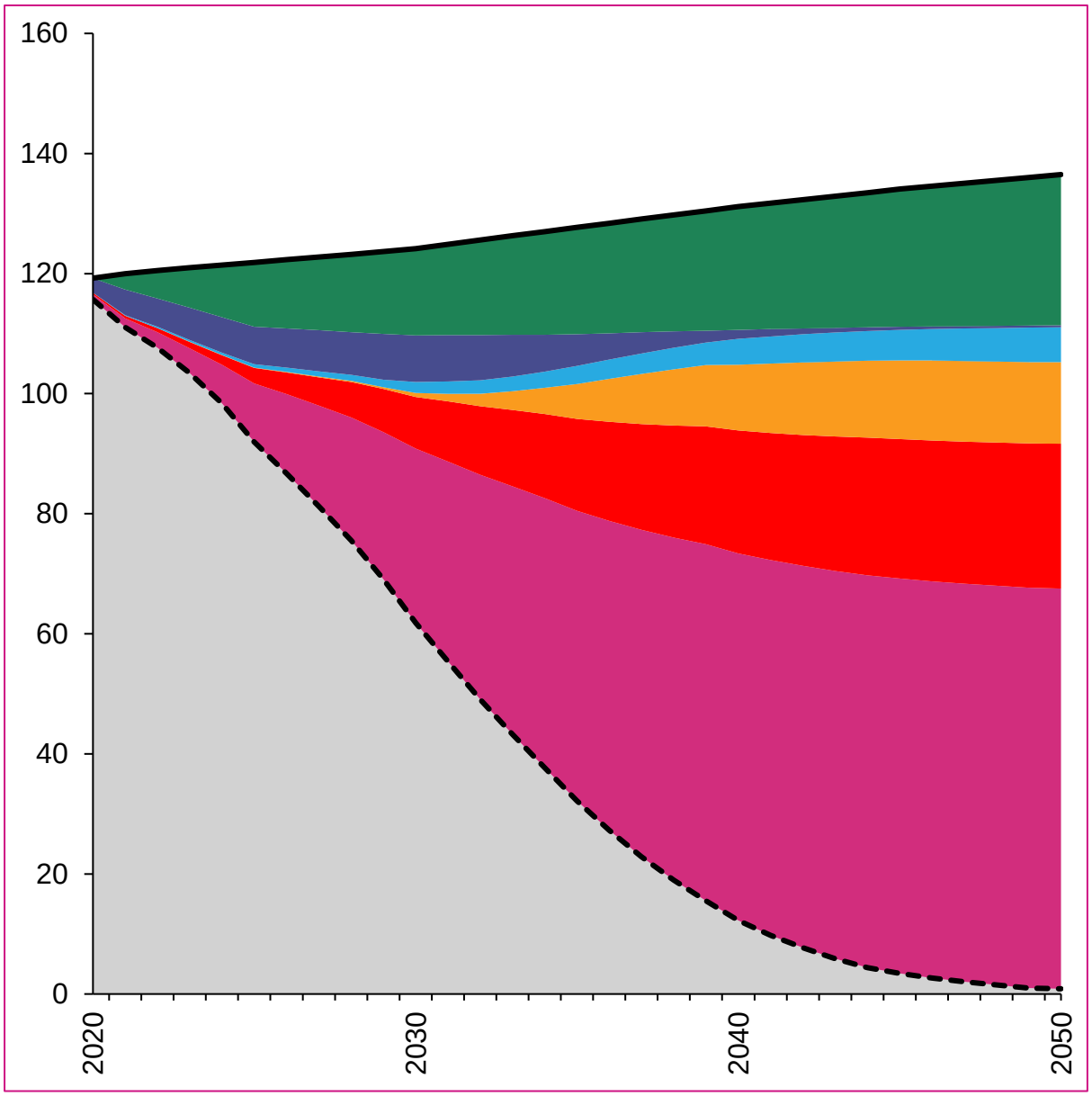

Reducing the Carbon Gap for car transport in Wales

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Imminent Welsh Government climate decisions this paper seeks to inform

1. Can Welsh Government rely on electric vehicle savings to hit the Climate Change Committee's recommended pathway to Net Zero, or does that pathway also require investment in measures to increase use of sustainable modes and to discourage car use?
2. Should Welsh Government adopt a 'no-regrets' approach that adds policies to those in the CCC recommended pathway in order to avoid foreseeable political, financial and climate risks (Wales specific risks and wider risks beyond Welsh Government control)?
3. Should Welsh Government add policies to those in the CCC pathway in order to reflect Welsh Government's leading position on climate change?
4. Specifically, should Welsh Government aim to achieve a (steeper) carbon reduction pathway to achieve the (higher) share of reductions that Tyndall Centre climate scientists recommend as internationally equitable?
5. Should Welsh Government add policies to those in the CCC pathway in order to reflect Welsh Government's wider social, environmental and economic priorities?
6. Specifically, to what degree should Welsh Government prioritise active travel, public transport and remote working policies in order to bring health, environmental, social, economic, regional and equity benefits to Wales whilst also tackling the Climate Emergency?
7. What level of potentially controversial demand management measures should Welsh Government consider to be sure it can achieve its Climate Emergency and wider objectives?

Executive Summary

- The Climate Change Committee has proposed a carbon reduction pathway for surface transport in Wales that means emissions need to be roughly halved between 2020 and 2030, from 6 to 3 million tonnes of CO_2. The biggest emissions cuts need to come from cars.

- Electric cars will eventually provide the biggest emissions savings, but their contribution will not be the main source of savings until the late 2020s at the earliest, and possibly later.

- Modal shift to public transport, walking and cycling and less travel overall (e.g. because of remote working) are essential to achieve the CCC carbon reduction pathway. During Wales Carbon Budget Period 3 (2026-2030), investment in modal shift and remote working, modelled in earlier papers, could meet about two-thirds of the demand reduction that the CCC says is required.

- There is a risk that uptake of electric cars in Wales will be slower than in England, and this makes demand reduction even more important.

- Climate scientists consider the CCC carbon reduction pathway to fall short of fully meeting the “international equity” aim of the UN Paris Climate Agreement, and argue UK carbon budgets should be halved. This would have major implications for transport in Wales, and would be difficult to achieve with the policy levers currently available to Welsh Government.

- The Wellbeing of Future Generations Act places a special responsibility on Welsh Government to take a lead in tackling climate change, and this may mean taking decisions that aim to ‘do what is right’ even where the route forward does not appear clear.

- Active travel, public transport and remote working policies can improve health, reduce air pollution, help our town centres, boost rural areas, and be fair to everyone. This means that even aside from their carbon benefits, there is a strong case for prioritising these policies, as proposed in the Wales Transport Strategy.

- A road user ‘benefits-and-charges’ package may be necessary even to meet the CCC pathway. To meet more ambitious climate targets and wider priorities, such a package would be essential.

1. Introduction

This report sets out our approach and analysis to quantify the 'carbon gap' between the reduction in carbon emissions from cars that is expected to happen as a result of vehicle electrification and efficiency improvements, and the emissions reduction that is necessary for Wales to meet its climate obligations (as part of an economy-wide package).

While much of the paper is necessarily technical, it provides the basis for some significant climate policy decisions by Welsh Government. These need to be considered now because they affect future transport policy as set out in the Wales Transport Strategy. Page 4 lists seven key decisions. The conclusions on page 23 summarise findings from our analysis, to help Welsh Government thinking in relation to these decisions.

The analysis covers the period 2020-2050 with a focus on Wales Carbon Budget Periods 2 and 3 (2021-2025 and 2026-2030). It looks only at emissions from cars, as these account for the largest proportion of transport emissions and are most impacted by the demand reduction and modal shift opportunities we are reviewing in other papers.

In the following sections, we set out:

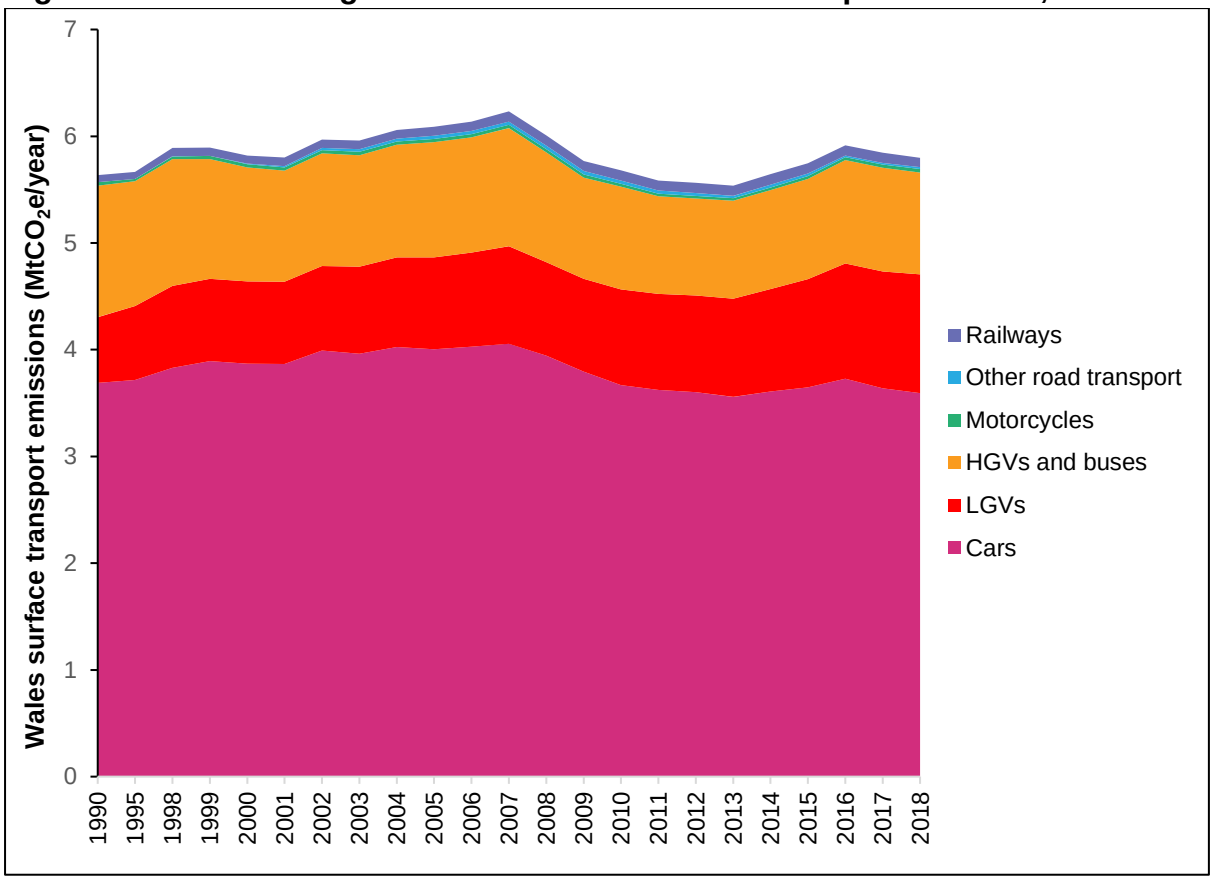
- Current carbon emissions from surface transport in Wales
- The Climate Change Committee's carbon reduction pathway, and how the CCC suggests it can be achieved
- How the CCC's proposed demand reduction compares with car mileage savings from investment in active travel, public transport and remote working, considered in previous papers
- Alternatives to the CCC carbon reduction pathway
- Uncertainties around the future rate of vehicle electrification
- The carbon gap between emissions from cars after electrification and the carbon reduction pathways, and the potential for investment in public transport, active travel and remote working to close that gap
- Insights from the analysis that may help Welsh Government with the significant climate policy decisions.

