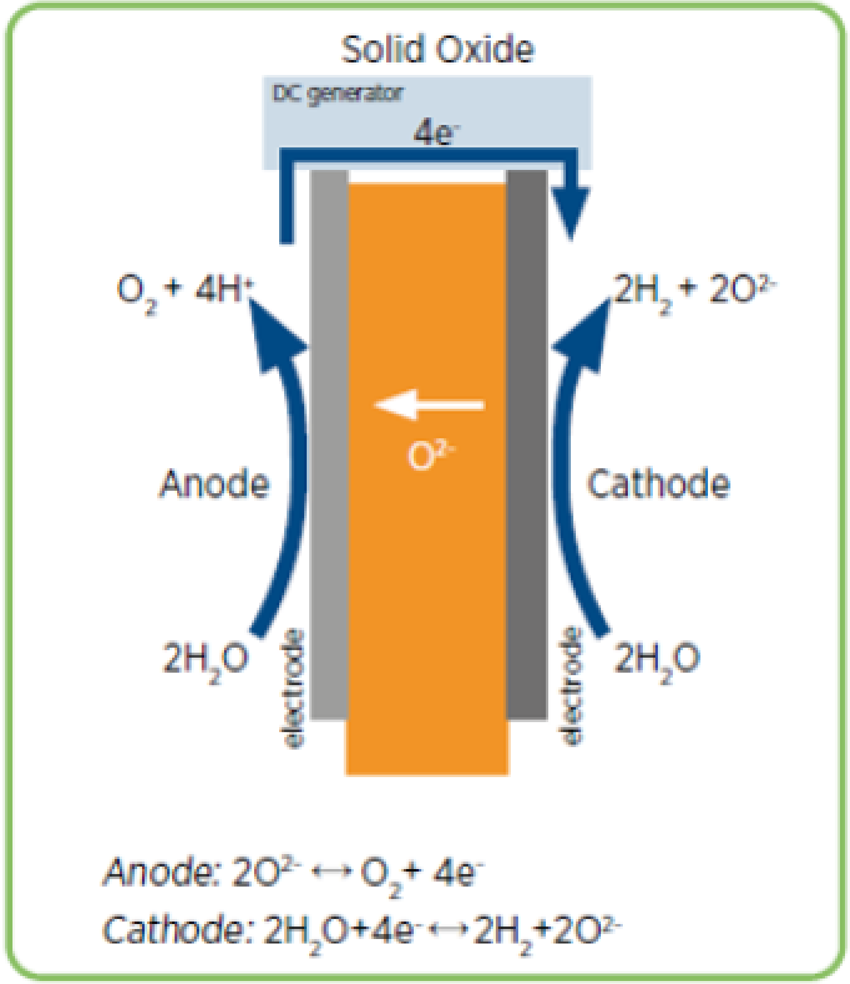
- High-pressure operation, fast response, and dynamic operation
- Expensive materials (e.g., iridium, platinum)
- Selective permeability of membrane: only H_2 pass through → inherent operational safety
- Ageing of the components

Orsted Gigastack project. 1 GW windfarm, 100MW electrolyser feeding Humber Refinery. Current demonstration project at industrial scale (5 MW) - FEED. Planned up-scaling at large scale.



Sources:IRENA (2020), Green Hydrogen Cost Reduction: Scaling up Electrolysers to Meet the 1.5ºC Climate Goal
https://orsted.co.uk/media/newsroom/news/2020/02/gigastack-phase-2

Solid Oxide Electrolysis (SOE)



- High operational temperatures: 500-600°C
- Able to operate as SOE or SOFC
- Advanced materials: porous Ni doped YSZ, LSM → operational degradation
- Limited field experience → only pilot projects

GrInHy (Green Industrial Hydrogen Via Reversible High-Temperature Electrolysis) up-scaling project (Sunfire). 150 KW.

