

Delivering a more sustainable world

New Energy - New Risks
Peter Verduijn



Heatwave & severe fires Canada 2021



Heavy Rain & Flooding Germany/ Belgium/ the Netherlands 2021





SUSTAINABLE DEVELOPMENT GOALS



Changes in projects... From this....



Oil- and gas production



Refinery



Classic Power Generation



To this....

Hydrogen

Wind Power

Biofuels

Concentrated Solar Power

New Chemistry



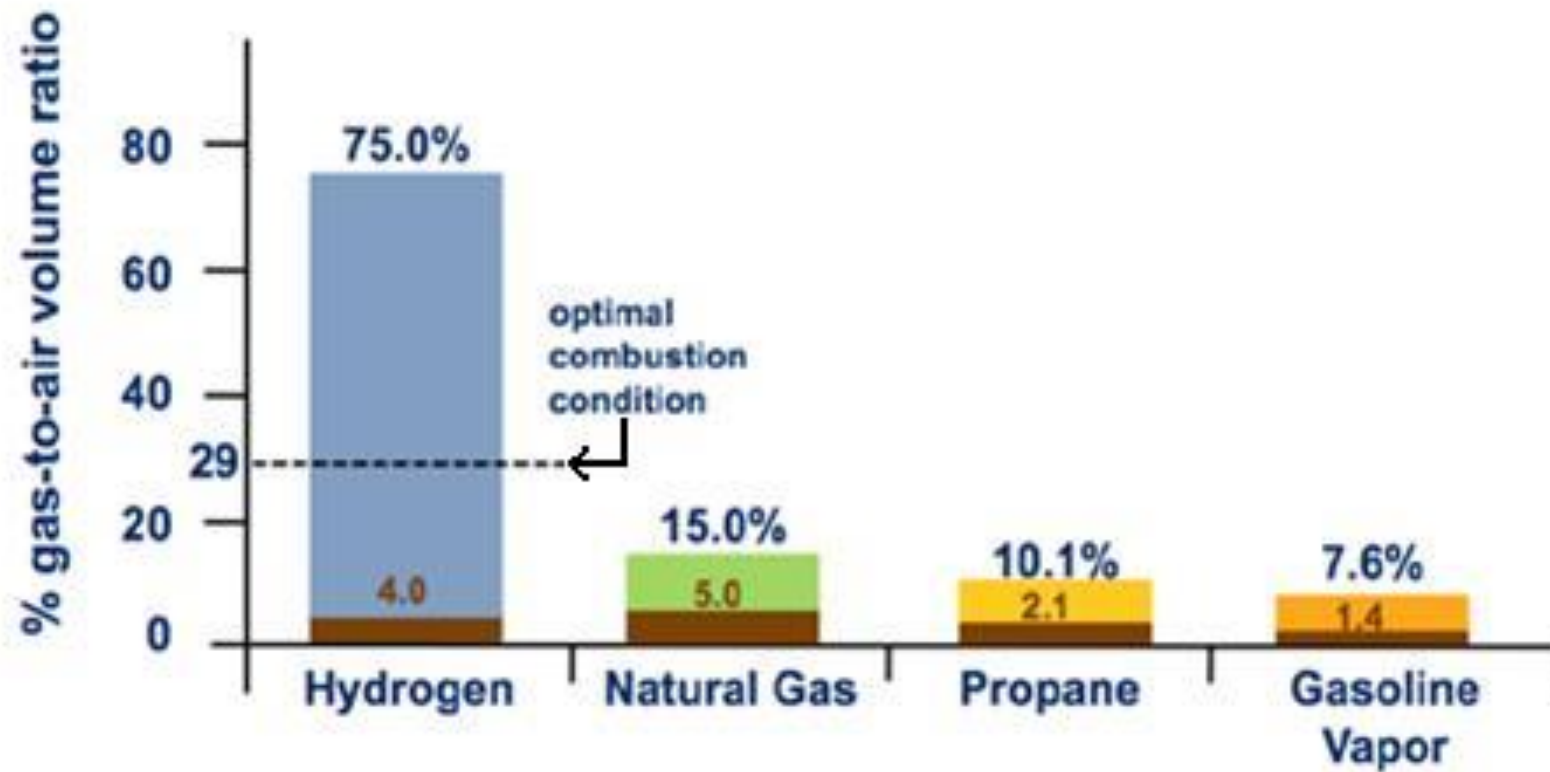
HYDROGEN Properties and Behaviours

- Lightest molecule in the universe. Small molecule with low viscosity
=> prone to leakage
- 14 x lighter than air => rises at almost 20 m/s and disperses rapidly.
=> built-in safety advantage in an outside environment.
- Colorless, odorless and tasteless.
=> undetectable by human senses
- High energy content by weight, but not by volume.
=> high pressure storage
- Non-corrosive, but it can embrittle some metals.
=> can significantly deteriorate mechanical properties of some metals.



