Written evidence submitted by UK H_2Mobility and Element Energy (EVP0124)

The role of hydrogen in achieving net zero

UK H2Mobility is a grouping of industrial players who are committed to the use of hydrogen as a fuel for mobility in the UK. Our evidence therefore focuses on the role of hydrogen vehicles in achieving a zero emission transport network. 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.

The feasibility, opportunities, and challenges presented by the acceleration of the ban of the sale of new petrol and diesel vehicles to 2030;

The group welcomes the bringing forward of the phase out of fossil fuel cars and vans to 2030. Because of this ambitious target, and the rate at which global vehicle supply chains are able to change and scale up we believe that the government should be actively supporting all zero emission technologies which can be produced on a large scale. Hydrogen fuel cells is one of these technologies and can offer customers a choice on vehicle performance as 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.

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.

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. Given the government's ambitious target, it is a mistake to focus only on supporting battery electric vehicles in the light duty sector for the following reasons:

- 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.
- 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 which is expanded on in the following section. 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.

The actions required by Government and private operators to encourage greater uptake of electric vehicles and the infrastructure required to support them;

Government funding for hydrogen vehicles has, to date, 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 hydrogen fuel cell 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.

The particular challenges around decarbonising buses and how these should be addressed;

There are two challenges surrounding the conversion of bus fleets to zero emission vehicles which relate to the business case and the real world operational and infrastructure challenges. This response will begin by setting out some of the operational and infrastructure challenges faced by converting to zero emission vehicles and how fuel cell buses can solve those. With the case established for hydrogen fuel cell buses as an important technology for decarbonising buses we will address how the business case challenges should be approached.

Infrastructure and operational challenges of decarbonisation

Range issues

Battery electric buses are not able to meet the range requirements for a significant fraction of current diesel bus routes. These are particularly common on long routes and long bus operation hours and are exacerbated at times when passenger demand is high or external air temperatures are low which increase the power demand of the bus per kilometre driven through extra weight and heating. To convert buses on these routes to battery vehicles would require deep route modification and/or additional battery buses to be purchased to service the route. Conversely, hydrogen fuel cell buses can match the range of diesel equivalent buses which can allow of a one for one replacement with a diesel bus which relieves and operational and financial burden on the operators and local authorities.

Accommodating bus recharging

Recharging a battery bus can take a number of hours and on some routes may be required in the middle of a route to complete the duty cycle. These can have significant operational and financial implications for operators who will need to modify their running boards and potentially buy additional buses to respond to time lost to charging. The refuelling process for a hydrogen bus takes approximately 5-10-minutes (depending on the amount of hydrogen in the bus when it returns), with the possibility to refuel up to ~30 kilograms of pressurised hydrogen being dispensed in that time. This compares with approximately a 2-5-minute refuelling time for diesel buses and compares highly favourably to battery buses as it can allow a transition to hydrogen while maintaining similar refuelling processes of washing and refuelling as the diesel fleet. The small amount of additional time required for refuelling can be easily accounted for by modifying the washing routine or the times at which the buses are scheduled to refuel or adding an additional dispenser if needed.

Space requirement for refuelling infrastructure

Hydrogen refuelling stations have a similar station footprint as diesel equivalent refuelling stations and scale up in a space efficient way. For example, a refuelling station to refuel 70 buses might have a footprint of ~350m^2 or about 8 bus parking bays but a station to refuel to refuel 280 buses would require around double the footprint size. This compares well with battery electric refuelling which requires a linear increase in the number of chargers and space required to charge additional buses. The space efficiency of hydrogen refuelling infrastructure is valuable to bus operators who often operate in space constrained depots and would otherwise have to reduce the number of vehicles they can operate from the depot. This problem is exacerbated while depots are transitioning from diesel to a zero emission technology where they need to have two sets of refuelling infrastructure for the diesel buses and the zero emission buses, increasing the pressure for space.

Ease of access to fuel supply
Hydrogen can be readily transported large distances from production hubs to bus depots via compressed gas tube trailers which are a mature and cost-effective technology at reasonable volumes. This can solve issues which bus depot operators are experiencing in installing large scale electric vehicle charging infrastructure as a full fleet conversion to battery vehicles introduces a large additional electrical load to the local grid which can often require costly and protracted upgrades to local grid infrastructure. Any bus depot across the UK can easily be supplied with clean hydrogen delivered by road haulage or pipelines and therefore make a rapid transition to zero emission buses without being held up by local grid constraints.