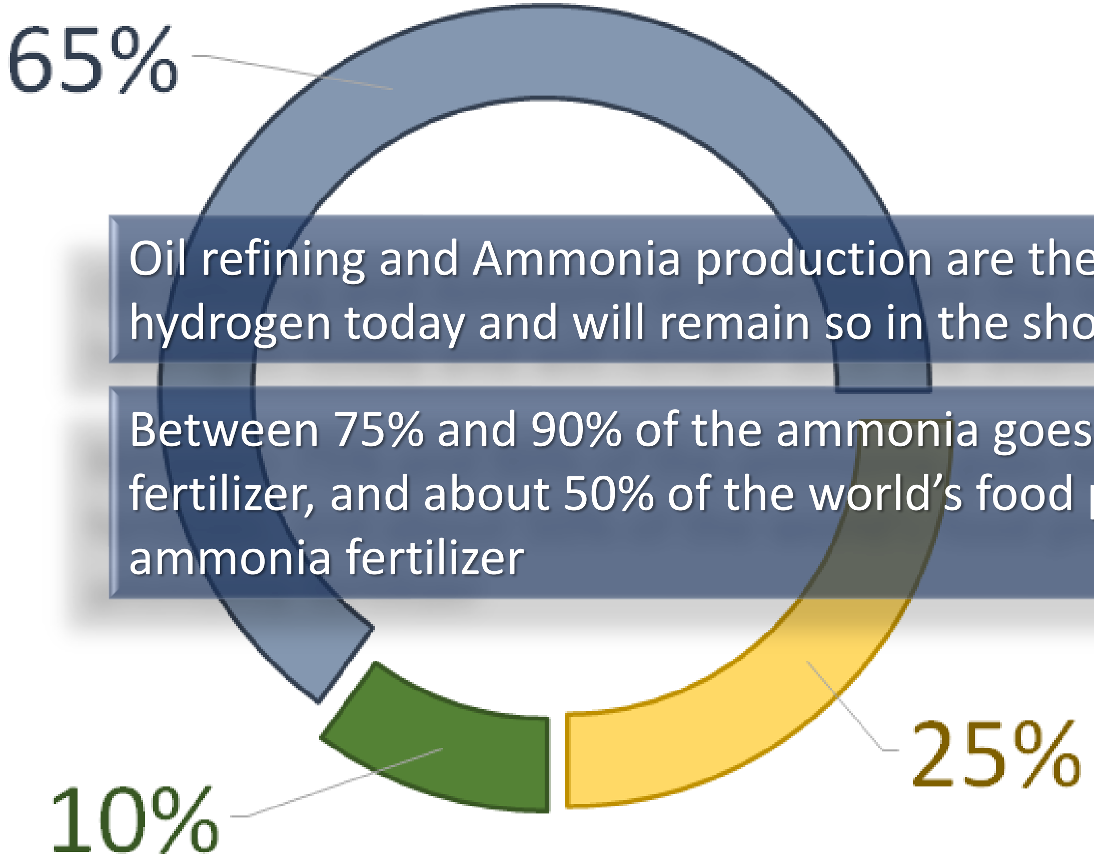
Sources:IRENA (2020), Green Hydrogen Cost Reduction: Scaling up Electrolysers to Meet the 1.5°C Climate Goal
https://www.green-industrial-hydrogen.com/project/grinhy-project

Industrial Applications

Isidro Pimentel
Senior Underwriter Engineering
Zurich Insurance plc

Applications in Heavy Industries

Industrial Sector	Application	Percentage of global demand
CHEMICAL	Ammonia	
	Polymers	
	Resins	
REFINING	Hydrocracking	
	Hydrotreating	
IRON & STEEL	Annealing	
	Blanketing gas	
	Forming gas	
GENERAL INDUSTRY	Semicon	
	Propellant fuel	
	Glass production	
	Food industry (hydrogenation)	
	Cooling of generators	

