Department for Transport and Office for Low Emission Vehicles Consultation

Ending the sale of new petrol, diesel and hybrid cars and vans

Joint UK Energy Research Centre and Centre for Research on Energy Demand Solutions Response

Dr Christian Brand, University of Oxford, UK Energy Research Centre and Centre for Research on Energy Demand Solutions

Professor Jillian Anable, University of Leeds, UK Energy Research Centre and Centre for Research on Energy Demand Solutions

Dr James Dixon, University of Oxford, University of Strathclyde, UK Energy Research Centre and Centre for Research on Energy Demand Solutions

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Contents

UK Research and Innovation

Engineering and Physical Sciences Research Council

Economic and Social Research Council

Introduction

The UK Government is seeking views on bringing forward the end to the sale of new petrol, diesel and hybrid cars and vans from 2040 to 2035, or earlier if a faster transition appears feasible. Government is asking for views on:

1. the phase out date,
2. the definition of what should be phased out,
3. barriers to achieving the above proposals,
4. the impact of these ambitions on different sectors of industry and society, and
5. what measures are required by government and others to achieve the earlier phase out date.

UKERC and other research groups have undertaken a range of research relevant to this inquiry over the last few years. The predominant focus has been the longer term transformation of the transport-energy system with particular focus on the electrification of light duty vehicles. This response takes a 'systemic' approach across the transport and electricity systems to how long term goals might be met and uses this to inform analysis of decisions on short to medium term targets. This consultation and impending publication of the 'Transport Decarbonisation Plan' mean now is a good time to consider the implications of a 'net zero' world that requires emissions to decrease faster and further than before.

1. The phase out date

A phase out date of '2035 or earlier' is sensible yet it might not be enough.

Our research, recently published in the journal Energy Policy, has found that **neither existing transport policies nor the pledge to bring forward the phase out the sale of new fossil fuel vehicles by 2035 or 2040 are sufficient to hit carbon reduction targets or make the early gains needed to meet the net zero targets for cars and vans**.[1] The research shows that technical substitution, while essential in the medium to long run, will be too slow to deliver 'net zero' carbon reduction targets on its own.[2] Even in the most optimistic case, fossil fuel cars and vans will dominate UK roads well into the late 2030s. This adds to the growing evidence base that the later targets for phasing out conventional fossil fuel vehicles may be inadequate and unfit for purpose.[3]

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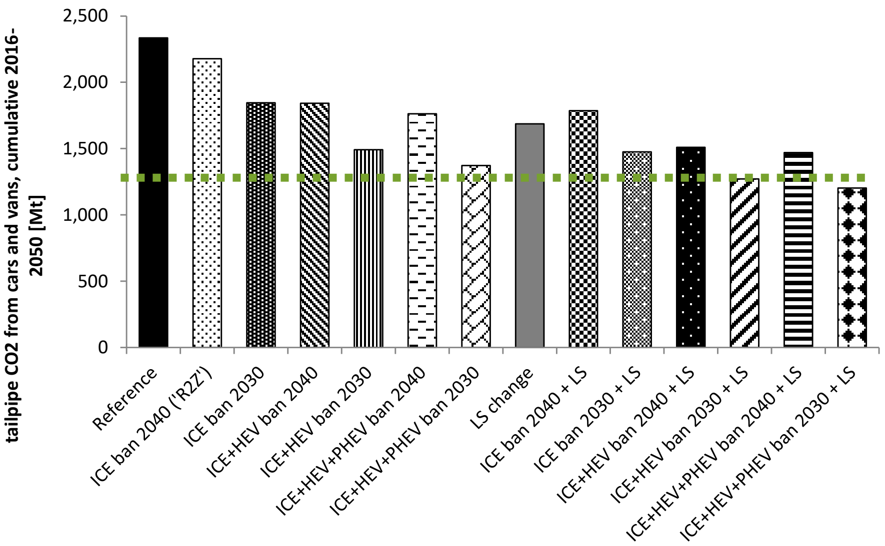
[1] Brand, C., Anable, J., Ketsopoulou, I. and Watson, J. (2020) Road to zero or road to nowhere? Disrupting transport and energy in a zero carbon world. *Energy Policy*, 139. 111334. doi:10.1016/j.enpol.2020.111334

[2] We estimated a potential Paris compliant carbon budget left for cars and vans at around 1.37GtCO_2, based on equal per capita emissions, constant share of total UK emissions for cars and vans of 23%, and excluding international aviation and shipping. Further details are described in the *Energy Policy* paper.

[3] House of Commons (2018) Electric vehicles: driving the transition, Fourteenth Report of Session 2017–19. London, House of Commons Business, Energy and Industrial Strategy Committee.