In carrying out this analysis, we have where possible adopted assumptions that are consistent with those used by the CCC in their Sixth Carbon Budget, except where those assumptions are for the whole UK and may not be appropriate for Wales. Where that is the case, we have used sensitivity tests to understand the effect of changing the assumptions.

2. Carbon emissions from surface transport in Wales

In 2018, surface transport in Wales accounted for 5.8 $MtCO_{2e}$[1]. As Figure 1 shows, there has been a slight increase in emissions since 1990 (5.6 $MtCO_{2e}$) as increases in vehicle efficiency have been offset by increases in traffic. The majority of emissions in 2018 were from cars (62%), followed by LGVs (19%) and HGVs and buses (16%).

Figure 1: Greenhouse gas emissions from surface transport in Wales, 1990-2018



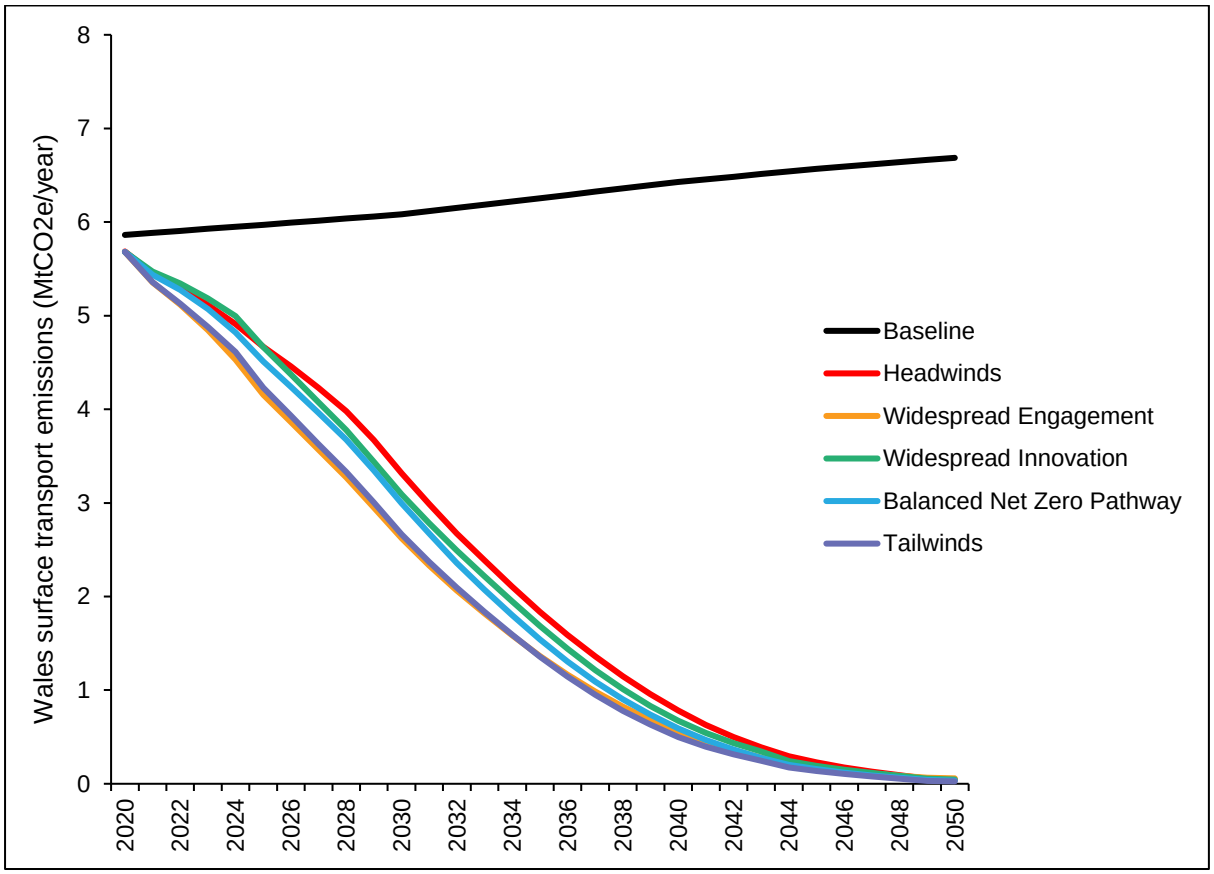
Source: NAEI Devolved Administration GHG Inventory 1990-2018

3. CCC 'Balanced Net Zero' carbon reduction pathway

The CCC's Sixth Carbon Budget has proposed a range of carbon reduction pathways for the UK, including Wales, to meet the 2050 net zero target. Figure 2 shows the different pathways for surface transport in Wales. In the CCC's central pathway, the Balanced Net Zero Pathway, emissions from surface transport in Wales will need to be roughly halved between 2020 and 2030, to around 3 $MtCO_{2e}$. The CCC's alternative pathways (Headwinds, Tailwinds, Widespread Engagement and Widespread Innovation), based on a range of different assumptions, follow fairly similar trajectories, so that in 2030 residual emissions range from 2.7-3.3 $MtCO_{2e}$; roughly +/-10% of emissions for the Balanced Pathway.

[1] National Atmospheric Emissions Inventory NAEI (2020) Devolved Administration GHG Inventory 1990-2018 June 2020

Figure 2: CCC carbon reduction pathways for surface transport in Wales, 2020-2050



Source: Sector Explorer tab in CCC 6CB dataset

The CCC Balanced Net Zero Pathway for surface transport (as well as the net zero budget as a whole) is based on what the CCC assesses to be achievable[2]. The target for the surface transport sector implies a smaller percentage reduction in emissions in 2030 (compared to 1990 levels) than has been set than for the economy as a whole. This appears to be based on past (under) performance of the transport sector[3].

While the CCC's assumptions about the potential for action at the level of the UK government may be correct, there is a question for Wales about how consistent the Balanced Net Zero Pathway is with the Well-being of Future Generations Act and the aspirations of the Wales Transport Strategy. We consider this in section 6.

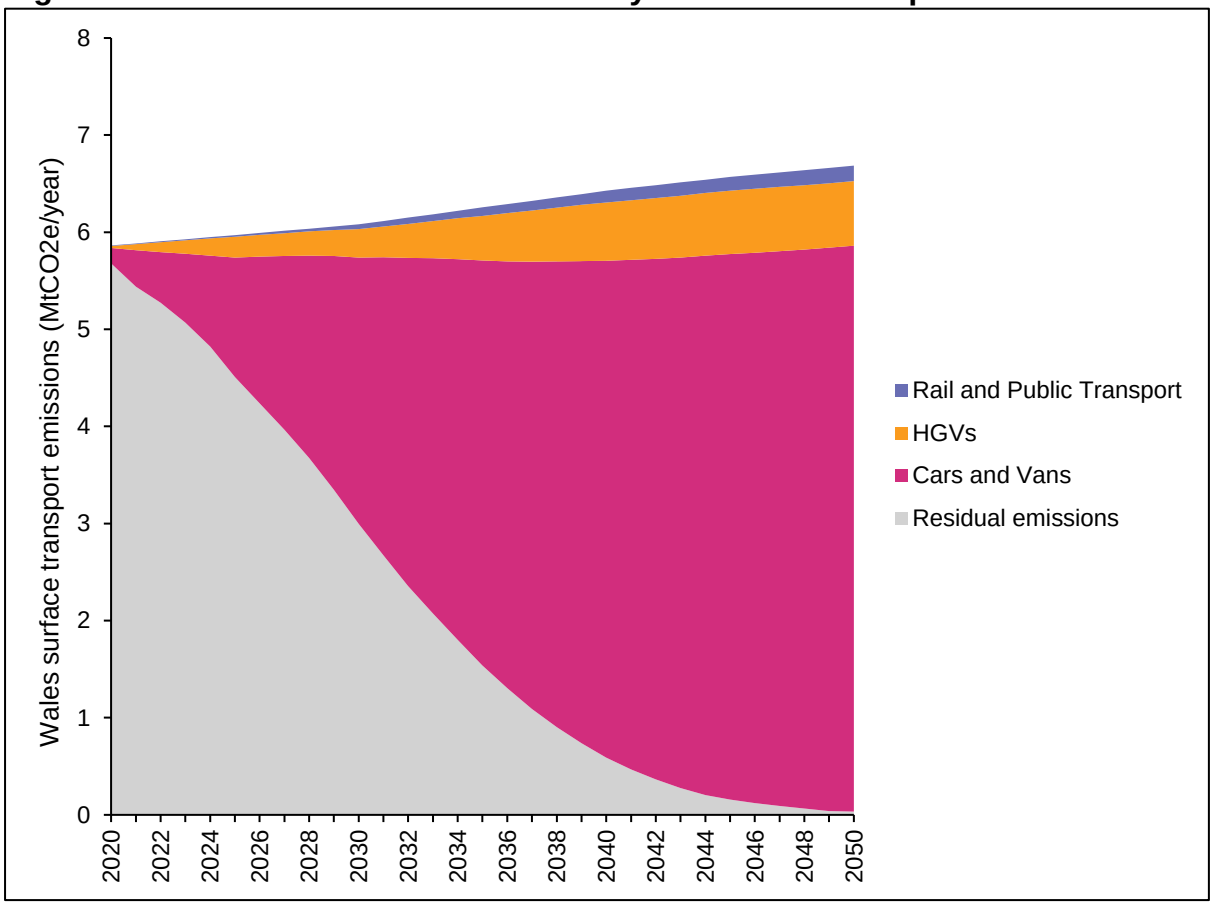
[2] One of the rationales for the CCC's 2050 Net Zero target is that the target is achievable in the UK. Thus their scenarios "are based on current consumer behaviours and known technologies, with prudent assumptions over their cost reduction." CCC (2019) Net Zero: the UK's Contribution to Stopping Climate Change