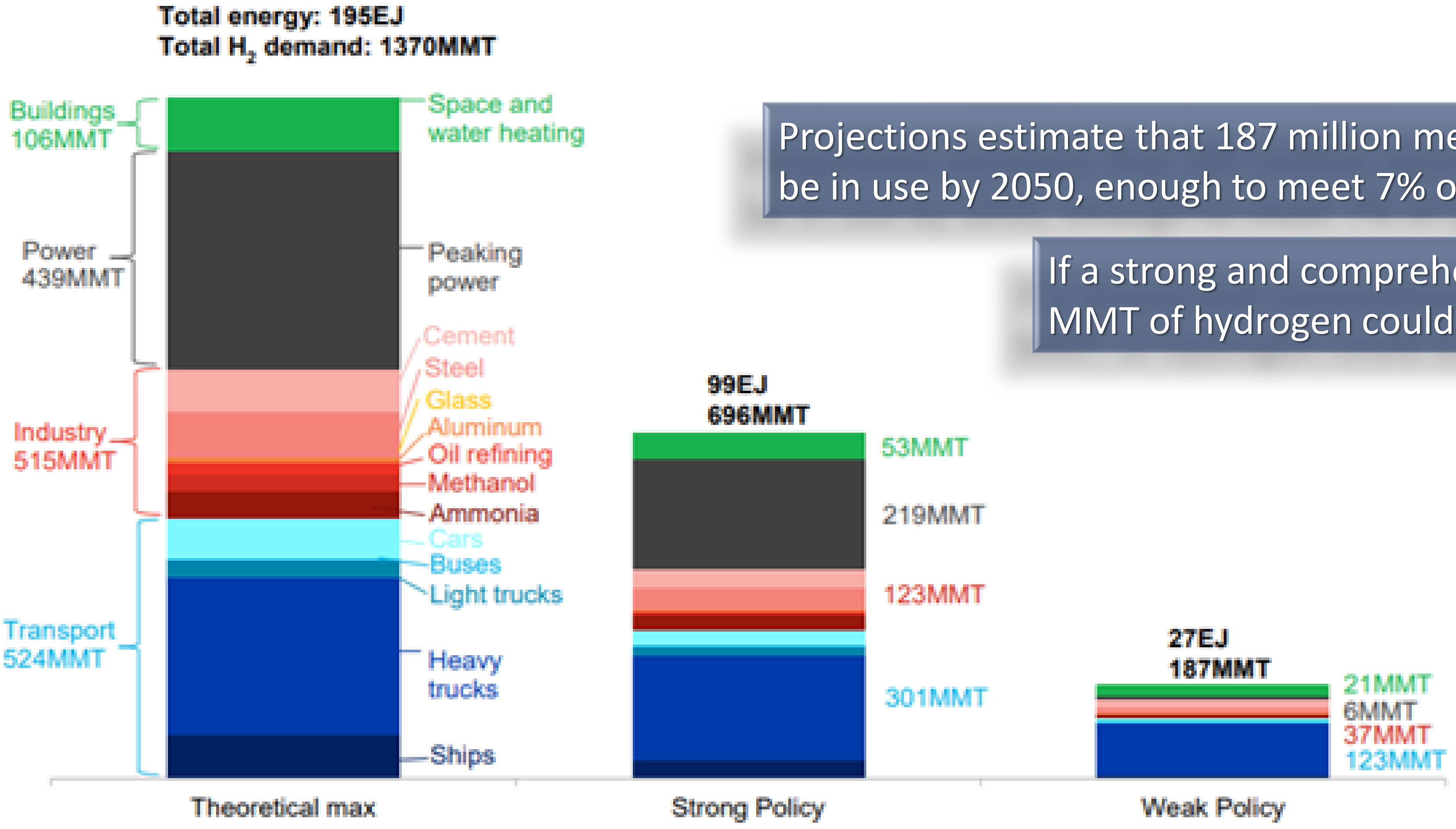


Oil refining and Ammonia production are the largest consumers of hydrogen today and will remain so in the short to medium term

Between 75% and 90% of the ammonia goes toward making fertilizer, and about 50% of the world's food production relies on ammonia fertilizer

Data source: IRENA, Hydrogen from renewable power. Technology outlook for the energy transport.

