Written Evidence Submitted by UK H2Mobility and Element Energy

(HNZ0033)

UK H2Mobility is a grouping of industrial players who are committed to the use of hydrogen as a fuel for mobility in the UK. The group includes the following industrial members:

Air Products	Alstom	Anglo American	BOC	Cadent Gas	Daimler
Honda	Hyundai	Inovyn	Intelligent Energy	ITM Power	RWE
	Shell	Toyota	Wrightbus	Vattenfall	

We also benefit from the insight and advice from observer partners from: BEIS, DfT, OLEV, Transport Scotland and the Welsh Assembly. Note that this response reflects only the views of the industrial stakeholders.

Overview of responses

This document is a response to the consultation from the UK Government's Science and Technology Committee and we are grateful for the opportunity to do so. Given the broad and diverse nature of the call we have chosen to respond to parts of the call which relate to hydrogen mobility which we have organised into the following sections:

1. The advantages of hydrogen compared to other low carbon options
2. An overarching proposal for the targets in the 10-point plan may best be co-ordinated and supported to create a viable business case across the mobility sector
3. Our response to the scale and timescale of some key transport measures
4. The progress of recent and ongoing hydrogen transport trials
5. The consortium's view on green vs blue hydrogen production
6. The engineering and commercial challenges of hydrogen as a fuel for mobility.

Summary of key asks

Below is a list to highlight the key asks contained in the response:

- 'Quick fix' adjustments to the Renewable Transport Fuels Obligation to boost hydrogen production
- In the medium term, a dedicated hydrogen support scheme per kilo sold at refuelling stations
- 'Quick fix' adjustments to the Plug in Car Grant, 4,000 Zero Emission Bus Fund and Zero Emission Truck Trial to recognise the operational advantages of hydrogen in a technology neutral way.
- In the medium term, a dedicated capital support for hydrogen vehicle purchase across all vehicle types

- Modifications to current vehicle support mechanisms to disfavour fossil fuels and support zero emission options in a technology neutral way e.g. in rail franchise auctions and Bus Service Operators Grant
- Catalysation support for the pre-construction activities of hydrogen production and refuelling infrastructure development to develop an early infrastructure portfolio.

Context

The UK H2Mobility group considers the strategic issues associated with the roll-out of hydrogen for transport. The most recent public strategy document is available here. The consortium is pleased to see the announcement of the 10-Point Plan, with the inclusion of support for a number of hydrogen applications. Also that these points have been carried over into the Spending Review. The partners look forward to seeing these high level policy aims fleshed out in the upcoming UK Hydrogen Strategy and the Transport Decarbonisation Plan documents.

1. Hydrogen as a transport fuel compared to other zero emission options

Mobility is among the three key sectors, including heat and industry, where hydrogen can have the greatest decarbonisation impact. Mobility is the most technologically developed of the three sectors and has reached a point where it has been demonstrated technically (there are 20 buses and over 200 cars and vans operating in the UK, with many thousands in other countries) and that the economics of hydrogen for transport are viable, particularly if the industry is allowed to scale.

Hydrogen has a number of advantages as a transport fuel versus other zero emission technologies:

- High energy density – which mean it is suited to even challenging applications such as heavy use vehicles (e.g. taxis) and in particular heavier vehicles such as buses, trucks and trains.
- Rapid fuelling – as a gas, hydrogen can be pumped onto a vehicle in roughly the same time it takes to refuel a conventional vehicle – this makes it particularly suitable for customers who prefer rapid refuelling as compared to a battery electric vehicle and government should ensure that the market can provide this choice.
- Multiple zero carbon sources – hydrogen can be generated from renewable electricity (thereby encouraging renewable energy deployment by improving business cases), any hydrocarbon coupled with carbon capture and storage (leading to neutral or even negative emissions) and even from nuclear sources, all of which lead to an essentially zero carbon fuel.
- Affordable – a recent study by the Hydrogen Council[1] of leading global companies with an interest in hydrogen demonstrates that, by 2030, “Commercial vehicles, trains, and long-range transport applications will compete with low-carbon alternatives” due to reductions in cost driven by scaling up the hydrogen mobility sector.