[3] Committee on Climate Change personal communication with authors by email, January 2021

4. How the CCC suggests the Balanced Net Zero Pathway can be achieved

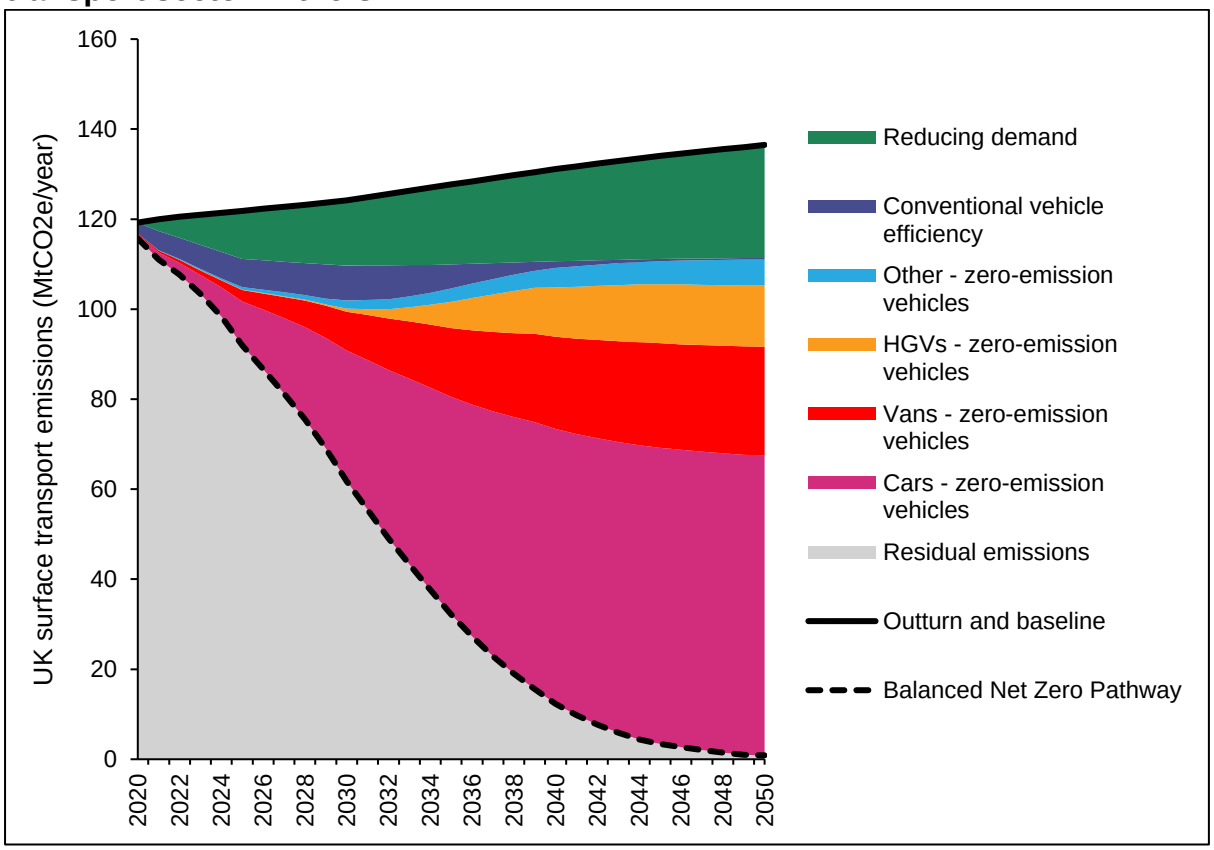
Figures 3 and 4 show how the CCC suggests the Balanced Net Zero Pathway could be achieved. As is clear from Figure 3, by far the largest reduction in emissions in Wales is expected to be from cars and vans. Figure 4 (which is only available for the whole UK, not for Wales) shows emissions reduction by **type of intervention,** distinguishing between carbon savings due to the switch to zero emission vehicles, improvements in conventional vehicle efficiency, and demand reduction.

Figure 3: CCC Balanced Net Zero Pathway for surface transport in Wales



Source: Sector Explorer tab in CCC 6CB dataset

Figure 4: Sources of abatement in the Balanced Net Zero Pathway for the surface transport sector in the UK



Source: Figure 3.1.a from CCC Sixth Carbon Budget

Key assumptions underlying the CCC's modelling for the Balanced Pathway are that:

- There is an increase in population and GDP, which will result in more overall demand in the assumed 'baseline' (i.e. if no action is taken).
- There are improvements in the average efficiency of conventional petrol and diesel cars, delivering emissions savings in the period from 2020 to 2040.
- The ban on sales of new internal combustion engine (ICE) and plug-in hybrid electric vehicles (PHEV) is brought forward to 2032. There is a rapid shift towards electric vehicles, such that by 2030, 43% of all cars on the road are electric vehicles, up from 1% in 2020.
- For drivers of electric vehicles, the cost of motoring becomes much lower. This is because fuel duty is not payable, and (by implication) not replaced by a road user charge. Car mileage therefore increases. It is assumed that 10-30% of the operating cost savings when a driver switches from a conventional vehicle to an electric vehicle are spent on increased mileage. This is described as a 'rebound effect'.
- The 'rebound effect' is offset by other measures that reduce demand for car use and encourage modal shift. The 'rebound effect' and demand management measures approximately cancel one another out, in terms of their effect on car mileage. Note that some of the CCC's alternative pathways (e.g. Tailwinds and

Widespread Engagement) have higher levels of demand reduction (16% reduction in car mileage by 2030 relative to the baseline compared to 6% for the Balanced Pathway).

Annex 1 lists other assumptions underpinning the CCC's modelling.

The CCC's policy package has some distributional and equity implications, which it would be helpful to consider further as part of the development of Low Carbon Delivery Plan 2. In particular:

- In the medium-term (mid-2020s to mid-2030s) the CCC's assumed policy package for the UK is beneficial for those people who can afford to buy electric cars, who will save money and drive more. Those on lower incomes, who continue to drive older conventional cars for longer, will not save money.
- There will be less money flowing into UK Treasury from fuel duty, possibly leading to lower public spending in England and Barnett consequentials for Wales. At the same time there will be a need for Welsh Government to spend more on public transport in order to stimulate mode shift.
- Despite the investment in modal shift, the rebound effect means that car traffic will stay about the same in Wales. This will have negative consequences in terms of congestion, road safety and particulate pollution (which comes from brake and tyre wear, and so is not reduced by the shift to electric cars).

