DfT/OLEV Consultation on ending the sale of new petrol, diesel and hybrid cars and vans – UKPIA Response

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Executive Summary

UKPIA is supportive of the role of electrification in decarbonising UK transport – one technology of many – and calls for close government-industry partnership, and regular and frank assessment of available technologies to ensure up-to-date, evidenced policy making. There are many diverse stakeholders and issues and given the importance of the transport sector and its decarbonisation, UKPIA and its members will continue to work constructively with government as we progress with the challenge of reaching net zero.

We agree with the CCC and DfT/OLEV that the electrification of light duty vehicles has a key role to play in the decarbonisation of UK transport. We also agree with the DfT Science Advisory Council view that electric vehicles (EVs) are not yet ready for immediate and large-scale replacement of the UK's cars and vans. Other low carbon technologies must be deployed and continuously developed if we are to create a net zero transport system in the UK.

UKPIA strongly suggests that government focuses on creating a regulatory framework that ensures net GHG emissions are reduced across all powertrain technologies. Market-based, technology neutral regulatory frameworks will deliver emission reductions at the lowest societal cost. Tailpipe emissions are an important variable, but all other GHG emissions sources must also be accounted for if the UK is to become a net zero economy.

Deployment of low carbon liquid fuels is already delivering carbon reductions now and could deliver more with the current vehicle parc whilst infrastructures and technologies are developed in the longer-term. Climate scientists are clear that GHG emissions reductions not made now will be harder to abate in future. Vehicle right-sizing and low carbon fuels offer clear opportunity to reduce transport GHG emissions today. Furthermore, these fuels in similar or improved form, are likely to be our energy vectors for the most difficult to decarbonise transportation sectors, ensuring their enduring decarbonisation value beyond 2050.

There is economic opportunity on this journey – with the right policies the UK could become a leader in low carbon fuels development, electric vehicle technologies and manufacture, and maintain its leading role in aviation as a hub for sustainable aviation fuels. However, this will only be possible when policies look at these as linked systems, not siloed transport modes. Ending the sale of new vehicles utilising a specific powertrain technology may have the intention of creating certainty, but may achieve quite the opposite, and dissuade investors from the UK.

Our sector recognises the need for action and aims to play an active role in shaping the global pathway to net zero emissions. This logically leads to a clear focus on net GHG emission reductions and short, medium, and long-term efforts based on feasibility and further reductions.

1. Introduction

In May 2019, the Committee on Climate Change (CCC) published their Net Zero Report[1] and accompanying technical report[2] recommending to the UK government a new emissions target for the UK: net-zero greenhouse gases (GHG) by 2050. This target was subsequently adopted by government and enshrined in law.[3]

The CCC then state that "clear, stable and well-designed policies to reduce emissions further are introduced across the economy without delay" to make such a net zero target achievable and that "current policy is insufficient for even the existing targets."

UKPIA agrees action should be taken, with clear, stable, and well-designed policies to reduce emissions whilst growing the economy, securing jobs in the UK, and protecting the consumer. Indeed, many of UKPIA's member companies have already made GHG emissions pledges – four have set out plans to achieve net zero emissions by 2050.[4,5,6,7] The UK downstream sector welcomes holistic, ambitious, and economically effective climate change policies and is eager to play its part in the transition to net zero.

The Department for Transport's (DfT) Science Advisory Council (SAC) highlighted that to tackle the challenge of achieving net zero GHG emissions by 2050, all transport modes and systems must be understood through the lens of energy vectors and understanding an energy vector's full life cycle.[8] UKPIA completely agrees that this is the technically appropriate and robust approach to the transport decarbonisation challenge.

Ending the sale of new cars and vans utilising internal combustion engines (ICEs) is a powertrain technology specific policy which sits at odds with the aforementioned DfT SAC position. All cars and vans require a means to onboard energy, store energy, and convert energy to work, and to focus on one technology type that achieves this at the exclusion of all others severs the link to our common, key objective – achieving net zero GHG emissions by 2050.

Any new transport policy should focus on how to pragmatically reduce the net GHG emissions of transport and build a policy framework under which the lowest net GHG transport practically available at the time is the logical choice for the consumer.

For the avoidance of doubt, UKPIA agrees with the CCC and DfT SAC on the need for action. Our sector has already delivered significant GHG emissions reductions for cars and vans for over a decade through meeting growing biofuels mandates[9], and stands ready to work with government to deliver further GHG emissions savings via low carbon liquid fuels in existing infrastructure as soon as practicable. In 2019, UKPIA published its *Future Vision* document[10], highlighting how this may be achieved and how in parallel, our sector's retail forecourts can support the electrification of cars and vans by increasing the presence of essential low carbon electricity charging points.

Technical experts are coalescing around the view that the use of low carbon liquid fuels in internal combustion engine vehicles offers greater or at least comparable GHG emissions reductions over a vehicle's lifecycle than a non-domestically manufactured battery electric

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1 Net Zero – The UK's contribution to stopping global warming, Committee on Climate Change, May 2019
2 Net Zero – Technical Report, Committee on Climate Change, May 2019
3 https://www.gov.uk/government/news/uk-becomes-first-major-economy-to-pass-net-zero-emissions-law
4 https://www.bp.com/en/global/corporate/who-we-are/reimagining-energy
5 https://www.shell.com/energy-and-innovation/the-energy-future/shells-ambition-to-be-a-net-zero-emissions-energy-business
6 https://www.total.com/media/news/total-adopts-new-climate-ambition-get-net-zero-2050
7 https://www.nationalgrid.com/stories/journey-to-net-zero/national-grids-net-zero-commitment
8 Position statement on transport research and innovation requirements to support the decarbonisation of transport, June 2020
9 Renewable Transport Fuel Obligation Annual Reports
10 The UKPIA Future Vision: The Downstream Oil Sector in a Low-Carbon World, July 2019

vehicle (BEV) on the current UK grid.[11,12] Low carbon liquid fuels offer the advantage being blended with increasing levels of renewable content in existing infrastructure and, importantly, the UK possesses world-class expertise in the area of fuel blending that can be harnessed to this end under the right policy environment.

Increased renewable fuel content could be achievable in the short-term while barriers to electrification are overcome and vehicle lifecycle GHG emissions for all powertrain technologies are reduced. Hydrogen as a low carbon energy vector is also likely to play a role in UK transport. The key message is that all technologies should be pursued in parallel – under a holistic GHG emissions policy framework – and co-exist in order to decarbonise the UK swiftly, pragmatically, economically and sustainably.

Included in the final chapter of this document is what UKPIA has assessed to be a viable pathway to decarbonising cars and vans in the UK. The stated approach incorporates factors such as infrastructure and placing the needs of the consumer first. It should be noted that our approach still highlights electrification as playing a crucial role in the decarbonisation of the UK's cars and vans. The key is to create an environment where electric vehicles may be the logical *choice* for consumers, not a powertrain technology *forced* upon them.

