Insuring Hydrogen Infrastructure

Construction & Operation - IMIA Working Paper 127(22)

IMIA
The International Association of Engineering Insurers

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The Royal Marine Hotel. September 19th, 2022

Picture courtesy of Gerd Altmann @ Pixabay

Agenda

Prologue: Why Hydrogen?

The Dilemma of the Hydrogen Economy

✓ Unprecedent political momentum

! Major projects & disrupting technologies

? Reaction of insurance market

How to secure bankability and insurability?

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

Latest developments

- **Geopolitics as game changer:** Hydrogen will play a key role to secure energy independence
- **US Inflation Reduction Act passed →** Tax credits and incentives for low-carbon hydrogen

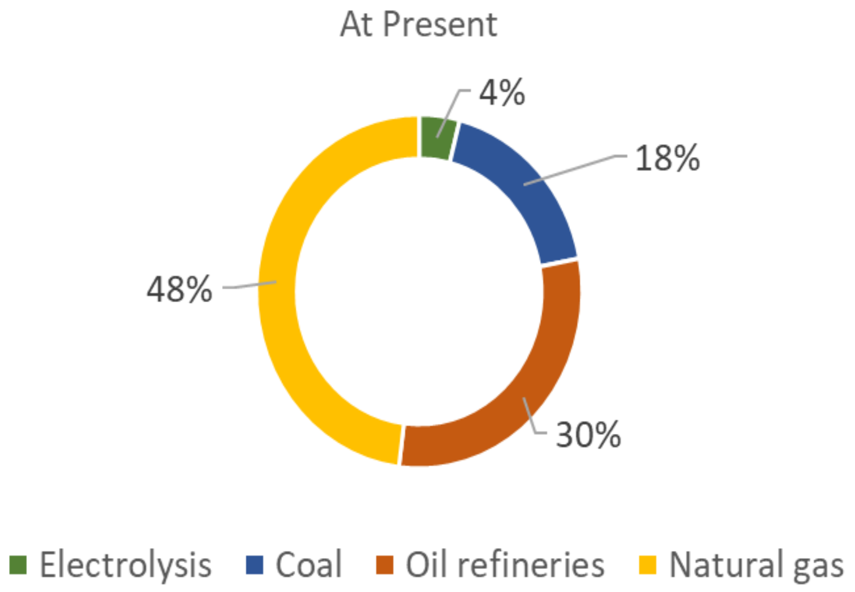
Image by Felix Mittermeier from Pixabay

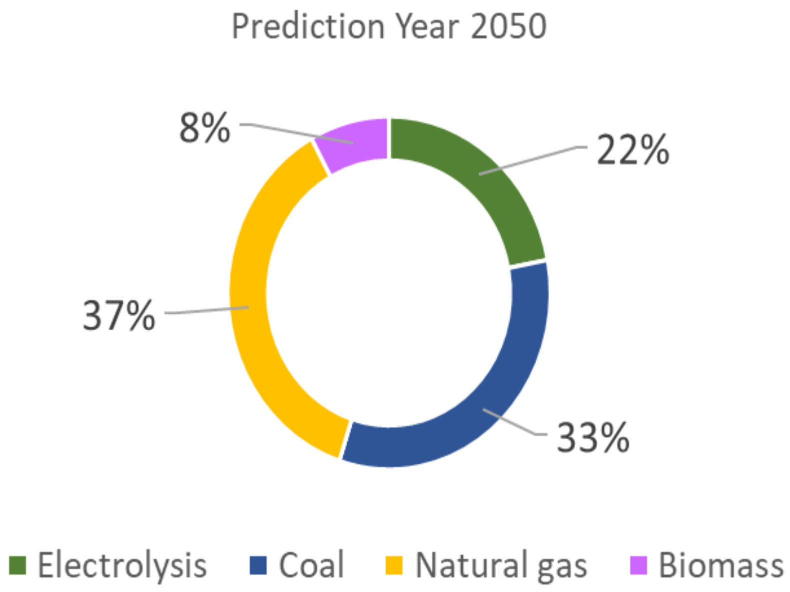
Hydrogen is an industry in its infancy, if we do not set the right standards now, insurability is at risk.