Applications in Heavy Industries

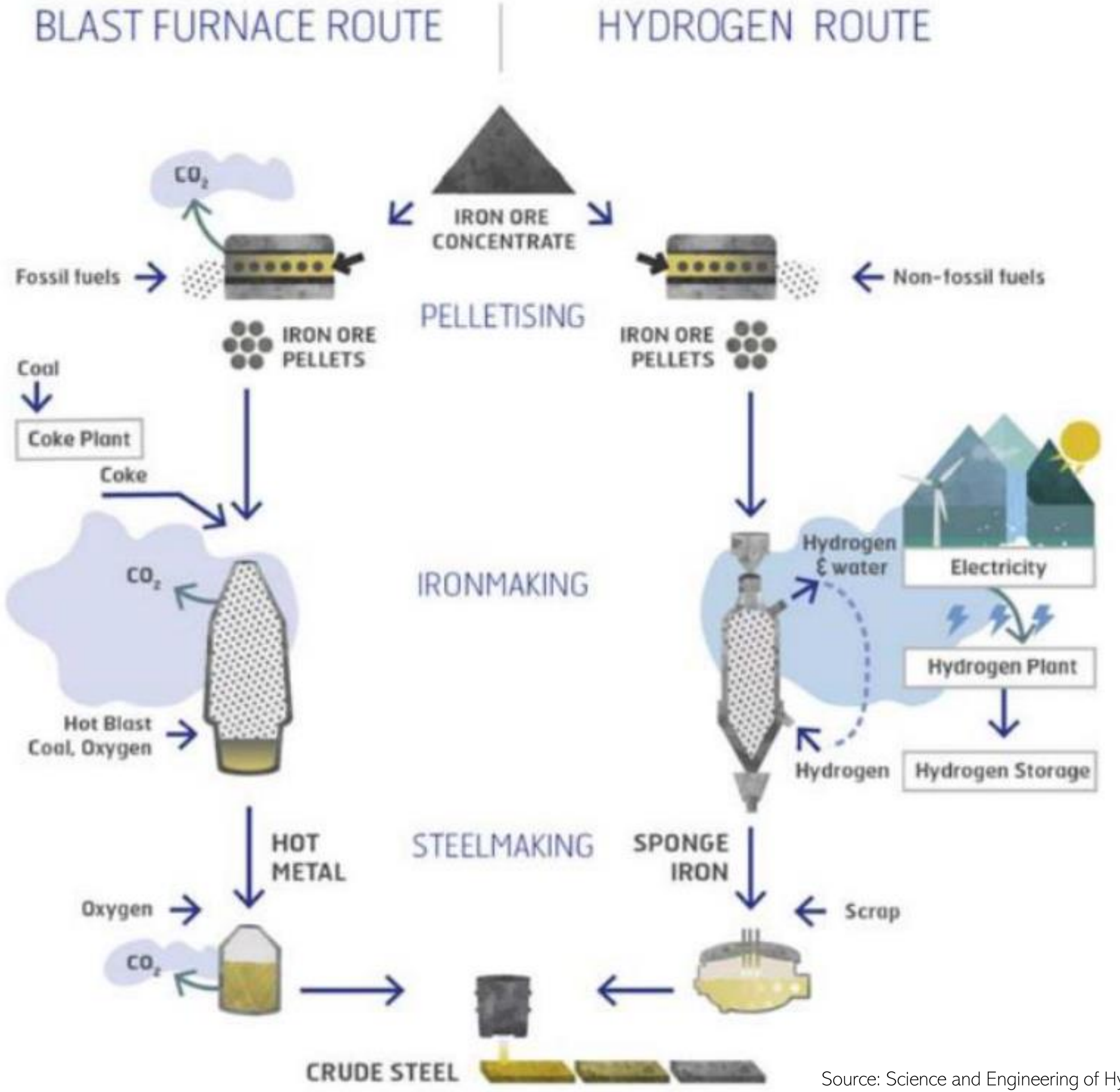


Projections estimate that 187 million metric tons of hydrogen could be in use by 2050, enough to meet 7% of projected needs

