Written evidence submitted by TRL Ltd (EVP0110)

TRL's response to the current call for evidence "Zero emission vehicles and road pricing" is attached.

The move to electrification has considerable challenges and will require considerable innovation and system-thinking. The future of zero-emission vehicles cannot be considered in isolation; the entire energy system needs to be included in thinking. As a result, hydrogen is likely to be required as part of the solution, not least due to the fact that it will lower the impact on the broader electricity system, which will be under pressure from other sectors which need to decarbonise (e.g. heating, industry). There is not a single solution that fits all use cases; the future of zero-emission vehicles will be defined by matching the right technologies to the right situations (vehicles, drive cycles, operational needs and so-on). The uptake of zero-emission vehicles will also depend on the right policies being in place to encourage adoption and economies of scale, as these will lead to affordability, which will increase demand. There are, despite these challenges, considerable opportunities to become a leading contributor to such areas as developing new battery types, energy transfer systems, hydrogen production methods, and carbon capture storage and utilisation. The UK is well placed to benefit from these opportunities.

There are two imperatives driving the need for road pricing; the need to reduce carbon emissions, and the need to find a replacement for revenue currently being generated by vehicle taxes. Road pricing has long been recognised as a technically viable mechanism for collecting vehicle taxes in a fairer way, as well as providing a means of demand-managing traffic to reduce congestion and emissions, replacing a current system of blunt, regressive existing taxes. As we point out below, the technology is not in question. What has prevented widespread road pricing being adopted anywhere in the western world is public opposition, and it is the management of this opposition that needs to be addressed. This must be done by either engaging with the public in a way to win their trust, or by finding a solution which does not have such potential to cause public distrust.

Our responses to the specific points are appended below under each, in blue text.

Call for Evidence: Zero Emissions Vehicles and Road Pricing

Accelerating the shift to zero emission vehicles

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

Feasibility

Near zero GHG emissions are feasible with biofuels and biogases; however, these still emit air quality pollutants. The feasible solutions to electrify road transport are shown in Table 1. Different solutions are feasible for different situations. The challenge of in-road systems is that they produce disruption at installation and can be expensive. Catenary systems can be installed with minimal disruption and have high energy efficiency; however, due to their height they are not feasible for smaller vehicles. Both systems (wireless and conductive), facilitate the reduction of battery capacity with the consequent benefits on increased payload, lower energy consumption and GHG savings. Hydrogen fuel cells present usage patterns akin

to petrol and diesel vehicles; however, infrastructure is expensive, and an extensive network would be needed.

Table 1: Feasibility of different transport electrification systems.

Type	Wireless			Conductive			Battery Only	Fuel cells
Energy Transfer	Overhead	In-road	Side	Overhead	In-road	side	Plug	Fuel tank
Infrastructure	Recharging point	Underground	Monorail	Catenary	On the ground	Monorail	Recharging points	Refuelling stations
Feasibility for Buses	Yes, static charging at bus stops and depots						Yes, at depots	
Feasibility for large HGVs	No	Yes, dynamic charging in the strategic road network and static charging at Depots					Yes, at depots and recharging points	Yes, at depots and refuelling stations
Feasibility for cars & LDVs	No	Yes	No	No	No	No	Yes, home and public access points	Yes, refuelling stations

Opportunities

Moving towards zero emission vehicles presents a myriad of opportunities to contribute to economic growth. The UK must invest in research and innovation to achieve leadership on those new technologies, implement favourable policies and help to the private sector to achieve economies of scale that will improve in the long term the affordability of these zero carbon vehicles. There exist opportunities to innovate in materials and production processes to achieve more effective batteries (e.g. solid state), more efficient fuel cells and energy transfer systems. The Faraday challenge is a good step in this direction. We suggest the creation of a National Hydrogen Centre to ensure that the country takes advantage of all the opportunities in the sector and that those are aligned with the UK industrial strategy. The UK has world leading manufacturers of relevant technologies that can help to decarbonise transport. The main opportunities reside on new battery chemistries, fuel cells efficiency and improved hydrogen production methods. There are also opportunities related to carbon capture, storage, and utilisation.

Challenges

Phasing our fossil fuels from road transport is challenging due to their high energy density and a fuel price that doesn't include all negative environmental externalities. Electric vehicles have much lower operating costs than the incumbent; however, their capital costs are so far

considerably higher. The literature suggests that battery electric, hydrogen and petrol/diesel cars and heavy-duty vehicles will reach whole-cost parity with ICE equivalents by 2030.

