Carbon Baseline Emissions

Quantification of Current Baseline Carbon Output from Transport Emissions and the Projected Pathways to Achieve Emission Targets

9th December 2021

Document control

ESC programme name	Transport East – Baseline Carbon Emissions
ESC project number	ESC 00525
Version*	3.0
Status	Final report post comments from the Transport East Forum (12.11.21)
Restrictions*	Public
Release date	03/12/2021
External release ID	N/A

* Refer to the Information Classification Policy

Review and approval

	Name	Position
Author	Fred Jones	Transport Modelling Consultant
Reviewer(s)	Thalia Skoufa	Practice Manager - Transport
Approver	Hayley Myles	Senior Manager - Advisory

Revision history

Date	Version	Comments
07.10.2021	1	Version 1 for comments prior to the Officers Meeting
30.11.2021	2	Version 2 Final report
09.12.2021	3	Version 3 Final report following comments

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1. Understanding of the Project Brief

The Energy Systems Catapult (ESC) was commissioned to establish a current baseline of carbon emissions[1] from transport modes within the region of Transport East (TE) and to map possible emission reduction pathways to achieve environmental goals between now and 2050.

Figure 1 Transport East Region

TE is one of the 8 subregional transport bodies covering the area extending from North Norfolk to the Thames Estuary and bordered to the West by the M1 motorway. The area covers the counties of Essex, Norfolk, Suffolk, Southend-on-Sea and Thurrock. The region has three international airports and also hosts the main road arteries out to the ports of Harwich, Felixstowe and Tilbury Docks – all of which are key import and export points for goods for the UK. TE recognises the significant challenge facing the UK and their region particularly. In 2019, domestic transport was responsible for emitting 122 MtCO2 e (million tonnes of carbon dioxide equivalent) – making transport the largest emitting sector of greenhouse gas (GHG) emissions, producing 27% of the UK's total emissions in 2019 (455 MtCO_2e)[2]. This is a 1.8% reduction in emissions from 2018.

Since 1990, overall emissions from rail, buses and domestic shipping have decreased by 2%, whereas on-road emissions (primarily from vans) have increased by 67% in the UK. And beyond domestic UK transport emissions, international aviation emissions, (which are not part of the UK's domestic emissions), have more than doubled since 1990. A graphic representing this trend is featured overleaf in Figure 2 and sets a backdrop against which the TE decarbonisation strategy is set[3].

According to Transport East's own work[4], transport emissions in the Transport East region are the largest source of CO_2 within the region, comprising 42% of total emissions. This is significantly above the average of 28% in other regions and the reasons for this are unpicked in greater depth in Section 3.1 (Baseline Results).

[1] All emission figures relate to tailpipe emissions rather than lifecycle emissions.

[2] https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/984685/transport-and-environment-statistics-2021.pdf

[3] Note the graphic reflects GHG emissions in terms of MTCO_2e, whilst the TE baseline report is considered in MTCO_2. The two metrics are not directly comparable. A CO_2 equivalent, (CO_2e) is the metric that is used to compare the emissions from seven greenhouse gases: carbon dioxide (CO2), methane (CH4), nitrous oxide (N2O), hydrofluorocarbons (HFC), perfluorocarbons (PFC), sulphur hexafluoride (SF6) and nitrogen trifluoride (NF3). It is the agreed metric that allows comparisons on the basis of their global-warming potential (GWP). Accordingly, they are not directly comparable to CO_2 figures.

[4] Decarbonisation Evidence Base and Strategic Recommendations Report - Nov 2020