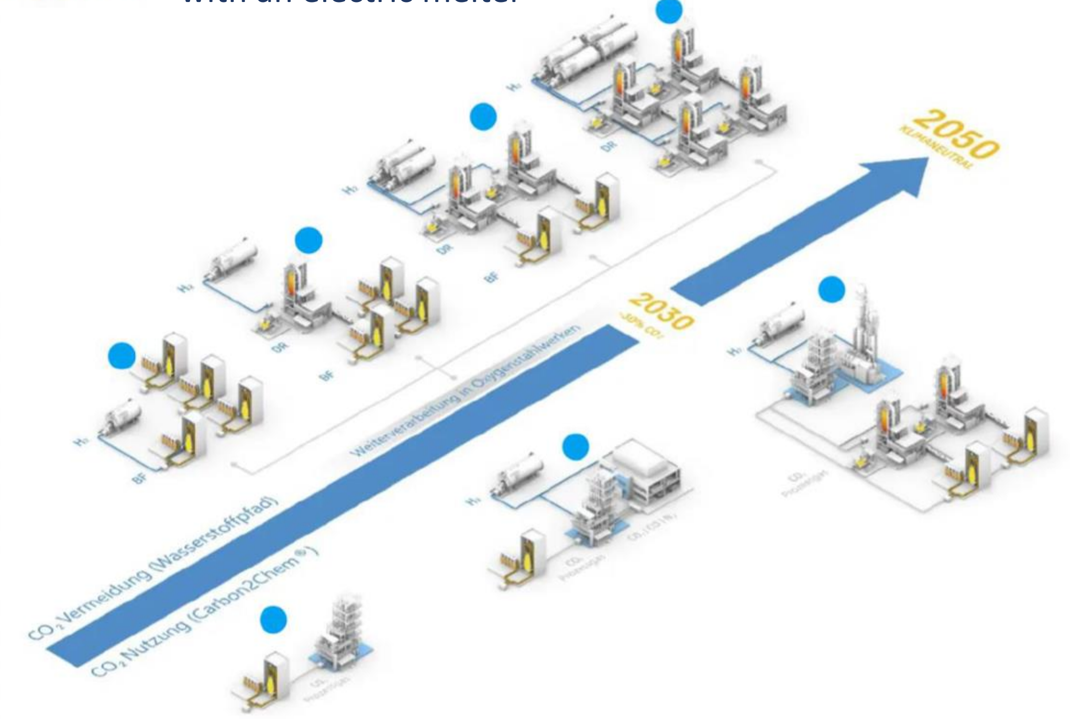
If a strong and comprehensive policy is in force, 696 MMT of hydrogen could be used, 24% of needs

Source: Bloomberg "Hydrogen Economy Outlook"

