Where will Hydrogen take us?

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Plan

Setting the Scene for Hydrogen

The Hydrogen Value Chain

What are the Risks for Insurers?

Setting the Scene

Limit global warming to well below 2°C

Current efforts are not enough to achieve the ambitions of the Paris Agreement

How to decarbonise the energy system:

1. improving energy efficiency,
2. developing renewable energy sources,
3. switching to low/zero carbon energy carriers,
4. implementing carbon capture and storage (CCS) as well as utilisation (CCU).

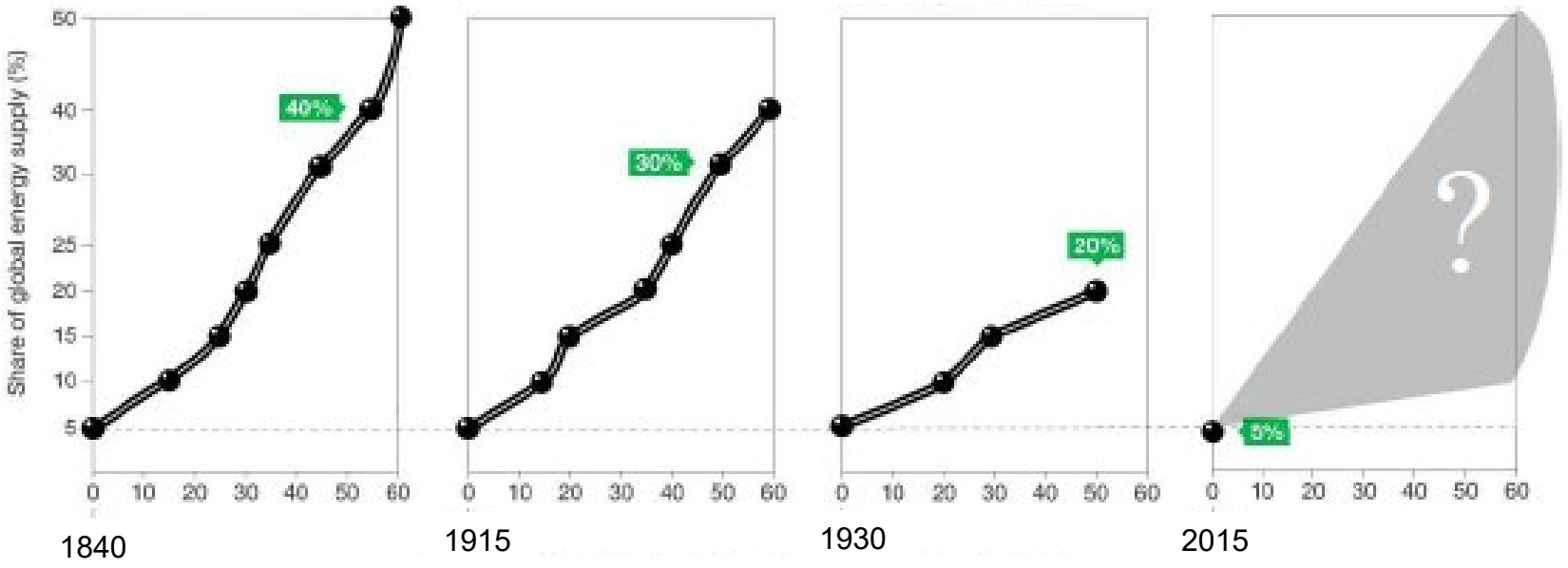
Energy Transitions Take Decades

Coal
50 years to provide 40% of global supply

Crude Oil
50 years to provide 30% of global supply

Natural Gas
50 years to provide 20% of global supply

Modern Renewables
Supplies only 5% of global demand

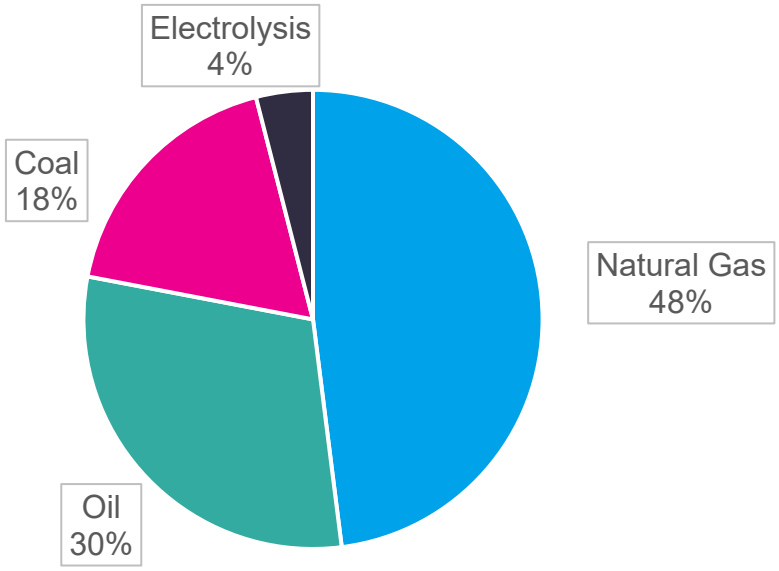


Source: Vaclav Smil. Modern renewables include: wind, solar, and modern biofuels

The Future of Hydrogen

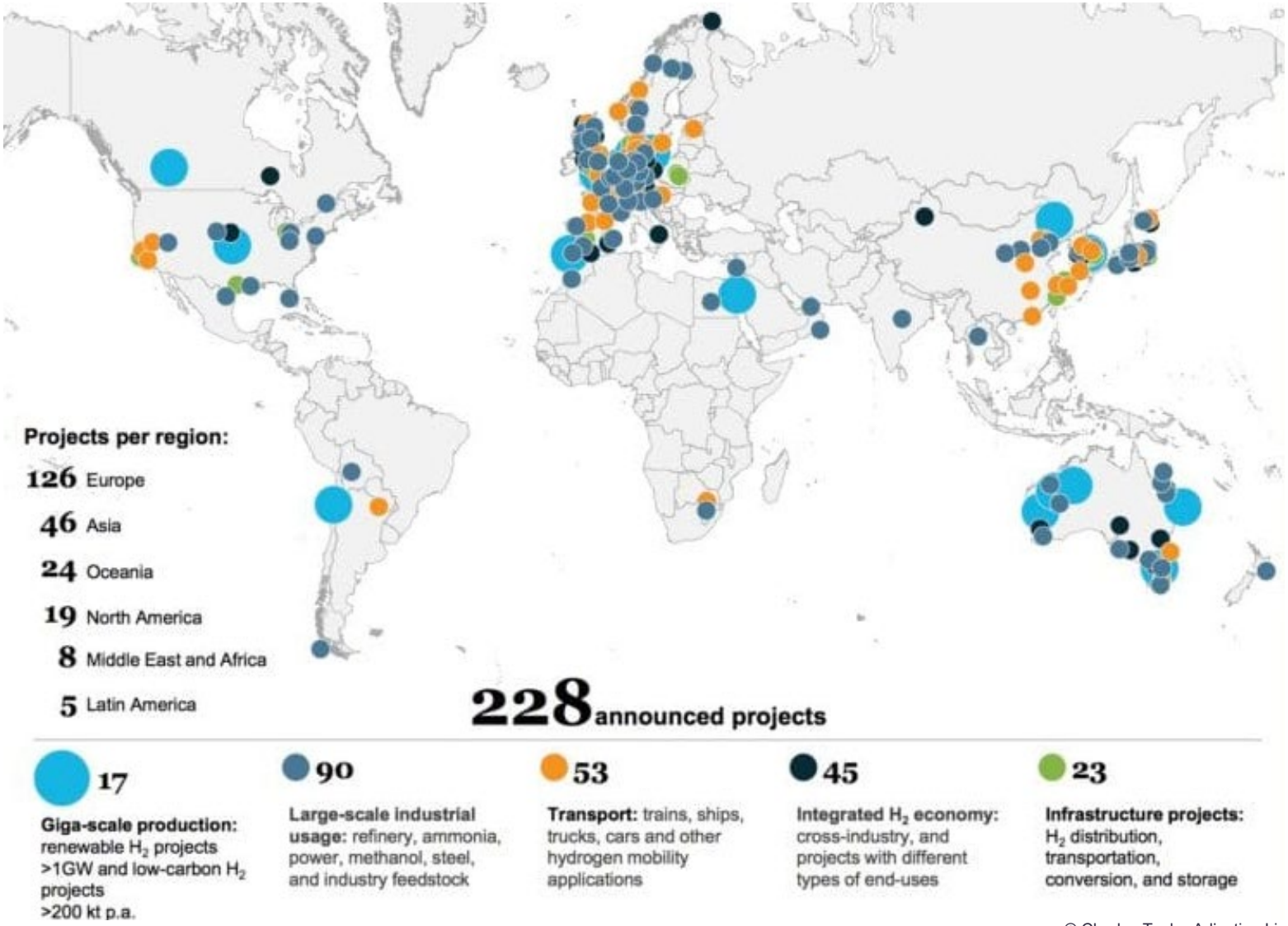
The future of hydrogen energy is wrapped up with the future of:

1. Natural gas
2. Renewable energy
3. Carbon capture and storage (CCS)



Current Methods of Production

Global Hydrogen Projects across the Value Chain



Source: Hydrogen Council / McKinsey & Company

Major Projects

Location	Project	Details
Canada	Air Liquide	8.2 tonnes of H2 per day.
Europe	HyDeal Ambition	To begin in 2022 aiming to deliver 3.6 million tonnes of H2 per year.
UK	HyNet North West	CCS & H2 – to deliver 80% of the UK's clean power target for transport, industry and homes by 2030.
Australia	Asian Renewable Energy Hub	Has approval for first 15GW phase and will include green H2 and Ammonia production.
	Infinite Blue Energy	AU$300 million 25 tonnes of Hydrogen per day expected to begin operating in 2022.
Kazakhstan/ Germany	Svevind	Plans for 30GW of Electrolysers to produce 3 million tonnes H2 per year.
Saudi Arabia	NEOM	$5 billion hydrogen project beginning production in 2025 aiming to produce a 1.2million tonne Ammonia plant.
Brazil	Enegix Energy	Singaporean/Australian company US$5.4 billion project aiming to produce around 600 million kg of H2 per year.