UKPIA is grateful for the opportunity to respond to the consultation on ending the sale of new petrol, diesel and hybrid cars and vans, and looks forward to an ever-strengthening partnership with UK government to decarbonise the UK's transport. This response considers all the questions posed in the DfT/OLEV consultation and we hope provides strong evidence needed in development of policy to decarbonise transport effectively. As always, we invite our consultation response's readers to engage with us at any time.

[11] Embedding LCA into automotive manufacturing & future vehicle policy, LowCVP and APC, November 2019
[12] Impact Analysis of Mass EV Adoption and Low Carbon Intensity Fuels Scenarios –Summary Report, Ricardo, August 2018

2. Barriers to Achieving the Proposals

In 2018, the UK's transport sector consumed 663 TWh of energy of which 0.7% was electricity-derived energy, and the remainder provided by petroleum and bioenergy products.[13] Even accounting for the share of this energy consumed by cars and vans, and the increased conversion efficiency of an electric motor relative to a combustion engine, electricity provision to transport needs to increase 50x to electrify those fleets[14] – approximately an additional 2/3rds of 2018 power generation capacity.[13]

The key challenge for cars and vans is that they are dependent on the combination of energy transfer, the conversion of energy into work, *and* on-board energy storage. It is the latter aspect in particular that results in even greater complexity than the significant infrastructure challenge of supplying electricity from point to point.

Batteries and electric motors are a powertrain type at least as old as fuel and ICEs. It is the prioritisation of movement at the lowest cost that led to the proliferation of the latter – in effect, a technology neutral approach resulting in a dominant powertrain type. Of course, there is now an additional priority: minimising the net greenhouse gas emissions of transport. However, the aforementioned fundamentals have driven decades of optimisation of ICE vehicles and this optimisation, in itself, presents barriers to a 'hard transition' which the proposed end of sales of new ICE-containing vehicles would be.

2.1. UK Light Duty Vehicle Parc Overview

Whilst electric vehicle sales are increasing, their penetration of the UK vehicle parc has only reached 0.3% as of 2019.[15] With the average age of cars in the UK as 8.3 years[16], and current sales share of 4.7% to date in 2020[17], whilst there will be accelerated growth, electric vehicles will likely remain a minor segment of the total UK vehicle parc through the 2020s. The scale and pace of the fleet renewal challenge, combined with multi-year product lifecycles, presents a significant challenge that blurs the link between prohibiting the sales of a specific powertrain technology and overall realised light duty transport GHG emissions savings.

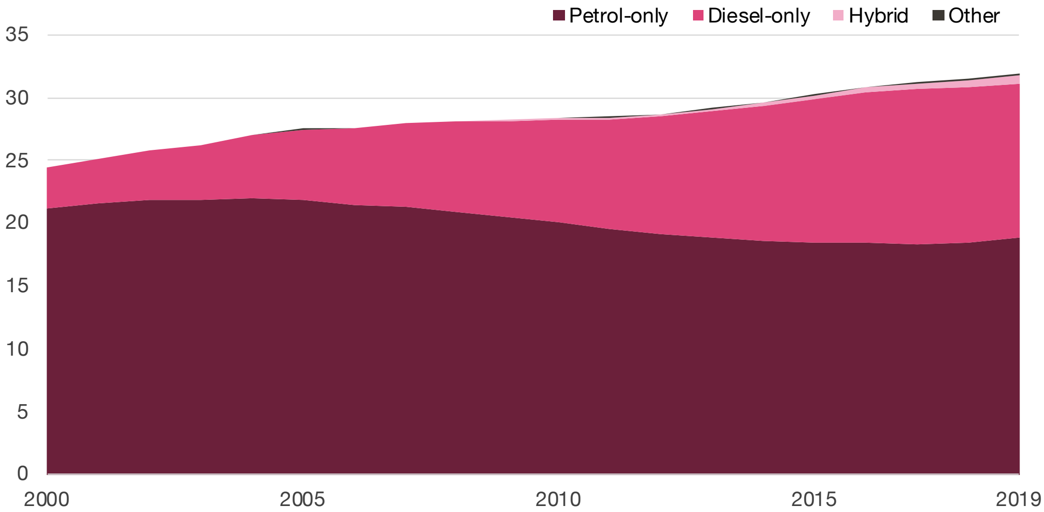

Figure 1: Great Britain Vehicle Parc since 2000 – DfT data

Therefore, prompt, ends-focused, and stable policy is needed to encourage swift and targeted fleet renewal. Encouraging the replacement of light duty vehicles with the highest fuel consumption and lowest Euro emissions standards with vehicles offering the best

[13] Digest of UK Energy Statistics, BEIS, 2019
[14] Decarbonising Transport: Setting the Challenge, DfT, 2020
[15] A community led approach to understanding decarbonised transport futures, University of Brighton, 2020 (using SMMT data)
[16] Vehicle Licensing Statistics, DfT, 2020
[17] EV & AFV Registrations, SMMT, 2020

balance of consumer affordability and low GHG emissions should be the consistent approach.

2.1.1. Car Ownership Models and Duty Cycles

Whilst ownership models are evolving, with a move to mobility as a service (MaaS) through applications such as Uber and subscription services such as Pivotal, in the UK the vast majority of car ownership is private – either through purchase or a lease. This places great importance on the upfront cost of a vehicle and is a significant barrier for the UK consumer in buying any car – even if new EVs do reach cost parity with new petrol and diesel vehicles.[18] Furthermore, the insurance costs of EVs are currently an average of 14% higher than the equivalent petrol or diesel vehicle[19] – offsetting a portion of the in-use cost benefits.

Consumer preferences when purchasing a vehicle are also a key barrier. There has been a clear trend towards the purchase of vehicles that accommodate the extremities of a consumer's usage (e.g. infrequent long journeys) and provide a perceived sense of safety and comfort (e.g. SUVs). As SUVs consume ~25% more energy than an equivalent medium sized vehicle[20], it is demonstrable that in-use costs and environmental impact are not as significant a consideration to the consumer as safety and convenience. This trend is further bolstered by a study completed by Deloitte highlighting that the vast majority of UK consumers would still opt for an ICE-containing vehicle for their next purchase.[21]

Such an approach by the UK consumer demonstrates prioritisation of subjective vehicle attributes in favour of optimising for their majority journey-type, and that the current vehicle re-energising model (refuelling at a retail forecourt) is considered suitably convenient. Whilst data suggests growing consumer receptivity to electrified vehicles, this slow evolution will have a significant dampening impact on vehicle parc renewal.