Figure 1 compares different scenario pathways in terms of *cumulative CO_2 emissions* over the period from 2016 to 2050. As outlined in the Appendix to this Response, the scenarios essentially include two groups of pathways: (a) a number of technology substitution pathways based on target dates and definition of ULEVs but *without* changes in travel demand and (b) the same technology substitution pathways but now *with* changes in travel demand. As might be expected, the largest and earliest savings were achieved by the 2030 phase outs of internal combustion engine (ICE) vehicles, hybrid electric vehicles (HEV) and plug-in hybrid electric vehicles (PHEV) combined with more sustainable travel patterns. While slightly less ambitious, the phasing out of ICE and HEV (but not PHEV) by 2030 resulted in 20% and 82% reductions in *annual* tailpipe CO_2 emissions by 2030 and 2050 when compared to the 'Road-to-Zero' scenario (labelled *ICE 'ban' 2040* below). In the 'Road-to-Zero' scenario, car and van emissions would utilise 37% of the remaining UK carbon budget on their own (based on equal per capita basis and 23% share of total for cars and vans, equating to 1.37 $GtCO_2$). The earlier bans[4] combined with lower demand for mobility and car ownership (here termed 'lifestyle change', or LS) would make significant contributions to reducing emissions within the remaining UK budget. The most ambitious case (*ICE+HEV+PHEV 'ban' 2030 + LS*) totalled savings of 1.2 $GtCO_2$ over the period from 2016 to 2050 (equating to 21%), so within the remaining budget for cars and vans (Figure 1).

Figure 1: Cumulative CO2 tailpipe emissions from cars and vans, 2016-2050 period



Notes: the green dashed line depicts a potential Paris compliant carbon budget left for cars and vans, based on equal per capita emissions, constant share of total UK emissions for cars and vans, and excluding international aviation and shipping. ICE=internal combustion engine; HEV=hybrid electric vehicle; PHEV=plug-in hybrid electric vehicle; R2Z=Road to Zero; LS=lifestyle and social change; Mt=million tons.

With increasing road transport electrification, a move towards widening the scope of emissions types and considering the use of life cycle emissions (that account for direct and embedded emissions) in policy making is recommended. This is explored in our response to question Q2 below. In practice, policy guidance could be updated

[4] Note a 'ban' here is shortcut to 'phase out the sale of'.

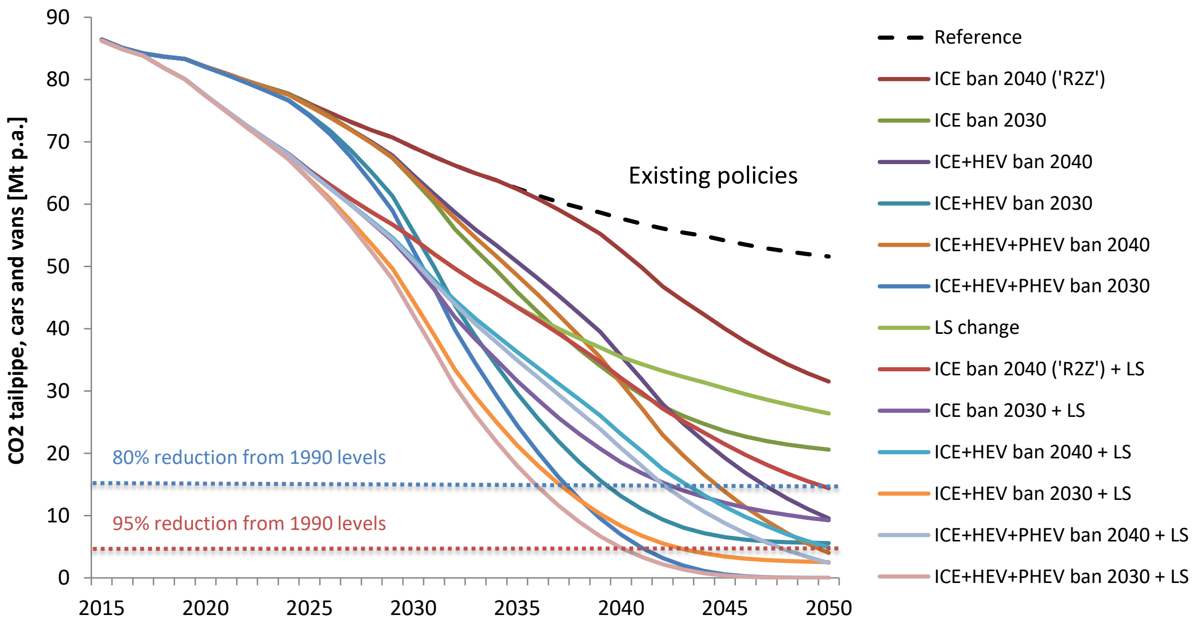
by providing a revised set of life cycle emissions factors for transport operations and travel activity.

2. The definition of what should be phased out

Our research[1] has shown that deeper and earlier reductions in carbon emissions and local air pollution would be achieved by a more ambitious, but largely non-disruptive change to a 2030 'phase out' that includes all fossil fuel vehicles. This would include all vehicles with an internal combustion engine, whether 'self-charging' or not.