Source: Hydrogen Council / McKinsey & Company

Hydrogen Value Chain – Supply to Market

PRODUCTION STORAGE DISTRIBUTION UTILISATION

- Electrolysis
- Reforming
- Thermal

- Chemical
- Combustion
- Fuel Cell

How well do you know your hydrogen colours?

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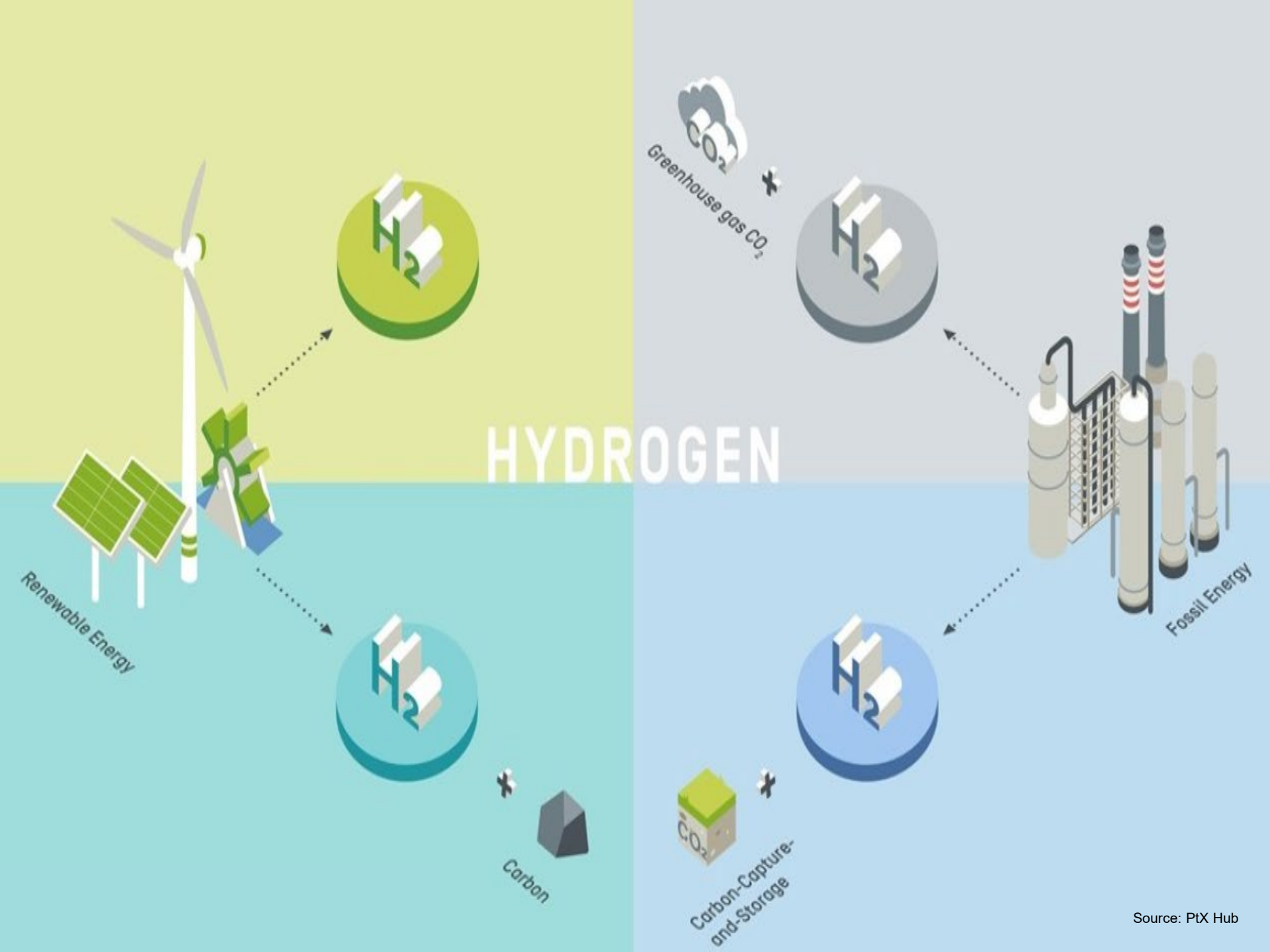
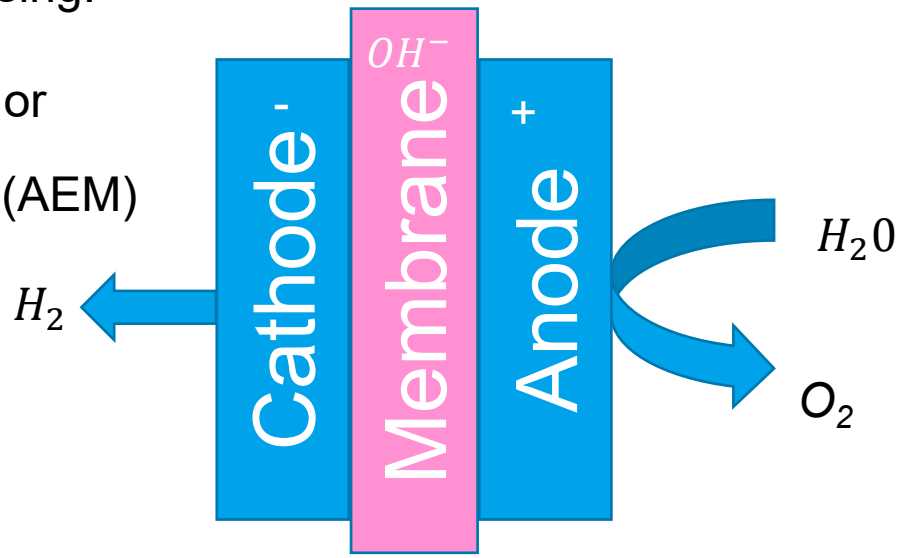