Creating a viable business case for zero emission buses

Bus Service Operator Grant (BSOG) reform
In England, the BSOG each operator receives is a flat subsidy based on the vehicle's annual fuel consumption with low carbon uplift based on kilometres driven which currently creates a financial disincentive for switching to low emission vehicles. This subsidy is outdated and has been shown by the Scottish government to be easily and quickly reformed to create a strong financial incentive for bus operators to take up zero emission buses.

Current English BSOG
In England, the amount of BSOG subsidy each operator receives is a flat subsidy based on the vehicle's annual fuel consumption[2] with a low carbon uplift which is valued on the kilometres driven by the bus each year.

Fuel category	Units	Value
Diesel	Pence / litre	34.57
Hydrogen (Road fuel gas other than natural gas)	Pence / kg	18.88
Low Emission Vehicle Uplift	Pence / km	6

Table of English Bus Service Operator Grant values

Reformed Scottish BSOG explanation
The Scottish BSOG is based purely on the distance that an eligible vehicle travels each year with additional support for carbon reduction and zero emission vehicle range. The base rate for the subsidy is 14.1 pence per kilometre WITH a support mechanism that is based on the carbon savings of the bus and its zero-emission range, which is set out in the table below. Qualifying buses are eligible for the grants for the first 5 years of their operations. A fuel cell bus supplied with wind electrolysis hydrogen would qualify as an Effectively Zero Emission Bus as it will easily meet the 30% saving compared to Euro VI diesel bus and has a zero-emission range well in excess of 50km.

Band		Rate	Eligibility threshold	
			LEB Certification	ULEB Certification
A	LEB	5 pence/km	15%-35% saving vs Euro V	15%-29% saving vs Euro VI
B	ULEB	10 pence/km	36%+ saving vs Euro V	30%+ saving vs Euro VI
	ZEC	15 pence/km	36%+ saving vs Euro V & 2.5km zero emission range* with geo fence capability	30%+ saving vs Euro VI & 2.5km zero emission range* with geo fence capability
C	EZEB	30 pence/km	36%+ saving vs Euro V & 50km zero emission range	30%+ saving vs Euro VI & 50km zero emission range

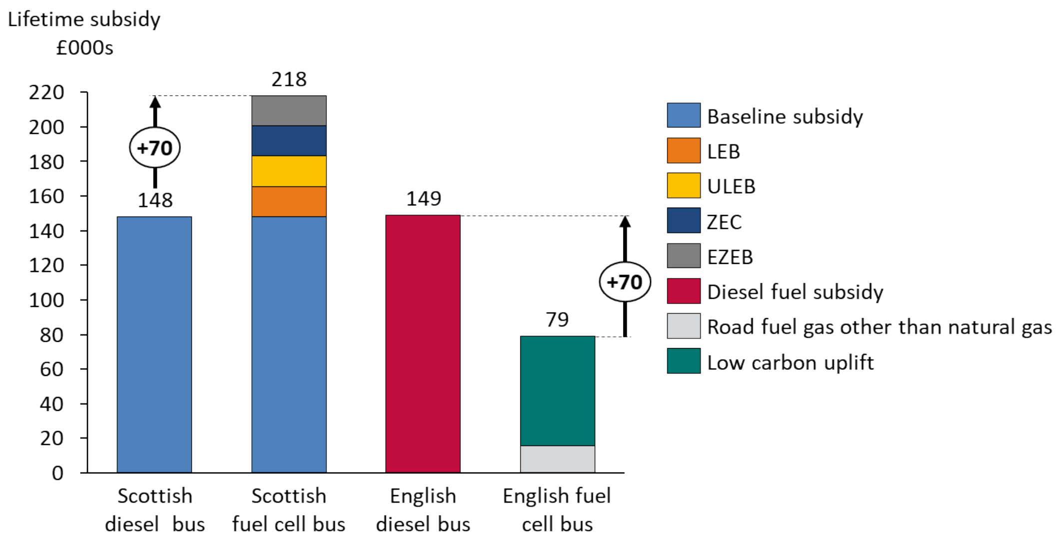
*2.5km zero emission range from the "inner urban" phase of the UK Bus Cycle
(LEB – Low Emission Bus; ULEB – Ultra Low Emission Bus; ZEC – Zero Emission Capable; EZEB – Effectively Zero Emission Bus)