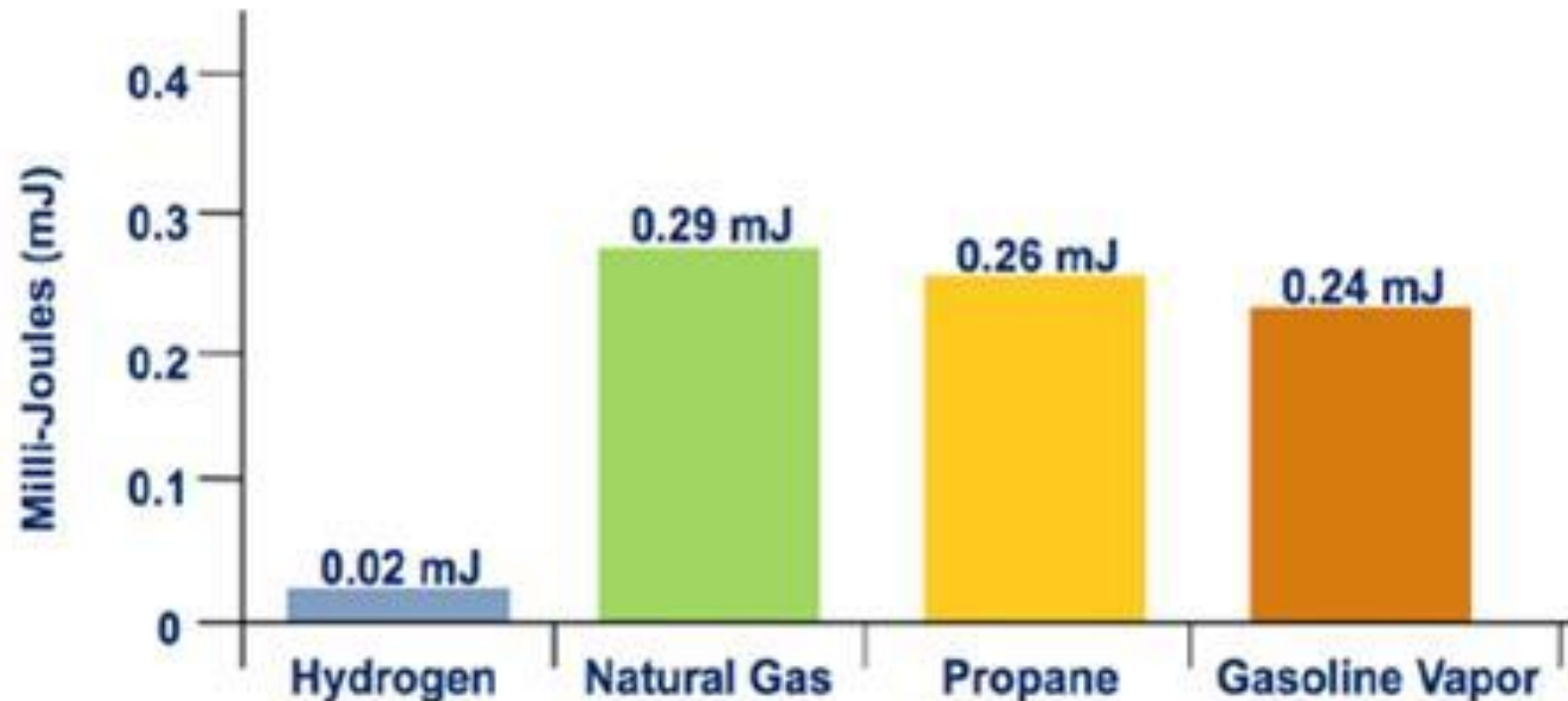
HYDROGEN Properties and Behaviours

- flammable and explosive over a wide range
=> 4%-75% in comparison with 5%-15% for natural gas