These factors combined present significant barriers to government implementing a prohibition on the sale of new ICE-containing vehicles in the 2030s or sooner. However, these considerations also present opportunity to empower the consumer in the transition to net zero. By continuing to offer a choice – such as low carbon fuels – under a holistic vehicle GHG emissions policy, the consumer can opt for vehicles that may satisfy some subjective requirements whilst contributing to the key objective of lowering transport GHG emissions.

2.1.2. Van Ownership Models and Duty Cycles

Vans are also majority owned by lease but are more sensitive to total cost of ownership (TCO) than subjective considerations. This is due to their use for business operations that see higher levels of utilisation than cars and a greater breadth in load offerings and duty cycle.

Whilst vans adopt a broader spectrum of loads and duty cycles compared to passenger cars, the applications are also generally more discrete. Urban-only vans are likely to be well placed to transition to BEVs due to advantages in fleet operating costs, charger proximity, and consistent low range demand.[22] However, larger vans may face a compounding significant barrier that their load and duty cycle does not practically permit the use of a battery electric powertrain owing to best available energy densities. This is due to their increased prioritisation of load space, and longer distance travel with such loads. A low carbon liquid fuel – or hydrogen fuel cell electric (infrastructure permitting, see 2.3) – powertrain may be the only viable options for some applications.

Therefore, vans should be considered by type, with barriers treated accordingly. A more appropriate approach in the light duty commercial vehicle space may be to adopt phases

[18] https://www.bloomberg.com/news/articles/2018-03-22/electric-cars-may-be-cheaper-than-gas-guzzlers-in-seven-years
[19] https://vantage-leasing.com/blog/what-you-should-know-about-electric-vehicles
[20] https://www.iea.org/commentaries/growing-preference-for-suvs-challenges-emissions-reductions-in-passenger-car-market
[21] 2020 Global Automotive Consumer Study, Deloitte, 2020
[22] Electric light commercial vehicles: Are they the sleeping giant of electromobility?, EC JRC, June 2020

and differing regulatory approaches. For example, the smallest vans treated (in a regulatory sense) as passenger cars and larger vans treated as heavy goods vehicles (HGVs).

2.2. EV Infrastructure

2.2.1. Consumer Barriers

As discussed previously, consumers are accustomed to a short, convenient, and readily available vehicle re-energising experience. This is currently made possible by the transfer of the energy taking place via liquid fuels and outlets being reliably available across the country's urban, rural, and major road networks – this infrastructure was built up over a number of decades as demand for mobility, and therefore for fuels, increased in the twentieth century.

Currently, the UK's growing public EV charger network faces a range of barriers that need to be overcome in order to offer a comparable vehicle re-energising experience for the consumer:

1. Coverage – whilst public EV charger availability is growing, consumers continue to have "charger anxiety" – particularly for longer journeys.[23] Such concerns are supported by available data – EV charger distribution is heavily skewed to the south east of England with lower provision in some rural areas such as Wales and southern Scotland.[24] Crucially, the lower rate of re-energising for EVs results in higher dwell times (see 'rapidity' below) necessitating more EV chargers. This is especially important for those unable to charge their EV at home (see section 2.2.3). To date, there are 18,962 publicly available EV charger devices in the UK,[24] compared to approximately 63,000 refilling pumps,[25] indicating thousands more EV charging devices are needed just to meet the demand of those unable to charge at home.
2. Reliability – related to 'coverage', in 2019, as many as 23.5% of the UK's public EV chargers were flagged as out of service on Zap Map,[26] highlighting a volatility in service levels that would be considered unacceptable to consumers who are accustomed to on-demand vehicle re-energising. The inability to reliably be able to re-energise one's vehicle impacts consumer confidence in EVs.
3. Rapidity – even with a low flow rate fuel pump (40 l/min),[27] refilling a vehicle via liquid fuels typically takes 1-2 mins. A typical ultra-rapid charger (~120 kW), whilst an order of magnitude slower in its rate of re-energising, can provide 105 miles of charge in 15 mins.[28] To date, only 3.2% of the UK's public EV charging points are ultra-rapid[24], leaving the vast majority of public EV recharging experiences to be at least 30 mins. This increase compared to the liquid fuel re-energising experience is another barrier to increased consumer adoption.
4. Charging Convenience – for decades, consumers have purchased vehicles with confidence that they can re-energise their vehicle at any retail forecourt in the country irrespective of which ICE ignition technology they opted for. This convenience is currently missing for EVs, with a diversification of charger types and payment models adding another barrier to the consumer.[23]
    a. There are currently 5 main types of EV charger connectors[29] that are incompatible with each other and results in some charging devices not being suitable for a certain EV – for example, Tesla's Supercharger network cannot

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[23] Energising Our Electric Vehicle Transition, Electric Vehicle Energy Task Force, LowCVP, ESC, OLEV, January 2020
[24] Zap-Map data updated 15th July 2020
[25] Retail Marketing Survey, Energy Institute, 2020 (with estimation of average number of nozzles per site)
[26] https://www.autocar.co.uk/car-news/industry/unreliable-charging-infrastructure-preventing-ev-rollout (using Zap-Map data)
[27] Certificate Pursuant to section 12 of the Weights and Measures Act 1985, BIS, 2011
[28] https://pod-point.com/guides/driver/how-long-to-charge-an-electric-car
[29] https://pod-point.com/guides/driver/ev-connector-types-speed

be used with all EVs. This diversity of connector types either limits charging device availability or increases charging device complexity (by offering the sufficient range of connectors) and creates consumer confusion when seeking to purchase and use an EV.

b. Whilst the government has made efforts to ensure all newly installed rapid and higher-powered chargers must offer pay as you go (PAYG) by credit or debit card[30], this requirement has not been required to be retrofitted to existing charging devices – potentially presenting a barrier to consumers. It should be noted that the two UKPIA members with significant EV charger networks in the UK offer PAYG payment at all of their rapid and higher-powered devices.

2.2.2. Other Barriers

Furthermore, to increase the availability of ultra-rapid chargers is a significant technical and infrastructure challenge. The power demands of ultra-rapid chargers require dedicated infrastructure[31] that may not be feasible in all areas. This year, Motorway Service Area (MSA) operators expressed their concerns that the UK's electricity network is not fit for purpose with significant technical, regulatory, and cost barriers to implementation.[32] Without readily available ultra-rapid charger access at the UK's MSAs which cover much of the strategic road network, charger anxiety will likely continue to be a significant consumer barrier. Whilst the government has announced efforts to address this through the launch of Project Rapid, it continues to be a significant gap. UKPIA welcomes working with government to offer its expertise in how to encourage a market-led deployment of EV chargers at the UK's key transport re-energising demand locations – an area the industry has demonstrated expertise in for decades.

Rural areas also face significant barriers as the current regulatory framework means distribution network operators (DNOs) can only spread the costs of grid strengthening if sufficient demand is demonstrated. As these areas have the lowest population density, greatest reliance on their vehicles for commuting, and lower rates of new vehicle purchasing, such demand is unlikely to be easily demonstrated.