Table of Scottish Bus Service Operators Grant Low Emission Vehicle incentive payments[3]

Comparison of the incentives of English BSOG and Scottish BSOG

The graph below shows a subsidy comparison between a double deck fuel cell bus and a diesel equivalent in England and Scotland over its 15-year lifetime. In Scotland, a hydrogen bus qualifying for the Effectively Zero Emission Bus would receive state support of £14,000 per year for its first 5 years of operation and £70,000 of additional revenue support over its working lifetime compared to a diesel Euro V bus. Conversely, in England a double deck hydrogen bus would qualify for £70,000 less in subsidy from the BSOG grants compared to a diesel equivalent.

The English BSOG is a broken subsidy mechanism from an environmental perspective as it incentivises buses which consume more diesel and therefore emit more CO2. A revision of this subsidy mechanism has been long overdue and should match the government's stated ambition to be technology agnostic and emissions focussed. The Scottish BSOG system provides a template for a revised BSOG scheme which would incentivise payments based on a vehicles ability to provide public mobility with lower carbon intensity.



Relative subsidy for a double deck fuel cell bus vs a diesel equivalent in Scotland compared to England over a 15-year lifetime

Use the 4,000 Zero Emission bus programme to drive the UK's fuel cell bus market

The consortium welcomes the 4,000 Zero Emission Bus Programme 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. 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 and issues set out above). 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 Government's ambition to phase out the sale of new diesel heavy goods vehicles, including the scope to use hydrogen as an alternative fuel.

The consortium welcomes the government's ambition to phase out the sale of new diesel heavy goods vehicles. We believe that a deadline for the phase out of fossil fuel powered trucks by 2035 and of biomethane powered trucks by 2040 would fit with the current development trajectory of fuel cell powered trucks with a number of European and global truck OEMs expecting to reach series production of fuel cell trucks by the mid to late 2020s.

With regards to the scope to use hydrogen as an alternative truck fuel, we would refer government to the UK Aggregated Hydrogen Freight Consortium which is a project created by the UK Hydrogen Mobility Consortium to bring 1000s of fuel cell vans and trucks to the UK over the early to mid-2020s.

We propose that the current £20 million funding for the first phase of the hydrogen truck trial should be directed towards the following three things which are listed in order of priority:

1. **Infrastructure development** – The program should support early work to identify strategic sites for refuelling infrastructure to be located. Many lessons can be drawn from the development of the biomethane refuelling infrastructure which has been deployed over the previous 20 years as well as the potential for collaboration with large infrastructure suppliers who have begun to consider these issues in detail. In addition, the scheme should support the companies in the initial land acquisition and early planning proposal development of promising sites for refuelling stations.
2. **Early barrier removal** – We see that there are still a number of barriers to the wide spread roll-out of fuel cell trucks in the UK which will require government support and activation to overcome. These range from:
    - developing appropriate refuelling protocols for fuel cell trucks to ensure safety and reliability from the vehicles and stations;
    - supporting the homologation of truck homologation to UK right hand drive standards;
    - amendments to the European Agreement on the Transport of Dangerous Goods by Road (ADR) which will allow hydrogen fuel cell vehicles to transport dangerous goods (e.g. FC trucks transporting hydrogen trailers which has strong business and cost synergies) and to allow hydrogen fuel cell vehicles to pass through tunnels.
    - Support for training hydrogen truck drivers and hydrogen drivetrain maintenance specialists

3. **Small trial deployment** – The UK Aggregated Hydrogen Freight Consortium is seeking to confirm if a small number of trucks might be deployed at an existing station in the financial years of 2021 or 2022. A small initial trial will draw out early learnings for the operation of fuel cell trucks which can be quickly integrated into a larger deployment with dedicated infrastructure and to assist in driving public perception that hydrogen vehicles are safe and reliable alternatives to diesel trucks.