Source: PtX Hub

Green Hydrogen Production

Low-temperature electrolysis of water using:

- Proton Exchange Membrane (PEM), or
- Alkaline Anion Exchange Membrane (AEM)



PROS

No negative emissions

Produces high purity H_2

CONS

Requires a constant electricity source

Requires significant volumes of fresh water

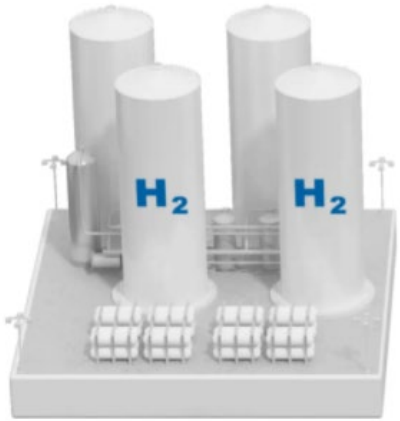
Economic issues

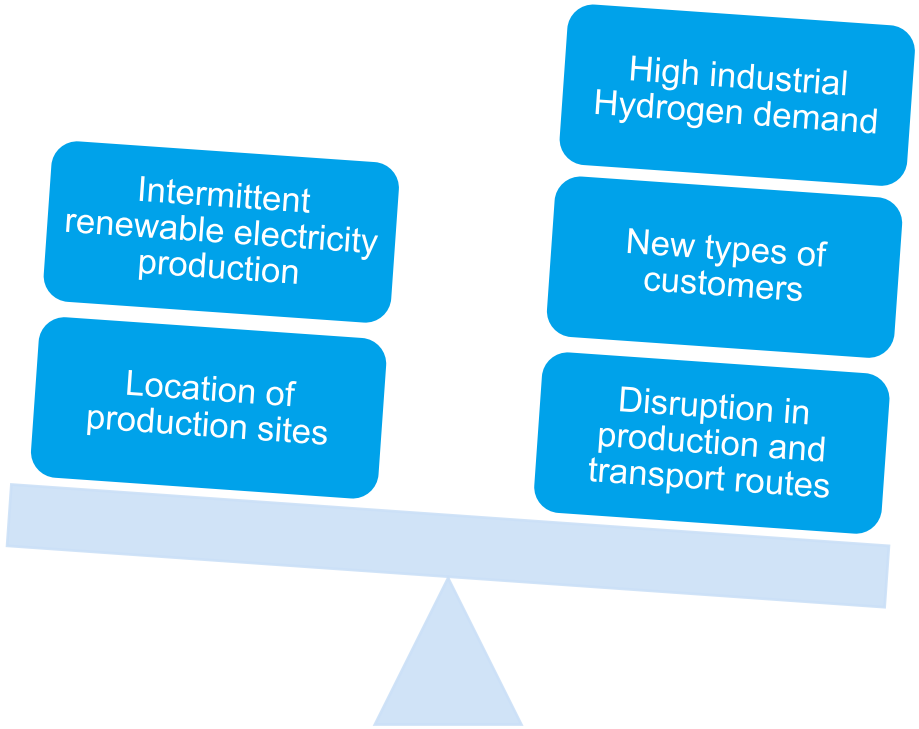
Requires storage and distribution

Hydrogen Storage and Distribution

Why do we need storage and transport solutions?

Supply vs. Demand





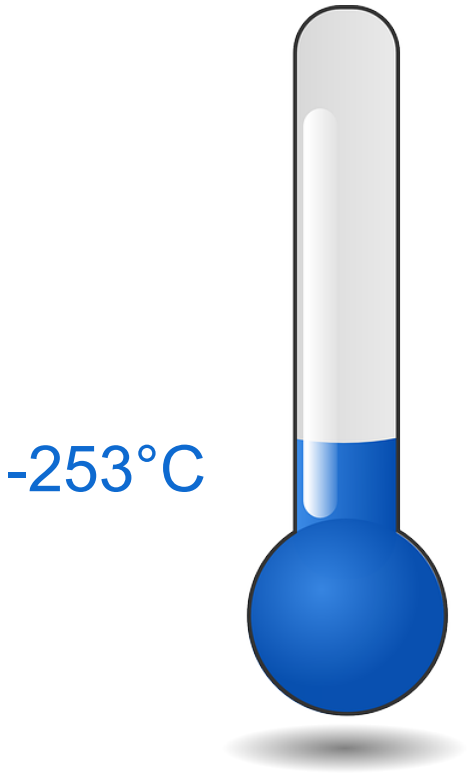
Hydrogen Storage

Factors to consider in finding the right method of Storage

- Safety
- Capital cost
- Capacity requirements
- Potential scalability
- Discharge time
- Efficiency
- Cycle life
- Replacement cost