It must be made clear that all vehicle electrification technologies require batteries. Hence, focusing on resolve the challenges around batteries is a sensible approach. Reducing or eliminating the use of critical materials is fundamental to avoid production constraints, social impacts and geo-political dependence. This includes cobalt and lithium in batteries, and platinum materials in PEM fuel cells. The main reservoirs of cobalt are in the Democratic Republic of Congo, a region where child labour and force labour are present[1] because of military conflicts. Lithium mining can have a high environmental impact. Another of the concerns regarding battery production is that is not cost-effective to recycle them. So far, the main ambition is to reuse them for home energy storage while a definitive solution is found.

Electric vehicles fitted with permanent magnet motors use rare earth metals because they are very efficient. It is necessary to mitigate the reliance on rare earths such as neodymium or dysprosium, to spread the risk associated with individual countries dominating supply. Processing rare earth metals also generates huge amounts of toxic waste. The UK should prioritise the research of alternative power traction solutions.

One of the greatest challenges for deploying electric vehicles is how to power them once they reach dominance, considering the characteristics of the UK energy system and the decarbonisation targets from other sectors. Smart grids, energy storage to balance the grid, and energy imports will need to be combined.

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

The UK Government should implement policies that disincentivise petrol and fuel vehicles with carbon taxes and schemes that induce behavioural changes (e.g. carbon credits).

Considerable investment is needed to promote research and innovation, the development of a skilled forces capable of installing and maintaining electric vehicles, and incentive to drive economies of scale.

The future of transport will include different solutions for different vehicle categories and duty cycles. Smaller vehicles could be charged at home, but this is not an option for most of the population, hence subsidising private recharging points does not seem to be an equitable policy. Deploying public access recharging infrastructure is more socially inclusive (e.g. using lampposts). Businesses with large HGV fleets may need to incur considerable expense to get the power capacity required for their operations. Adapting the EU Alternative Fuel Infrastructure Directive with mandatory targets to reach high levels of hydrogen refuelling stations is likely to encourage the uptake of compatible HGVs, overall if these fit range extenders of hybrid (battery/hydrogen) powertrains that can be charged for the first miles on the depots and refuelled on the road network.

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

Battery powered buses present technical challenges. Firstly, under extreme low temperatures, they cannot run. Secondly, under very low or very high temperatures, passengers expect adequate heating and cooling, respectively, leading to reductions in range. With current batteries it is unlikely that the first challenge can be resolved. The second could by deploying other charging infrastructure (e.g. catenary, third-rail feeding systems or wireless induction

recharging points). This recharging strategy can also reduce vehicle mass and improve fuel economy, saving well-to-tank GHG emissions and reducing the impact on vehicle operations by allowing these to operate more hours.

Another of the challenges is to mitigate the impact of the higher total cost of ownership of electric buses on bus fares. Due to the low economies of scale, net zero emission buses are more expensive. Research suggest that for orders of over 200 hydrogen buses, these can be competitive with battery electric ones; however, cost parity with diesel buses is not expected until 2030. To mitigate this impact, subsidisation schemes should support the deployment of decarbonised buses.

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.

Phasing out the sale of new diesel heavy goods vehicles (HGVs) will have a very positive impact. Phasing diesel out from 2030 is an ambitious target considering the lack of cost-efficient solutions before 2030[2] due to poor economies of scale for hydrogen fuel cell and battery powered HGVs. To make this feasible the UK Government needs to ensure that an alternative refuelling and recharging infrastructure is deployed. While battery electric (28t GVW and over) and proton-exchange fuel cell HGVs (FC HGVs) are already commercially available in the EU market, technical and operational challenges still need to be resolved. A comparison between Hyundai XCIENT FC (36t GVW) with a DAF CF Electric (27t GCW) (a battery electric HGV that will be available in the UK market from March 2021), reveals that FC HGVs are 66% more powerful, have 28% higher payload, 100% longer range and 10 times faster refuelling/recharging time. Furthermore, as refuelling is faster, range is virtually unlimited, should hydrogen refuelling infrastructure be available. The UK needs to implement a significant scheme to deploy recharging infrastructure for HGVs (e.g. at least 250kW/400A to enable a relative 75 minutes 'fast' recharging time). The size and volume of batteries could be reduced, or the range extended by deploying overhead catenary electrification systems for HGVs. However, due to the high costs and disruption of this option, this is unlikely to be deployed beyond the boundaries of the strategic road network. In both cases, powering HGVs with batteries and catenaries still need to consider the limitations of the UK energy system due to the current capacity installed and the phasing out of coal power, the animosity towards nuclear power and the high costs of energy interconnectors. A whole energy system approach will reveal that due to the competition for electricity form other sectors (industry, heating, cars) hydrogen fuel cell HGVs can avoid the constraints of the energy system, as the low carbon hydrogen can be imported from abroad (ideally from countries where low cost electrolytic hydrogen can be produced from renewables).