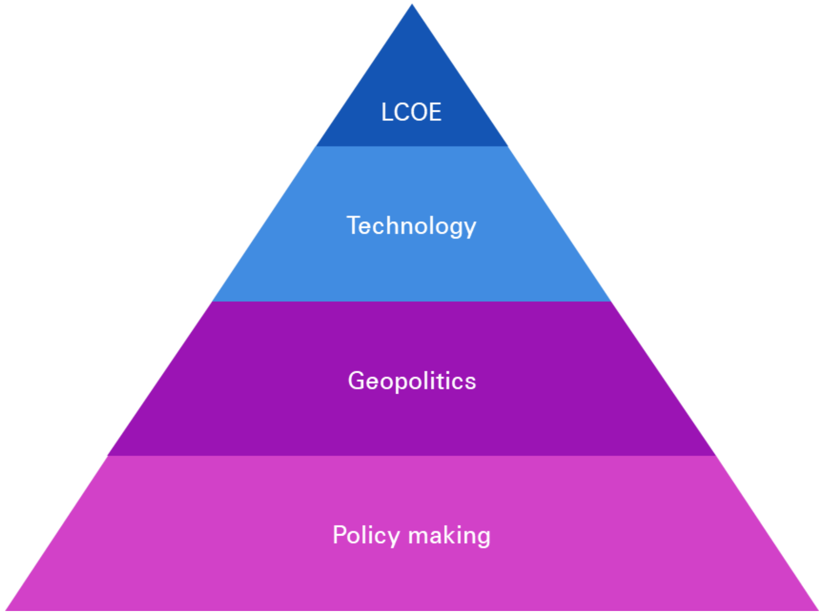
Image by Gerd Altmann from Pixabay

Hydrogen Outlook

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







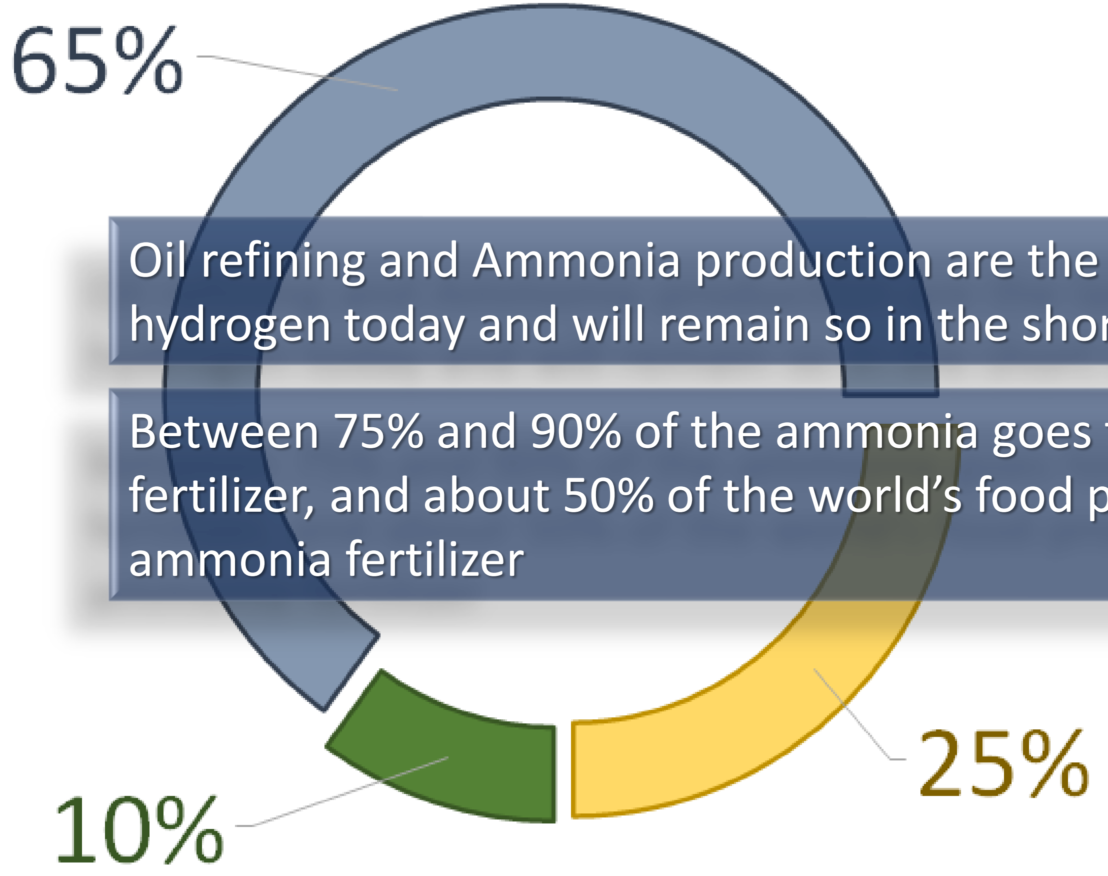
Between 200 and 700 million metric tons of hydrogen could be in use by 2050, up to 24% of final energy needs

Applications in Heavy Industries

Industrial Sector	Application
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