[1] https://hydrogencouncil.com/wp-content/uploads/2020/01/Path-to-Hydrogen-Competitiveness_Full-Study-1.pdf

These benefits demonstrate that there is a stand-alone case for hydrogen in transport. However, there are also clear benefits of hydrogen when used in other hard to decarbonise sectors, notably industry and heat. The transport sector stands to benefit from deployment in these sectors as they will create scale of hydrogen production, which decreases cost, further improving the economics of hydrogen for transport.

We recommend that of these applications, transport is the ideal option to "go first" for a number of reasons:

- the value of energy is highest in the transport sector (i.e. petrol/diesel cost more per unit than the natural gas currently used for heat and industry).
- The displacement of internal combustion vehicles with fuel cell vehicles removes a source of local air pollution and replaces it with a vehicle that actively filters out particulates and cleans the air which it uses for the hydrogen conversion reaction. This provides a public health benefit even above that of Battery Electric Vehicles and hydrogen used in heat or industrial applications.
- Also, transport applications are inherently scalable i.e. you can start small and prove out hydrogen in an initial captive fleet, without needing the very large commitments to hydrogen which are required by the heat and industry sectors.

2. How the proposed measures could best be co-ordinated and the business models could attract private investment

Over the past 5 years, the hydrogen mobility sector has received less than £40m in support for deployment from UK Government, compared to the EV sector which has received more than £800 million. This funding has been delivered via a series of ad hoc competitions for funding. We would characterise this support as "demonstration funding". The group believes now is the time to move from this ad hoc competition-based support to a "commercialisation support" scheme which will have a multiplier effect to attract more private investment, creating a support mechanism around which companies can scale up.

Specifically, we have two requests for commercialisation support:

- *A subsidy per kg of hydrogen sold.*
  This would be related to the volume sold by a given hydrogen station. It would also be used to require low CO_2 hydrogen. Ideally this scheme would be designed for the needs of the hydrogen mobility sector, but this is likely to take some time. At present the Renewable Transport Fuels Obligation (RTFO) can be used to support hydrogen as a Renewable Fuel of Non Biological Origin. However, the rules around the way hydrogen can be implemented under the RTFO are inflexible and not designed from the perspective of helping to boost hydrogen itself. Amending these rules would be a quick win, and the Government is due to issue a consultation on the RTFO in early 2021.
- *A capital subsidy for hydrogen vehicle purchase*.

This would be paid at the point of sale and would be sector specific, with different levels for different vehicle types. It would be capped by volume so that it only applies to the first tranche of qualified vehicles sold and would be expected to reduce to zero as the vehicle sales volumes increase, the technology gains market traction and reduces in price with volume.

Simple modifications to existing vehicle support schemes, such as: the plug-in car and van scheme, Bus Service Operator Grants, or future schemes like the Zero Emission Truck Trial and new rail franchise contracts could allow the government to organise a co-ordinated, legal and technology neutral way support the deployment of low carbon hydrogen vehicles across the entire vehicle spectrum.

Example technology neutral vehicle support modifications could include:

1. A **zero-emission vehicle range uplift** - would include an uplift in the vehicle subsidy for a vehicle with zero emission driving ranges above a certain threshold. This could include different tiers of support for zero emission range in the different vehicle technologies as each technology will require different incentives to achieve this. This kind of tiered incentive for the quality of a zero emission product is in operation in Scotland in the Bus Service Operators Low Emission Vehicle Grants.

2. A subsidy contribution for **annual zero emission kilometres driven per vehicle** - would provide a subsidy on a per zero emission kilometre driven by a particular vehicle. The definition of a zero emission technology would be defined based on its lifecycle carbon emissions per kilometre. This would incentivise both the deployment of zero emission technology and its effective utilisation as vehicle operators would only collect subsidy while they were using or providing a mobility service. The subsidy would be weighted based on the different vehicle segments it is supplying for. A similar incentive mechanism for this has been taken in Switzerland which taxes freight vehicles that cannot comply with zero emissions standards on a per kilometre basis.

Because hydrogen vehicles tend to have long range and be intensive use and/or heavy duty vehicles, incentives of this type would automatically help hydrogen vehicles come to market, whilst remaining technology neutral in design.