Applications in Heavy Industries

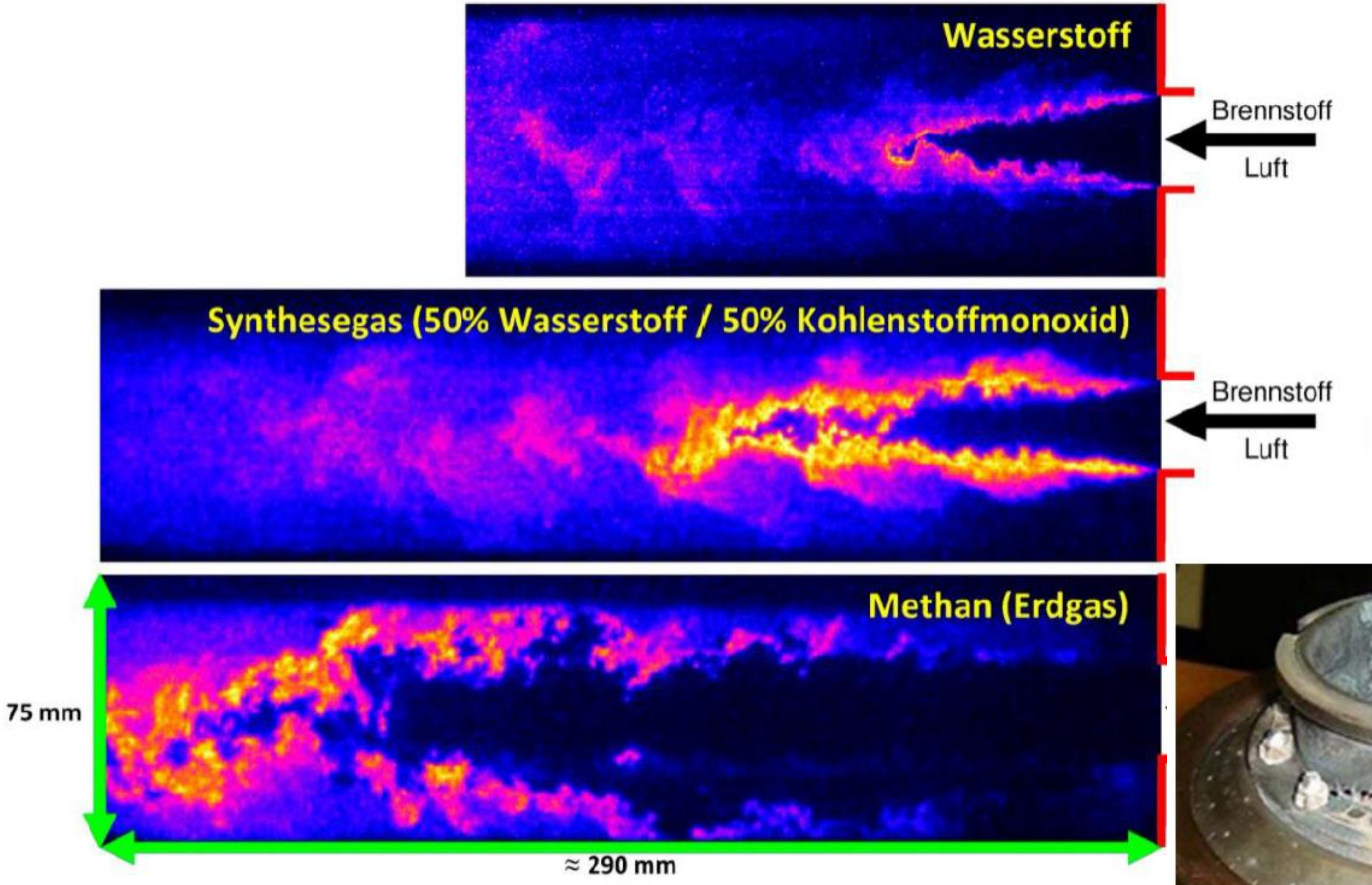


Thyssenkrupp Steel announced 2021 its decarbonization project tkH2Steel, which aims to implement direct reduction in combination with an electric melter



Source: Science and Engineering of Hydrogen-Based Energy Technologies. Hydrogen Production and Practical Applications in Energy Generation. 2021

Applications in Heavy Industries



Source: Paul Scherer Institute

Transport & Bulk Storage

Dr. Lui Terry
Research Associate
Bristol Composites Institute

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Bulk Hydrogen Storage

Global move towards hydrogen is related to the option to securely store energy from renewable sources

Mixture of storage mediums proposed to be aware of

- Compressed gas
- Liquid storage
- Sorbent materials
- Chemical hydrogen storage
- Liquid organic hydrogen carriers
- Salt/rock cavern storage

Risks related to <u>leakage, rupture and failure to detect</u>

- Containment material corrosion, hydrogen embrittlement, Valve condition, pressure relieving devices, purge

	Type 1	Type 2	Type 3	Type 4
	Steel	Metal steel/aluminium tank and composite fiber (hoop wound)	Composite with thick metal liners fully wrapped.	Carbon Fiber Composite HDPE lining
Normal Economic Pressure Range	175 Aluminum and 200 Bar Steel (350 bar special applications)	300 Bar	700bar Normal (1000 bar Special)	380 or 500 Bar (normal applications higher 700 bar in special applications)
Storage Mass	Unlimited	Unlimited		Up to 1164 kg transportable
Transportability	Generally, too heavy. Some are transportable but inefficient	Better Than Type 1 but still heavy	Improved capacity versus weight but still limited standard road transport	ADR Approved as Standard and below street legal weight limits

Typ I

Typ II

Typ III und IV

Hydrogen Distribution

Major infrastructure for distribution involves pipelines

- Existing natural gas pipelines
- New hydrogen pipelines
- 100% hydrogen service vs. natural gas/hydrogen blend