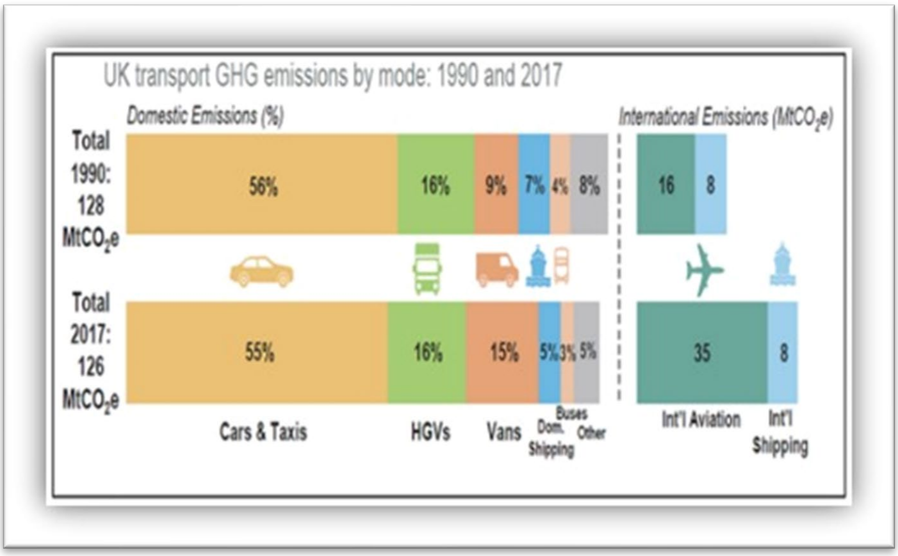

Figure 2 UK Transport Emissions by Mode (1990 & 2017)[5]

Clearly the challenge for Transport East is significant, but their decarbonisation agenda has to be balanced with adjacent economic and social goals so that any intended low carbon transport infrastructure investment is aligned with the broader strategic goals which relate to "place" within the TE area. These are detailed below.

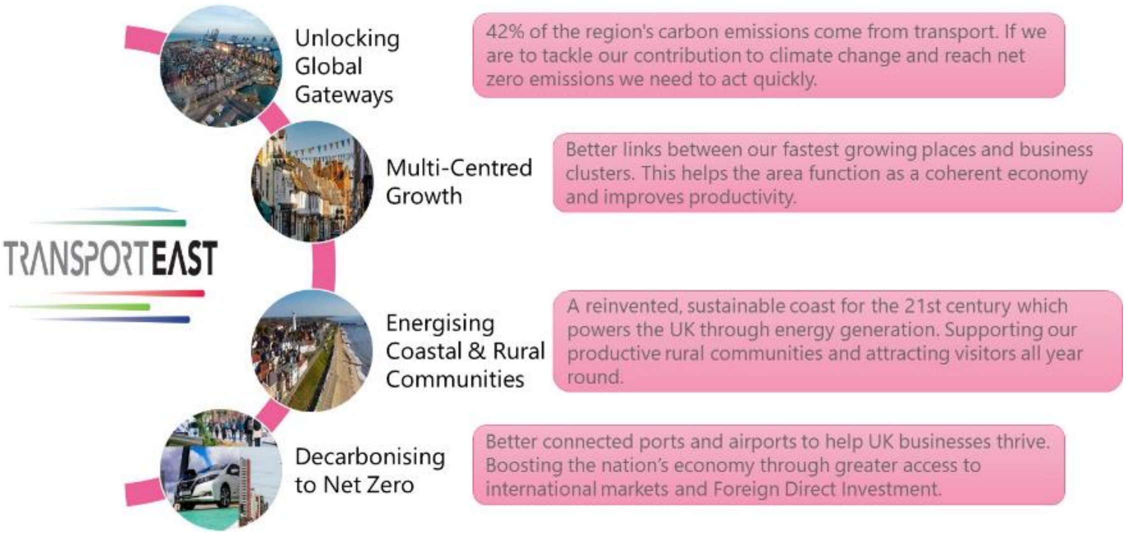

Figure 3: The Four Tenets of the TE strategy

To inform this process, the modelling of baseline emissions has been disaggregated across the region according to agreed geographic groupings to enable this strategic alignment to be considered.

The ESC modelling has furnished a carbon baseline across "on-road" and rail transport modes and forecasts the CO_2 footprint according to a "Business as Usual" (BAU) scenario out to 2050. In parallel, ESC has modelled three adjacent transition pathways across 3 scenarios, the conclusions of

[5] https://www.gov.uk/government/publications/trend-deck-2021-infrastructure/trend-deck-2021-infrastructure

which provide insight as to the extent of measures that need to be deployed to meet these time driven objectives / aspirations. It should be noted that the analysis is based on $MTCO_2$ rather than $MTCO_2e$ and parties should be mindful about drawing direct comparisons, albeit CO_2 is the dominant contributor to on road emissions[6].

Understanding the composition of the baseline emissions will be critical in helping TE understand what "levers" the regional transport body has at its disposal to complement national policies, and where it must co-ordinate with local authorities across the region to help implement wider initiatives which will create an environment which "*enables*" decarbonisation across transport modes and journey types.