Percentage of global demand

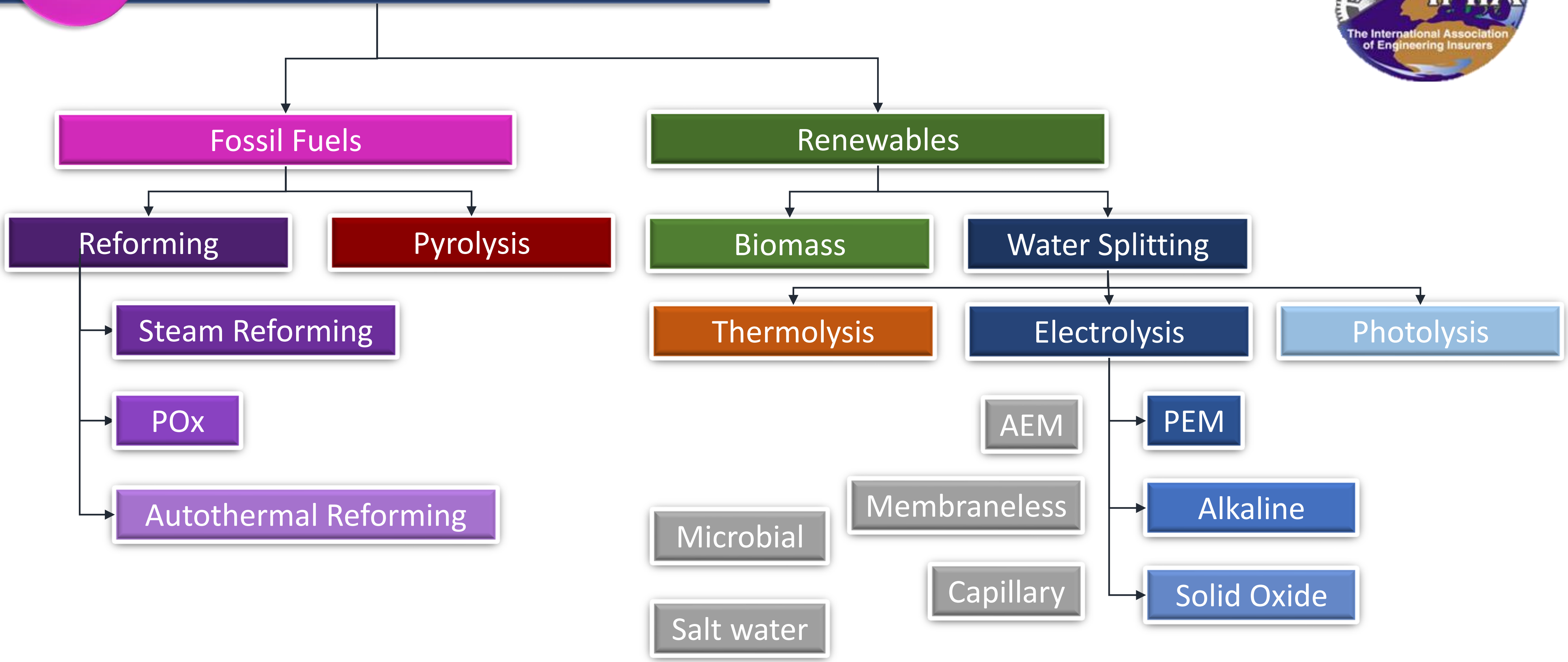
Data source: IRENA, Hydrogen from renewable power. Technology outlook for the energy transport.



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

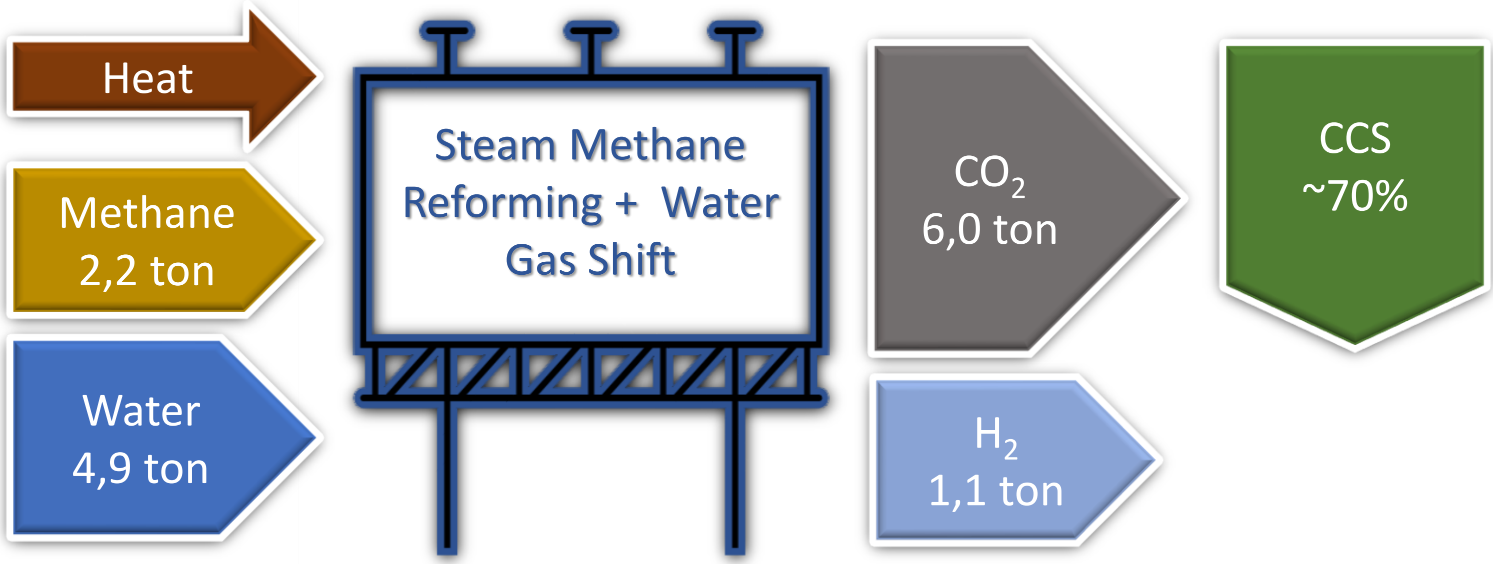
Hydrogen Production



From Grey to Blue Hydrogen

Steam Methane Reforming with Carbon Capture and Storage

No greenfield projects expected but huge potential for retrofits



Partial Oxidation with CCS

Autothermal Reforming with CCS

Biofuels via CCS

Is CCS a viable solution?

→ Technologically on good track

→ Business and regulatory boundaries are key

"Every dollar spent on this climate technology is a waste…Of 12 commercial projects in operation in 2021, more than 90% were engaged in enhanced oil recovery, using carbon dioxide emitted from natural gas processing facilities or from fertilizer, hydrogen or ethanol plants"
Dr. Charles Harvey (MIT)

"The majority of 13 flagship CCS schemes worldwide, representing 55% of captured carbon dioxide, have either failed entirely or captured much less CO_2 than expected…there may be a future role for CCS in heavy industries where emissions are hard to prevent, such as cement making"
Bruce Robertson (IEEFA)

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

CCS can be retrofitted converting grey hydrogen to blue.

