Written Evidence Submitted by TRL

(HNZ0069)

TRL is an independent research organisation that provides world-leading innovative research, technology and software solutions, spanning from public and private transport, to active travel and logistics. TRL core areas of expertise include decarbonisation, monitoring and evaluation of freight and mobility trials, development and assessment of climate adaptation and resilience plans, human factors and behavioural science, vehicle safety engineering, and infrastructure asset management. Our responses to this enquiry focus around the role of hydrogen in achieving Net Zero in transportation. We work on this space and we have been involved in hydrogen trials for heavy duty fleets.

1. **The suitability of the Government's announced plans for "Driving the Growth of Low Carbon Hydrogen", including:**

- **the focus, scale and timescales of the proposed measures;**

We believe that the scale of low carbon hydrogen production suggested (5GW) and funding allocated (£240m) is insufficient to have a meaningful impact in development of a hydrogen market in transport, as this hardly cover the needs of road haulage alone, according to our calculations. If this has to be shared with other uses, such as heating, the budget is clearly insufficient. We need more ambitious targets to accelerate the decarbonisation of the energy system.

- **how the proposed measures—and any other recommended measures—could best be co-ordinated;**

The UK should create a National Center for Hydrogen coordinating research and development efforts with the likes of the H2FC Supergen and the UK National Hydrogen Transport Centre, as well as advising central government on hydrogen policy matters and in charge of stimulate opportunities for UK businesses operating in this sector.

- **the dependency of the Government's proposed plans on carbon capture and storage, any risks associated with this and how any risks should be mitigated; and**

It is unfeasible to generate the amounts of hydrogen needed in transport by 2030-2040 without CCS. The main policy target that justify the use of hydrogen is the reduction of GHG emissions. Low carbon hydrogen can be generated via a broad range of pathways, including SMR and coal gasification in combination with CCS and still yield low carbon emissions. CCS is a necessary step until 3rd countries can generate enough low carbon and low-cost hydrogen at scale. This is unlikely to happen for a couple of decades, hence the dependence is fully justified, if we want to meet the decarbonisation objectives.

- **potential business models that could attract private investment and stimulate widespread adoption of hydrogen as a Net Zero fuel**;

BEIS has already commissioned research on this area and we do not have anything else to add.

2. **The progress of recent and ongoing trials of hydrogen in the UK and abroad, and the next steps to most effectively build on this progress;**

TRL has been involved in Innovate UK's Low Emission Freight Trials monitoring and evaluating the project. In this project that concluded in 2020 dual-fuel hydrogen-diesel internal combustion engine heavy goods vehicles were demonstrated. The outcome of the trial indicated that the technology needed further investment to rise technology readiness level. Furthermore, when designing trials, the upstream supply chain should also be included, as availability of hydrogen may be a challenge and impacts the availability of the fleets.

We recommend that the new Zero Emissions Road Freight Trial that will start in 2021 (we believe) includes heavy goods vehicles based on hydrogen fuel cells, solid oxide fuel cells, battery electric powertrains with hydrogen range extenders and dual-fuel biomethane-green hydrogen internal combustion engines. We also recommend that those trials include hydrogen transport refrigeration units, as the transport of food represents ~4% of the GHG from transport. It is not realistic to power a heavy duty truck with batteries and expect those to power frozen multi-temperature trailers (e.g. 10 kW ~ 4L diesel equivalent/hr). However, hydrogen can work.

While we expect fuel cells will to reach cost parity by 2030 (or sooner), alternative hydrogen powertrains (e.g. dual fuel) can still play a role in the transitional period. These can help to build the skills and knowledge required, improve the maturity of the supply chain and to accelerate cost reductions as a result of the economies of scale.

Future trials conducted in rail, shipping and aviation should also include refuelling systems for hydrogen, liquid organic hydrogen carriers and ammonia supply chains.

Attention should be put to calculate carbon intensity factors for energy pathways (on a well-to-wheel basis) to yield realistic emission factors for each transport mode rather than using BEIS emission factors, as the transport sector may have slightly different supply chains.

3. **The engineering and commercial challenges associated with using hydrogen as a fuel, including production, storage, distribution and metrology, and how the Government could best address these;**

No new evidence to supply. The commercial challenge is that low carbon hydrogen is still too expensive (electrolytic of SMR+CCS) compared to fossil fuels (as the negative externalities are not internalised). The commercial challenges of green hydrogen guarantees of origin needs to be investigated and how these will fit between the UK and the EU.

The engineering challenges are multiple and well documented. TRL doesn't have additional new evidence that can share publicly.