Risks related to leakage, rupture and failure to detect

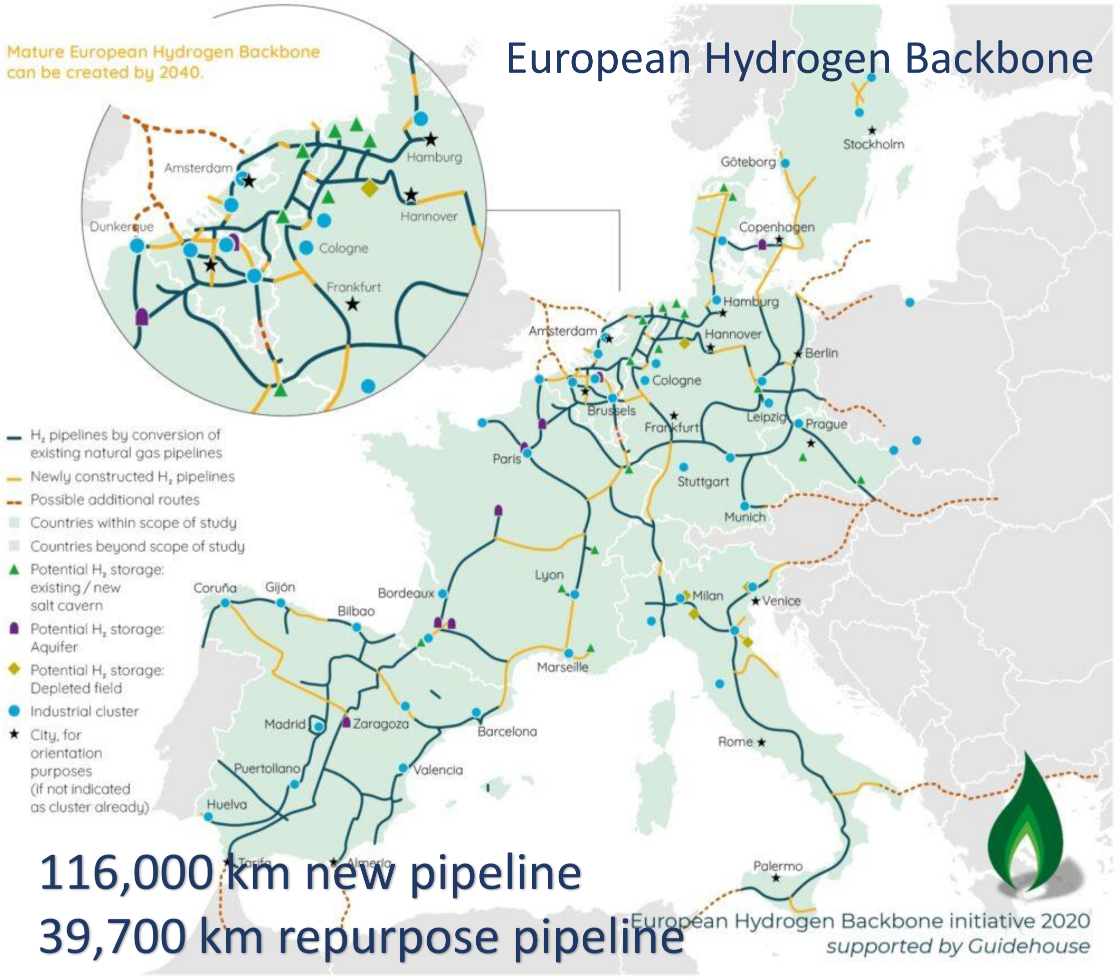
- Gasket failure, poor weld, valve condition, Containment material corrosion, hydrogen embrittlement

- Pipeline maintenance and support

<u>Historical claim</u>

AB Speciality Silicones Plant explosion

European Hydrogen Backbone



116,000 km new pipeline

39,700 km repurpose pipeline

Hydrogen Embrittlement

Currently, no structural metal can be labelled as “immune” to hydrogen embrittlement.

- Each metal has a varying degree of susceptibility.
- In designing structures for hydrogen service, one cannot simply select a material from a list of hydrogen compatible alloys
- But susceptible metals / alloys can be avoided.
- The main question is not if but when
- Plastics less susceptible, but permeable

Underwriting

Hydrogen technology as such is not new, but the sources, applications and the scale has changed

Obvious risks continue to remain an issue

- Fire, explosion
- Mechanical damage

Novel and less obvious risks require careful consideration

- Design / defects: Lack of standards / prototypes / unproven nature → defect exclusions, maintenance, warranty covers
- Modular technology: Serial loss clause (SLC) → occurrence language / event definition
- Testing & operation: No standards nor experience → Policy terms / solid definitions and deductibles
- Storage & distribution: Existing assets → equipment fit for purpose or refurbishment required, replacement value / scope of indemnity
- Downstream integration: Risks to / or resulting from existing property → TPL risk, integration with existing assets (e.g. hot-tie in), deductibles and defects cover for downstream equipment (e.g. gas turbines), external MPL scenarios
- DSU/BI: Increased interdependencies due to evolving business models and interconnected high-risk elements (e.g. integration with renewables)

