UK H_2Mobility White Paper on Hydrogen Refuelling Station Reliability

Introduction

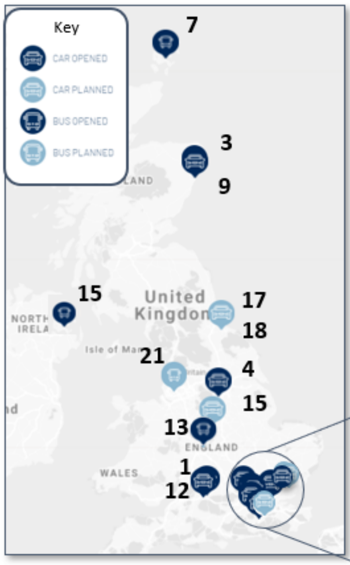
The UK H_2Mobility consortium brings together leading industrial players with an interest in the use of hydrogen for mobility in the UK. The group works in partnership with the UK Government (BEIS and DfT) and devolved administrations (Transport Scotland and Welsh Government) who attend the group as observer partners. The industrial members include:

The consortium partners helped to establish the early deployment of hydrogen vehicles in the UK and continues to press for an expansion of the use of hydrogen as a fuel for mobility. This document summarises the learning from some of these early deployments with respect to the reliability of hydrogen refuelling stations when in day to day operation, providing a perspective on the performance of the first generation of stations and prospects for the next wave of station deployment.

Achievements to date

The UK hydrogen mobility sector can be considered to have completed a ‘first generation’ trial of hydrogen refuelling stations, hydrogen supply chain and vehicles on the roads which has been developed over the previous 10 years and now sees 15 publicly available refuelling stations and ~300 hydrogen vehicles on the roads in the UK.

Hydrogen refuelling stations in the UK today



#	Location	Operator	Capacity (kg/day)	Pressure (bar)	H_2 source	Launch
1	Swindon, Honda	BOC	200	350 &700	On-site WE	2011, 2014
2	Hatton Cross, London	Air Products	80 (250)	350 & 700	Delivered SMR	2012 (2021)
3	Kittybrewster, Aberdeen	BOC	360	350 & 700	On-site WE	2015, 2018
4	AMP, Sheffield	ITM Power	80 (540)	350 & 700	On-site WE	2016 (2022)
5	NPL, Teddington	ITM Power	100	350 & 700	On-site WE	2020
6	CEME, Rainham	ITM Power	100 (270)	350 & 700	On-site WE	2016 (2021)
7	Orkney	ITM Power	80	350	On-site WE	2016
8	Shell, Cobham, London	ITM Power	80	350 & 700	On-site WE	2017
9	Tullos, Aberdeen	Aberdeen City Council	80	350 & 700	On-site WE	2017
10	Shell, Gatwick, London	ITM Power	80	350 & 700	On-site WE	2019
11	Shell, Beaconsfield	ITM Power	80 (270)	350 & 700	On-site WE	2018 (2021)
12	Swindon, J Matthey	ITM Power	80	350 & 700	On-site WE	2018
13	Tyseley Energy Park, Bham	ITM Power	1,200	350 & 700	On-site WE	2021
14	Metroline, Perivale	Nel/Ryse	1,500	350	Delivered WE	2021
15	Belfast	Energia	60	350 & 700	On-site WE	2021
16	Barking	ITM Power	270	350 & 700	On-site WE	[2022]
17	Tees Valley 1	TBC	TBC	TBC	TBC	[2022]
18	Tees Valley 2	TBC	TBC	TBC	TBC	[2022]
19	Derby, Shell	ITM Power	270	350 & 700	On-Site WE	[2022]
20	Liverpool	BOC	TBC	TBC	TBC	TBC

Reliability of vehicles and stations

During this period, fuel cell vehicles including passenger cars and buses have operated safely and reliably (>99% availability) with numerous vehicles driving over 50,000 miles/year without major fault.