However, **only the earlier phase outs combined with lower demand for mobility and car ownership would make significant contributions to an emissions pathway that is both Paris compliant and meets legislated carbon budgets and urban air quality limits**. This is illustrated in Figure 2, which shows direct (tailpipe) CO_2 emissions from UK cars and vans compared to two emissions reduction targets for 2050: an 80% reduction that is in line with the Climate Change Act 2008; and a more stringent 95% target that is closer to the requirement for a net zero economy.[5] Overall, this adds to the growing consensus that fewer, and cleaner, vehicles are needed,[6] plus more cycling and walking and better transit systems.

Figure 2: Comparison of direct (tailpipe) CO_2 emissions from cars and vans in the UK



ICE=internal combustion engine; HEV=hybrid electric vehicle; PHEV=plug-in hybrid electric vehicle; R2Z=Road to Zero; LS=lifestyle and social change leading to lower demand for mobility and car ownership; Mt=million tons.

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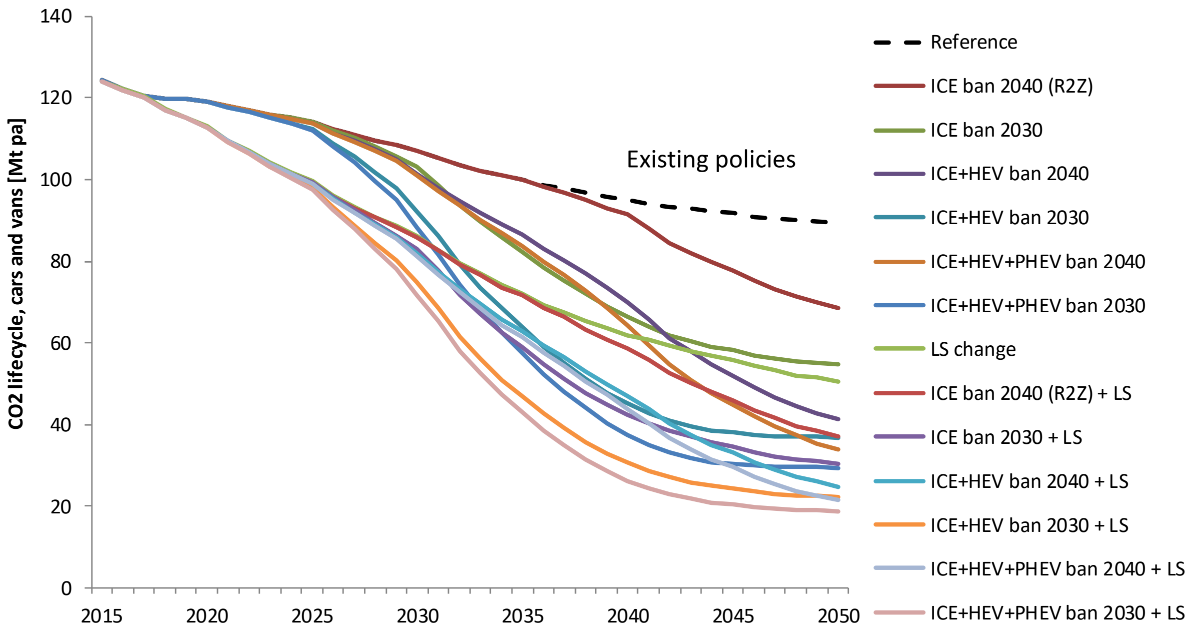
[5] Based on baseline 1990 emissions of 70.3 $MtCO_2$ for cars and 11.5 $MtCO_2$ for vans, i.e. a total of 81.8 $MtCO_2$. Assuming national targets were shared equally across the economy, the transport sector and cars and vans, the legislated -80% and the 'near zero' -95% targets were 16.4 MtCO2 and 4.1 MtCO2 respectively.

[6] The Guardian (2017) Electric cars are not the answer to air pollution, says top UK adviser.

Electric mobility is generally cleaner and lower carbon on a lifecycle basis.[7] Lifecycle emissions include those all the way from fuel production and refinery, electricity generation and distribution, vehicle manufacturing and use, and end of life impacts.

Something that is often ignored in the debate around electric mobility is our finding that any increases in emissions from generating additional electricity are more than offset by a reduction in upstream fossil fuel emissions.[1] This is illustrated in Figure 3, which shows that adding upstream and downstream CO_2 emissions from vehicle manufacture, maintenance & disposal and the supply of energy (fossil fuel production, electricity generation) basically shifts the tailpipe emissions trajectories (Figure 2) up by between 19 and 38 $MtCO_2$ p.a. by 2050. This is largely due to *total* upstream and downstream CO_2 emissions remaining roughly constant over time as emissions from the generation and distribution of electricity replace those from fossil fuel production and distribution. While the increase in electricity use in the high electrification scenarios is significant,[1] the significant decrease in the carbon content[8] coupled with decreases in upstream emissions from fossil fuel production balance each other out. We need to bear in mind that not all of upstream and downstream emissions are within the UK boundaries or accounts; therefore, a direct comparison with national climate change targets is inappropriate.

