Hydrogen Storage
UKHA Fact Sheet Number 4

THE STORAGE CHALLENGE

The automotive sector presents a particularly clear example of the scale of the challenge. Given that 5 kg of hydrogen is roughly equivalent to 5 gallons (or 22 litres) of petrol, to store it under ambient conditions would require a 5 metre diameter vessel – which is impractical. This shrinks to 0.5m if you store the hydrogen at its triple point. Storing it as a liquid (at -253 degC), creates challenges in insulation and avoiding evaporation losses. Storing it as a gas under pressure (say 350 bar) requires a heavy, thick-walled tank or the development of new, lightweight composite materials. Doubling the storage pressure (in order to extend vehicle range by 60%) increases the challenge considerably. In all cases, there remains the question of safety – and perceived safety – in the event of road accidents. Similar questions arise when looking at storing hydrogen indoors for CHP applications or when looking at ways of fuelling portable fuel cell devices.

Photo: Ford Hydrogen Tank – from National Hydrogen Association media downloads

CURRENT PRACTICE

<u>Storage under pressure</u>
Cylinders typically store hydrogen at 200 bar. A standard K cylinder contains about 4 kg of hydrogen and weighs about 400 kg. For larger hydrogen systems a Manifolded Cylinder Pack (or MCP) of 16 cylinders can be supplied to avoid the need for frequent cylinder changeover. When empty, the MCP is either replaced or refilled from a hydrogen tube trailer. Above that size, and in an industrial setting, one could consider a dedicated hydrogen pressure vessel designed and operated in compliance with the relevant codes and standards. Underground storage in salt caverns formed by solution mining is also practised where storage of several hundred tonnes of hydrogen is required. Typical storage pressure would be 40 bar. Such a system can be dry (gas only) or wet (using brine for displacement).

<u>Storage at low temperature</u>
Hydrogen can be stored as a liquid at -253 degC. Given high enough levels of thermal insulation and a suitably rapid rate of hydrogen use, evaporation losses can be kept low.

<u>Storage in solid form</u>
Various metal hydrides are being used. Hydrogen reacts with metals like Lithium to form a solid metal hydride, which can then release the hydrogen under controlled conditions on demand.

FUTURE DEVELOPMENTS

The diagram overleaf illustrates a range of possibilities and compares them in terms of operating temperature, the energy required to release the hydrogen from storage, and the percentage of the material weight that is actually hydrogen.

<u>Porous materials</u>
Recent research results show that hydrogen can be stored on porous materials (using metal organic frameworks) at 6-8 wt% at temperatures of minus 196 degC. The search is on to find ways of achieving similar levels of storage at temperatures closer to ambient, perhaps by raising the pressure to around 50 bar.

<u>Chemical storage/release</u>
One possibility is to use liquid organic hydride technology such as the reversible reaction between methyl cyclohexane and toluene.

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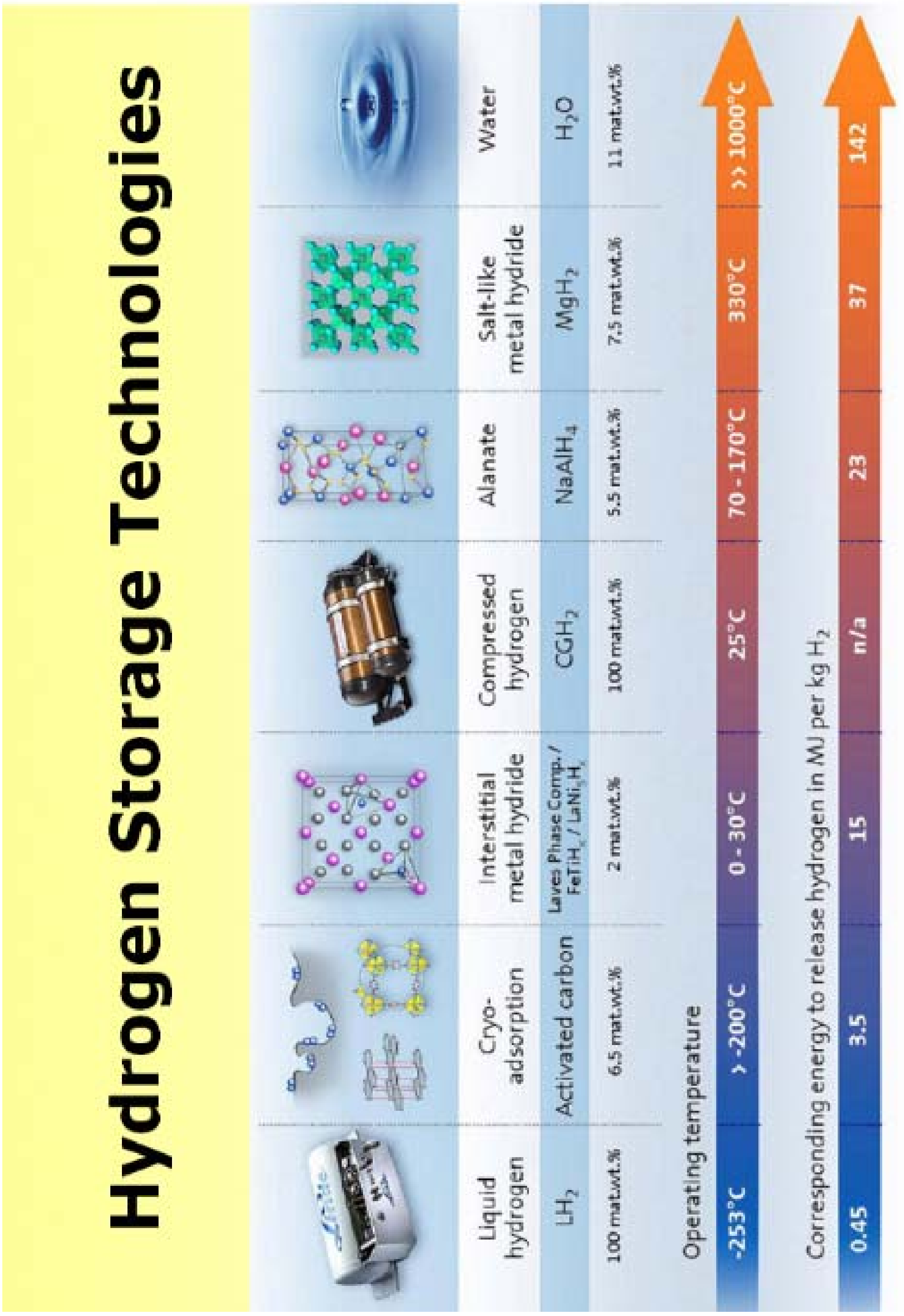
UNITED KINGDOM HYDROGEN ASSOCIATION



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