5. Car mileage demand reduction in Wales

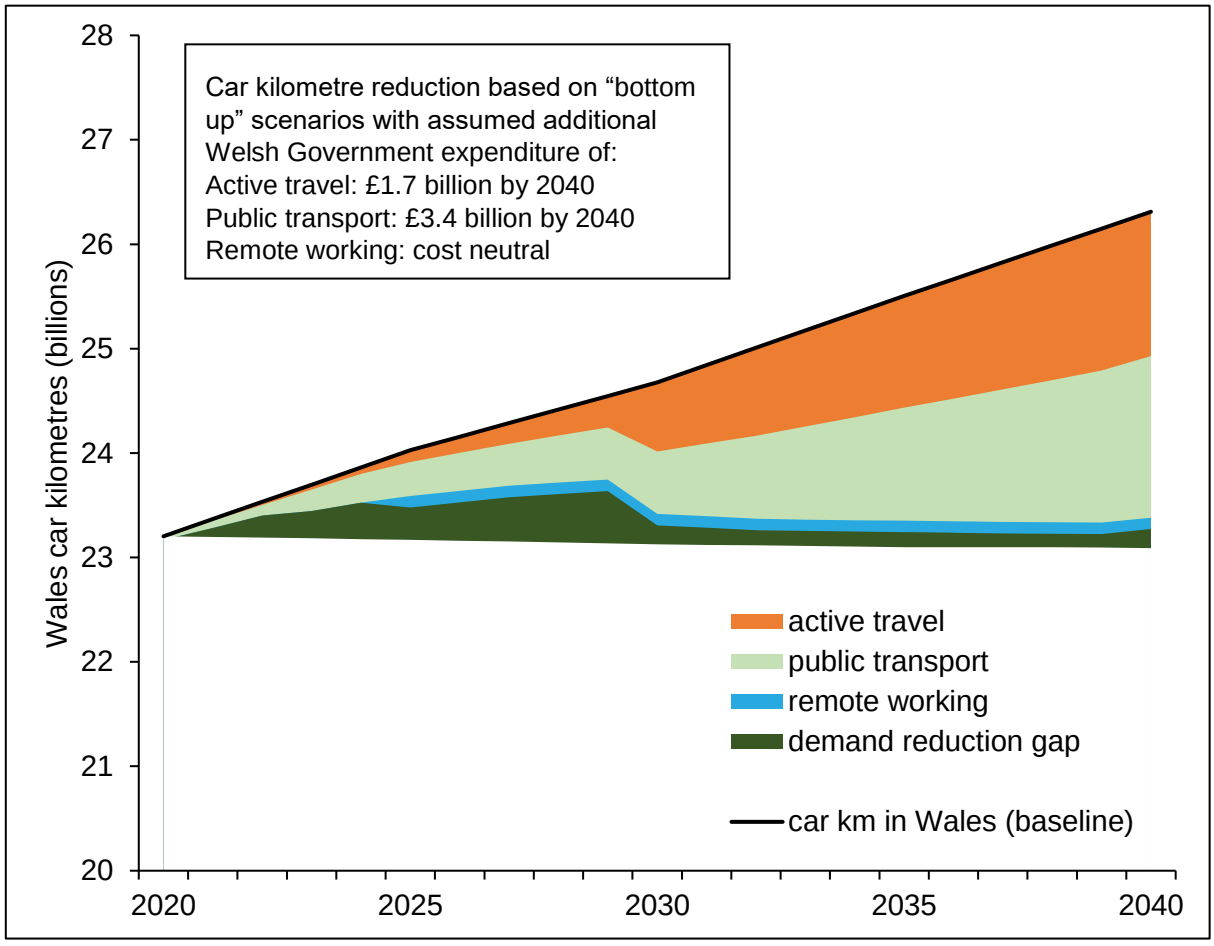
We have used two approaches to assess whether the modal shift and trip reduction that was modelled in previous papers is enough to close the carbon gap. The first approach, looking at car *mileage*, is described here. The second approach, looking at car *carbon savings* (which is more complex, requiring assumptions about changes in vehicle efficiency and the proportion of electric cars in the fleet), is described in Section 9.

The "reducing demand" dark green wedge on the chart shown in Figure 4 is based on a CCC assumption about how much mileage can be switched from car to alternative modes of transport (active travel or public transport), or not travelled (e.g. as a result of remote working). In the Balanced Net Zero Pathway, demand reduction is 6% of baseline car mileage in 2030, rising to 12% in 2040.

We have compared this to the car mileage savings resulting from increased investment in active travel and public transport, and a shift to remote working, as modelled in the "bottom up" scenarios in previous papers. The result is shown in Figure 5. The car mileage saving as a result of increased investment in public transport and active travel, and encouragement of remote working, is around two-thirds of the necessary demand reduction in the late-2020s, and around 90% in the 2030s. The dark green area in Figure 5 is the remaining demand reduction gap. This suggests that the investment assumed in the "bottom up" scenarios would get Wales a significant way towards the amount of demand reduction (modal shift and less travel) identified as necessary by the CCC, but would not on its own be sufficient. A table in Annex 4 compares the CCC assumptions about how car mileage savings could be

achieved with the assumptions in our “bottom up” scenario and “top down” assessment of maximum potential.

Figure 5: Extent to which car kilometre savings from investment in active travel, public transport and remote working match the demand reduction required in CCC Balanced Net Zero Pathway



6. Is the Balanced Net Zero Pathway ambitious enough?

We noted earlier that the Balanced Net Zero Pathway appears to have been set pragmatically, based on what the CCC assesses to be politically possible for the UK government.

This assessment is based on two observations:

- The fall in surface transport emissions since 1990 in the Balanced Net Zero Pathway (47%) is lower than the fall in emissions for the UK economy as a whole (68%).
- Surface transport emissions in 2030 in the Sixth Carbon Budget Balanced Net Zero Pathway are the same as proposed in 2030 in the Fifth Carbon Budget, which was published when the UK government was committed to cut emissions by 80% by 2050 (rather than 100%).

However, the CCC has said that “*the reason for this is that surface transport has made less progress in reducing its emissions from 1990 to today. Indeed, total emissions*

from surface transport have remained relatively static since 1990, whereas the UK's economy-wide emissions are 41% lower today than in 1990. Our report highlights that it is now time to deliver reductions in transport too. Under our Balanced Pathway, surface transport emissions reduce by 47% between now and 2030. This is actually more ambitious than the pace of change required across the economy as a whole, which requires a 36% reduction by 2030."[4]

While the CCC's reductions are generally based on the cost-effectiveness of reducing emissions from a particular sector, many cost-effective policy measures previously recommended by the CCC for transport have not been implemented[5] thus increasing transport's share of the carbon budget at the expense of other sectors. The increasing cost-effectiveness of EVs[6] means that cutting emissions from surface transport is now more cost-effective than at the time of the fifth carbon budget. It would therefore make sense for transport to aim to take a higher share of emissions reductions over the next 10 years compared to the Fifth Carbon Budget.

Looking more broadly, it has been argued that the overall net zero carbon budget does not fully satisfy the "international equity" aim of the Paris Agreement (that is, the requirement for richer countries to reduce emissions faster in order to leave more headroom for less-developed countries to expand their economies). Climate scientists suggest the UK's carbon budgets should be halved to allow for a fair allocation between developed and developing countries and to reduce reliance on negative emissions technologies at scale (see for example Anderson et al. 2020[7]). This implies very steep reductions for the UK and other developed countries, but scientists warn that "*failing to take appropriate action will increasingly lock-in devastating climate impacts, imposed initially on poor and climate vulnerable societies, but ultimately across all of the international community and natural ecosystems*."

If the international equity aim of the Paris Agreement is taken seriously, the Tyndall Centre for Climate Change Research estimates that at 2017 emission levels, the entire Paris-compliant CO_2 budget for the energy sector (including transport) is likely to be used up before 2030[8]. The current level of ambition in the Sixth Carbon Budget for transport especially does not therefore seem commensurate with the scale and urgency of the challenge.

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[4] Committee on Climate Change personal communication with authors by email, January 2021

[5] Examples of cost-effective and cost-saving measures previously recommended by the CCC but not implemented include: road user charging; prioritising broadband investment over road building; enforcing the 70mph speed limit on motorways and dual carriageways; reducing the speed limit from 70mph to 60mph; wider training in eco-driving techniques; and 'smarter choice' behaviour change programmes in all cities and towns. Some cost-effective measures that help reduce emissions but that are reserved to UK government have been abolished: for example, Vehicle Excise Duty graduated by carbon emissions was abolished in 2017, resulting in increases in emissions from the average new car in the following year.

[6] The CCC shows that driver savings will be £20 billion per year by 2035 compared to cost investment in vehicles and charging infrastructure of £12 billion per year in 2035. Committee on Climate Change (2021) The Sixth Carbon Budget. Surface Transport, Fig A3.1.g, p55.

[7] Anderson K, Broderick J F and Stoddard I (2020) A factor of two: how the mitigation plans of 'climate progressive' nations fall far short of Paris compliant pathways. Climate Policy, 20:10, 1290-1304, DOI: 10.1080/14693062.2020.1728209

[8] Tyndall Centre for Climate Change Research Carbon Budget Tool

Road user charging (examined in a previous paper) may offer one policy lever that would deliver larger carbon reductions than assumed in the Balanced Net Zero Pathway. The CCC Net Zero Pathways are based on assumptions that car mileage[9] and ownership[10] will grow by 2050, partly due to growth in population and GDP, but also because of the rebound effect when the cost of driving falls. The CCC's sensitivity analysis shows that a reduction in car ownership and car mileage (due to greater reliance on car sharing and public transport) would result in lower emissions, equivalent to 8MtCO_{2e} over the Sixth Carbon Budget Period[11].

7. Alternative pathways towards 'Net Zero' emissions in 2050

We have considered two other possible Net Zero Pathways for surface transport in Wales, alongside the CCC Balanced Net Zero Pathway. These are:

- 'Tyndall International Equity Pathway': a Paris-aligned pathway based on the Tyndall Centre carbon budgets for local authorities in Wales[12].
- 'Wales Bigger Vision Pathway': a pathway roughly mid-way between the CCC pathway and the Tyndall pathway[13]. Aiming for this pathway for transport would maximise wider benefits of transport investment (e.g. to health); push the transport sector to identify additional cost-effective measures which might otherwise be neglected because they are seen as difficult; and reduce the risk of failing to achieve the CCC pathway.

The Tyndall carbon budgets (for CO_2 only) translate the "well below 2°C and pursuing 1.5°C" aim and equity principles in the United Nations Paris Agreement to a national UK carbon budget. They are significantly more ambitious than those proposed by the CCC, particularly over the next ten years, and propose an average 13.6% year on year reduction in CO_2 emissions for Wales as a whole[14]. For our Tyndall Pathway, we have assumed that the reduction in surface transport CO_2 should be the same as for energy CO_2 (i.e. a 13.6% year on year reduction). This would mean that in 2030 the surface transport budget would be 1.3 MtCO_2, i.e. less than half of the 2030 surface transport emissions in the CCC Balanced Net Zero Pathway.

These more ambitious emissions reduction pathways would increase the likelihood that the Wales Transport Strategy would align with a 1.5˚C warming scenario that is

[9] Although the CCC assumes a reduction in vehicle km *relative to the projected baseline*, because the baseline assumes a significant increase in mileage, even with abatement measures (i.e. the balanced net zero pathway) there is a slight increase in total car or vehicle km over the next 30 years.

[10] The CCC forecast also assumes an absolute (30%) increase in car ownership between 2020 and 2050, which seems inconsistent with the demand reduction ambition, as well as with population growth for Wales which is projected to be 3% between 2020 and 2043 (Stats Wales 2018-based population projections)

[11] Committee on Climate Change (2020) The Sixth Carbon Budget Methodology Report. December 2020. pp77-78

[12] Separate budgets for 22 Welsh local authorities can be found here Carbon Budget Tool and have been aggregated for this analysis, courtesy of Dr Jaise Kuriakose of the Tyndall Centre.