4. The infrastructure that hydrogen as a Net Zero fuel will require in the short- and longer-term, and any associated risks and opportunities;

While the UK has vast amounts of renewable generation potential (mainly off-shore wind), to get significant levels of low carbon hydrogen will require the import of hydrogen from countries with very lower production costs (e.g. electrolytic H2 from the South of Spain, Saharan Africa or even Middle East). This means that UK port terminals will need to be converted from LNG to hydrogen and its carriers, and the safety of salt caverns will have to be certified. As different end uses require different hydrogen qualities, infrastructure will be necessary to increase purity and supply pressure of hydrogen for its use on proton-exchange membrane fuel cells at the point of use (as the heating network doesn't require such quality it more efficient not to purify all hydrogen).

5. Cost-benefit analysis of using hydrogen to meet Net Zero as well as the potential environmental impact of technologies required for its widespread use; and

Nothing new to add to the literature. Due to the high cost of platinum and materials used in fuel cells, these have high value and are widely recycled. Hence, their environmental impact is considerably lower than lithium base batteries. Furthermore, the absence of cobalt and other critical materials mined in deprived and conflict afflicted countries also reduces the likelihood of using forced and child labour, and therefore the social costs imposed to developing economies to satisfy the demand for electro-mobility.

6. **The relative advantages and disadvantages of hydrogen compared to other low-carbon options (such as electrification or heat networks), the applications for which hydrogen should be prioritised and why, and how any uncertainty in the optimal technology should be managed.**

Battery electric powertrains are more energy efficient than the ones powered by fuel cells. However, due to the characteristics of the UK energy system, it is not possible to electrify heating, industry and transport simultaneously. Hydrogen should be prioritised in some transport modes where batteries can impose a penalty on occupancy factors or payload (e.g. rail freight, long-distance passenger rail, aviation, long-haul heavy goods vehicles (e.g. over 26 t). In the Table below we present a SWOT analysis of hydrogen and fuel cells in transport compared to battery electrification.

Strengths
Long range (even longer when hydrogen is liquified) Fast refuelling time (even faster at higher pressure) Lower impact on payloads (e.g. a battery electric freight locomotive can weigh 250t while a FC one weighs around 30t) Contributes to provide energy flexibility (multiple zero carbon energy pathways and feedstocks avoids the electricity generation capacity constraint – SMR / gasification / electro-fuels) Contributes to improve the resilience of the grid (hydrogen can be stored for long time and use for providing different services to the power sector – e.g. energy balancing, avoiding curtailment, etc.) Contributes to improve the security of the energy system (multiple generation pathways to reduce geopolitical dependency on oil producing countries) Similar user experience as conventional cars.
Weaknesses
Higher procurement costs than BEV, until 2030 Poorer refuelling infrastructure than incumbents and higher capital costs refuelling stations Lower WTW energy efficiency than BEV Storage of liquid hydrogen produces boiling-off (up to 1% leakages daily). Recovery is

recommended when possible
Opportunities
With economies of scale, total costs of ownership potentially cheaper than the other powertrain technologies. New guidelines allowing co-location HRS with conventional pumps will decrease capital costs New catalysts could improve systems efficiency. New storage vectors could result in higher volumetric energy densities Possibility to improve instant torque Potential to improve power density fuel cells Role of different FC types such as SOFC in combination with biofuels (e.g. biomethane) Decisive role to support the development of a UK green industrial strategy Potential synergies with other energy systems (heating, industry and power sectors). Soft transition pathway for oil companies to reduce reliance on fossil fuels Inclusion of hydrogen as a renewable fuel of non-biological origin in the Renewable Transport Fuel Certificates Possibility for a market for Guarantees of Origin for green hydrogen and an enables for vehicle-to-grid technologies
Threats
Breakthroughs from battery technology innovation could make FC technology obsolete (and vice-versa) As other electric road vehicles, the taxation system needs to be adapted to cover for the lack of revenue for the exchequer NIMBY attitudes towards HRS deployment and customers' acceptance of hydrogen as a fuel for transportation (safety) Lack of harmonisation of green hydrogen standards and potential misalignment between UK and EU Production of hydrogen at large scale require fossil fuels and CCS in the short-term to yield low GHG emissions Inefficient delivery and transformation systems (liquefaction, transportation) Except electrolysis, most production pathways require complex filtration/purification systems Production costs of green hydrogen are expensive Lack of UK natural reserves of platinum and other critical materials (most platinum reserves are in South Africa) Due to slow reaction time of FC, FCEV still require batteries (relatively small) Need for worldwide harmonisation of quality, safety and engineering standards (e.g. nozzle shapes, etc.) To power the transport sector we need CCS and imports.

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