3. Key transport policies in the 10-Point Plan and Spending Review

Begin the introduction, next year, of at least 4,000 more British built zero emission buses

The consortium welcomes this policy as a step forward for UK zero emission transport and see it as important to move quickly to maintain the UK's position as a world leader in hydrogen transport. Whilst the policy announcement is technology neutral, we would suggest that there is an opportunity to capitalise on the plan to deliberately kickstart the wider hydrogen sector. The UK's hydrogen bus market is the most developed hydrogen market to date, with all three UK bus manufacturers making hydrogen buses. Already, several hundred vehicles deployed in the JIVE fuel cell bus projects and trial fleets of 10 buses operating in both Aberdeen and London for (in many cases) more than 30,000 hours service life[2]. New fleets of hydrogen buses will enter service in London, Belfast, Birmingham, Aberdeen and Dundee in the coming year.

Furthermore, bus operators are coming around to a position that they cannot meet all of the needs of their routes with battery electric buses alone (due to range limitations). Operators vary, but there is a general view that 30% of routes at least will need an alternative zero emission propulsion system and that hydrogen is the most promising option.

The bus market has been a suitable "go first" option for hydrogen due to the public facing aspect of the business and the high-capacity, depot-based refuelling infrastructure. Commercialisation of hydrogen buses for this market would not only benefit the decarbonisation of buses but also kick start the hydrogen economy in the UK for other end use sectors where clean hydrogen production is seen as a necessity to reach zero emissions.

A large Government commitment to use a large fraction of the 4,000 zero emission bus program to support hydrogen buses (which are produced by all three of the UK bus manufacturers), will instantly stimulate private investment across all forms of hydrogen mobility as well as wider investment in hydrogen production.

At the indicative levels of funding per bus which are implied by the announcements which have been made around the 4,000 zero emission bus scheme, hydrogen bus options become viable. Given the potential to use the bus sector to stimulate hydrogen activity in the UK and get started on a commercial basis (with associated competitive benefits vs other countries), we urge the Government to consider the wider context and benefits of getting going with hydrogen and deliberately carve out a fraction of the funding intended for the 4,000 zero emission bus program for hydrogen activities.

The phase out of petrol and diesel cars and vans by 2030 and the plug-in car grant extension.

The group welcomes the bringing forward of the phase out of fossil fuel cars and vans to 2030. However, given this ambitious target we believe that it is a mistake to focus only on supporting battery electric vehicles in the light duty sector. This is because:

- The all-battery electric vehicle has so far achieved ~1% of total market penetration. It is far from clear that the drivetrain can be offered and made attractive to every segment of the market, given the cost, range and refuelling time challenges inherent with the technology.

[2] Fuel cell buses. (2017). CHIC final publishable summary report

- There are a number of factors which could make battery electric vehicles hard to scale, including materials scarcity for battery components, the cost of scaling up the national grid, challenges at peak times in key public refuelling spots, the high cost of installing new charging infrastructure and the overall challenge of making charging accessible to all (e.g. in terraced streets). By contrast hydrogen has low resource intensity and will scale very well, with many of the costs associated with the early roll-out decreasing rapidly as the quantity of hydrogen used increases. For example, today, a hydrogen filling station for a fleet of 50 passenger cars costs ~£1m to install, whilst a station for 2,000 cars costs £2.5m – this type of economy of scale occurs throughout the hydrogen system. These costs will also fall rapidly with technology advances in coming years. In addition, the material used to make on Tesla are enough to make at least 50 Toyota Mirais.

A reform of the £582 million extension to the plug-in car grant should focus on supporting vehicles which can meet long zero emission ranges and heavy duty cycles as we have detailed above. This would provide a technology neutral way of supporting the heavy use vehicle segments which can be best served by the emerging suite of long range hydrogen passenger vehicles.

4. The progress of UK hydrogen mobility trials

The UK hydrogen mobility sector can be considered to have completed a ‘first generation’ trial of the fuelling stations, hydrogen supply chain and vehicles on the roads which has been developed over the previous 10-years and now sees 12 publicly available refuelling stations and ~300 hydrogen vehicles on the roads in the UK.

Among a number of detailed learnings, the trials have yielded the following observations:

- The bus, taxi and passenger car vehicles deployed have performed safely and with good reliably, >99% availability, over a total of more than 12 million kilometres driven across Western Europe.[3]
- The refuelling infrastructure and supply chain has operated safely but has had a level of availability at ~91% which has not been sufficient to provide vehicle operators with a satisfactory customer experience.