Hydrogen Fundamentals

- A colourless, odourless, non-toxic gas
- Low ignition energy
- Wide flammability range
- It has the lowest density of all gases
- A very large energy density on a mass basis

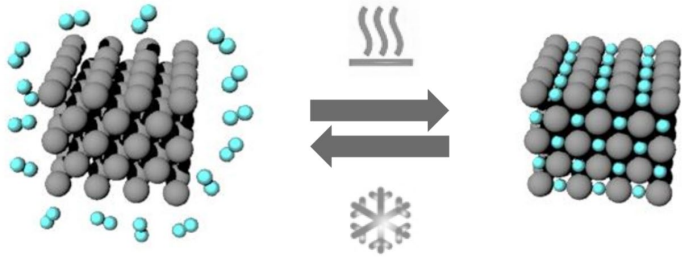


Hydrogen Storage

- Pressurised storage
- As a liquid

Energy Intensive

- Within a metal hydride



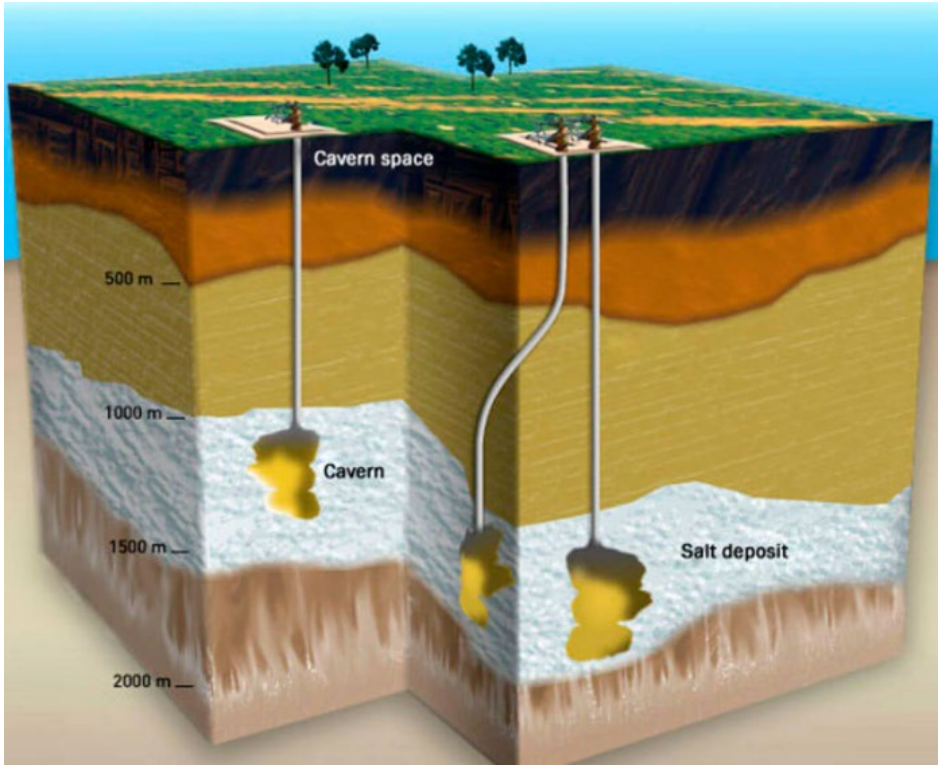
- As “Chemical Hydrogen” – as a chemical containing hydrogen which is then processed to release the hydrogen