Figure 3: Comparison of life cycle CO2 emissions from cars and vans in the UK



ICE=internal combustion engine; HEV=hybrid electric vehicle; PHEV=plug-in hybrid electric vehicle; R2Z=Road to Zero; LS=lifestyle and social change; Mt=million tons.

[7] Carbon Brief (2020). Factcheck: How electric vehicles help to tackle climate change, https://www.carbonbrief.org/factcheck-how-electric-vehicles-help-to-tackle-climate-change, London.

[8] The average carbon content of supplied electricity is assumed to gradually decrease from 335 gCO_2/kWh in 2015 to 178 gCO_2/kWh in 2020, 98 gCO_2/kWh in 2035 and 46 gCO_2/kWh in 2050.

The current debate about what should be phased out and when is somewhat inconsistent with the need to respond to an emergency – why wait 10 years if we can (and should) act now?

We suggest that setting one target date in the future which defines a binary before/after market, is too blunt and will lead to distortions and perverse behaviours in the new and second hand markets in the lead up to the target date. We propose and support a more comprehensive policy (in terms of what should be phased out) which would be introduced more gradually by following a **market transformation approach to be implemented throughout the 2020s**. The highest-emitting vehicles would gradually be phased out prior to the target date (e.g. 2030), after which only zero emission vehicles are allowed to be sold. The idea is to end the sale of the highest emitting vehicles as soon as realistically possible, starting with the previous car tax (VED) band 'M' (rated emissions over 255 gCO_2/km) from say 2022, band 'L' (>225 gCO_2/km) from 2023, and so on. By 2030, only band A (=zero tailpipe CO_2) vehicles would be sold new. **Preliminary findings of scenario modelling by UKERC[9] suggests such a policy would save around 35 $MtCO_2$ between 2021 and 2030 alone.** These early carbon savings and market transformation will have even more beneficial cumulative carbon savings up to 2050, saving around **95 $MtCO_2$ between 2021 and 2050** when compared to an already ambitious ICE+HEV phase out by 2030 (*'ICE+HEV ban 2030'* in Figure 2).

This policy is likely to reverse the current trend that average tailpipe CO_2 emissions from new passenger cars have been increasing for the past three years. We know that switching from diesel accounts for a small proportion of this increase; the main culprit is a continued swing towards larger passenger cars, particularly Sports Utility Vehicles (SUVs).[10,11]

Setting a clear and phased market transformation approach will provide motor manufacturers with market certainty as consumers will be steered towards buying certain vehicles. If implemented early, it may also buy time beyond 2030 to mean that the 'black and white' phase out date can be pushed a little further, thus alleviating some manufacturers' concerns that they cannot transition in time. In addition, **such a clear policy steer from the UK government is needed in order to ensure that UK consumers have *more* choice of cars than they may otherwise get if the Original Equipment Manufacturers (OEM) restrict their sales of the most efficient vehicles into the UK market once out of the EU regulatory regime** because selling these cars here will not count towards their sales weighted CO_2 averages in the much larger EU market.

So, we recommend that in the medium term Government should not only bring forward the end to the sale of fossil fuel cars and vans but include hybrids and plug-in hybrids. In the short term, a market transformation approach targeting the highest

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[9] Deploying the UKERC Transport Energy and Air pollution Model (TEAM) for the UK: https://ukerc.ac.uk/project/team-model/ and https://ukerc.ac.uk/publications/team-energy-for-mobility/

[10] UK Energy Research Centre (2019). Review of Energy Policy 2019. London, UK Energy Research Centre.

[11] BBC News (2019). Rise of SUVs 'makes mockery' of electric car push, 09/12/2019.

emitters is recommended. Both policies need to be supported by accelerated investment in charging networks and battery development and deployment.

3. Barriers to achieving the above proposals

The proposed policy will involve high levels of coordination, intention and buy-in by policy makers, business and wider civil society.

The underlying difficulty can be viewed as a problem of 'lock-in' to the current dominant system of supply and demand, i.e. "petroleum fuels plus internal combustion engines" and the "dominance of private cars as a surface travel mode". Conceptually this type of problem is well understood from historical examples. Although 'lock-in' can be difficult to address, systemic change does happen. Research findings show that, for changes of this type:

- it is important to support promising, innovative new technologies and associated business models now, even if full deployment is not envisaged for many years, and;
- effective policy will need to be consistent and sustained across multiple areas including technology support, infrastructure choice, supply chain development, market rules, fiscal and social policies.