Risk Mapping

Risk clusters relevant to all hydrogen applications

Main exposure explosion, leakage control and operational excellence are key. Standards in development yet

Higher exposure and rather severe worst-case scenarios derived from natural catastrophes

The prototype nature of most applications will remain for years

Most relevant risk element: Human Factor

Engineers and Underwriters will need a firm relationship to successfully navigate the underwriting world of hydrogen

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Coverage, Claims

Jan Sebastian Rögener
Expert Claims Manager
Axa Versicherung AG

The International Association of Engineering Insurers

Coverage, Claims

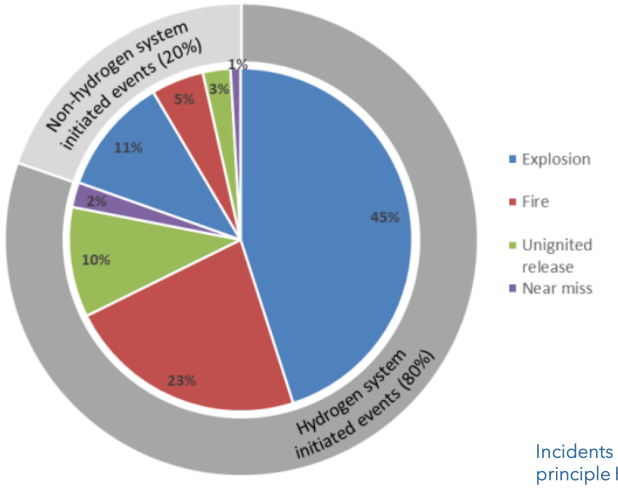
Claim Databases

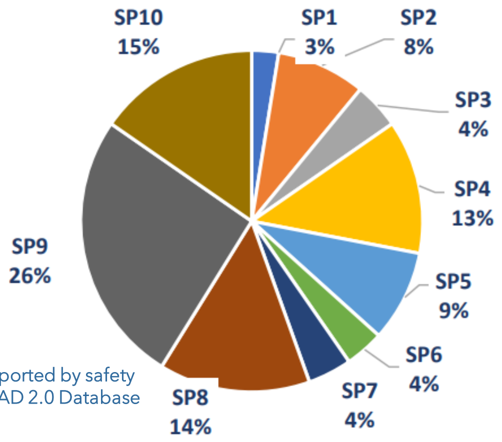
<u>Chemical plants and refineries + Transport and handling of Hydrogen (Pipeline, Truck, cylinders, pumps, valves):</u>

- Failure in detection system leads to explosion
- Hydrogen leak from embrittlement, pipe breaks, pumps, leads to explosion
- Valves e.g., failures in handling / design / installation
- Failure in detection system leads to explosion
- Lack of safety / HSE rules / Human error

<u>Hydrogen Pyrolysis:</u> No claims in databases: new process

<u>Storage of Hydrogen (Cavern):</u> No incidents on caverns found





Incidents reported by safety principle HIAD 2.0 Database

Exemplary claims

Electrolyser runoff leading to explosion in an experimental fuel cell power system

- Static spark in buffer tanks while >6% of [O_2]
- no oxygen remover & no spark remover
- Operated below design power level / solar powered
- 3% [O2] measurement ignored
- Safety regulation “monitor [O_2]” not followed

Coverage, Claims

Franco D’Andrea
Legal Director
Clyde & Co

Coverage, Claims

Hypothetical claim scenarios. A taster:

- Consistency of energy supply – an inherent problem for “green” hydrogen?
- Membrane / diaphragm deterioration.
- Obsolescence in a technologically fast-paced industry.
- Lead times / availability for repairs / parts
- Supplier insolvency – who wants to take the risk?

Epilogue

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Q&A, Paper release

https://www.imia.com/wp-content/uploads/2022/06/IMIA-Insight-Hydrogen.pdf