The hydrogen refuelling stations built during these public vehicle trails were small (~80kgH2/day) and designed to minimise cost which meant that they had little, or no redundancy built into their hydrogen compressing and dispensing systems. However, because of the high number of moving parts and hydrogen safety requirements the systems require regular downtime for maintenance. If any part in the compressing or dispensing system is not operational then the system and therefore the station would be unavailable. Larger stations which have enough hydrogen demand to justify redundancy of parts (i.e. two or more compressions and dispensing system operating in parallel) can still dispense hydrogen when a part fails which gives them higher availability. This has been evidenced in

[3] H2ME data

the data for the larger stations which have been built to supply hydrogen bus fleets in London and Aberdeen which have both achieved extremely high reliability (>99%).

The learning and next steps from these trials is that hydrogen refuelling stations built in future should be co-ordinated with the clustered deployment of hydrogen vehicles in sufficient volumes to ensure that their hydrogen demand can justify the cost of larger stations with in-built redundancy. The numbers of vehicles needed to make these stations commercially viable imply many 10s of trucks or buses or 100s of cars refuelling each day.

As the numbers of vehicles being deployed and diversity of heavy duty vehicle options increases, the demand for hydrogen transport will grow which will help to justify the construction of more, large hydrogen refuelling stations with inbuilt redundancy which will help to reinforce hydrogen station availability and supply chain resilience.

5. The short-term and long-term approach towards hydrogen production – the need for both green and blue hydrogen

Both renewable hydrogen (green) and hydrogen from hydrocarbons with CCS (blue) can generate ultra-low carbon hydrogen. The UK H_2Mobility consortium is committed to a "do both" approach to hydrogen production options. We see three timescales:

- Short term (pre 2025) – in the short term, renewable hydrogen either from electrolysis using renewable electricity or reformation of biogas are the only viable low carbon options for hydrogen transport projects of any realistic scale. As a result, we see that stimulation of the transport sector pre-2025 will provide an opportunity to begin the early deployment of the green hydrogen option. This gives the renewable hydrogen sector the opportunity to scale and hence will start the process of reducing costs of the green hydrogen option. We believe even in this early phase green hydrogen can lead to economically viable transport options today (albeit with some Government support).
- Medium term (2025-2030) – from 2025, blue hydrogen (i.e. from hydrocarbons with carbon capture and storage) could start to become available. This will have a low cost and be available in large volumes. This will open opportunities for local clusters of high throughput transport activities near the CCS plants, including even having hydrogen fuelling stations fed by pipeline. These could be marginally cheaper than the renewable hydrogen options at the point of first deployment, but we would expect the renewable hydrogen to remain viable (and decreasing in costs), particularly with Government incentives tuned to ensure continued incentivisation of the green hydrogen option alongside the blue option.
- Long term (post 2030) – the trend of continued renewable energy and hence renewable hydrogen cost reduction is expected to continue until the blue and the green options approach parity, with some forecasters even suggesting green will be cheaper than blue on these timescales. See, for example, recent studies including from Bloomberg[4] and the International Renewable Energy Agency (IRENA)[5]. Hence,

[4] https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2019/Sep/IRENA_Hydrogen_2019.pdf

we see both options co-existing, with exact ratios of each depending on future energy economics which are hard to predict (essentially the difference between natural gas, biomass and renewable energy prices).

6. Potential engineering and commercial challenges of hydrogen production in the medium term

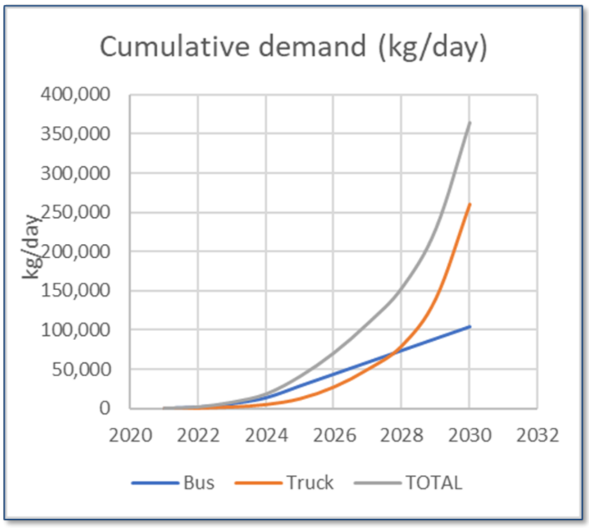
In the medium term, there is a risk that a success scenario for hydrogen mobility could create a shortage of hydrogen supply. This risk comes from the discrepancy between the time required to build and deploy a hydrogen vehicle (~6 months) versus the time required to put in the infrastructure to produce and supply and dispense hydrogen at new stations which is currently as much as 3 years and will increase as the scale of hydrogen production capacity increases from 10s of Megawatts to 100s of Megawatts.