The over-arching challenge of decarbonising transport is that it requires systemic change, i.e. changes are required in the technologies used, their supply chains (and hence business models), the way in which people travel and use energy, and therefore the regulatory and policy framework. These changes need to happen concurrently and will be a multi-decadal process, not quick fixes.

By far the biggest barrier to change will be the incumbent industries – the OEMs. They have a well-known track record of pushing back against EU vehicle regulations on the grounds of cost. In the case of electric powertrains, this push back is evident, with added resistance on the base of restricted supply chains and time to alter production processes. **We suggest this is all the more reason to publish and implement a market transformation strategy now so that early wins – which do not rely on supply chains or large transformations to the production line – can mitigate against any later genuine supply-side constraints.**

The car-buying public might be assumed to present another barrier to any earlier phase out date or early constraints on which cars can be purchased in this market. However, these propositions have been tested in robust deliberative research exercises with members of the UK public. In 2008, for instance, participants preferred regulation – through restricting access to high CO_2 options – to taxation, seeing this as less regressive and as having more impact.[12] Earlier this year, the UK Climate Assembly put forward three scenarios to the participants, each with different phase out dates for fossil fuelled vehicles, and one of them based on the market

[12] See e.g. ITS (2009) Exploring public attitudes to climate change and travel choices: deliberative research, Final report for Department for Transport. London and Leeds: PSP and ITS Leeds. http://www.sasig.org.uk/wp-content/uploads/2009/07/Attitudes-to-cl-ch-trnsprt_ITS-PeoplePolicyScience_Jan-2009.pdf

transformation approach put forward here. The early phase out of the most polluting vehicles gained significant support. The detailed results of the Citizens Assembly will be published on September 10th 2020.

4. The impact of these ambitions on different sectors of industry and society

UKERC research into various phase-out policies has looked at how 'disruptive' they would be for key stakeholders of the transport-energy system, and how much coordination would be needed to achieve the policy goals. This research[1] has shown that in the 'Road-to-Zero' ICE phase out by 2040 the main actors of the road transport and energy system are unlikely to undergo disruptive change. This is due to the relatively slow and limited evolution of the fleet towards 'unconventional' low carbon fuels, the continuation of fuel duty revenue streams well into the 2040s and little additional reductions in energy demand and air pollutant emissions. However, **in the earlier (2030) and stricter (in what constitutes an ultra-low carbon vehicle) 'phase-outs' we can expect *some* disruption for technology providers, industry and business – in particular vehicle manufacturers, global production networks, the maintenance and repair sector as well as the oil & gas industry**. There will also be localised impacts (some potentially disruptive) on electricity distribution networks and companies – research[13] shows that although controlled ('smart') charging can reduce the proportion of Britain's distribution networks that require reinforcement from 28% to 9%, there remain networks that require reinforcement even with 'smart' charging. There may be significant employment disruptions, e.g. due to some car and engine production plants downsizing or closing unless restructuring to EV production is successful and timely, and the policy instruments to foster the shift can therefore be expected to generate some backlash. There is some evidence that the *overall* impact on jobs from a shift to EVs may not be that bad, in part because of work created in upgrading the distribution networks.[14]

The stronger policy signal of a 2030 phase-out that includes HEV would provide certainty to manufacturers to invest and innovate, backed up by much improved market conditions for EVs that go beyond the 2018 Road-to-Zero strategy. Measures such as increased consumer awareness through marketing and awareness campaigns, and increased and earlier certainty of access for fleet operations could help to manage the potential disruption, while technological developments such as higher battery capacities, charging rates and faster off-street charging might also mitigate this from the mid-2020s onwards.

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[13] Crozier, C., Morstyn, T. and McCulloch, M. (2020) The opportunity for smart charging to mitigate the impact of electric vehicles on transmission and distribution systems, *Applied Energy*, vol. 268. DOI: 10.1016/j.apenergy.2020.114973

[14] Turner, K., Alabi, O., Calvillo, C., Katris, A. (2020) Who Ultimately Pays for and Who Gains from the Electricity Network Upgrade for EVs to Support the UK's Net Zero Carbon Ambition? https://doi.org/10.17868/72954

If the UK succeeded in phasing out conventional *and* hybrid EV cars and vans, the UK oil and gas industry would gradually lose an important demand sector at potentially disruptive rates of change in the medium term (beyond 2030). However, some global scenario exercises[15] suggest that even a 2030 ban would not affect total oil demand very much because oil is used in many other modes of transport (aviation, shipping, heavy goods vehicles, rail) and sectors of the economy. Clear and early policy directions from Government would help to support those parts of the oil and gas sector that are developing strategies for their businesses in a lower carbon world and help them to defend their strategies against sceptical investors/shareholders.

The loss of fuel duty revenues from fossil fuel use has been recognised as a potentially disruptive change. However, some commentators have argued that the loss of annual income does not matter when compared to the wider economy, as the level of excise from road fuels is similar to the annual changes in expenditure and payments discussed at budget time.[16] In any case, any loss could be compensated by introducing some form of universal, dynamic road pricing or a road fuel duty.