Assuming the technical challenges can be overcome, and government are able to support with the regulatory burden, the significant challenge of cost remains. National Grid estimate that the cost of an ultra-rapid charging network of 50 sites will cost at least £500 million,[33] an estimate consistent with GRIDSERVE's plans to deliver 100 EV forecourts at a cost of £1 billion.[34]

Such an abrupt and high financial barrier may prove highly disruptive in a post-COVID-19 economy, with more cost-effective and phased approaches leading to increased uptake of EVs likely to prove a more effective course of action.

2.2.3. Residential and Workplace Charging

Many EV owners may be able to fulfil the majority of their vehicle re-energising needs at home and/or their workplace. However, a significant competing factor will be the use of electricity to decarbonise building heating as government policy increases the use of heat pumps to displace both on- and off-grid combustion heating.[35] Existing infrastructure is limited in the

[30] https://www.gov.uk/government/news/all-new-rapid-chargepoints-should-offer-card-payment-by-2020
[31] Code of Practice for Electric Vehicle Charging Equipment Installation, 4th Edition, IET, 2020
[32] https://www.ft.com/content/594345dc-20d0-11ea-b8a1-584213ee7b2b
[33] https://www.nationalgrid.com/uk/electricity-transmission/Keeping-36-million-electric-vehicles-on-the-mov
[34] https://www.gridserve.com/post/breaking-news-1
[35] https://www.gov.uk/government/groups/heat-in-buildings

provision of both increased building demand and EV charging[36] with fewer/higher cost technologies available to decarbonise building heating.

In addition, 40% of households do not have off-street parking available.[37] Whilst some of this demand may be met by on-street, low voltage charging, this will continue to face significant demand challenges as homes decarbonise. There will also be some households with regulated off-street parking where EV charger installation is not authorised by the consumer, or multi-vehicle households where simultaneous charging is not feasible. Therefore, there will remain a significant proportion of vehicles where a suitable public, ultra-rapid charging network is required.

Therefore, unless the electricity infrastructure challenge is to be compounded by necessitating upgrades to the majority of the low voltage system, the infrastructure upgrades may need to focus on electricity network upgrading of the aforementioned re-energising hubs/forecourts.

2.3. Gas Infrastructure

The infrastructure challenges are given further context when considering other low carbon transition infrastructures that may be required in the coming decades. Hydrogen is likely to become an appropriate low carbon energy vector for a variety of applications such as home heating, heavy duty road vehicles, industry and shipping.[38,39,61]

Therefore, the significant investment in energy vector infrastructure required to decarbonise transport must be viewed holistically. Not only does this balance of investment potentially present a barrier to EV adoption, but artificially forcing new vehicle sales to be only EVs, rather than a market-led increase, presents significant risk to investment in other necessary infrastructure as EVs are forcibly prioritised.

Fuel cell electric vehicles (FCEVs) are already forming a significant part of bus fleets in the UK and is forecast to grow.[40] FCEVs may also form part of the light duty vehicle fleet in the coming decades – vehicles with this powertrain have been on sale for a number of years in the UK and are expected to increase their share of both the van and passenger car parc.[41] Perhaps even more than EV charging, the retail forecourt sector is likely to play a crucial role in the re-energising of FCEVs; several UKPIA members already operate in the hydrogen refuelling space and are actively exploring this area.

Currently, the natural gas infrastructure offers some support to transport activities however this is predominantly in the heavy-duty vehicle sector, and therefore out of the scope of this consultation.

2.4. Domestic EV Manufacturing

Authoritative studies highlighting the lifecycle GHG emissions benefits of BEVs compared to ICE vehicles operating on fossil-derived fuels highlight that the maximum GHG emission saving is realised when the BEV is manufactured domestically.[42] This is principally derived from reduced cradle-to-grave emissions of the vehicle resulting from supply chain efficiencies and an increasingly decarbonising grid in the UK.

Satisfying increasing EV demand with a domestic EV manufacturing presence offers significant economic and GHG emissions saving opportunities for the UK. However, such a presence does not yet exist, and requires a suitable policy and investment framework to

[36] Electric Vehicle and LCT Loads on Constrained Distribution Networks: An Investigation of Impacts and Options, S. Broderick, July 2020
[37] Spaced Out: Perspectives on parking policy, RAC Foundation, July 2012
[38] Hydrogen in a low-carbon economy, Committee on Climate Change, November 2018
[39] Future Energy Scenarios 2020, National Grid, July 2020
[40] https://fuelcellbuses.eu/public-transport-hydrogen/uk-become-pioneer-development-hydrogen-fuel-cell-buses
[41] https://www.smmt.co.uk/industry-topics/technology-innovation/ultra-low-emission-vehicles-ulevs/
[42] Vehicle lifecycle CO_2e emissions – integration into vehicle policy and automotive design, LowCVP, September 2019

realise. Ending the sale of new vehicles containing ICEs is unlikely to achieve this, as a technology-specific restriction at the point of retail is unlikely to translate to investor certainty with respect to domestic manufacturing. Without a sufficient domestic manufacturing presence, EVs will predominantly need to be imported – increasing reliance on other markets and reducing the GHG emissions benefit as manufacturing is conducted in higher carbon intensity markets and the logistics emissions increase (in-use emissions will still benefit from the UK grid).

Furthermore, not only does the above present a barrier, if new vehicle sales are forced to be EVs without a suitable domestic supply, the UK may become more heavily dependent on countries with possibly variable political environments and postures towards the UK. Such international leverage is likely to be over fewer markets than the UK's current energy reliance which is spread over global commodity and finished product markets. The APC have published a report of opportunities for the UK – with a potential value of £24 billion – through a domestic electric vehicle supply chain.[43]

2.5. Electricity Market Limitations

In addition to challenges regarding local network capacity, the UK electricity market is currently not able to balance supply and demand with the needed response time and scale.[44] Greater demand side flexibility is required to meet the demands of elevated electrification, along with scope for the transmission grid to increasingly shift supply on a decentralised network.[39] The current electricity sector regulatory framework and lack of ready market access for flexibility providers are barriers to this necessary evolution.

2.6. Utilising Existing Liquid Fuels Infrastructure

Carbon-based chemical energy is the current primary energy vector for UK light duty transport and the majority of this energy is derived from crude oil. However, whilst the existing UK infrastructure may be dependent on physicochemical considerations, it is blind to the *origin* of the transported energy vectors. Considering that the UK has one of the most efficient pre-tax fuels supply chains in Europe,[45] one can appreciate the significant potential for cost-effective decarbonisation via low carbon fuels.