In addition, the fuel cell heavy duty freight market will drive the deployment of hydrogen refuelling infrastructure and will open up access to low cost hydrogen for fuel cell vehicles in the lighter duty vehicles segments. Government should consider the impact and benefits of this effect and factor into decision making the relatively low cost and low regrets decision to maintain support for light duty vehicle deployments which can take advantage of the infrastructure and hydrogen supply chain economies from freight to provide low cost decarbonisation options in the hard to treat segments of light duty transport.

Road pricing

- **The case for introducing some form of road pricing and the economic, fiscal, environmental and social impacts of doing so;**

Elected not to answer

- **Which particular road pricing or pay-as-you-drive schemes would be most appropriate for the UK context and the practicalities of implementing such schemes;**

Elected not to answer

- **The level of public support for road pricing and how the views of the public need to be considered in the development of any road pricing scheme;**

Elected not to answer

- **The lessons to be learned from other countries who are seeking to decarbonise road transport and/or utilise forms of road pricing.**

In the mobility sector, the UK has established an early adopter position through the Government's early deployment support, but it is not on the same scale as many other countries and the UK is at risk of being left behind. For example, Japan, Korea and China have Government plans for 1,000's of heavy-duty hydrogen vehicle and passenger car deployments, Germany has over 80 hydrogen stations (vs the UK's 14) and many countries have committed to £multi-billion hydrogen strategies for the coming years. The UK has not yet made such a commitment.

There are two main points to note from other countries successful strategies:

• **Scale** - Other countries are now committing to commercialisation of this technology at scale. The recently announced German €9 bn strategy is based on allowing this technology to scale up in the same way as the country supported the early scale up of the renewable energy sector. Whilst there are elements of innovation support in the strategy, the primary aim is to get technologies deployed and begin commercialisation. This is true of the leading hydrogen supporting countries.

• **Focus** – the most active strategies have been focussed on a country's strengths, supporting selectively. One of the challenges of the hydrogen sector is that it can apply to nearly all aspects of our energy system. This diversity can lead to support being spread too thinly. The more effective strategies have selected a limited number of national strengths and backed them aggressively, allowing the benefits of scale to be captured (for example buses and trucks have been the focus in China, massive expansion of renewable electrolysis in Germany, the marine sector in Norway). This has given hydrogen industry advocates a hydrogen demand segment to rally around and begin to develop viable and investable business models.

The UK still has an opportunity to act and lead if its support is a) focused, b) commits on a scale which unlocks the economics of the sector, c) introduces support alongside shifts in the regulatory environment to enable viable business models for hydrogen deployment and d) which is internationally competitive (to ensure the attention of external investors).

The success of the Swiss Heavy Duty Sector
The example set by the Swiss system of taxing heavy duty vehicles over a 3.5 tonne total weight based on the amount which they pollute has provided a strong incentive to deploy zero emission trucks which has lead to Switzerland becoming a world leading market in the deployment of zero emission trucks through the 1600 trucks project. The taxation scheme taxes diesel vehicles based on their Euro emissions category at a rate which accounts for the number of kilometres each tonne of cargo is transported. Vehicles with electric traction are exempt from this which includes hydrogen fuel cell electric drivetrains. This system strongly incentivises the uptake of large vehicles which can do high zero emission ranges and can refuel rapidly as the further a zero emission truck drives per year and the heavier the cargo it transports the larger the delta in taxation to diesel equivalents becomes.

Tax category	Euro category	Rate
I	Euro 3*, 2*, 1 and 0	3.10 ct./tkm
II	Euro 4 and 5 (EEV)	2.69 ct./tkm
III	Euro 6	2.28 ct./tkm

For a 26 tonne truck Euro 6 travelling 120,000 kilometres per year, the tax on the truck will equate to ~£57,000 per year which would be avoided using a hydrogen fuel cell truck. This tax regime created a business case for commercial roll-out hydrogen fuel cell trucks which brings into question why the UK needs to be initiating trials of hydrogen trucks when a near neighbouring country is already demonstrating that the technology is ready for large scale roll-out. The scale of the roll-out and the tax regime which has driven are both initiatives which the UK can learn from and imitate.

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Endnotes

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

[2] Department for Transport, (2019), Bus services: grants and funding

[3] Transport for Scotland, (2019), Bus service operators grant