Hydrogen Storage Technologies

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Aim of the Project

The Aim of the project is to research in detail each form of Hydrogen storage, identify current research challenges associated with each method, and to identify research challenges/limitations.

Background

Hydrogen can be a key energy source in the battle for net zero carbon emissions. It is an ideal fuel source with a calorific value of roughly 130 MJ/kg, 3 times that of fossil fuels such as petrol and diesel. Hydrogen can be produced via electrolysis of water meaning the entire process of production to use is fully carbon free. The key difference between Hydrogen and other leading renewable energy sources is it can be produced all year round with no ‘off seasons’. With more research into how to store Hydrogen safely and efficiently, it can be pivotal in our goal of saving the planet.

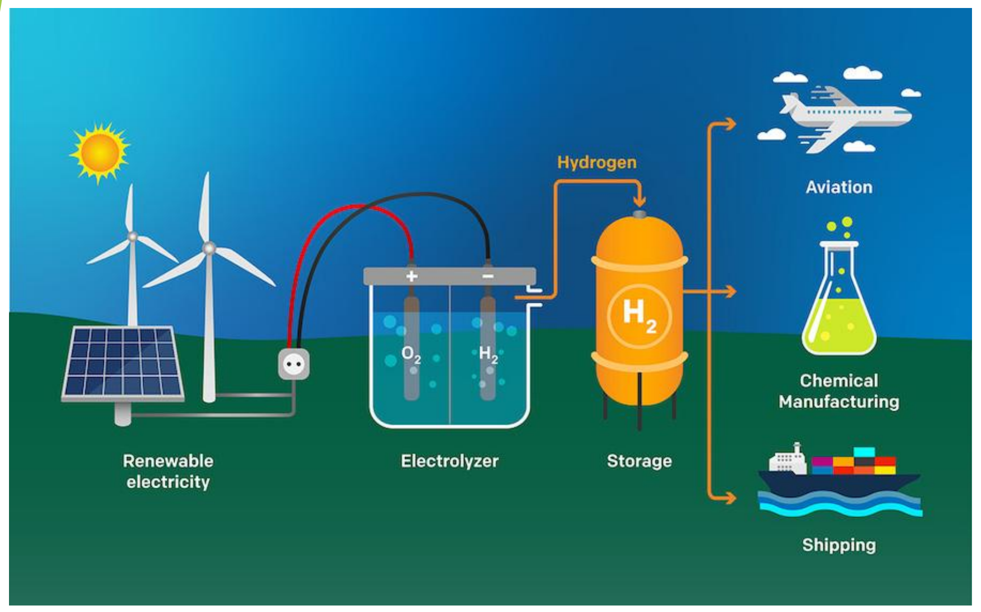

Figure 1: Green Hydrogen Production

Hydrogen has 3 states in which it can be stored, solid, gas, and liquid. Each state comes with its own pros, cons, and research problems.

Compressed Gas Storage

Gas storage is the most widely used form of hydrogen storage. There are 4 types of vessels, 1-4, which store Hydrogen at pressures of 350-700 bar. They are made of high strength materials such as carbon fibre composites or metal alloys with the higher pressure rating vessels having polymer linings.

Gas storage for Hydrogen is at TRL 7 and is already in commercial use. As its already a well researched and proven the only future path for compressed gas storage is improving on storage capacities via stronger materials and higher storage pressures.