Effective use of the UK's existing liquid fuels infrastructure to decarbonise existing transport swiftly is not a barrier to increased EV adoption but an opportunity for cost-effective and consumer friendly EV adoption. Low carbon fuels can co-exist alongside EVs with consumer demand and lifecycle GHG emissions driving the most suitable powertrain technology and energy vectors. The UK's objective should be to ensure vehicles adopt *fit-for-purpose* energy transfer, storage, and conversion, with a range of technologies permitted to decarbonise transport pragmatically and at the lowest £/MtCO_2e to maximise emission reductions and reduce societal cost.

For example, ICE vehicles operating low well-to-tank (WTT) GHG emission fuels such as waste-derived biodiesel or paraffinic fuel offer comparable or improved lifecycle GHG emissions savings compared to BEVs.[11,42] The point of limited feedstock availability is a valid one, and may limit supply, but it is precisely because of the limited supply in the decarbonisation of all energy vectors that they should be encouraged to co-exist and support the most suitable duty cycles.

Furthermore, whilst alternative financing and carbon accounting models are explored with vehicles, this is a relatively nascent exploration in the area of fuels. New models could be utilised to ensure the in-use emissions of ICE vehicles are suitably offset. This can be achieved either by traditional offsetting measures – already offered by some UKPIA members

[43] Strategic UK opportunities in passenger car electrification, Advanced Propulsion Centre UK, June 2020
[44] Delivering the Potential for Flexibility, Energy UK, February 2020
[45] UKPIA Statistical Review 2019, UKPIA

– or could include other innovative solutions such as pricing-in the use of low carbon fuels at vehicle purchase.

Such an approach utilises existing infrastructure and expertise but may provide greater upfront assurance of low carbon use. This also enables the lower cradle-to-gate GHG emissions of ICE vehicles compared to BEVs to be combined with lower well-to-tank GHG emissions.[42]

3. The Impact of these Ambitions on Different Sectors of Industry and Society

3.1. Upstream GHG Emissions

Whilst DfT/OLEV's proposal would bring the tailpipe CO_2, CO, and NO_x emissions of newly sold vehicles to zero from the year of implementation, this does not bring the lifecycle emissions of the transport product/service to zero. Ending the sale of new ICE containing vehicles without supporting domestic supply will result in increased cradle-to-gate GHG emissions of vehicles. The European Environment Agency's lifecycle analysis of BEVs concluded that the cradle-to-gate emissions of BEVs are greater than equivalent ICEs,[46] and even strong EV proponents' analysis has confirmed the increased GHG emissions risk of vehicles manufactured in higher carbon intensity markets.[47]

The engineering community has also flagged the "unforeseen consequences of backing particular technologies," with the Institution of Mechanical Engineers (IMechE) recommending "the adoption of a life cycle approach for all government policy."[48]

3.2. Other Possible Upstream Impacts

In addition, lack of suitable provision and regulation of domestic manufacturing can result in additional lifecycle impacts. For example, there is the possibility of increased human toxicity potential relative to an equivalent petrol ICE vehicle – even accounting for end-of-life recycling savings.[49,46] It should be noted that in the same study, BEVs offered acidification potential benefits relative to an equivalent petrol ICE vehicle. This highlights that whilst the primary focus is on GHG emissions, additional lifecycle impacts should not be ignored.

Arguably most controversial is the impact of raw material extraction to meet the surge in battery demand. Last year, many leading scientists in the UK sent a letter to the Committee on Climate Change highlighting that complete electrification of the UK's cars and vans – even with the most resource-frugal NMC 811 batteries – would require double the current global production of cobalt, and three quarters of the world's lithium production.[50] Both of these elements have been linked to human rights violations in their extraction,[51] and whilst progress is being made in safeguarding the supply chain and ensuring due diligence is conducted[52], the spike in demand resulting from prohibiting the sale of new ICE vehicles – rather than a phased approach – may result in unintended consequences on mineral extraction and increased volatility in price.[53]

An additional consideration is the use of graphite as the anode material in lithium ion batteries; the most commonly used battery technology in EVs with much of the graphite used being obtained from petroleum coke. Despite the UK being one of few major producers of

[46] Electric vehicles from life cycle and circular economy perspectives, European Environment Agency Report 13/2018, 2018
[47] How clean are electric cars?, Transport & Environment, April 2020
[48] Accelerating Road Transport Decarbonisation, IMechE, January 2020
[49] Life Cycle CO_2e Emissions from Electric Vehicle Production and Wider Sustainability Impacts, Ricardo, July 2020
[50] https://www.nhm.ac.uk/press-office/press-releases/leading-scientists-set-out-resource-challenge-of-meeting-net-zer.html
[51] https://www.amnesty.org/en/latest/news/2019/03/amnesty-challenges-industry-leaders-to-clean-up-their-batteries/
[52] Drilling down into the cobalt supply chain: how investors can promote responsible sourcing practices, UN PRI, 2018
[53] Statistical Report 2020, Fuels Europe, June 2020

high-grade graphite coke, it is currently exported to China for manufacture of EV batteries.[54] At present, production of synthetic graphite coke relies on refining of crude oil, with demand rising steadily as the EV market also develops. This is likely to continue for the foreseeable future and supports the need to decarbonise coke manufacture along with other refining processes to produce low carbon liquid fuels. It also highlights the need to enable domestic battery manufacture.

3.3. Supply Chain Bottlenecking

Whilst domestic/EU supply chains are growing to meet battery demand, lithium demand is forecast to outstrip all projects that are operational, planned, unfinanced and recycling initiatives.[55] As aforementioned, leading UK scientists have also expressed concerns regarding the cobalt, neodymium, and copper supply chains[50] as neodymium is a critical element for the manufacture of electric motors.[56]

Whilst efforts are underway to develop batteries less reliant on cobalt, and European supply chains are seeking to improve their resilience to elemental exposure, what is clear is that in even the most optimistic scenarios, European countries will be exposed to lithium and neodymium supply chain volatility.[57]

Therefore, prohibiting the sale of new vehicles containing ICEs, without allowing scope for low carbon liquid fuels nor rightsized battery PHEV options, will place significant strain on the EV supply chain. Even optimistic estimates of extracted raw material supply (rather than theoretical reserves in the Earth), concede that temporary supply chain disruption cannot be ruled out,[58] with possible resulting consequences on EV supply resilience and cost.

3.4. Disadvantaging Poorer Demographics

As aforementioned, cost is currently a consumer barrier for EVs and whilst projected decreases in battery costs will aid in this area, there may also be competing dampener effects such as supply chain bottlenecks (see 3.3). These factors also have a knock-on impact on the UK's used vehicle market where almost 8 million vehicles are purchased every year (~3.5x more than new vehicles).[59] Assuming similar vehicle retention periods with EVs as with ICE vehicles, even with rapidly increasing new EV sales, the used EV market will continue to be in a relatively immature state through the 2020s.