HYDROGEN Properties and Behaviours

- Very low ignition energy => 0.02 mJ in comparison with 0.29 mJ (Natural Gas) => small spark can already cause ignition (e.g. static electricity, mechanical impact/friction/metal fracture, hot surfaces) => safety distance from combustible materials

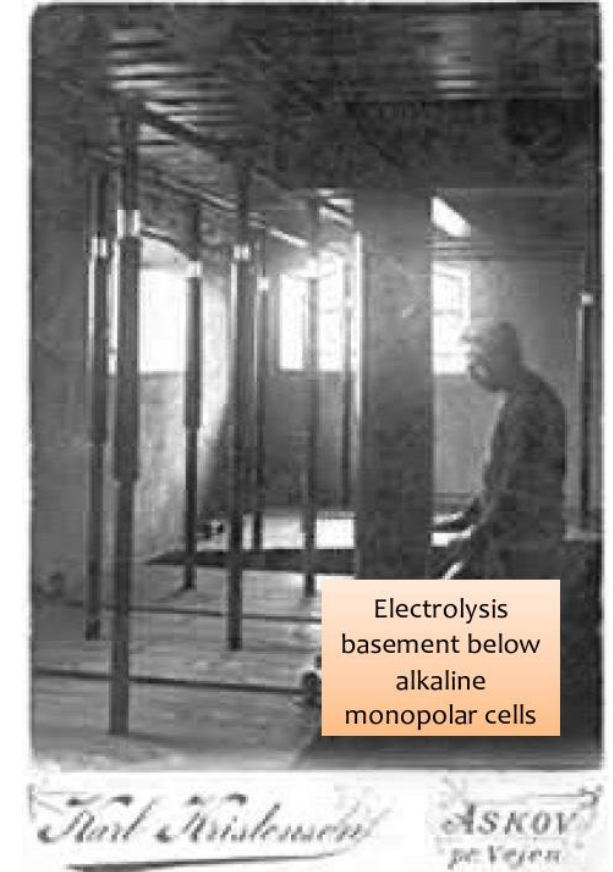
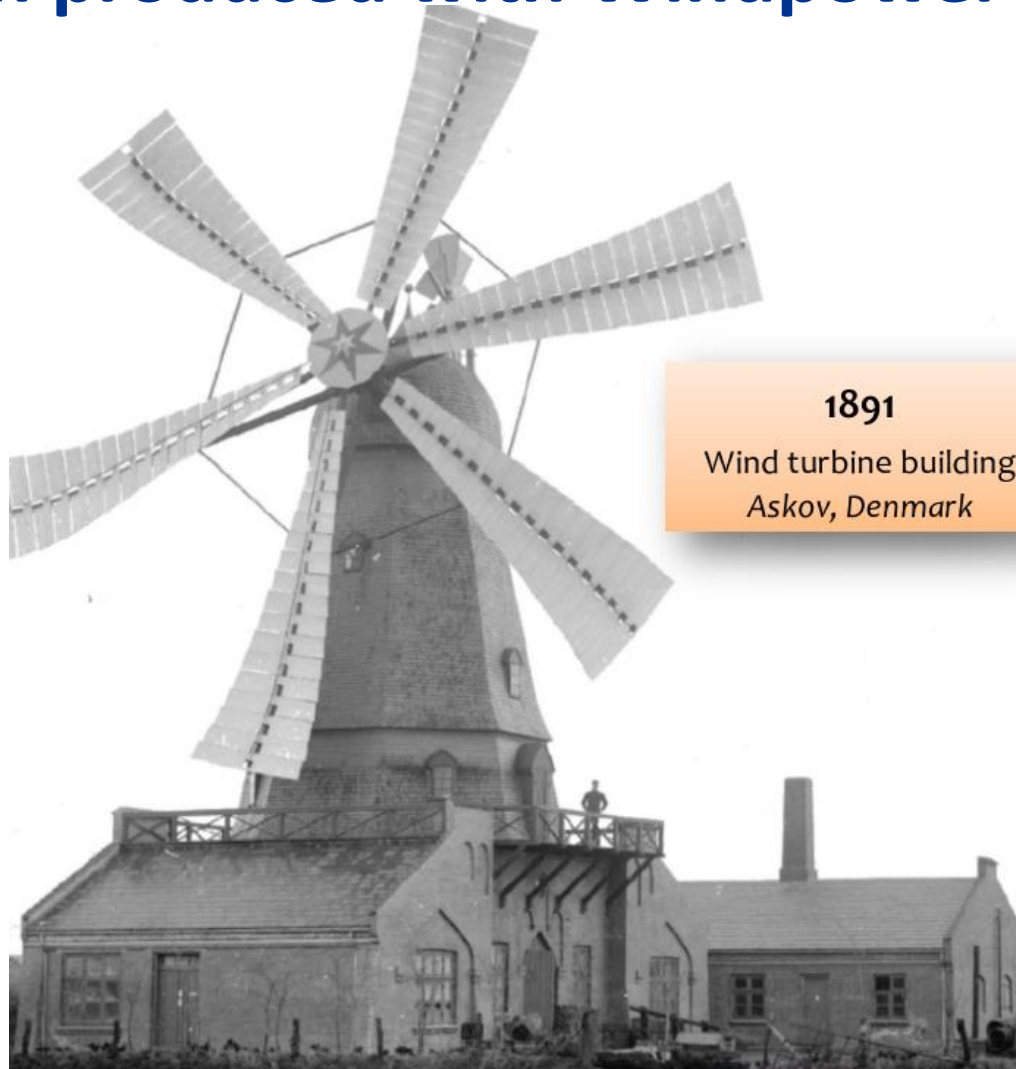
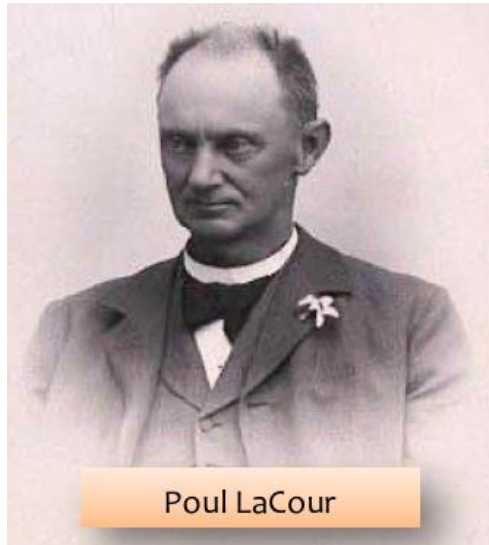