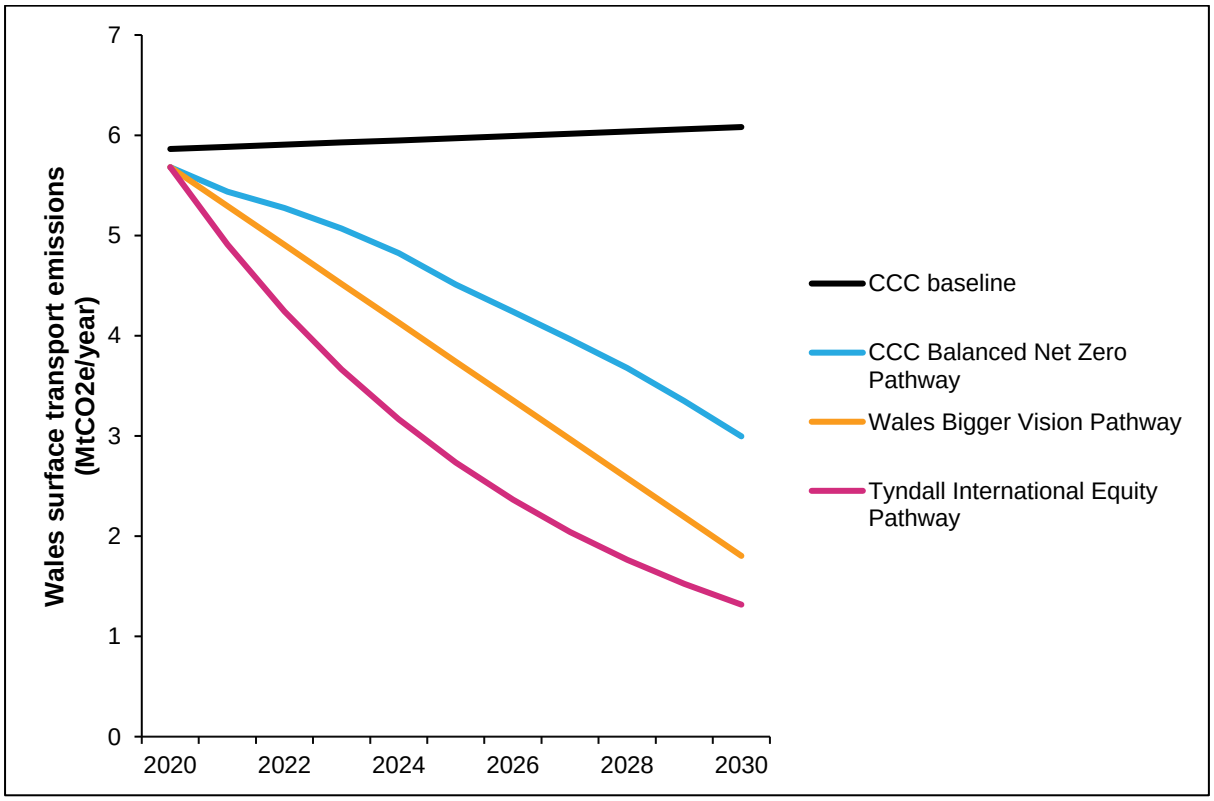
[13] In this pathway, transport emissions would be 68% lower in 2030 than in 1990, matching the UK economy-wide emissions reductions in the CCC Balanced Net Zero Pathway.

[14] Tyndall data for Wales energy CO_2 courtesy of Dr Jaise Kuriakose of the Tyndall Centre. Note aviation and shipping emissions remain within the national UK carbon budget and are not scaled down to sub-national budgets. Land Use, Land Use Change and Forestry (LULUCF) and non-CO_2 emissions are considered separately to the energy CO_2 budget developed by the Tyndall Centre. We have applied the same year-on-year reduction for energy CO_2 to surface transport.

equitable, both globally and locally. Aiming for early emissions reductions in line with these more ambitious pathways would also help future-proof the Low Carbon Delivery Plan 2, so that if take-up of electric cars in Wales happens more slowly than assumed by the CCC (as discussed in section 8), it will still be possible for Wales to achieve the carbon budgets set by the CCC.

Figure 6 provides a comparison of the three alternative Net Zero Pathways with the CCC baseline up to 2030, which is the end of Wales Carbon Budget Period 3. Although the Tyndall Pathway is based on CO_2 rather than greenhouse gas (CO_{2e}) emissions, surface transport greenhouse gas emissions are 99% CO_2 so this makes little difference in practice. A table in Annex 2 shows what the surface transport emissions in Wales in 2030 need to be under the alternative pathways and the percentage reduction relative to 1990.

Figure 6: CCC baseline and Balanced Net Zero Pathway for surface transport emissions in Wales and alternative pathways, 2020-2030



8. Rate of electrification

Figure 4 shows that in the CCC Balanced Net Zero Pathway, zero emission cars provide the greatest source of emissions reductions from the late 2020s. However, there is significant uncertainty about how quickly electric cars will replace conventional cars. This will depend on a number of factors, including when the sale of ICE cars is banned, costs for consumers, the regulation of manufacturers and how long people keep their current cars on the road. These factors are largely outside the control of Welsh Government.

The CCC has assumed a ban on sales of new ICEs and PHEVs in 2032. The previous UK position was a ban on new ICE cars/vans in 2040, but the UK government has announced it will bring this forward to 2030 for ICEs and 2035 for PHEVs[15]. With a phase-out date of 2032 (the CCC assumption), just over 40% of all cars on the road in the UK in 2030 will be plug-in electric. If the phase-out date is 2040, less than 30% of all cars on the road in the UK in 2030 will be electric.

Looking at how new car sales will ramp up in the period leading up to the ban, the CCC's electrification scenario for the UK is more ambitious than the government's current proposal. In the Balanced Pathway the CCC assumes nearly three-quarters (73%) of new cars will be electric by 2025 (nearly half of which will be BEVs), 97% of new cars will be BEVs by 2030 and 100% will be BEVs by 2032. The government assumes 100% of new cars will be electric by 2030, but a proportion of these will be PHEVs and these will continue to be sold until 2035. It appears that the CCC's analysis does not factor in any difference between each nation in terms of EV uptake[16]. However, at present Wales has significantly lower numbers of electric cars than England or Scotland, with less than half the number of plug-in cars (BEVs and PHEVs) (measured per resident or as a proportion of the car fleet), as shown in Table 1.

Table 1: Comparison of uptake of plug-in electric cars in the UK nations

	England	Wales	Scotland	N. Ireland	UK
Total plug-in car fleet Q3 2020	304,554	6,626	20,678	3,958	341,024
Plug-in cars per 1000 residents	5.4	2.1	3.8	2.1	5.1
Total car fleet 2019 ('000s)	27,146	1,583	2,524	982	32,884
Plug-in cars as % of car fleet	1.1%	0.4%	0.8%	0.4%	1.0%

Source: DfT tables VEH0130 and VEH0105

There are a number of reasons why Wales may be slower to electrify its fleet than other parts of the UK including an older car fleet, the lower proportion of EV cars in the fleet as a starting point in 2020 and lack of charging infrastructure in rural areas. Any slowdown in the economy following Covid/Brexit will also impact the rate of uptake of new EVs and car sales.

While there has been a surge in sales of electric cars in 2020 following the entry into force of the 2020/21 EU car CO_2 target, there is a risk that this momentum could stall unless post-2020 standards are strengthened[17]. Others have suggested that "a single cliff-edge date for the phase-out of ICEs will lead to distortions and perverse behaviours in the new and second hand markets in the lead-up to the target date"[18]. For example as 2030 approaches, used petrol/diesel car values are likely to fall steeply

[15] Department for Transport (2020) Government takes historic step towards net zero with end of sale of new petrol and diesel cars by 2030. News story, 18/11/20.
[16] CCC (2020) Sixth Carbon Budget. Surface Transport (pp37)
[17] Transport and Environment (2021) Cars CO_2 review: Europe's chance to win the emobility race. January 2021.
[18] Brand C, Anable J and Dixon J (2020) Joint UK Energy Research Centre and Centre for Research on Energy Demand Solutions Response to Department for Transport and Office for Low Emission Vehicles Consultation Ending the sale of new petrol, diesel and hybrid cars and vans

and new petrol/diesel cars are likely to be heavily discounted. Without a binding mandate for EV car sales up to 2030, market forces may result in lower sales than assumed by the CCC.

The proportion of electric vehicles in the fleet over the next five years will be a key indicator of whether ICE phase-out is happening at the speed required to achieve the assumed CO_2 reductions. It will be important that this is tracked within Wales (and for the whole of the UK). There are uncertainties in vehicle modelling about how long people will keep their current cars, the popularity of larger cars and vans, and other factors.

9. Could Wales achieve reductions in emissions to align with more ambitious carbon reduction pathways?

We undertook a core analysis to understand the size of the "carbon gap" between:

a) carbon savings from cars in Wales as a result of vehicle electrification and efficiency improvements; and

b) the carbon savings from cars that are necessary to achieve the CCC Balanced Net Zero Pathway.

Two further analyses of the carbon gap between (a) and the Wales Bigger Vision and Tyndall International Equity Pathways were also undertaken.

All three of these analyses used CCC assumptions about the percentage of electric cars in the fleet.

We also undertook a sensitivity analysis to understand how much more carbon would need to be saved in other ways if vehicle electrification occurs more slowly than assumed by the CCC in their Balanced Net Zero Pathway.

The differences between the assumptions in the analyses and sensitivity test are summarised in Tables 2-4. Figure 7 shows the proportion of cars on the road that will be electric (BEV / PHEV) up to 2035, under our "higher" and "lower" assumptions about the rate of electrification.