For other actors, particularly consumers and leasing companies, a switch to zero-emission vehicles does not represent a disruptive change as "a car is still a car" *in most respects*. Range anxiety and longer recharging times are considered to be short term barriers that are expected to be overcome in the short to medium term as i) battery capacities and charger power level increase and ii) drivers have access to charging at a greater range of locations[17]. We also expect a 'lack of disruption' for local government (a key actor in delivering charging infrastructure) and wider civil society, with gradual air quality improvements in the second half of the assessment period, even in the most stringent scenarios.

'Smart' EV charging has enormous potential to support the further decarbonisation of the power system via the provision of 'balancing services' and flexibility to the grid[18] as large thermal power stations are decommissioned in favour of renewable generators. As the market further develops Vehicle 2 Grid (V2G) technology, some of which is already based in the UK, it may start to become a significant contributor to grid operation and support of local demand for electricity.

Many of the co-benefits of a reduction in fossil-fuelled road traffic have become apparent due to the current global Coronavirus pandemic and associated lockdown measures, which temporarily have resulted in significant reductions in CO_2 emissions

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[15] BP (2019). BP Energy Outlook: 2019 edition. London, BP p.l.c.

[16] BVRLA, 2019. Road to Zero: time to shift gear on tax. British Vehicle Rental & Leasing Association, Amersham.

[17] Dixon, J., Andersen, P.B., Bell, K., Træholt, C. (2020) On the ease of being green: An investigation of the inconvenience of electric vehicle charging, *Applied Energy*, vol. 258. DOI: 10.1016/j.apenergy.2019.114090

[18] F. Teng, Y. Mu, H. Jia, J. Wu, P. Zeng, and G. Strbac. (2017) Challenges on primary frequency control and potential solution from EVs in the future GB electricity system, *Applied Energy*, vol. 194. DOI: 10.1016/j.apenergy.2016.05.123

and air pollution.[19] It remains to be seen what long-term impact on car/van purchasing choices, lifestyles and social norms this may have when lockdown restrictions are lifted further.

5. What measures are required by government and others to achieve the earlier phase out date

Ending the sale of new petrol, diesel and hybrid cars and vans earlier, coupled with the electrification of road transport should form a key part of long term decarbonisation policy, but it is not a panacea. Here we take a look at some of the *do's* and *don'ts* to achieve transport-energy system decarbonisation.

First, an earlier phase out date of 2030 implies we have 10 years to plan for and implement a transition away from fossil-fuel ICE cars and vans. As we discussed in our answers to questions Q1 and Q2, our research suggests that **this is achievable without significant disruption to the transport-energy system, but it needs to be linked to accelerated investment in charging networks and battery development[20] and deployment. We also need to address the short term, as suggested earlier.**

In terms of technology substitution, electricity and hydrogen can be used significantly more efficiently than fossil fuels at the point of use, and therefore there are some carbon mitigation benefits in moving to battery electric or hydrogen fuel cell vehicles. Research[21] has shown that even at the current carbon intensity of electricity in the UK, emissions per mile driven by a typical EV are already 70-80% less than that of ICE cars.[22] However, the largest mitigation benefits come with the use of decarbonised electricity. The combination of relatively low uptake of electrification (a few percent of the new fleet at present) and the current carbon intensity of electricity means that most decarbonisation benefits from electrification will arise after 2025 or so.[23] As was discussed in our response to question 4, higher penetrations of EVs can support the decarbonisation of the power system, adding a 'positive feedback' loop in the decarbonisation of the private vehicle fleet. Early adoption of electrification should therefore be considered as an opportunity to support the development of promising 'niches' that can grow significantly in the early 2020s. In both cases the technologies

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[19] Le Quéré, C. et al. (2020) Temporary reduction in daily global CO2 emissions during the COVID-19 forced confinement. *Nature Climate Change*. http://doi.org/10.1038/s41558-020-0797-x

[20] E.g. the Battery Intelligence Lab at Oxford University, http://howey.eng.ox.ac.uk/research/

[21]Dixon, J., Bukhsh, W., Edmunds, C. and Bell, K. (2020) Scheduling electric vehicle charging to minimise carbon emissions and wind curtailment, *Renewable Energy (Accepted/In Press)* [Online]. Available: https://strathprints.strath.ac.uk/73065/

[22] Carbon Brief (2020) Factcheck: How electric vehicles help to tackle climate change, Update 7/2/2020. https://www.carbonbrief.org/factcheck-how-electric-vehicles-help-to-tackle-climate-change

[23] See e.g. Hill, G., O. Heidrich, F. Creutzig and P. Blythe (2019) The role of electric vehicles in near-term mitigation pathways and achieving the UK's carbon budget. *Applied Energy* 251: 113111. https://doi.org/10.1016/j.apenergy.2019.04.107

have already been demonstrated, costs are already attractive to early adopters and some of the mass market, and the economics are improving, particularly for the fleet/business car (52% of new car sales) and light commercial vehicle markets.[24]