HYDROGEN Properties and Behaviours

- Hydrogen flames are pale blue => nearly invisible in daylight => detection equipment required.



1891 – Hydrogen produced with Windpower



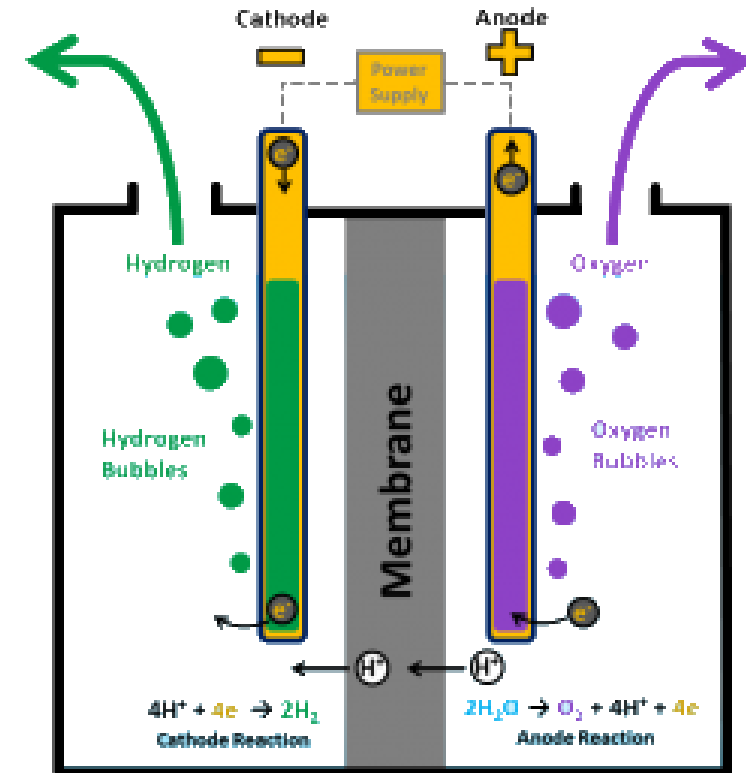
On windy days up to 1000 litres of hydrogen and 500 litres of oxygen were produced per hour.