Image by David Mark from Pixabay

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 $NaHCO_3$ 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

Development focusing on cost reduction, efficiency and scaling up

Process run-off risk: Explosion protection limit varies between 4% to 2% hydrogen concentration

Diaphragm / Membrane durability influenced by operating regime

PEM: Selective permeability of membrane
Only H_2 pass through
→ Inherent operational safety

Feed quality / stable electrical supply are key

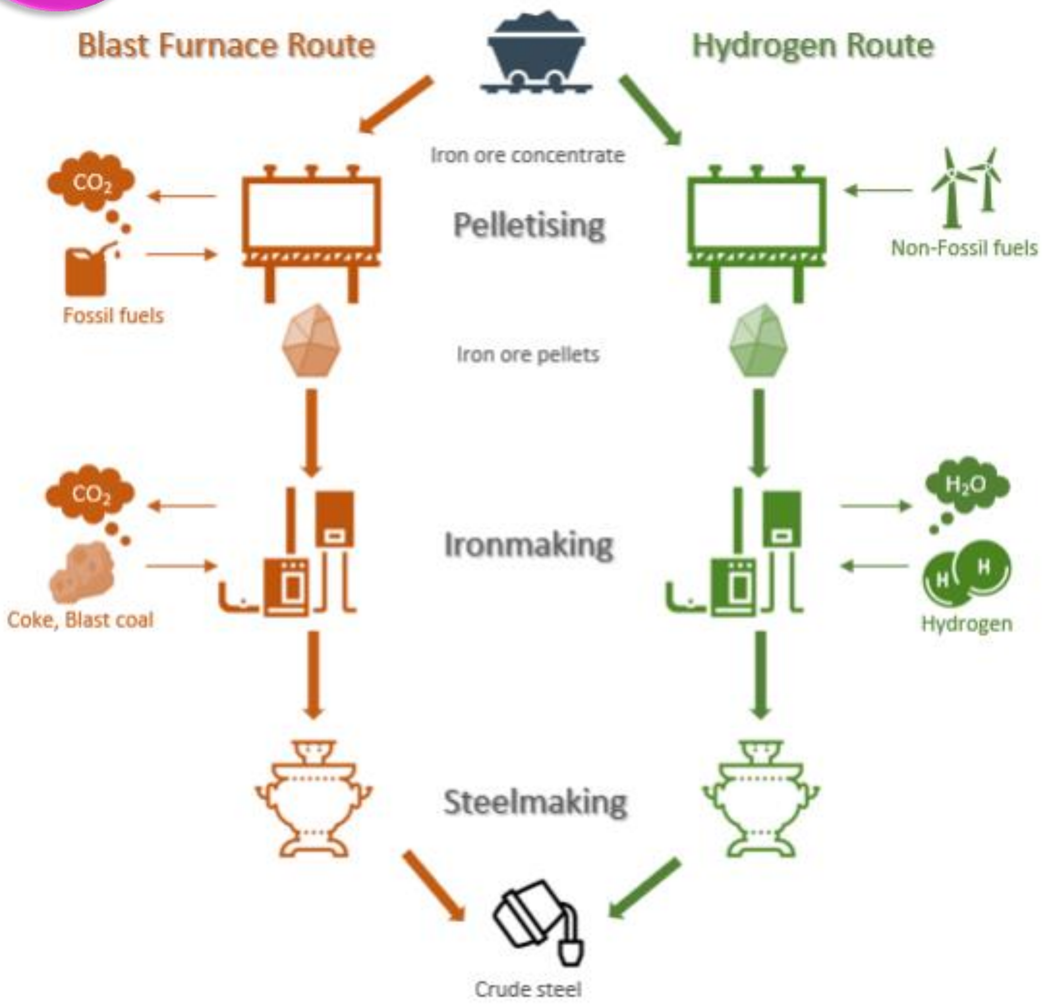
Source:IRENA (2020), Green Hydrogen Cost Reduction: Scaling up Electrolysers to Meet the 1.5°C Climate Goal