Crucially, the poorest demographics in the UK correlate with rural residence and heavy reliance on their sole private car.[60] Therefore, without significant cost reductions, the retail of FCEVs and BEVs-only may result in compounding issues for the most financially disadvantaged:

- Those reliant on new vehicles on Personal Contract Purchase (PCP), for example, to operate a vehicle under manufacturer warranty, may be forced to spend a significantly greater proportion of their income on a higher purchase price EV.
    - These consumers are likely to be dependent on low power charging due to the aforementioned rural electricity infrastructure challenges.
- Consumers unable to afford the higher purchase price EVs will be forced to retain their older ICE containing vehicle.

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[54] The Economic Contribution of the UK Downstream Oil Sector, UKPIA, 2019
[55] Sustainable Supply Chains, Benchmark Mineral Intelligence, July 2020
[56] Can the UK Build a Sustainable Supply Chain for Electrified Vehicles?, Advanced Propulsion Centre, July 2020
[57] Assessment of potential bottlenecks along the materials supply chain for the future deployment of low-carbon energy and transport technologies in the EU, EC JRC Science for Policy Report, 2016
[58] Ensuring a Sustainable Supply of Raw Materials for Electric Vehicles, Agora Verkehrswende, March 2018
[59] https://www.smmt.co.uk/2020/02/uk-used-car-market-holds-steady-in-2019-with-7-9-million-sales/
[60] Inequalities in Mobility and Access in the UK Transport System, Government Office for Science, March 2019

- These consumers may be forced to maintain these vehicles in an increasingly dwindling workshop base and therefore may have to travel further or pay more for their vehicle maintenance.
- These consumers will have limited options in the used market should EV values remain buoyant and ICE vehicle supply reduce.

A fairer approach would be to encourage and support fleet renewal across all demographics (see section 4.3), lest the most vulnerable demographics of UK society be unnecessarily penalised for utilising a cost-effective powertrain.

Fleet renewal is not the only means of decarbonising transport for the most vulnerable demographics, however, low carbon fuels offer the opportunity to decarbonise the legacy ICE-containing vehicle fleet with existing infrastructure. Therefore, the impact on prohibiting the sale of new ICE-containing vehicles on vulnerable demographics can be mitigated against by supporting the proliferation of low carbon fuels in parallel.

3.5. Impeding the Necessary Mobility Paradigm Shift

The Energy Systems Catapult (ESC) Innovating to Net Zero report highlights that in order to achieve net zero emissions by 2050, a whole systems approach to energy uses and vectors must be adopted.[61] This includes significant shifts in how consumers use transport: with modes integrated, increased vehicle utilisation, and evolved ownership/operation models.

Ultimately, a mobility paradigm shift is required for net zero to be achieved, with inefficient ownership models reduced, and all technology options available to ensure the most fit-for-purpose energy transfer, storage, and conversion is utilised for a given application.

Ending the sale of new vehicles of any specific powertrain technology risks undermining this approach. Limiting powertrain technologies and inadvertently reinforcing the siloed roles of light duty transport limits consumer attitude shift and available technologies. The ESC report is clear – electrification of transport has a key role to play – however the implementation should be guided by the most efficient approaches and investment across the total system. The powertrain's efficiencies will lead to its most appropriate utilisation under a holistic approach.

3.6. Impeding Low Carbon Fuels Proof of Concept

Despite the range of energy vectors and boundary conditions available in transport decarbonisation scenario planning, one view is clear across stakeholders: the energy intensity and density demands of long distance aviation will necessitate the use of low carbon sustainable aviation fuels (SAFs).[62] However, the utilisation of SAFs must grow from almost zero, presenting significant technical, logistical, and regulatory challenges.

An essential phase in the development of a new fuel, fuel component, or fuel manufacturing process, is trialling the fuel and demonstrating operational confidence in the lowest risk manner cost effectively feasible. In the case of SAFs, the operational confidence needs to be extremely high as the transport mode is high risk and there are limited contingency fuel storage opportunities.[63] Therefore, an effective means of demonstrating viability from a fuel quality, operational resilience, and supply failure mode analysis perspective is by deploying such fuels in the road sector.

Jet fuel and diesel fuel share many input blending components, therefore feasibly it would be in diesel vehicles that some SAF fuel components could be deployed. This would be a cost-effective route of demonstrating new fuel viability and manufacturing plant reliability by completing millions of km travelled and thousands of manufacturing hours before a novel fuel

[61] Innovating to Net Zero, Energy Systems Catapult, March 2020
[62] Long-term aviation fuel decarbonization: Progress, roadblocks, and policy opportunities, ICCT, January 2019
[63] Economic regulation at Heathrow from April 2014: notice of the proposed licence, Civil Aviation Authority, January 2014

might be deployed in aircraft.[64] The commercial viability of SAF plants is likely to also depend on the deployment of some manufactured blend components in other fuels, as whilst plants may be optimised for SAFs, flexibility in feedstock input and blend output will be needed. Therefore, any new transport policy should also be considered in the context of not inadvertently limiting opportunities to test new SAF blending component options or processes in the UK.

3.7. Urban Congestion

Some local authorities have announced initiatives that deviate from DEFRA's Clean Air Zone (CAZ) framework, providing preferential access to BEVs over an ICE containing vehicle.[65, 66] As EVs still have a local air quality impact[67] – particularly PM_{10} and $PM_{2.5}$ – newly retailed vehicles exclusively being EVs may inadvertently result in elevated congestion levels in some urban areas, and a corresponding detrimental impact on urban air quality.

It should be noted that Euro 6 diesel vehicles have been demonstrated to have negligible increase in impact on urban air quality compared to BEVs,[68] therefore, the crucial policies to support urban air quality improvements are the existing DEFRA CAZ framework and congestion management.

3.8. Reduced Public Revenue

The UK government currently raises at least £30 billion through fuel duty and VAT charged on fuel representing over 3.5% of all receipts.[69] Ending the sale of ICE containing vehicles, and the subsequent impact it will have on evolution of the UK vehicle parc and fuel demand, will severely reduce this significant revenue stream. It is unclear at this stage how government intends to address this funding shortfall.

UKPIA welcomes further conversation with government on this topic as it considers how to address this funding shortfall. Taxation should not be shifted to new energy vectors or their vehicles without serious consideration first as this may have consequences on vehicle uptake and introduce new barriers to adoption.

3.9. Impacting UK Manufacturing

In addition to the significant impact a prohibition of selling ICE-containing vehicles will have on our sector, this approach will also significantly impact the UK's vehicle manufacturing sector. The UK currently produces 1.4 million cars and vans (of which the majority are ICE-containing) and 2.5 million ICEs – a major export business at risk.[70] Vehicle product cycles are multi-year, with many products targeted for sale in the early 2030s already under development. Therefore, ending the sale of ICE-containing vehicles will significantly impact manufacturing in the UK, and without suitable government policies and support for decarbonisation technologies, may impact investor confidence in the UK.