Images, text – <https://www.poullacour.dk/en/storing-wind-power/>

Setting the scene - H2 - In Equipment detonation

One of the major hazards related to H2 Electrolyser projects is **In Equipment Detonation**.

In Equipment Detonation could occur after Cross-over between O2 and H2 Product storage due to Cell membranes degradation.



Safety in Design Green Hydrogen



In Equipment Explosion : AEME research facility South Korea
2 men died and several buildings 100 meters away have been seriously damaged

For a 5 MWe pressurized electrolyzer module an in equipment detonation of hydrogen is equivalent to approx. 110 kg TNT. Requires 60 cm thick walls to mitigate explosion risk.

With scaling up these installations with 10x, 100x, 1000x will result explosion power of **x ton TNT**.



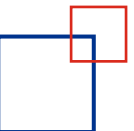
In comparison: on 13 mei 2000 in the city of Enschede NL there was an explosion in a firework production plant (23 people were killed and 947 injured).

This explosion was equivalent to approx. **4.5 ton TNT**.

Considerations

- **Green hydrogen industry is still immature**
 - Technology vendors, Operators and Contractors are **inexperienced** and in a race for scale up
 - Current largest built and operating Electrolyzer in Europe = 10 MW Scale up while current projects scale up to 4 GW or more.

		Potential Consequences				
		L6	L5	L4	L3	L2
		Minor injuries or discomfort. No medical treatment or measurable physical effects.	Injuries or illness requiring medical treatment. Temporary impairment.	Injuries or illness requiring hospital admission.	Injury or illness resulting in permanent impairment.	Fatality
Likelihood	Expected to occur regularly under normal circumstances	Not Significant	Minor	Moderate	Major	Severe
	Expected to occur at some time	Almost Certain	Medium	High	Very High	Very High
	May occur at some time	Likely	Medium	High	Very High	Very High
	Not likely to occur in normal circumstances	Possible	Low	Medium	High	Very High
	Could happen, but probably never will	Unlikely	Low	Low	Medium	High
		Rare	Low	Low	Low	Medium

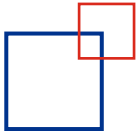


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- **Risk Assessment for Energy transition projects are more complex:**
 - 1.Increased unknown unknowns
 - 2.New players

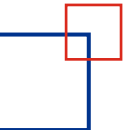
Learning from recent natural disasters; risks are not always adequately assessed and therefor no proper mitigations are in place.



Considerations

- **(Increased) involvement Authorities**
- **Early start required Permitting application process for applying for funding and subsidies.**
- **Need to conduct Consequence assessments for more complex situations in early stage of the project.**

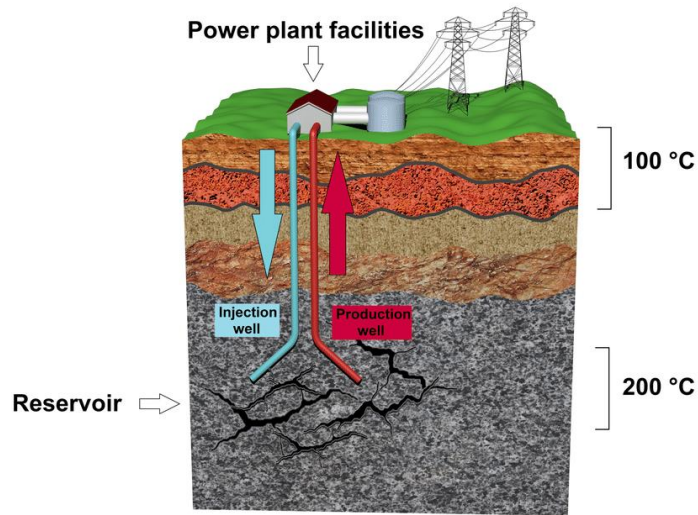
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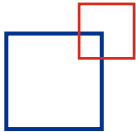
- New Energy will introduce new Risks

		Potential Consequences				
		L3	L4	L5	L6	L7
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Never downplay risks, aim on Inherently safer design and ALARP.

Better safe than sorry.





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