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

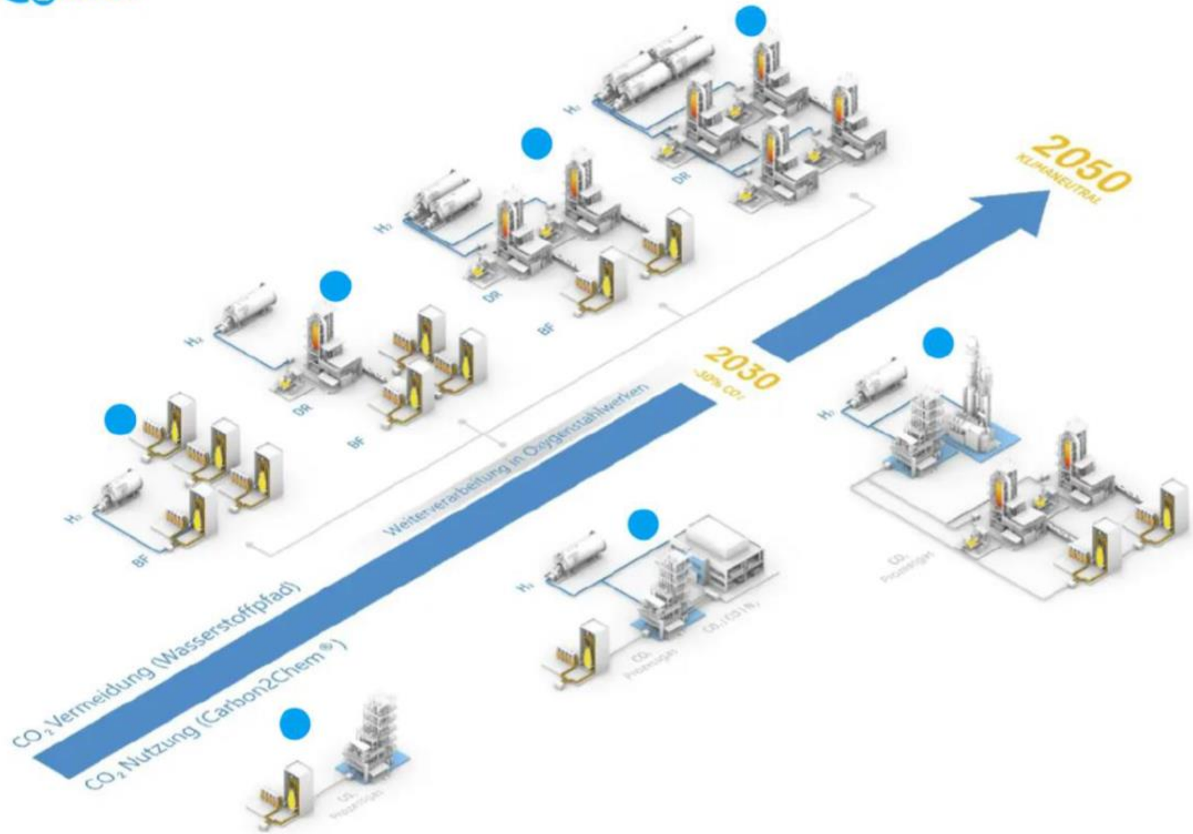
Main risks of electrolysers are process run-off, lifetime of key components, balance of plant and systems integration.

Image courtesy of Swiss Re

Steel production

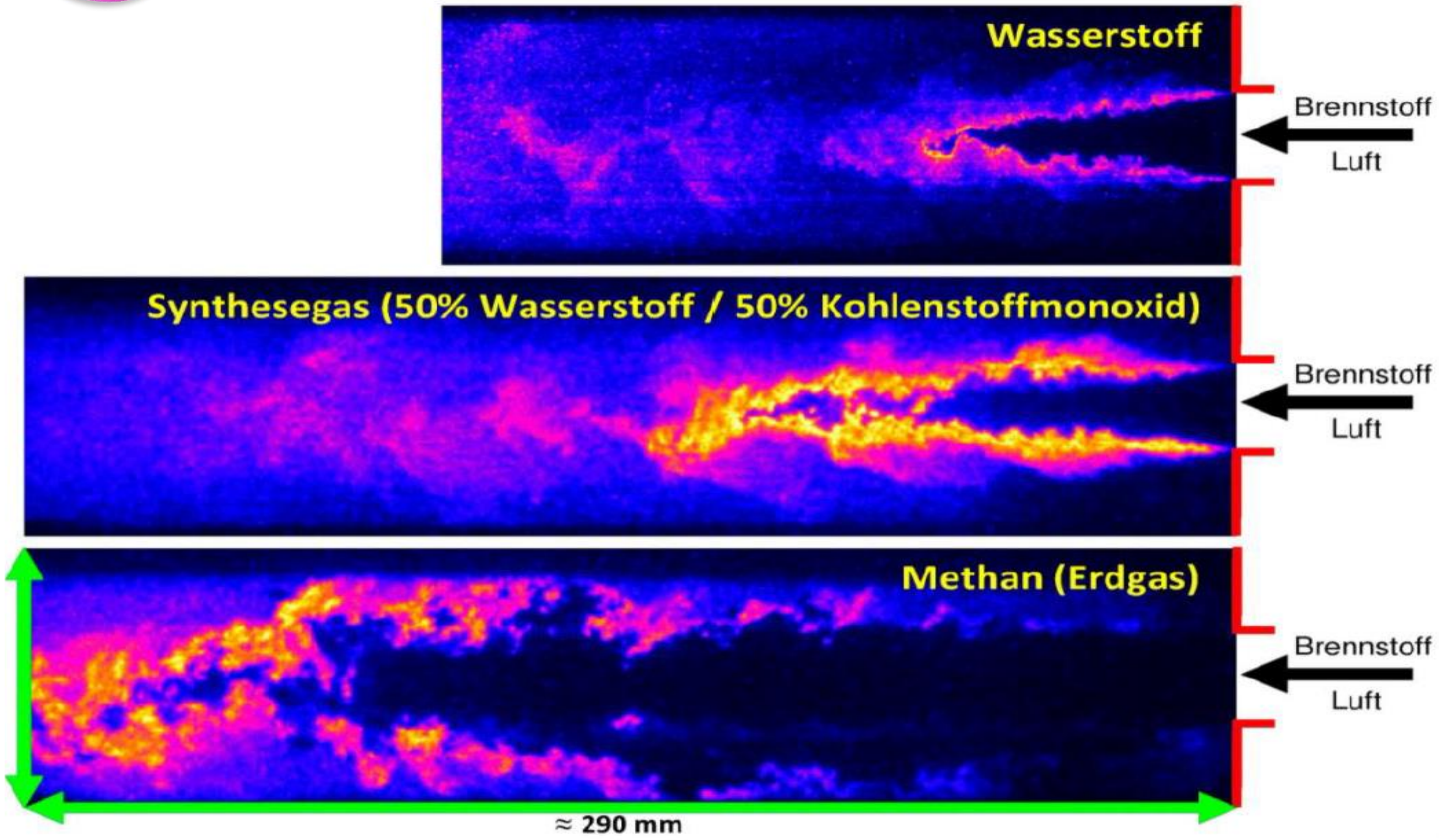


Thyssenkrupp Steel announced 2021 its decarbonization project tkH2Steel, which aims to implement direct reduction in combination with an electric melter