The refuelling infrastructure and supply chain has operated safely but has had a lower level of availability at ~91% across all stations. This reflects the first generation nature of the stations and the relatively limited supply chain able to maintain and support the stations. This level of reliability is not sufficient to provide vehicle operators with a satisfactory customer experience for mass adoption and will need to be improved for the next wave of station roll-out.

Learnings on Reliability

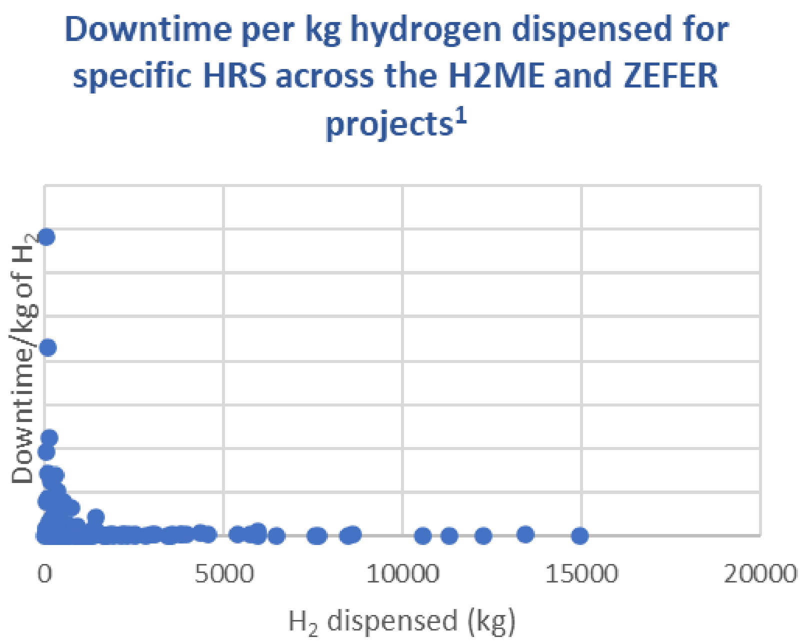
The hydrogen refuelling stations built to date have largely been designed to serve the very small fleets of vehicles associated with the first wave of hydrogen fleet roll-out in the UK. These small fleets create limited revenues for sale of hydrogen and as a result it has been necessary to minimise cost, which has resulted in:

- **Slow repairs:**
    - **Limited supply chain investment** – limited investment in supply chains of parts which has resulted in slow fixing of the stations. Germany, in contrast, with a larger station network, have increased overall network reliability by investing in spare parts and systems to identify issues at stations preventatively.

- **Shortage of trained technicians –** limited investment in trained technicians on hand to repair stations. This has been a specific problem during the COVID-19 period, as technicians have needed to be brought in from abroad, which has been challenging with restrictions on international movement.

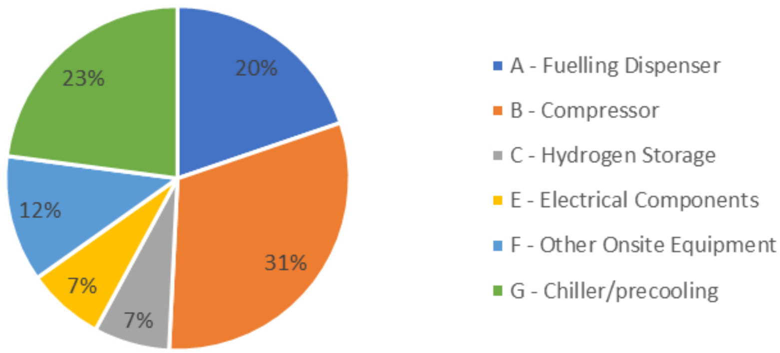
- **User error** – a number of the issues which have effected early stations have been caused by user error, particularly with respect to the hydrogen refuelling nozzles, which have been damaged due to being dropped and poorly fitted.