NH_3

Hydrogen Storage

Underground Storage

- Aquifers
- Salt caverns
- Depleted fields



Source: Northern Gas Networks

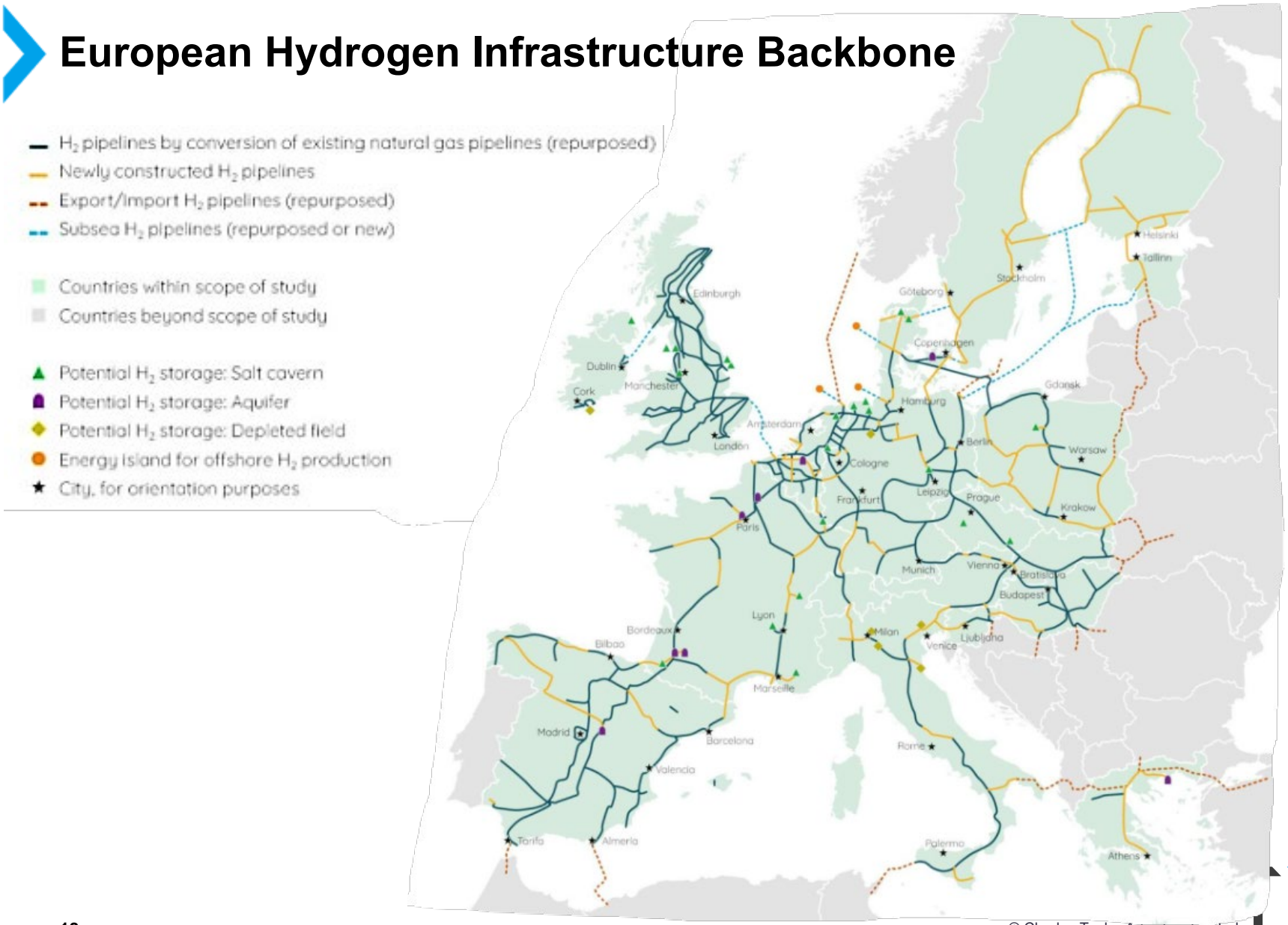
Hydrogen Distribution

- Repurposing Natural Gas pipelines
- New pipelines
- Repurposing import pipelines
- New subsea pipelines
- Ship
- Truck

Suiso Frontier (Source: HySTRA)

Liquid Hydrogen Tube Trailer

European Hydrogen Infrastructure Backbone



Hydrogen Utilisation

Hydrogen is already a well established market, but currently based on fossil feedstock