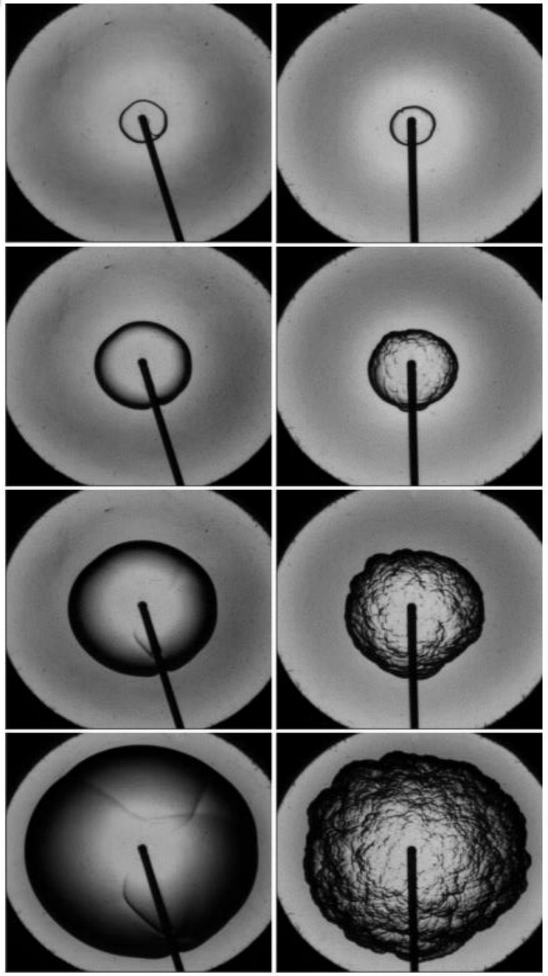


Decarbonization implies not only the implementation of new technologies, but operational and safety procedures, control systems, process integration and balance of plant

Hydrogen Combustion



Source: Paul Scherer Institute



Courtesy of Joachim Beeckmann, ITV RWTH Aachen University

Hydrogen flame velocity and reactivity is 9-10 times higher than natural gas; This is why it is so difficult to optimize an existing combustor for full fuel flexibility.

Bulk Hydrogen Storage

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

Variety of storage media:

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

Risks related to leakage, rupture and failure to detect

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

Source: Clean Carbon Conversion AG

	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

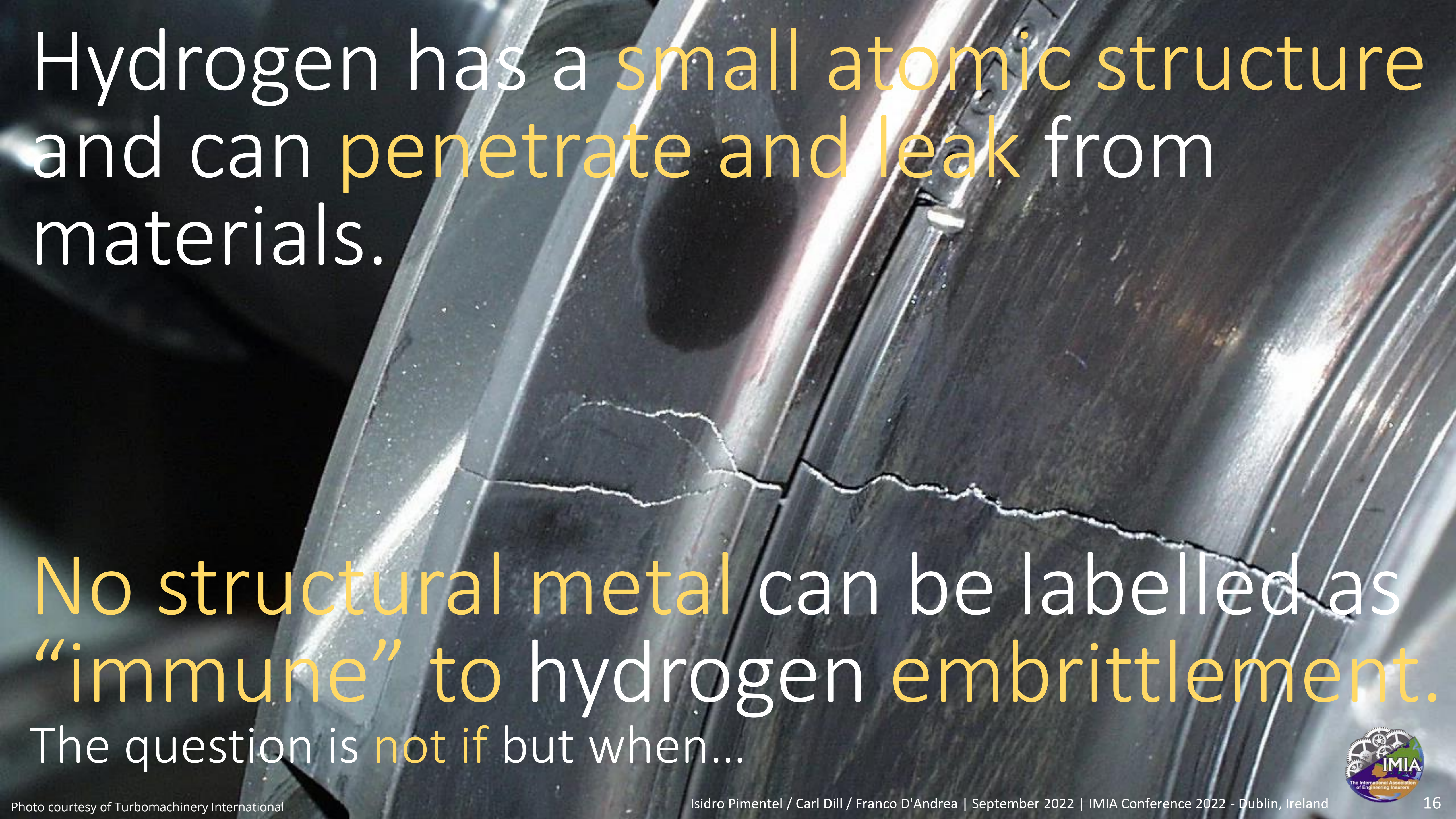
Leakage in steel and ductile iron systems mainly occurs through threads or mechanical joints