- **Poor reliability:**
  - **Small stations** – the current stations are small and can only refuel ~80kgH_2/day with little, or no redundancy built into their hydrogen compressing and dispensing systems. The systems require regular downtime for maintenance because of the high number of moving parts, hydrogen safety requirements, and the fact that many of the components are novel and built bespoke for these smaller stations. If any part in the compressing or dispensing system is not operational then the system, and therefore the station, would be unavailable to refuel.
  - **Low utilisation** – stations have a large number of moving parts which tend to suffer from long periods of being idle. As the number of hydrogen vehicles is low, the stations are often under-used, which appears to cause more issues for the components involved. The graphic below from the H2ME project illustrates how the average reliability has improved for these early stations as utilisation increases.



The graphic below summarises the reasons for station downtime across the H2ME and ZEFER projects (which log over 30 early stations across Europe)[1].

HRS downtime hours by reported category (H2ME and ZEFER projects, 2018-2020)[1]



Improvements expected in a next wave of stations

Based on these observations from the first wave of stations, there are a number of improvements expected in the next wave of stations which will be deployed:

- **Larger stations** – the next stations to be built will be larger, this allows them to be:
  - **More affordable –** the stations will be more economic for the station operator, whilst delivering affordable fuel for the vehicle customer.
  - **More reliable** – stations which have larger hydrogen demand (>500kgH_2/day) are able to justify redundancy of parts (i.e. two or more compressions and dispensing systems operating in parallel) which can still dispense hydrogen if a part fails or requires maintenance. This makes the station more resilient and results in higher station availability.
  - ➔ For example, this is supported by data for the larger stations which have been built to supply hydrogen bus fleets in London and Aberdeen, both of which have achieved extremely high reliability (>99%), whilst delivering hundreds of kg per day every day.
- **More reliable components** – the components in the next generation will be based on standardised designs, built explicitly for hydrogen refuelling stations (as opposed to the first generation stations where they were adapted from other industries). In particular, compressors will be built to be more flexible to the repeated cycling expected at a refuelling station, and dispensers will be built to be more robust to cope with user mishandling.
- **Better utilisation –** the stations in the next wave will be deployed to refuel larger fleets of vehicles in dedicated demand centres. This in turn will increase utilisation and can be expected to improve reliability.

[1] Data from the Hydrogen Mobility Europe (www.h2me.eu) and ZEFER (www.zefer.eu) projects

- **Greater investment in support and spares** – greater utilisation will improve the turnover for the hydrogen station network. This in turn will allow greater investment in UK-based technicians and stocks of spare parts.

Taken together, with these measures it is reasonable to expect individual station reliability in the next wave to **exceed 98%.** The impact of the 2% of the time where stations are not available can then be mitigated by hydrogen station network operators, using strategies such as:

- **Mobile refuellers** – to provide temporary backup.
- **Station clustering** – so that in the event of an outage at one station, a nearby station can act as a fallback.
- **Live mapping –** enables the communication of issues at a particular station to drivers, and direct them to alternate stations.
- **Planned down time** – scheduling periods of planned down time in low utilisation periods for the station.

Conclusions & Next Steps

A number of the existing fleet of hydrogen stations are currently being upgraded to larger capacity stations to achieve the reliability discussed above. In future, new hydrogen refuelling stations should be incentivised to be built larger and ideally with in-built redundancy. To do this, station construction needs to be coordinated with the clustered deployment of hydrogen vehicles in sufficient volumes to ensure that their hydrogen demand can justify the cost of larger stations. The numbers of vehicles needed to make these stations commercially viable imply many 10s of trucks or buses (20-40kg/H_2 demand per vehicle per day) or 100s of cars or vans (1-2kg/H_2 demand per vehicle per day) refuelling each day. If these vehicles cannot be deployed in these volumes in the early years, support in the form of government guarantees for minimum demands will help to support larger station construction costs in advance of demand arriving.

As the current fleet of stations expands to become a basic national refuelling network, network solutions to ensure individual station availability can also be deployed cost effectively. For example, a centralised, transport-grade hydrogen storage facility could improve network resilience and be delivered to stations with issues in their hydrogen supply chain. Additionally, nearby stations can serve to back each other up or mobile refuelling technologies can be deployed to provide temporary relief to stations with outages.