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64 The Flight Paths for Biojet Fuel, US Energy Information Administration, October 2015
65 https://www.oxford.gov.uk/info/20299/air_quality_projects/1305/oxford_zero_emission_zone_zez
66 https://www.cleanairforbristol.org/
67 Non-exhaust traffic related emissions. Brake and tyre wear PM, EC JRC Science and Policy Reports, 2014
68 A comparison of real driving emissions from Euro 6 diesel passenger cars with zero emission vehicles and their impact on urban air quality compliance, Aeris Europe (for Concawe), April 2018
69 https://obr.uk/forecasts-in-depth/tax-by-tax-spend-by-spend/fuel-duties/
70 SMMT Motor Industry Facts 2020, SMMT, June 2020

4. Measures Required by Government and Others to Achieve the Earlier Phase Out Date

4.1. EV Infrastructure

For BEVs to be used as a sole vehicle in a household, and therefore make consideration of ICE vehicle phase out possible, the following measures would need to be made by government to address infrastructure limitations:

1. Reduce/remove the regulatory burdens for DNOs to upgrade local networks and support the installation of substations.
2. Publish thorough, dedicated guidance (via the HSE) for the safe installation of EV chargers at dedicated sites or existing retail forecourts.
3. Monitor charger reliability and penalise providers not making reasonable efforts to swiftly return charger back into service.
4. Partner with the retail forecourt industry, as the industry to have already identified where and how to support the UK motorist’s mobility needs, to support the installation of ultra-rapid EV chargers.
5. Ensure all charging devices offer a pay as you go option, with minimal variation in charger connector types.
6. Endorse/draft a data exchange framework, allowing the consumer to swiftly identify when chargers are in use/available.
7. Ensure any policies do not prevent or hinder future implementation of climate neutral technologies such as low carbon fuels or hydrogen.

4.2. Consumer Attitudes

Once the infrastructure barriers are addressed, consumer “charging anxiety” should reduce, with concerns remaining regarding used reliability and cost. For the former, government and the OEMs have a key role to play in providing assurances and demonstrations that used battery performance is sufficient for consumer requirements and is not comparable to Li-ion battery degradation they may have observed elsewhere (such as mobile phones and laptops).

4.3. Fleet Renewal

The remaining challenge, cost, will be a key barrier to greater EV proliferation in the UK vehicle parc. It is important that any efforts to increase the EV segment are at the replacement of the oldest, least efficient, and most polluting vehicles, rather than more modern, efficient vehicles.

4.4. Electricity Market Evolution

The electricity sector will require regulatory changes and a corresponding evolution in the electricity market that includes mechanisms such as smart charging. This needs to be implemented swiftly to allow suitable market evolution in advance of significant EV presence in the UK vehicle parc. Any approach to encouraging the use of smart charging should be market-led, enabling the offer of cost-effective and innovative approaches for the consumer. Clearly, the incremental electricity supply required to meet increased demand for vehicle charging and home heating must also be renewable, in addition to that required to further decarbonise the existing supply.

4.5. Holistic, Systems Approach to UK Energy

The key to cost-effective and swift decarbonisation of UK energy is to adopt a systems approach to all energy vectors and uses. Efforts to exclude specific powertrain technologies – particularly ones so deeply embedded into UK society with highly efficient supply chains – will inevitably result in unintended consequences with no margin for error with respect to sustainability and, due to the severe impacts of COVID-19, the economy.

UK government ministers recently participated in the International Energy Agency (IEA) Clean Energy Transitions Summit[71] where ministers discussed sustainable and resilient recovery from the COVID-19 crisis and how to achieve a definitive peak in global carbon emissions. A key principle shared by the IEA is that reducing global GHG emissions "will require a broad range of different technologies working across all sectors of the economy in various combinations and applications" and that net zero emissions will not be achieved by focusing on a single technology.[72]

Adopting an effective systems approach will ensure focus is made on high impact (greatest GHG emissions reduction) areas, without conflict with other areas (for example, competition on the low voltage network of EV charging vs home heating). Such an approach will encourage the required transport integration and modal shifts, lowering overall transport energy, and will subsequently accelerate the phase out of ICE containing vehicles in the transport modes highly suited to electrification.

This will also ensure that the transport modes with requirements and duty cycles less suited to the best available electrification technology at the time are met by the most GHG emissions-effective powertrain technology for the application. It is essential that any efforts made to accelerate EV adoption do not come at the expense of other decarbonisation technologies such as low carbon fuels or hydrogen.

[71] https://www.iea.org/news/40-ministers-from-around-the-world-gather-to-address-the-world-s-energy-and-climate-challenges
[72] Energy Technology Perspectives 2020, IEA, July 2020

5. Definition of what Should be Phased Out

As aforementioned, UKPIA is supportive of powertrain technologies becoming more fit-for-purpose – meeting climate, consumer, and economic needs – and the greater technology diversity that may result. Whilst some technologies may organically phase out, there is insufficiently compelling technical justification to prohibit the sale of a specific powertrain technology in new vehicles (see previous chapters). Robust, well-designed product GHG emissions policy will drive vehicle adoption in the right direction at the lowest societal cost.

Taking the DfT/OLEV proposal on face value, it is particularly noteworthy that all hybrid vehicles have been included in the scope of the prohibition on new vehicle sales. Such an approach appears to be technically inconsistent with the objective of lowering net GHG emissions of light duty vehicles with the least disruption to the consumer as many hybrid technologies – in particular PHEVs and REEVs – offer zero tailpipe emission operation at distances typical of UK consumer journeys.

PHEVs and REEVs can offer lower cradle-to-gate emissions and reduced supply chain demand than BEVs from the "right-sizing" of their batteries and ICEs. In use, PHEVs or REEVs are equally as carbon intensive as BEVs under electric-only operation and can result in minimal net GHG emissions impact when operating on low carbon fuels. The aforementioned lifecycle analysis studies have highlighted that a PHEV operating on low carbon fuels can offer lower cradle-to-grave net GHG emissions than an equivalent BEV on current or similar grid carbon intensity.

It is on this basis, that if such a policy is implemented by government, UKPIA strongly agrees with the positions of many OEMs[73, 74] that hybrid vehicles should not be included in the scope of a new vehicle powertrain technology-based retail ban. UKPIA proposes that upfront in-use GHG emissions reduction measures for ICE vehicles, such as offsetting or novel low carbon fuel provision, also be out of scope of any ban.