- Gasket failure, poor weld, valve condition, Containment material corrosion, hydrogen embrittlement
- Pipeline maintenance and support

<u>Historical claim</u>
AB Speciality Silicones Plant explosion

Most common causes of pipeline incidents (35%) involve equipment failure

Source: https://gasforclimate2050.eu/ehb/



Hydrogen has a small atomic structure and can penetrate and leak from materials.

No structural metal can be labelled as “immune” to hydrogen embrittlement.

The question is not if but when…

Photo courtesy of Turbomachinery International

Underwriting

Hydrogen technology as such is not new, but the sources, applications and the scale have evolved

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

Modular technology: Serial loss clauses (SLC)

Storage & distribution: Equipment fit for purpose, standards for refurbishment?

Downstream integration: Risks to / or resulting from existing property (TPL, hot-tie ins)

DSU/BI: Interdependencies due to evolving business models, lead times & volatility

LEG Green Hydrogen Exclusion (draft)

Significant initiative

Good checklist of key hydrogen risks for Underwriters, brokers and clients

IMIA is glad to further support

Risk Outlook

The hydrogen economy is still in its infancy, no doubt it will expand in the future

Key risk trends we anticipate:

- Industry standards & certification in the hydrogen economy likely to develop in line with other industries (e.g. renewables)
- Regulatory gap concerning the hydrogen economy will be closed → legal landscape (e.g. transport & storage) will be harmonized
- (OEM) market structure: with plenty of new entrants there will be more consolidation and professionalization
- Formation of industry bodies will help to foster the exchange of technical know-how and best practices

Recommendations to ensure bankability & insurability:

- Joint industry projects
  → OEMs, contractors, operators to join forces with investors, insurers, and trusted certification bodies to improve risk management
- Type tests & certification for key hydrogen equipment such as electrolysers
- Certification of projects to mitigate interface risk

Picture courtesy of Gerd Altmann @ Pixabay

While assessing hydrogen risks there is no one size fits all nor magic formula…

Comprehensive and careful Underwriting is essential.