Table 2: Core analysis and sensitivity tests

CARBON REDUCTION PATHWAY	**REPLACEMENT RATE FOR ICE AND PHEVS**	
	Higher	Lower
CCC Balanced Net Zero	CORE	TEST C
Wales Bigger Vision	TEST A	-
Tyndall International Equity	TEST B	-

Table 3: Rate at which ICE and PHEVs are replaced by BEVs

	Assumptions	Likelihood
Higher	UK bans sales of new ICE and PHEVs from 2032 (earlier than current UK commitment). BEV and PHEV uptake in Wales matches that of the UK. By 2030: • 97% of new car sales in Wales are BEVs • 34% of cars on the road in Wales are BEVs	May be unlikely. EV uptake in Wales was slower than England and the UK as a whole before COVID. Post-COVID economic impacts mean fewer car sales and Wales' car owners will keep their old cars even longer.
Lower	UK bans sales of new ICEs from 2030 and PHEVs from 2035 (as consulted on by UK government in 2020). Numbers of BEVs/PHEVs in the Welsh car fleet and % of new car sales in 2020 approximate actual figures. By 2030: • 67% of new car sales in Wales are BEVs • 17% of cars on the road in Wales are BEVs	More likely. ICE ban likely to be brought forward from 2040, but uptake in Wales is likely to be lower than CCC estimate for UK as a whole.

'Higher' uses CCC assumptions on percentage of electric cars in fleet.

Annex 3 provides further figures on the proportion of cars on the road in Wales that are assumed to be electric (BEVs or PHEVs) in 2025 and 2030, and the date by which half of all cars on the road are BEV / PHEV in both scenarios as well as the different BEV take up rates assumed by the CCC in their alternative pathways.

Figure 7: Proportion of *all* cars in Wales that will be BEV or PHEV under different assumptions about phase-out dates for sale of new ICEs and the rate of electric vehicle uptake

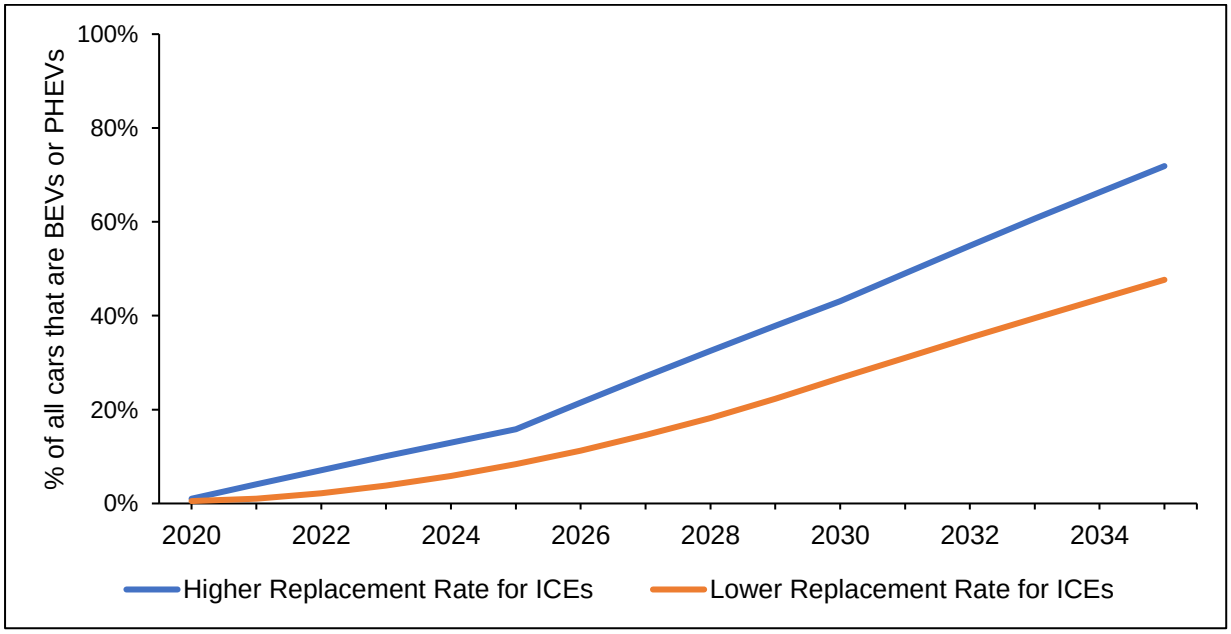


Table 4: Carbon reduction pathways

Pathway	Required reduction in emissions from cars		Comments
	Between 1990 and 2030	between 2020 and 2030	
CCC Balanced Net Zero	47%	45%	Less demanding reduction in emissions than for other sectors of the Wales economy. Not seeking to be consistent with "international equity" principle of Paris Climate Agreement.
Wales Bigger Vision	68%	70%	Similar reduction in emissions as for the UK domestic economy as a whole. Not seeking to be consistent with "international equity" aim of Paris Climate Agreement.
Tyndall International Equity	75%	77%	Reduction in emissions that is consistent with the "international equity" aim of Paris Climate Agreement.

In order to estimate the carbon saving from electrification and efficiency improvements in the core analysis and sensitivity tests, we took a series of steps, summarised below:

- The CCC has not published its modelling estimates that are specific to cars in Wales. In the absence of this Wales-specific data, we simulated the CCC UK baseline and pathways in Figure 4, using data provided by the CCC, and then given this provided a reasonable fit, applied similar assumptions to estimate equivalent baseline and pathways for cars in Wales. See Annex 1 for assumptions used.
- We used the CCC's baseline traffic mileage for Wales[19].
- We used the CCC assumptions on emission factors for PHEVs and ICE cars. For simplification we assumed that the car fleet composition (% EV/ICE cars) is equivalent to kilometres travelled by those vehicles.
- Because we are only estimating tailpipe emissions, not mileage (and BEV emissions are assumed to be zero) we ignored the rebound factor which will only apply to the mileage driven in purely electric mode.

[19] Committee on Climate Change, personal communication with authors, February 2021.

By simulating the assumed reductions from electrification of cars and improvements in car efficiency for Wales, we are able to estimate the gap between the latter and the alternative pathways.

Table 5a summarises the size of the carbon gap in the core and other analyses and sensitivity test, for Wales Carbon Budget Period 2. Table 5b summarises the carbon savings resulting from increased investment in active travel and public transport, and a shift to remote working, as modelled in the "bottom up" scenarios as well as the "top down" maximum potential from previous papers. In the sensitivity test, carbon savings from increased active travel, public transport and remote working use the lower electric vehicle uptake rates.

Tables 6a and 6b give the same figures for Wales Carbon Budget Period 3. At this stage all results should be treated as indicative, as they are based on a number of assumptions and simplifications which are potentially subject to change following further discussion with the CCC to clarify their assumptions for Wales.

Table 5a: Size of carbon gap between savings due to electrification / vehicle efficiency and savings required to achieve different carbon reduction pathways ($MtCO_2$), 2021-2025

CARBON REDUCTION PATHWAY	SIZE OF CARBON GAP ($MtCO_2$), 2021-25	
	Higher EV uptake rate	Lower EV uptake rate
CCC Balanced Net Zero	0.4	1.2
Wales Bigger Vision	2.1	-
Tyndall International Equity	4.7	-

Table 5b: Carbon saving from increased investment in active travel and public transport, and shift to remote working ($MtCO_2$), 2021-2025

Costed bottom-up	**-0.2**	**-0.2**
Top-down assessment of maximum potential	**-1.6**	**-1.7**

Table 6: Size of carbon gap between savings due to electrification / vehicle efficiency and savings required to achieve different carbon reduction pathways ($MtCO_2$), 2026-2030

CARBON REDUCTION PATHWAY	SIZE OF CARBON GAP ($MtCO_2$), 2026-30	
	Higher EV uptake rate	Lower EV uptake rate
CCC Balanced Net Zero	0.7	3.0
Wales Bigger Vision	4.7	-
Tyndall International Equity	7.1	-

Table 6b: Carbon saving from increased investment in active travel and public transport, and shift to remote working ($MtCO_2$), 2026-2030

Costed bottom-up	**-0.5**	**-0.6**
Top-down assessment of maximum potential	**-3.3**	**-3.9**