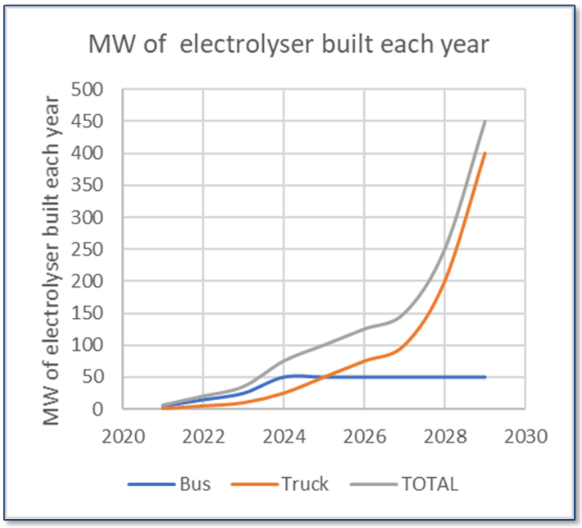
We can illustrate this point with a simple and modest deployment scenario using trucks and buses and electrolysers but it will apply to all production and transport modes:

Assumptions table

Hydrogen demand per bus	15	kg/day
Hydrogen demand per truck	30	kg/day
Electrolyser production efficiency	60	kWh/kgH2
Electrolyser load factor	75%	
Sales per year	**Bus**	**Truck**
2021	50	0
2022	100	10
2023	300	50
2024	500	100
2025	1000	250
2026	1000	500
2027	1000	750
2028	1000	1000
2029	1000	2000
2030	1000	4000

[5] https://data.bloomberglp.com/professional/sites/24/BNEF-Hydrogen-Economy-Outlook-Key-Messages-30-Mar-2020.pdf





As the rate of vehicle deployments increases, the amount of hydrogen the transport sector consumes will continue to rise. The UK hydrogen supply chain will require increasingly large capacities of hydrogen production and dispensing plants to be commissioned each year. By the mid and late 2020s, the demand from trucks and buses will require the construction of 100s of Megawatts of new electrolyser capacity and 100s of tonnes of dispensing capacity each year. The lead time associated with projects of the 100MW size can currently be over 5 years which creates a risk that the hydrogen supply chain may not be able to keep pace with hydrogen demand in a transport deployment success scenario and will constrain the rate of deployment. An early vehicle deployment strategy will enhance economies of scale in electrolyser related technology aggregation and achieve early cost reduction to ensure compatibility across both fleet and dispensing requirements.

If the UK government recognise this potential supply chain risk, then there is currently a need and an opportunity to act early to support the development of a pipeline of hydrogen projects which will be able to meet the increasing demand of hydrogen in the mid and late 2020s. Government activities to support the development of hydrogen production, distribution and retail infrastructure like:

- strategic site identification
- land acquisition
- planning assessment and applications, and
- Front End Engineering Design studies

will help to prevent this situation from developing into something which could become a barrier to deployment of low carbon mobility in the future.

Infrastructure for the storage and distribution of hydrogen

Ultimately there are a number of options for ensuring hydrogen gets to customers. These include distribution by road (as compressed hydrogen or in a liquid form for large demands), production on-site next to the demand (through electrolysis or methane reformation) and distribution via pipeline from centralised course (which will likely be cheapest, but only once we reach very large-scale demands). There are also exciting research advances going on around novel carriers such as liquid organic hydrides. In the near term, where it is unlikely that demands from the transport sector are large enough to stimulate pipelines or investment in new liquefaction plant, we are assuming the majority of hydrogen will come from either on-site production or distribution by road in a compressed form. Our analysis suggests that these modes can lead to attractive economics for hydrogen, with economic upside to come as the larger scale pipeline and liquid/novel carrier options become available.

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