Road Pricing

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

Background

Vehicle taxes (vehicle excise duty, fuel duty, HGV Levy etc.) are easy to understand, simple and cheap to collect, and difficult to evade. However, they have some current and long term limitations:

- VED is a blunt instrument as currently formulated as it takes no account of usage and takes very little account of environmental impact (this aspect has in fact gone backwards since 2017[3]).
- Fuel duty is more progressive as the amount of tax paid is related to both the distance travelled and to some extent the size/weight of the vehicle. However, it is regressive in that poorer people tend to driver older, less efficient vehicles.
- With the increasing fuel efficiency of vehicles, fuel duty is a tax with diminishing returns. This trend is accelerating as electric vehicles are becoming increasingly prevalent, and the government's intention of banning new petrol/diesel only vehicles from 2030.
- There is currently no easy way of gathering usage-based taxes from the electricity used by vehicles without taxing all electricity, which is politically untenable. It is technically feasible to tax electricity usage by battery electric vehicles separately, though this would require investment in metering and enforcement infrastructure and would be relatively easy to evade.
- VED and fuel duty cannot be used to impose extra charges for usage in areas of high congestion/pollution. This has led to the imposition of other blunt taxes to attempt some form of demand management, like congestion charging and clean-air zones.

Charging for use of the roads

Simple road pricing or tolling is widely used to finance the building and running of specific roads and structures like bridges and tunnels. Traditionally, tolls are collected at manned toll booths, though over the years increasing automation has been used to lower costs and improve flow.

Current automated tolling systems use a range of different technologies, the most common being radio-frequency "tags" which are carried in the vehicle and read by roadside/overhead infrastructure (so called Tag-and-Beacon systems), and automatic number-plate recognition (ANPR). One thing common to these automation solutions if that they require regular, significant roadside infrastructure for compliance and enforcement.

The long-term non-viability of fuel taxes was recognised more than two decades ago, and various experiments with all-roads road pricing (charging vehicle by the mile no matter where they drive) were attempted. TRL has taken a leading role in many of these experiments, both in in the UK and internationally.

A tax which replaces VED and fuel taxes needs to be usage based, so charges need to be calculated based on, at the very least, distance travelled and vehicle type. The charges should be calculated for all roads. However, this type of system is somewhat simplistic. If a charging system is introduced, the ability to vary the unit price by time and location has significant benefits. This allows charges to be increased during peak hours and in areas of high congestion and/or emissions.

Tag-and-beacon and ANPR systems as used in tolled structures are not viable for all-roads distance-based pricing due to the infrastructure required. This has led to the development of systems which rely on secure in-vehicle 'black boxes' which track distance driven and send the information to central servers for processing and billing. Almost universally, these rely on GNSS[4] to measure location and distance travelled. This kind of solution allows road pricing

to be implemented with charges varied by Time, Distance and Place (TDP), as well as by vehicle size/class.

While various trials and demonstrations, including in the UK, have largely proved the technical viability of road pricing, no country has yet introduced national road pricing, largely due to public opposition (see below).

The Future

The changes required will take time; planning should start now for a replacement to fuel taxes (and possibly VED).

Several options present themselves. When considering the options, we must of course consider how effective is it as a tax (raises sufficient revenue, cost effective, fair), and what impact it might have on behaviour. The wider landscape of transport taxation, including rail, air and public transport systems should also be considered.

1: Do nothing

As the revenues from fuel duties decrease over time, manage the reduction in income by increasing other taxes, or cutting spending. Given the toxicity of any suggestion of raising taxes, this is not tenable. Replacing fuel taxes with increased VED is regressive, and not tenable.

This (non) solution is environmentally and socially unacceptable.

2: Simple distance-based road pricing

It would be possible to introduce a system of flat rate distance charging based on odometer readings (which would need to be secured) and vehicle characteristics. Certain routes (e.g. motorways) could attract additional charges through, for example, motorway tolling schemes. Tolls for bridges, tunnels etc. would still be required.

This solution does not require tracking of individuals so addresses privacy concerns. However, it is technically difficult to achieve this securely. The lack of possibility of demand management by TDP charging means that other schemes to manage congestion, emissions etc. will still be required.