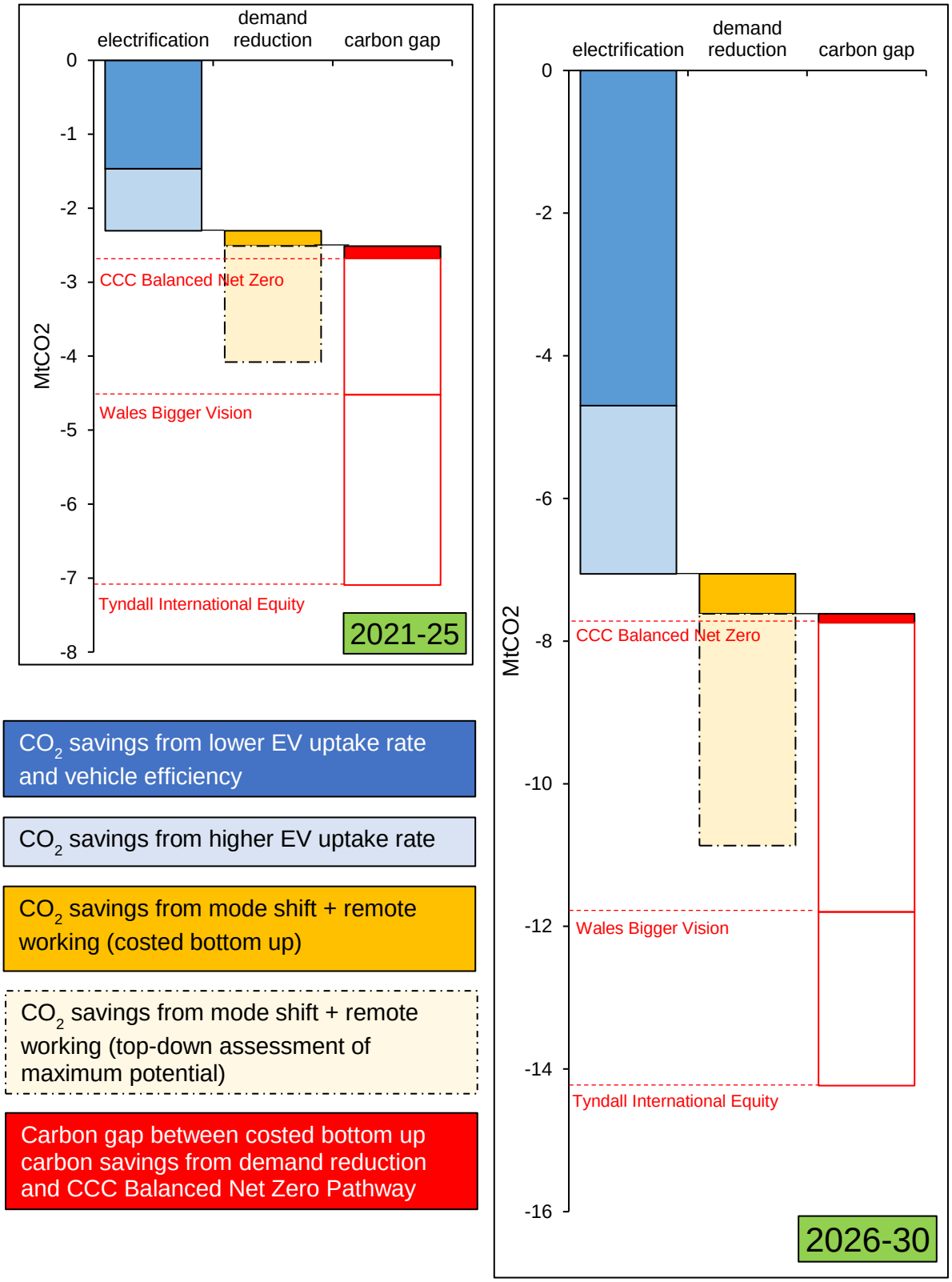
Comparing the carbon gap in Tables 5a and 6a with the carbon savings in Tables 5b and 6b, the costed “bottom-up” carbon savings modelled in previous papers are not on their own sufficient to enable Wales to meet even the Balanced Net Zero Pathway, still less the Wales Bigger Vision or Tyndall Pathways. It is also clear that if the uptake rate for electric cars in Wales falls below that assumed by the CCC (i.e. matches the ‘lower’ rate rather than the ‘higher’ rate), there is a substantial gap still to be closed between the costed “bottom up” carbon savings and the Balanced Net Zero Pathway.

More positively, the “top-down” assessment of maximum potential that was modelled in previous papers *does* enable the Balanced Net Zero Pathway to be met, even if the uptake rate for electric cars in Wales falls below that assumed by the CCC. If the higher uptake rate for electric cars is achieved, the “top-down” assessment of maximum potential would get Wales some way towards the Wales Bigger Vision Pathway.

The contributions from electrification and vehicle efficiency, and from investment in active travel, public transport and remote working, are shown in Figure 8 for Wales Carbon Budget Periods 2 and 3 (2021-25 and 2026-30).

Finally, it should be noted that the carbon impact of a number of other policy tools to reduce car emissions has not yet been considered. These include changes in travel patterns as a result of better land use planning; physical measures to discourage traffic in inappropriate locations (e.g. Low Traffic Neighbourhoods); lower speeds on motorways and trunk roads (which would also offer safety benefits); and demand management measures including road user charging, workplace parking levies and Clean Air Zones. These may also offer significant potential to reduce car mileage.

Figure 8: Contributions from vehicle electrification / vehicle efficiency, and mode shift / remote working, to achievement of three carbon reduction pathways, during Wales Carbon Budget Periods 2 and 3 (2021-25 and 2026-30)



10. Conclusions and wider issues

Can Welsh Government rely on electric vehicle savings to hit the Climate Change Committee's recommended pathway to Net Zero, or does that pathway also require investment in measures to increase use of sustainable modes and to discourage car use?

Emissions cuts from vehicle electrification will not be enough to hit the CCC's recommended pathway to Net Zero. The CCC states that demand reduction is also necessary. An investment package for active travel, public transport and remote working, which formed the basis for suggested mode share targets for the Wales Transport Strategy, could deliver most but not all of the demand reduction that the CCC says is required. It would meet about two-thirds of the demand reduction requirement during Wales Carbon Budget Period 2, 2026-30.

Should Welsh Government adopt a 'no-regrets' approach that adds policies to those in the CCC recommended pathway in order to avoid foreseeable political, financial and climate risks (Wales specific risks and wider risks beyond Welsh Government control)?

Uptake of electric vehicles is slower in Wales than in England, partly for structural reasons that are not easy to change. It is likely that electric vehicle uptake in Wales will continue to lag. This means that in order for Wales to achieve the CCC's recommended pathway to Net Zero, greater demand reduction than assumed by the CCC for the UK as a whole will be necessary. This is especially important between now and 2035, as most cars on the road in Wales are likely to still be petrol or diesel until then. This means there is a case for setting a more stretching mode share target and allocating more investment to sustainable transport, and also for taking other measures to reduce car use, like the benefits-and-charges road user package considered in an earlier paper.

Should Welsh Government add policies to those in the CCC pathway in order to reflect Welsh Government's leading position on climate change?

The Wellbeing of Future Generations Act places a special responsibility on Welsh Government to take a lead in tackling climate change, and this may mean taking decisions that aim to 'do what is right' even where the route forward does not appear clear. There is strong justification from climate scientists at the Tyndall Centre for Climate Change Research and elsewhere for pushing beyond what the CCC sees as 'achievable'.

Specifically, should Welsh Government aim to achieve a (steeper) carbon reduction pathway to achieve the (higher) share of reductions that Tyndall Centre climate scientists recommend as internationally equitable?

Tyndall Centre climate scientists believe that the UK's carbon budgets should be halved to allow for a fair allocation between developed and developing countries and to reduce reliance on speculative and expensive large-scale negative emissions technologies. This implies very steep emissions reductions for the UK from 2020 onwards. For transport, it would require a reduction in car mileage that might be as much as was seen during the first COVID-19 lockdown in Spring

2020. While such a major shift may be justified by the science, and by equity considerations, we do not see how it could be achieved with the policy levers that are currently available to Welsh Government.

Should Welsh Government add policies to those in the CCC pathway in order to reflect Welsh Government's wider social, environmental and economic priorities?

The CCC assumes that the cost of driving will go down for drivers of electric cars, because fuel duty will not be payable. They do not assume there will be road user charging to compensate. People who are well-off will benefit most, buying electric cars sooner, saving money, and driving more; whereas people on lower incomes will continue to drive older conventional cars for longer, and will not save money. To reflect wider social priorities, Welsh Government could place more emphasis on creating a comprehensive public transport "Network of Alternatives" as recommended by the Burns Commission, to give everyone a good alternative to driving.

A key economic risk for Welsh Government is that as less money flows into UK Treasury from fuel duty, there will be lower public spending in England and Barnett consequentials for Wales. At the same time there will be a need for Welsh Government to spend more on public transport in order to stimulate mode shift. One way of addressing this would be for Welsh Government to introduce road user charging before UK Treasury, retaining the income here in Wales to spend on improving public transport and active travel

Specifically, to what degree should Welsh Government prioritise active travel, public transport and remote working policies in order to bring health, environmental, social, economic, regional and equity benefits to Wales whilst also tackling the Climate Emergency?

Active travel, public transport and remote working policies provide the best available package to improve people's health, reduce local environmental harm from air pollution, support thriving communities, help the economy of our town centres, boost rural areas of Wales, and enable everyone, whatever their circumstances, to play an active role in our society. They are also necessary in order to tackle the Climate Emergency in a way that is fair to everyone. This means that there is a strong case for prioritising these policies, as proposed in the Wales Transport Strategy.

What level of potentially controversial demand management measures should Welsh Government consider to be sure it can achieve its Climate Emergency and wider objectives?

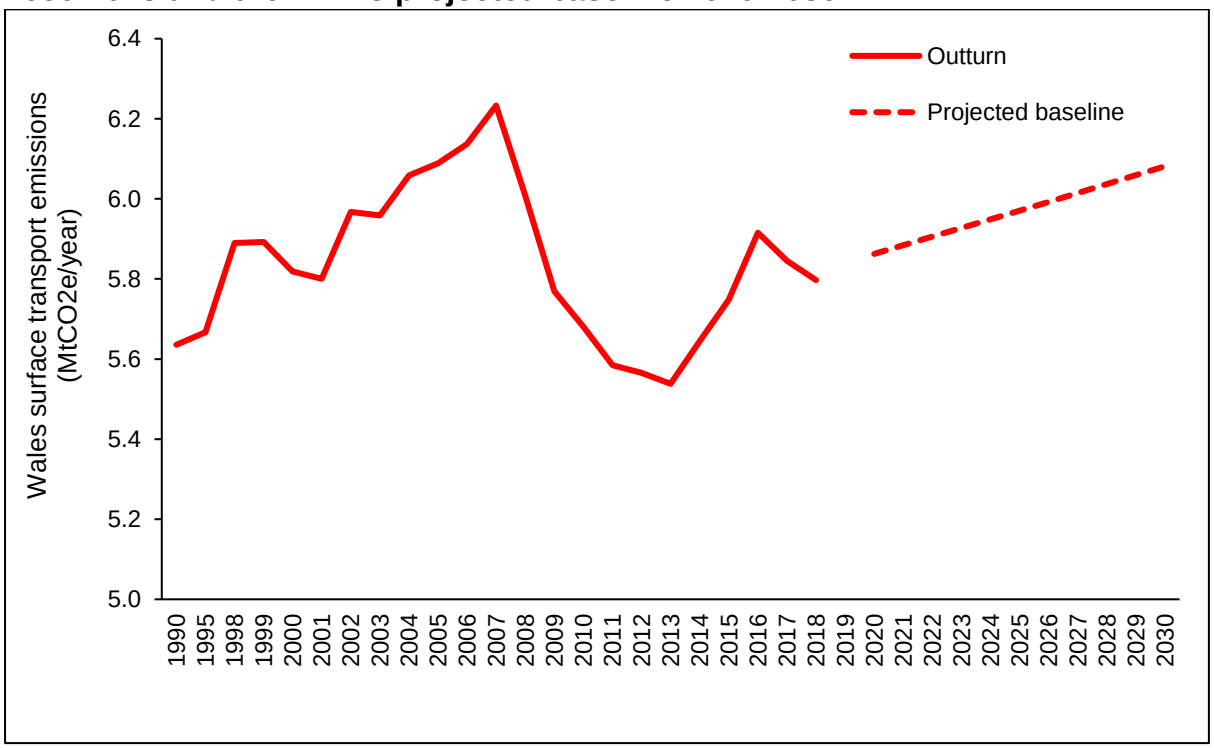
This needs more consideration. But as noted in an earlier paper, a low level of road user charging could raise large amounts of money for Welsh Treasury, sufficient to completely transform transport in Wales. A road user 'benefits and charges' package has the potential to deliver very significant reductions in car mileage, and this could be pivotal in enabling Wales to meet its climate and wider ambitions.