Second, our research has shown multiple times that **further and earlier policy measures that impact the transport-energy system are needed**, including access bans in urban areas and regulation to reduce the availability and sale of 'unnecessarily' high-emitting cars (see above). Dynamic road pricing - where charges vary by time and location - may be needed to sustain £billions of fuel duty revenues, curb travel demand and tackle congestion. Careful policy design, adaptive policy making, targeted investment and hypothecation of taxes to improve alternatives to fossil fuel mobility are essential to minimise political and economic risks.[25]

The earlier date also implies that fossil fuel ICE vehicles will be on the UK's roads for about 12 years after the date, so we can expect petrol and diesel ICEs to slowly 'disappear' from Britain's roads from the late 2030s onwards. By 2050, only a few percent of light duty vehicles on the road would be ICEs.

Car scrappage programmes have a high likelihood of merely bringing forward purchases of vehicles which would have happened anyway. There is then a question of net CO_2 reductions over the longer term, especially when impacts on the second-hand and repair markets are considered. For cumulative carbon budgets, the earlier we accelerate the uptake of alternatively fuelled vehicles whilst reducing the most fossil-fuelled intensive vehicles, the better. However, scrappage schemes achieve this at a very high price per tonne of CO_2 saved relative to other parts of the economy and relative to other ways of doing this (such as through bans of the most gas guzzling vehicles or restructuring vehicle taxes). For example, the 'Cash for Clunkers' programme in the US following the 2008 economic downturn was estimated to cost $91 to $301 per tonne of CO_2 saved.[26] Our own research and analysis deploying UK-specific scenarios of different purchase incentive schemes concluded *"Scrappage schemes are found to save little carbon, particularly when direct and indirect impacts are considered and may even increase emissions on a life cycle basis."*[27]

Conclusion

We support bringing the phase-out date forward and urge it to be earlier than 2035 and include phasing out any non-zero tailpipe vehicles using a market transformation approach. We strongly believe Government has a crucial role to play in leading the

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[24] SMMT (2020) UK new car and LCV registrations outlook to 2021 – April 2020. London: SMMT.

[25] Brand, C., J. Anable and M. Tran (2013). Accelerating the transformation to a low carbon passenger transport system: The role of car purchase taxes, feebates, road taxes and scrappage incentives in the UK. *Transportation Research Part A: Policy and Practice* **49**(0): 132-148. doi:10.1016/j.tra.2013.01.010

[26] Li, Shanjun & Linn, Joshua & Spiller, Elisheba, 2010. "Evaluating "Cash-for-Clunkers": Program Effect on Auto Sales, Jobs, and the Environment," Discussion Papers dp-10-39, Resources For the Future.

[27] Brand, C., Anable, J. and Tran, M. (2013) Accelerating the transformation to a low carbon passenger transport system: The role of car purchase taxes, feebates, road taxes and scrappage incentives in the UK. Transportation Research Part A: Policy and Practice, 49, 132-148 (p146)

way to decarbonize transport, going well beyond the proposed policy change of bringing forward the end to the sale of new petrol, diesel and hybrid cars and vans from 2040 to 2035 or earlier.

By taking a more systemic view of the transport-energy system, Government should support policies and measures that avoid ‘unnecessary’ transport of people and goods, shift ‘necessary’ transport to more sustainable modes than single-person car and empty-running van travel, and significantly improve the efficiency of the system (vehicles, passenger services, logistics) as well as reducing the ‘real carbon content’ of the remaining vehicles miles to zero. Our research suggests that such a hierarchical strategy of travel demand reduction, mode shift, electrification of road transport, hydrogen and biofuels in difficult to electrify sectors, low carbon electricity and hydrogen supply, is needed to meet our challenging climate and air quality goals. This would have multiple co-benefits for all of society, be fairer and more inclusive. It would be able to reduce costs and transport inequality, and enable more active lifestyles.

Contact

If you have any queries about this response please contact Jessica Bays (j.bays@ukerc.ac.uk) in the first instance.

Scenario pathways – key assumptions from Energy Policy paper[1]

Storylines around future policy ambition and lifestyle change were developed and then quantified to yield a suite of prospective scenarios. First, six alternative 'ban scenarios'[28] were developed and quantified, each with a different policy ambition in terms of (a) target date and (b) definition of what constitutes an ULEV. We explored two target dates (2040 and 2030) and three ULEV definitions (ICE ban, ICE+HEV ban, ICE+HEV+PHEV ban). Second, a 'lifestyle and social change scenario' was developed building on previous UKERC work for Scotland[29], but obviously framed within the UK context and updated with UK data on trip patterns, vehicle fleets, vehicle tax regimes, and so on. The Lifestyle (LS) scenario was then combined with each of the six 'ban scenarios' to generate a total of 14 policy scenarios. Table 1 summarises the narratives and key assumptions for each scenario. To avoid duplication the narratives for the combined 'ban' and 'lifestyle' scenarios are not shown.