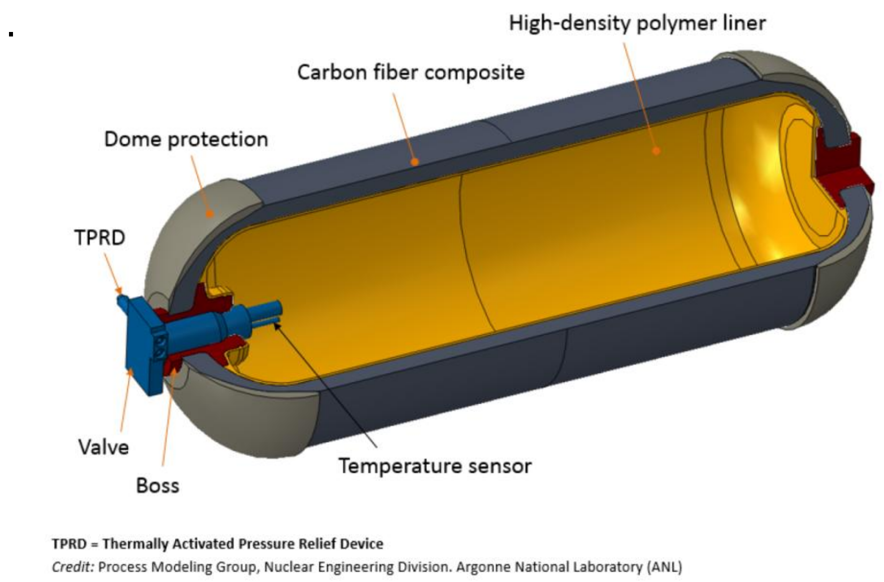

Figure 2: Type 4 Compressed Gas Storage Vessel

The main drawback to compressed gas storage is risk of leak/explosion. While this is not an issue for stationary storage, as the Hydrogen Economy advances so do the applications for hydrogen as a fuel. Risk of damage to the vessel storing hydrogen in a vehicle is significantly higher and can be catastrophic making other storage methods more appealing.

Figure 3: H4M Test Vehicle

Solid State Storage

Solid state Hydrogen storage, in particular metal hydrides, is a promising solution to the drawbacks of compressed gas hydrogen.

Metal hydrides involves a metal adsorbing hydrogen, creating a composite formed of strong chemical bonds. This process is reversible with the input of heat and occurs typically at low pressure, eliminating the risk of explosion/leakage associated with gas storage.

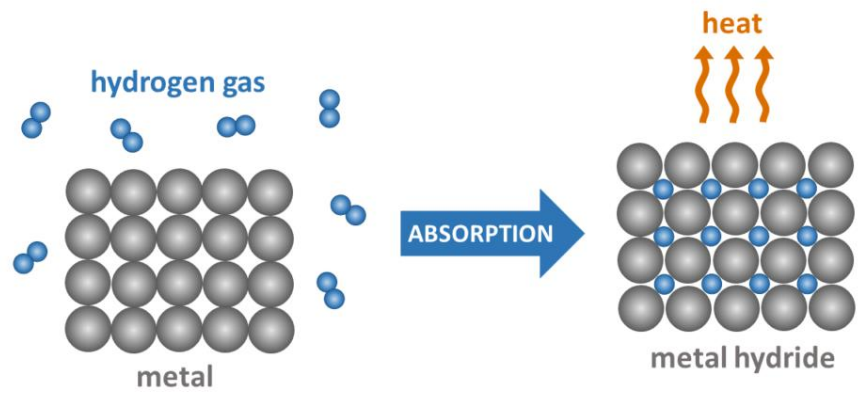

Figure 3: Metal Hydride Process

Metal hydrides are only at TRL 5 meaning they havnt seen commercial use yet, however there have been successful uses of them in test tanks and vehicles. The most popular/researched metal is magnesium. This is due to its high storage capacity of roughly 7.6 wt%. The difficulty with magnesium is for the process to occur it requires 300 ºC. Researchers are aiming to reduce the operating temperatures, and increase cyclability and kinetics. This is done by altering the composition of materials in the hydride such as adding catalyst and other compounds.

This is costly and time consuming research, done through experimentation, multiscale modelling, and use of Neural Network AI. Researchers believe that metal hydrides will be commercially viable in the next 10-15 years.

Conclusion

Hydrogen is the future of renewable energy. The key to unlocking hydrogen for further commercial use is developing storage technologies so that hydrogen can be used across multiple applications.
With gas and liquid storage being highly researched and used the next step is to get solid state hydrogen to the same level.
Research into hydrides comes with a few limitations mainly cost and availability of materials and the time to model a composite. Multiscale modelling can take up to 6 months for a single composite.
The methodology of researching hydrides is sound and with additional resources and time it will become commercially viable.
The ultimate goal is to be able to integrate a 100% green energy source across all sectors, from powering homes and vehicles to fuelling rockets used to explore space.

References

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