Photo by Mario Hofer @ Pixabay

Coverage, Claims

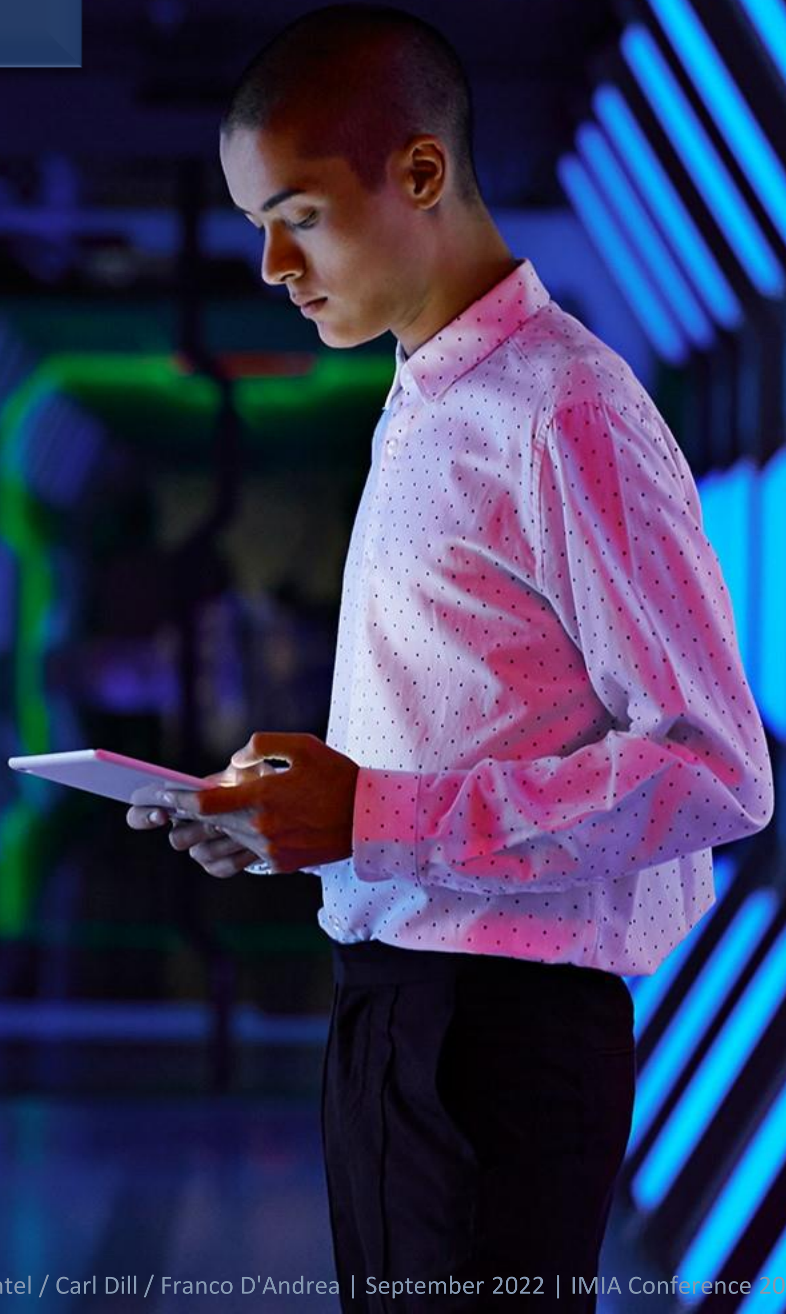


Image by DeSa81 from Pixabay

Coverage, Claims

Hypothetical claim scenarios

- 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
- Supplier insolvency – who wants to take the risk?

Epilogue

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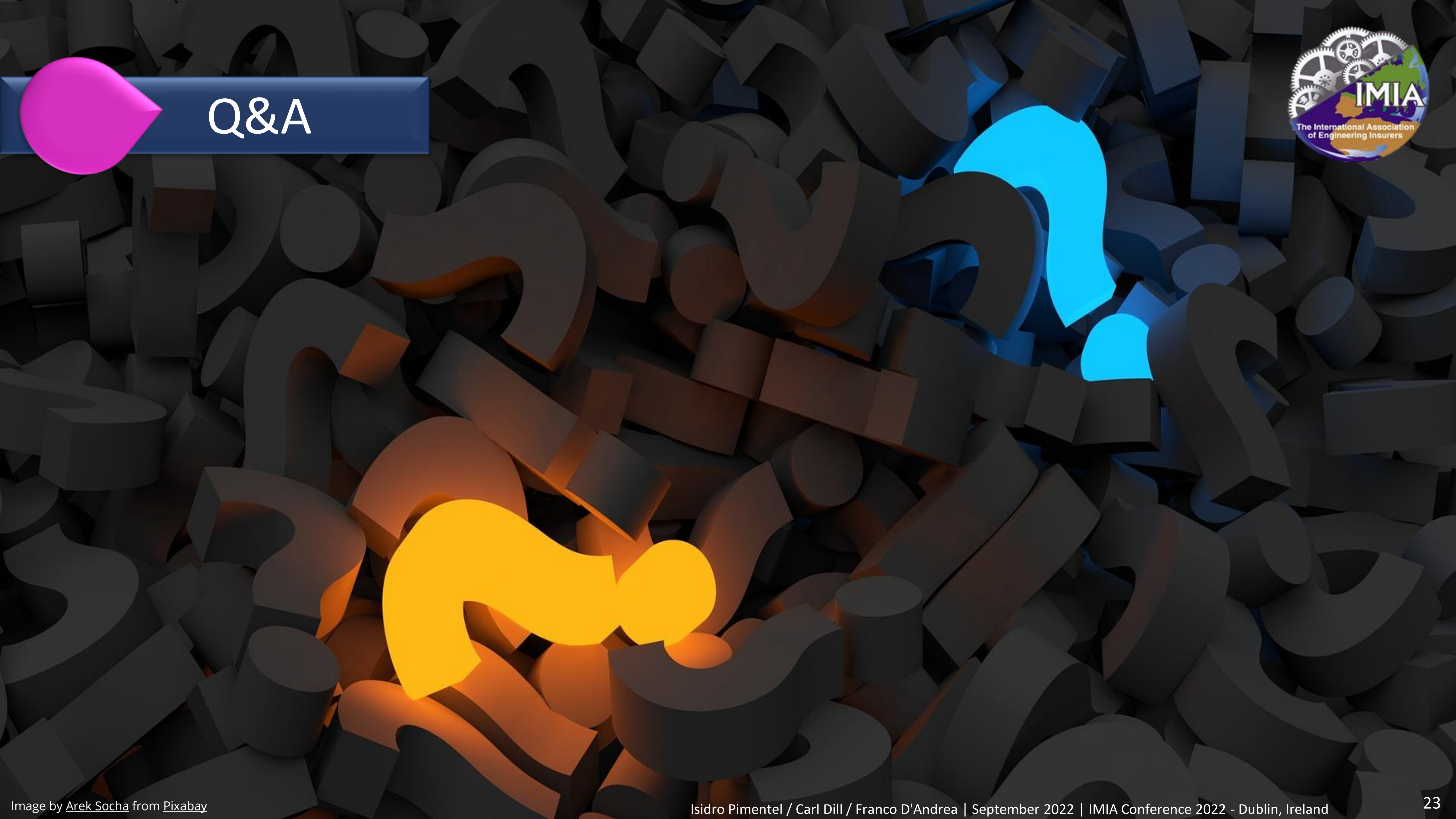

Q&A

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