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[73] https://europe.autonews.com/automakers/auto-industry-criticizes-uk-plan-bring-forward-ban-combustion-engine-cars

[74] https://www.fleetnews.co.uk/news/manufacturer-news/2020/06/24/hybrids-will-still-be-required-if-government-bans-ice-cars-in-2035-says-ford-boss

6. The Phase Out Date

6.1. Feasibility of 2035

In the absence of an impact assessment or economic analysis, it is highly challenging for UKPIA to comment on government's assessment of the feasibility of a 2035 implementation. Given the composition of the UK vehicle parc, and average vehicle age (as discussed in section 2), UKPIA is unable to develop or reference technical justification to change from the originally proposed date of 2040.

6.2. Long-Term Opportunity

Whilst it is clear that predominantly fossil-derived carbon-based chemical energy will be used in light duty vehicles in at least in the next decade, we need to ensure it is used more efficiently and the "fossil portion" is transitioned to zero over time.

What can be introduced in its place is a wide range of compelling, climate neutral fuels (and fuelling models, see section 2.5) to power UK transport with net zero emissions.[75,10] These fuels will be readily deployable in existing infrastructure and proven on road transport. Their deployment can continue as needed depending on climate neutrality and supply – for example in the case of limited feedstocks they can be diverted to aviation and marine as light duty is electrified.

FuelsEurope have identified a realistic pathway for the deployment of low carbon fuels up to 2050, with a clear increasing role for the use of hydrotreated vegetable oils (HVO) and lignocellulosic residue fuels. These fuels offer a cost-effective and pragmatic route to GHG emissions reduction and complement the simultaneous deployment of other decarbonisation technologies.

Increasing utilisation of low carbon fuels is an approach endorsed by the engineering community – one of the recommendations by the IMechE in its 'Accelerating Road Transport Decarbonisation' report was for "substantial investment (similar to that provided for battery electric vehicles and charging infrastructure) in sustainable and low-carbon fuel development and associated internal combustion engine technology."[48]

UKPIA has recently demonstrated its support for increased deployment of low carbon fuels in the UK by responding to the DfT's consultation on the introduction of E10 with full support for its mandated introduction. UKPIA looks forward to engaging with government further regarding renewable fuel content in the UK's fuels such as the upcoming consultation on the Renewable Transport Fuel Obligation (RTFO) Order.

[75] Clean Fuels for All - A Potential Pathway to Climate Neutrality by 2050, FuelsEurope, June 2020

7. Viable Roadmap for Road Transport Decarbonisation

7.1. Pathway

Vehicle Rightsizing

- Disincentivise new vehicles with excessive mass, high drag coefficients, inefficient engines (cf. France vehicle tax).
- Incentivise ICE containing vehicles with broad range of fuel compatibility and right sized batteries.
- Develop strategy for implementation of lifecycle CO_2 based vehicle policy.

Low Carbon Fuels and…

- Increase deployment of low carbon fuels – deployment of renewable oxygenates in petrol and biodiesel in diesel should be maximised.
- Commercialisation of “low hanging fruit” (e.g. HVO) should be supported so further blending can be achieved.

…Infrastructure Roll-Out in Parallel

- Support a market-led roll-out of EV charging infrastructure (including all items stated in section 4.1) and prioritising the key road network.
- Further decarbonise power generation for improved in-use GHG emissions of all partially and fully electrified vehicles.
- Consider H_2 infrastructure deployment in parallel.

Support Fleet Renewal

- Consumers should be incentivised to replace the least efficient and most polluting ICE vehicles with modern vehicles.
- Sufficient decreases in upfront vehicle cost and available charging should result in increased proliferation of EVs in urban light duty commercial vehicles.
- OEMs provide assurance regarding used BEV durability.

Passenger Car Parc Evolution

- Additional technologies such as hydrogen may increase their proportion of the vehicle parc depending on infrastructure presence.
- A significant used EV market emerges and increases EV accessibility.
- Lifecycle CO_2 based regulation is implemented and necessitates the use of only EVs or low carbon fuel ICE vehicles.

Powertrain coexistence

- Electrified (battery or hydrogen) and low carbon liquid fuel vehicles co-exist on the UK's roads.
- Low carbon fuels transition to climate neutral fuels.

7.2. Summary of Suggested Pathway

The pathway presented seeks to frame, at a very high level, a possible roadmap for the decarbonisation of light duty vehicles in the UK. Climate scientists are clear that GHG reductions missed in the short-term will be more difficult and costly to abate in the long-term. Therefore, low cost, readily implementable policy steers should be provided to increase the reduction of GHG emissions tomorrow.

Necessary and logical steps for decarbonisation are highlighted without prescribing specific dates – the pace of change is highly dependent on policy and investment. It is possible that the market-led reduction of ICE-containing vehicles could occur swiftly with the appropriate modal shifts, consumer support, and holistic GHG emissions regulation.

The first phase would be to curtail the unnecessary proliferation of oversized vehicles, which have resulted in an increase in GHG emissions in recent years, a trend that can be reversed. This can be achieved by disincentivising – rather than prohibiting - by scaling vehicle costs based on efficiency variables such as weight, drag coefficient, and tailpipe emissions. HMT's renewed interest in the area of vehicle taxation provides an excellent opportunity for such reforms, and UKPIA looks forward to responding to the VED call for evidence. The WTT GHG emissions of road transport can also be readily reduced by increasing the low carbon fuel content of the UK's fungible fuel mix.

In parallel, further low carbon fuel development and EV infrastructure improvements can take place, ensuring energy vectors are brought to net zero and consumer concerns regarding charging can be alleviated. OEMs and government can provide clear assurances that used battery life need not be a concern to increase the momentum of a used EV market.

Lifecycle CO_2-focused vehicle policy is then implemented, most likely achieved by incorporating well-practised cradle-to-gate, well-to-tank, tailpipe, and end-of-life emissions models. This, combined with increased use of mobility as a service, results in new light duty vehicles that are likely to be majority electrified with ICE vehicles operating on very low carbon or climate neutral fuels. Electric vehicles are powered by a mix of battery and hydrogen fuel cell systems leading to the co-existence of multiple powertrain technologies.

As we have argued, UKPIA strongly believes a robust, viable roadmap, supported by holistic policy measures across government departments will be needed to decarbonise UK transport.

8. Glossary

BEV	Battery Electric Vehicle
CAZ	Clean Air Zone
DNO	Distribution Network Operator
ESC	Energy Systems Catapult
FCEV	Fuel Cell Electric Vehicle
GHG	Greenhouse Gas
HGV	Heavy Goods Vehicle
HVO	Hydrogenated Vegetable Oil
ICE	Internal Combustion Engine
LCA	Lifecycle Assessment
MaaS	Mobility as a Service
MSA	Motorway Service Area
PAYG	Pay As You Go
PCP	Personal Contract Purchase
PHEV	Plug-in Hybrid Electric Vehicle
REEV	Range Extended Electric Vehicle
RTFO	Renewable Transport Fuel Obligation
SAF	Sustainable Aviation Fuel
TCO	Total Cost of Ownership
WTT	Well-to-Tank