Grey hydrogen costs **~ $1.80/kg**

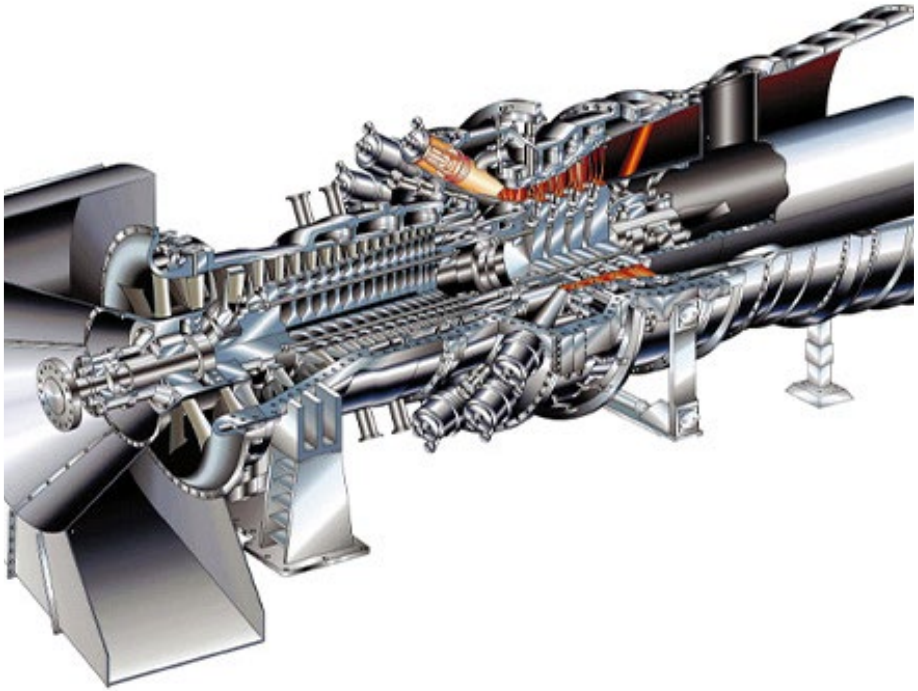
Blue hydrogen costs **~ $2.40/kg**

Green hydrogen costs **~$5.00/kg**

Source: S&P Global, April 2021

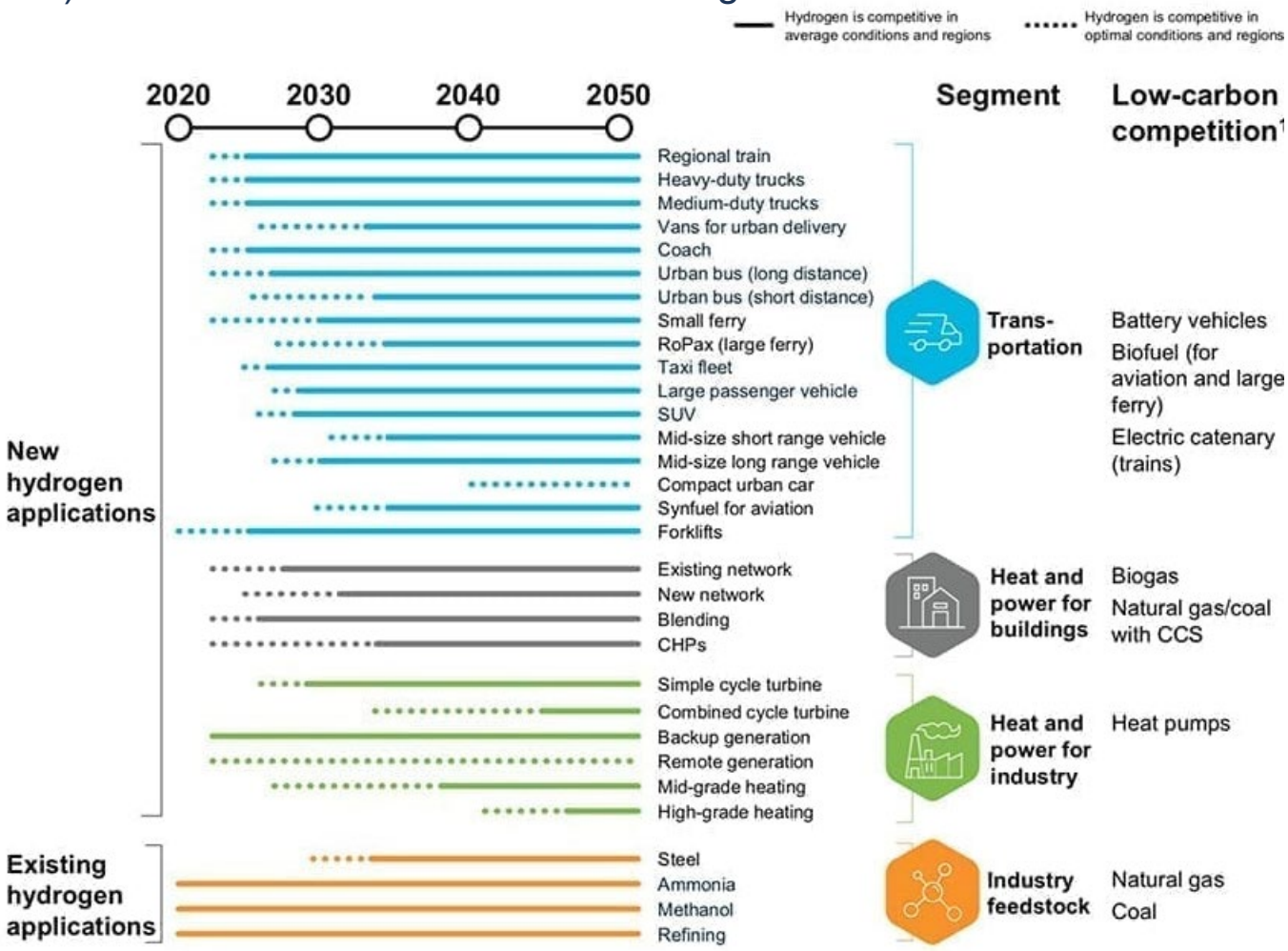
Hydrogen Utilisation

1. Industry
    - Refining
    - Ammonia
    - Methanol
    - Steel
2. Transport
    - Fuel Cells
    - Shipping
    - Aviation
3. Heat
    - Hydrogen boilers
4. Power
    - Gas turbines



Competing with other energy products

How Hydrogen solutions could compete with currently available low-carbon (such as batteries) and conventional alternatives through 2050.



Source: The Hydrogen Council

What are the Risks?

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Hazards

- Hydrogen easily ignites and has a wide flammability range
- It is a light gas and should rise unless trapped or discharged at high pressure when it will mix with air and form and explosive cloud
- Hydrogen is often stored at high pressure with High Pressure Vessel Rupture potential
- Hydrogen explosions are possible
- Ammonia is a toxic gas and also flammable/explosive
- Metallurgical problems under certain conditions (Hydrogen Embrittlement, High Temperature Hydrogen Attack.

The Risks

- Freezing of liquids at low temperatures
- Effect of cold liquids on ordinary metals
- Piping design to eliminate leaks
- Brittle fracture of steels
- Thermal shock
- Boil-off creating high pressure in a tank
- Handling highly volatile liquids
- Mechanical failures
- Stringent operating procedures required
- Storage capacity
- Tanker hull Size
- New Technology

What do Underwriters need to know?

- How big an event?
- How likely?

How Big?

- Hydrogen has a higher energy content than many gases but is much lighter. If unconfined jet fires, flash fires and fireballs are more likely than a Vapour Cloud explosion.

  Note that hydrogen flames are almost invisible during daylight and fires might not be detected.