3: Plan for a privacy aware, secure national road pricing system to replace VED, fuel taxes, congestion charges, tolls etc.

The technology exists for this, but the political hurdles have proven insurmountable in various international attempts, particularly in open Western democratic societies. Overcoming the political hurdles will be extremely tricky and will probably require cross-party consensus to have any hope of success.

4: Introduce an "electricity fuel tax"

This will require the implementation of differential electricity metering, where the electricity used to charge vehicle batteries is metered at a higher rate than normal household/industrial usage.

In the last decade there have been several trials of "dynamic power transfer" systems where vehicles draw electric power while driving on the roads. These would in principle be simple to tax, though this would in turn be a disincentive to use the system.

Conclusion

This response has largely addressed the issue of road pricing from the perspective of replacing motoring taxes. It should however also be considered in the wider context of sustainability, future travel patterns (of which there is considerable uncertainty following COVID-19), future technological development (connected and automated vehicles, alternatively fuelled vehicles). TRL addresses all of these as part of our vision and strategic research areas.[5]

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?

The most comprehensive and fairest system would be one which charges for distance driven on all roads, with charges varied by vehicle type (more polluting vehicles pay more), location (higher charges in areas of congestion/high pollution), time (higher charges at peak times). This is only practical using a 'black box' fitted to every vehicle, as per option 3 above.

It is recognised however that this solution is very difficult to sell politically, so alternatives may need to be considered. For example, option 2 above which levies a basic charge per mile driven, and introducing widespread toll surcharges for the strategic road network (all motorways and some dual-carriageway A-roads). Careful research would be required to understand the impact of such a solution on rural and urban roads as some drivers may attempt to avoid tolled sections of roads.

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

Previous experience has shown that initiatives fail not from technical issues, but from public/political resistance. The common thread is that a significant number of people feel uncomfortable with the possibility that their personal journeys may be tracked by state actors, even though they are seemingly largely content when this is done by commercial companies (e.g. Google). TRL has done research into this in the ACCEPT project. Interestingly, the Dutch solution used aggregated distance information which did not reveal travel patterns, but this was simply not believed by those objecting to the system.

A second reason of the lack of public support is that road pricing is seen as a 'new tax' and claims that it will only replace existing taxes and will not be used to collect extra net revenue are simply not believed.

We should also consider the well documented differences in the perceived and actual prices per journey of various travel choices. A private car is an expensive capital asset which is visibly taxed but is often perceived as a sunk cost. Fuel is paid for infrequently, and not in a way that is usually psychologically linked to any given journey. The marginal cost of a journey by private car is often not transparent and may not be compared with the marginal cost of a journey by public transport. The external costs of a journey by private car (carbon footprint, particulate pollution, negative health impacts) are not transparent.

If there is to be a future for road pricing, the public must be won over, early in the process. This means that initiatives must be open and transparent from the start, engaging with the public (particularly those who have significant influence, i.e. the media, politicians). In the current climate of distrust in experts and open platforms allowing fringe views unprecedented prominence, careful management of public opinion will be more important than ever.

At a political level, cross-party support may be required. A project of this sort will require years to design and implement, giving plenty of opportunities for political opponents to use it

for partisan points-scoring. If a wide enough spectrum of political views can be convinced that this is fair, proportionate, achievable, and necessary to meet fiscal and environmental targets, this political hurdle can at least be mitigated.

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

Tolling of specific roads, mainly motorways, has been a way of life in many western countries (France, Italy, USA etc.) and has not been controversial. Ubiquitous road pricing for private vehicles on the other hand has not been successfully applied in any western country. Several countries have started to plan for it, but all such attempts have failed. Many of the lessons learned have already been presented in the responses to the earlier questions.

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Endnotes

[1] Haider, 2017. Modern slavery in the Democratic Republic of Congo. University of Birmingham. Source: https://gsdrc.org/wp-content/uploads/2017/03/052-Modern-slavery-in-the-DRC-v2.pdf
[2] Staffell, I., Scamman, D., Velazquez Abad, A., Balcombe, P., Dodds, P. E., Ekins, P., . . . Ward, K. R., 2019. The role of hydrogen and fuel cells in the global energy system. Energy & Environmental Science. Retrieved from http://dx.doi.org/10.1039/C8EE01157E
[3] From 2001 to 2017, VED was graduated into 13 bands depending on emissions. Since 2017 the graduated VED was replaced by a flat rate VED for all cars except zero emissions vehicles, which are zero-rated
[4] Global Navigation Satellite System, of which GPS is the most widely used.
[5] See https://www.trl.co.uk/about-us/our-vision-mission