Annex 1: Key assumptions underpinning the CCC's pathway for surface transport

Baseline carbon emissions

The baseline surface transport carbon emissions for all scenarios are based on a very high trajectory of emissions (see Figure A below) and do not represent expected emissions, but a hypothetical scenario with all policy measures such as electrification or improved vehicle efficiency excluded. This has implications for the apparent scale of abatement reductions.

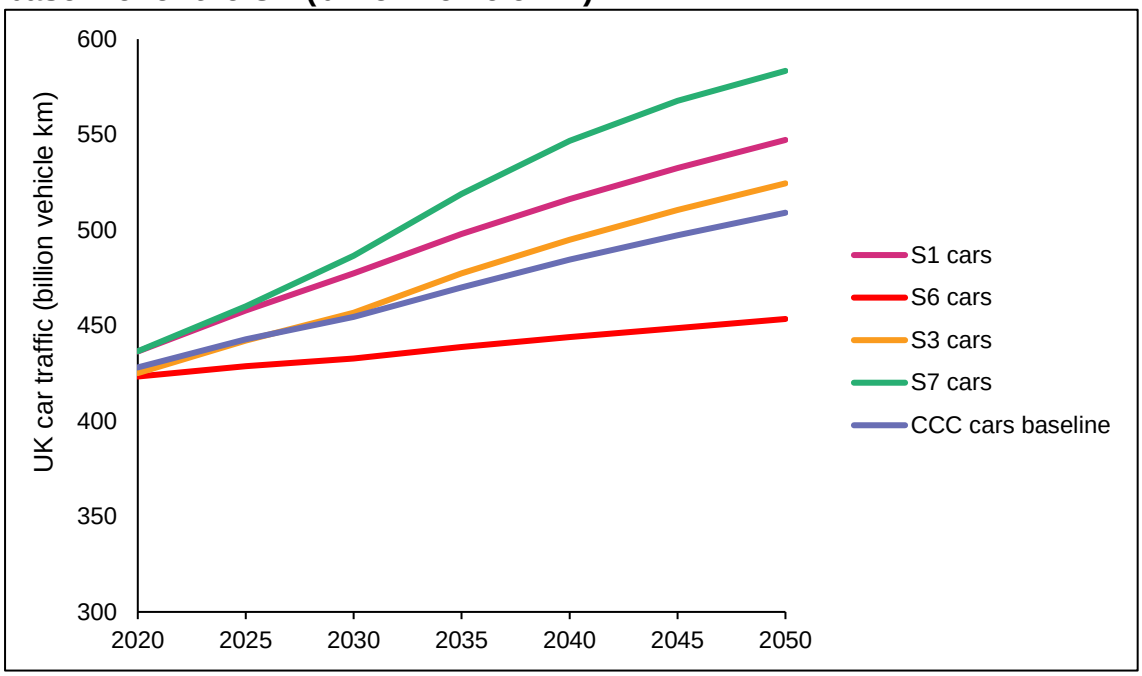
Figure A: Outturn greenhouse gas emissions for surface transport in Wales 1990-2018 and the CCC's projected baseline 2020-2030



Traffic scenarios

The CCC use bespoke traffic scenarios for their baseline, which appear to be most similar to DfT's 2018 Road Traffic Forecast S3 (low GDP, high fuel) but much lower traffic (and higher carbon) than S7 (high EV) where the potential effects of electrification are included. Figure B below illustrates the difference between the various scenarios for car demand, with scale adjusted for easier comparison. We assume the difference between S3 and the CCC baseline largely occurs because S3 assumes 25% of mileage will be driven by EV in 2050 whereas the CCC baseline assumes zero EV mileage throughout. Electrification will lead to a 'rebound 'effect, in that cheaper costs of motoring then increase car mileage. This is most evident after 2030.

Figure B: DfT car demand scenarios (scaled to the UK) compared to the CCC baseline for the UK (billion vehicle km)[20]



Key: S1 = reference; S3 = Low GDP High Fuel; S6= Extrapolated travel trends; S7 = Shift to EVs

Other assumptions used are given in the Table below:

Table A: Comparison of input assumptions used by the CCC in their Balanced Pathway and our assumptions used for Wales

Input	CCC assumption	Our assumptions for Wales
(a) car/van mileage	***Baseline***: CCC commissioned a bespoke run of DfT's National Transport Model (NTM), with all policy options turned off[21]. The baseline growth for ALL road traffic is 6% by 2030, 11% by 2035 and 19% by 2050. ***Abatement***: Car km are expected to reduce relative to the baseline[22] before the rebound effects from EVs are included. Overall there is a net increase in car km in 2050 relative to 2020.	***Baseline***: We have used the CCC's baseline traffic figures for cars in Wales. ***Abatement***: We have applied the same relative reductions (for demand management) as the CCC to the baseline traffic figures.

[20] RTF figures scaled to the UK using an approximate factor of 1.12, and CCC car figures provided by the CCC in personal communication with the authors, January 2021.
[21] The 'Policy Off' run was creating using the NTM with the same assumptions as RTF18 and Electric Vehicle Mileage Splits and Fuel Efficiencies created by Environment Analysis. The run assumes: (1) No improving fuel efficiencies; (2) Electric mileage splits set to 0% throughout. Pers. Comm. CCC and Prof Anable.
[22] Car traffic is expected to reduce relative to the baseline by -6% (2030); -9% (2035) and -17% (2050)

(b) uptake of EVs	97% new car/van sales by 2030; 15.9% cars on road are EVs by 2025; 43% by 2030	Higher rate: as for CCC Lower rate: see Table 3
(c) Car/van fleet size	30% increase in car fleet from 33.6m in 2020 to 43.6m by 2050	Higher rate: as for CCC Lower rate: used Welsh car fleet figures for 2019 and assumed fleet grew at the same rate as CCC assumed for the UK
(d) CO_2 from average ICE cars/vans	CCC figures provided for baseline and abatement scenario	***Baseline***: As for CCC ***Abatement***: As for CCC
(e) CO_2 from EVs	CCC figures provided for PHEVs. BEV tailpipe emissions zero.	***Baseline***: n/a ***Abatement***: As for CCC.

Annex 2: Surface transport emissions in Wales in 2030 under alternative net zero pathways

Alternative pathway for Wales surface transport	**Surface transport emission in 2030 (MtCO2)**	**% reduction relative to 1990**
CCC Balanced Net Zero	3.0	47%
Wales Further Ambition	1.8	68%
Tyndall International Equity	1.3	77%

Annex 3: Comparison of EV take up rates in different scenarios in 2025 and 2030

Table A: EV (BEV/PHEV) cars as % of Wales car fleet in different scenarios in 2025 and 2030

Replacement rate for ICES and PHEVs	**EV cars as % of cars on the road, Wales**		**Approximate date when 50% cars on road are EVs**
	2025	**2030**	
Higher	16% (a)	43% (b)	~2031-32
Lower	8%	27%	~2035-36
DfT's RTF S7 scenario	~10% (c)	~ 27% (c)	~2034-35

(a) CCC assume 5.6m electric cars on the road out of a total of 35.2m by 2025 for the UK – same percentage assumed for Wales
(b) CCC assume 15.9m electric cars on the road out of a total of 36.8m by 2030 for the UK – same percentage assumed for Wales
(c) Approximate figures only

Table B: BEVs as % of new cars in different CCC Pathways in 2025 and 2030 compared to our lower scenario

Scenario	BEVs as % new cars	
	2025	2030
CCC Balanced Pathway	48%	97%
CCC Tailwinds	57%	100%
CCC Headwinds	24%	90%
Our lower replacement rate	34%	67%

Annex 4: How CCC assumes demand reduction can be achieved, compared to assumptions in costed bottom-up analysis and top-down assessment of maximum potential[23]

Demand reduction & modal shift	**CCC assumed change by 2030**	**Costed bottom-up assessment**	**Top-down assessment of maximum potential**
Societal & technological changes (e.g. remote working)	1-4% reduction in car mileage by 2030 relative to baseline (pp8)	0.4%	7%
Increase in car occupancy	Increase from 1.6 today to 1.7 by 2030 (pp9)	-	-
Modal shift to active travel	5-7% car **journeys** switch to walking and cycling including e-bikes by 2030 (pp9)	3% of **mileage**	7% of **mileage**
Modal shift to public transport	2-4% car mileage switches to public transport by 2030	2%	17%
Combined effect	Reduction in demand of 6-16% of total car mileage in 2030 (a) (pp10)	5%	31%

(a) 6% for balanced pathway and up to 16% for tailwinds

[23] CCC (2020) Sixth Carbon Budget. Surface Transport