- High Pressure Vessel Rupture (HPVR) is a potential hazard.

- Releases of ammonia provide a liability exposure.

- Current Emergency Response practices may need to be modified – for example to deal with invisible flames.

How Often?

- Incidents in Ammonia plants (which produce hydrogen) are not uncommon but more plants could mean more incidents.
- As more hydrogen transportation infrastructure is produced, there is potential for fires, explosions and toxic gas releases.
- There could be small incidents but numerous – for example, a car leaking hydrogen in a garage could have a similar affect to a natural gas explosion.
- There has been extensive research into Hydrogen distribution as storage but this might not have identified all hazards.

https://www.thechemicalengineer.com/features/hydrogen-informing-a-safe-decision-to-achieve-net-zero/

Other Factors

- Contingent exposures may increase for example, loss of power for electrolysis units or incidents at Carbon Capture and Storage facilities may result in hydrogen from methane units closing.
- The basic technology is known for all parts of the hydrogen economy, but rapid expansion may reveal previously unrecognised hazards, for example the suitability of pipelines for 100% hydrogen duties is unclear. https://www.osti.gov/servlets/purl/1646101
- Liability exposures may increase with large numbers of hydrogen powered vehicles on the road and a massively increased infrastructure.
- Scale-up of equipment sizes may generate problems.
- Demand for hydrogen facilities could result in corner cutting by suppliers.
- There will need to be a rapid increase in the workforce at hydrocarbon facilities
- Regulatory oversight will vary between countries.

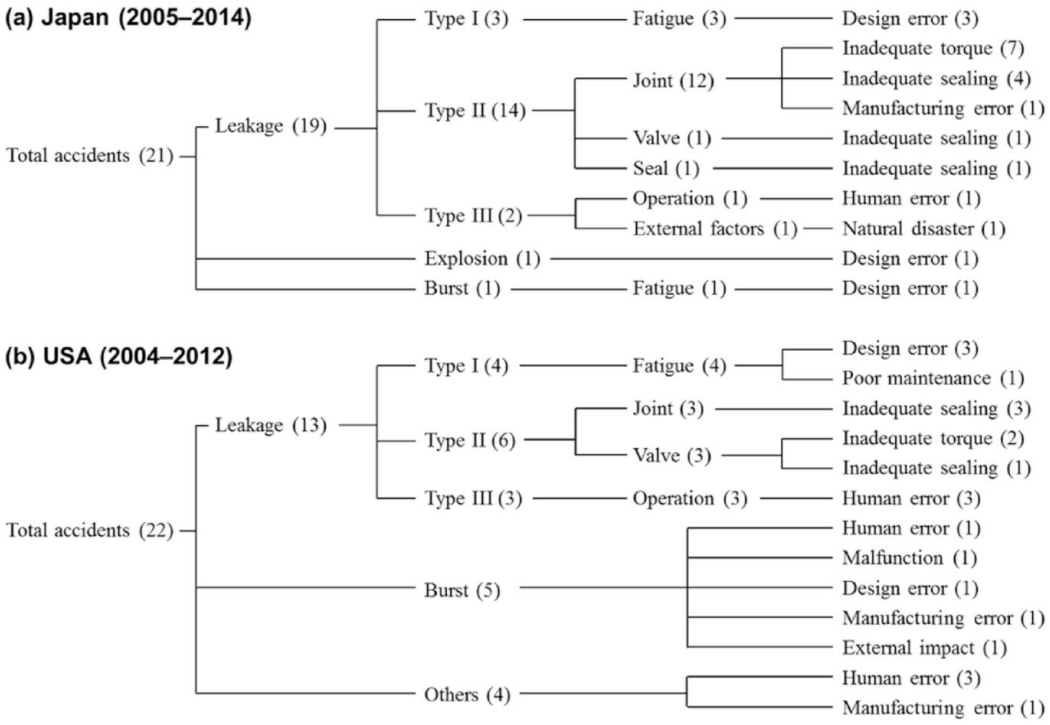
Experiences so far (1):

- Accidents in the ammonia and chlor-alkali industry (a similar electrolysis process to electrolytic hydrogen production) are well known and number may increase as the number of production units increase.

- Three incidents involving hydrogen have been reported in recent years:
  - Gangneung (Korea)
  - Santa Clara (USA)
  - Baerum (Norway)

Experience so far (2):

A separate study compared incidents in Japan and US and hydrogen refuelling stations over a period of years with the following incidents recorded https://www.sciencedirect.com/



Reported cause of many of the incidents suggest lack of familiarity/knowledge of hydrogen operations.

Final Thoughts

- Interest in Hydrogen projects is surging and inevitable
- To see an uptake in Hydrogen projects requires suitable policy and regulatory framework
- Collaboration between industries
- Needs to be a focus on developing the storage and distribution infrastructure
- With rapid expansion plans for Hydrogen production and infrastructure are adequate industry standards in place?
- Industry's role is to establish the market for Hydrogen
- Need to monitor the new technology developments
- Despite the relatively simple processes, Green Hydrogen producers will suffer from a lack of knowledge and experience
- Those already writing traditional grey hydrogen as part of refineries, will existing policy wordings work?

What does the Insurance market need to do to prepare for a Hydrogen Economy?

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