Table 1: Narratives and key assumptions for the alternative scenarios for phasing out fossil fuel cars and vans (top half) and the 'Reference' and 'Lifestyle change' scenarios (bottom half – note the combined 'ban' and 'lifestyle' scenarios are not shown)

	Ban (= end the sale of) non-ULEV cars and vans from	
ULEV def.	**2040**	**2030**
ICE ban	*ICE ban 2040:* Availability of new conventional gasoline and diesel ICE cars and vans is drying up from 2035, with no ICE vehicle sold from 2040 onwards. No change in Reference (REF) assumption for the plug in vehicle grant or other incentives.	*ICE ban 2030:* Availability of new conventional gasoline and diesel ICE cars and vans is drying up from 2025, with no ICE vehicle sold from 2030 onwards. Modestly improved market conditions for EVs (consumer awareness, charging infrastructure, increased range of makes and models) from mid-2020s onwards.
ICE+HEV ban	*ICE+HEV ban 2040:* Availability of ICE and HEV cars and vans is drying up from 2035, with no ICE or HEV vehicle sold from 2040 onwards. Much improved market conditions for EVs incl. 'universal' consumer awareness by 2035, increased certainty of access for fleet operations (up to 80%), higher battery capacities, charging rates and faster off-street charging from the late 2020s onwards.	*ICE+HEV ban 2030:* Availability of ICE and HEV cars and vans is drying up from 2025, with no ICE or HEV vehicle sold from 2030 onwards. Much improved market conditions for EVs incl. 'universal' consumer awareness by 2025, increased and earlier certainty of access for fleet operations, higher battery capacities, charging rates and faster off-street charging from the mid-2020s onwards.

[28] In this paper we have used the term 'ban' interchangeably with 'end of sale of', largely to cut down the word count and shortening the scenario labels.

[29] Brand, Anable, Morton (2019) Lifestyle, efficiency and limits: modelling transport energy and emissions using a socio-technical approach, *Energy Efficiency* **12**, 187-207. https://doi.org/10.1007/s12053-018-9678-9

ICE+HEV +PHEV ban	*ICE+HEV+PHEV ban 2040:* Availability of ICE, HEV and PHEV cars and vans is drying up from 2035, with no ICE, HEV or PHEV vehicle sold from 2040 onwards. Much improved market conditions for EVs incl. 100% consumer awareness and certainty of access for fleet operations by 2040, higher battery capacities, charging rates and faster off-street charging from the late 2020s onwards.	*ICE+HEV+PHEV ban 2030:* Availability of ICE, HEV and PHEV cars and vans is drying up from 2025, with no ICE, HEV or PHEV vehicle sold from 2030 onwards. Much improved market conditions for EVs incl. 100% consumer awareness and certainty of access for fleet operations by 2030, higher battery capacities, charging rates and faster off-street charging from the mid-2020s onwards.
Reference (comparison scenario)	*REF*: Projection of transport demand, supply, energy use and emissions as if there were no changes to existing transport and energy policy. No ban. Consumers increasingly shy away from diesels post 'Dieselgate' (Brand, 2016). Existing UK plug-in vehicle grant (OLEV, 2018) for cars, vans, taxis and motorcycles (up to £3,500 for cars, depending on how 'plugged-in' the vehicle is) to be 'phased out' gradually in the 2020s. Consumer awareness of EVs increases to ~50% by mid 2020s then levels out. Certainty of access to charging for fleet operations stays at 40%. Private access to overnight charging level at 70%. See Brand et al. (2019b) for detailed assumptions of the Reference case.	
Lifestyle change (+ combinations with ban scenarios)	*LS*: Radical change in travel patterns, mode choice and occupancy levels leading to relatively fast transformations and new demand trajectories. Concerns relating to health, quality of life, energy use and environmental implications drive social change. Shift away from mobility towards accessibility of services and jobs and from speed to quality and resilience of journeys. Triggered by worsening conditions, social norms promote status of more sustainable modes of transport and demote single-occupancy car travel, fossil fuelled vehicles, unnecessarily long distances and speeding. Current car-based systems increasingly replaced by zero emission public transport, active travel, and shared mobility. ICT facilitates rapid behavioural change by making cost and energy use transparent to users, changing everything from destination choice, substitution of shopping and personal business trips by home delivery, car choice and models of 'ownership', driving style and paying for travel, including in the freight sector. Renewed focus on localism. Changes in work patterns and business travel fuelled by renewed emphasis on quality of life but also facilitated by increasingly sophisticated ways of substituting disproportionally impactful long commuting and business trips by digital technology. Increased internet shopping *increases* the use of vans, which somewhat offsets the positive effects of decongestion from fewer cars on the road.	