Our analysis provides oversight of what can be realistically achieved across transport modes and provides signposting to the type of measures that may be required to achieve those pathways (both via public and private means). Equally the modelling provides clear metrics as to the current emission footprint and the cumulative footprint over the duration of the decarbonisation pathway.

We understand that this baseline modelling exercise forms the first of two stages of work being pursued by TE. The second is the development of a regional carbon reduction pathway which would attribute the required reductions to different interventions executed by TE (such as encouraging alternative fuels, promoting modal shift and enabling regional infrastructure).

Collectively, both phases will support the required investment that will shape TE's approach to regional transport infrastructure deployment in the next 30 years.

[6] The two metrics are not directly comparable. A CO_2 equivalent, (CO_2e) is the metric that is used to compare the emissions from seven greenhouse gases: carbon dioxide (CO2), methane (CH4), nitrous oxide (N2O), hydrofluorocarbons (HFC), perfluorocarbons (PFC), sulphur hexafluoride (SF6) and nitrogen trifluoride (NF3). It is the agreed metric that allows comparisons on the basis of their global-warming potential (GWP). Accordingly, they are not directly comparable to CO_2 figures.

2. Methodology and Architecture of the Modelling Procedure

2.1. High Level Methodology

The provenance of emissions has been mapped according to the following components to secure an estimation of the regional CO_2 footprint:

- Transport type (on road [car, van, HGV] and rail);
- Geographic location (regional city, a town and rural area);
- Time period (AM, IP, PM, OP)7;
- Trip Length; and
- Purpose (commute business, other).

Thereafter, a BAU scenario was mapped out to 2050, with the analysis building upon work conducted by TE authorities, Highways England, National Rail & neighbouring STBs[8].

ESC modelled appropriate transition pathways which account for:

- National policy mandates and incentive interventions – with insight drawn from a comprehensive understanding of the policy support landscape driving the transport transition. This is based upon ESC's engagement on the UK Government's EV Taskforce and related activities;
- Consumer trends – Drawing upon ESC's significant consumer engagement work which has sought to understand drivers' purchase trends, the total cost of ownership and the emotional inflection points in the adoption of EV's and alternative fuels;
- The changing face of transport (e.g., active travel, MaaS, logistic trends);
- Mobility price signals against an ICE counterfactual;
- Infrastructural factors – drawing upon technical insight gathered during regional trials relating to DNO activities and vehicle to grid (V2G) trends; and
- Goods haulage research extracted from ESC's work covering "Decarbonising Road Freight"9.

The Transition pathways[10] cover three-time periods, notably

- 2050 – **Net Zero by 2050 Target** - UK National Net Zero target to be achieved by 2050.
- 2035 – **6th Carbon Budget** - wherein a 78% reduction in CO_2 is achieved by 2035 compared to 1990 levels;
- 2040 – **Paris 10 years early** - Accelerated Net Zero target to be achieved by 2040.

To accord with TE discussions and adjacent work in the neighbouring STB (England's Economic Heartland consortia), ESC, in discussion with TE, elected to use the Transport for the North's (TfN) No Carb Model[11]. Where information was missing in the TfN model, the analysis has been

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[7] AM Peak: average hour 07:00-10:00, Inter Peak: average hour 10:00-16:00, PM Peak: average hour 16:00-19:00, Off Peak: average hour 19:00-07:00.

[8] Sub Regional Transport Bodies.

[9] https://es.catapult.org.uk/reports/decarbonising-road-freight.

[10] The ESC modelling only covers CO_2 and does not account for other emissions (i.e. CO_2e as noted in Footnote 3 - page1).

[11] https://transportforthenorth.com/wp-content/uploads/Annex-B-NoCarb-Development-ReportPDF.pdf

complemented using factors and assumptions from ESC's CVEI Analytical Framework[12] to ensure a comprehensive perspective was achieved.
To deliver the modelling assignment, the following datasets were used:

Data	Source
Demand Data	Highways England's Region Traffic Model
Emission Data	NAEI emissions factors.
Vehicle Registration data	DfT vehicle licensing data by MSOA.
DfT Automatic Number Plate Recognition (ANPR) data	This data is available from TfN
Future policy inputs	Proprietary knowledge and publicly available announcements
Models	TfN's NoCarb model provided freely by Transport East/TfN CVEI Analytical Framework and RFM[13] outputs provided by ESC.

Table 1 Data and Software Used

2.2. Detailed Model Architecture

Visually, the process of the NoCarb modelling architecture is presented below.

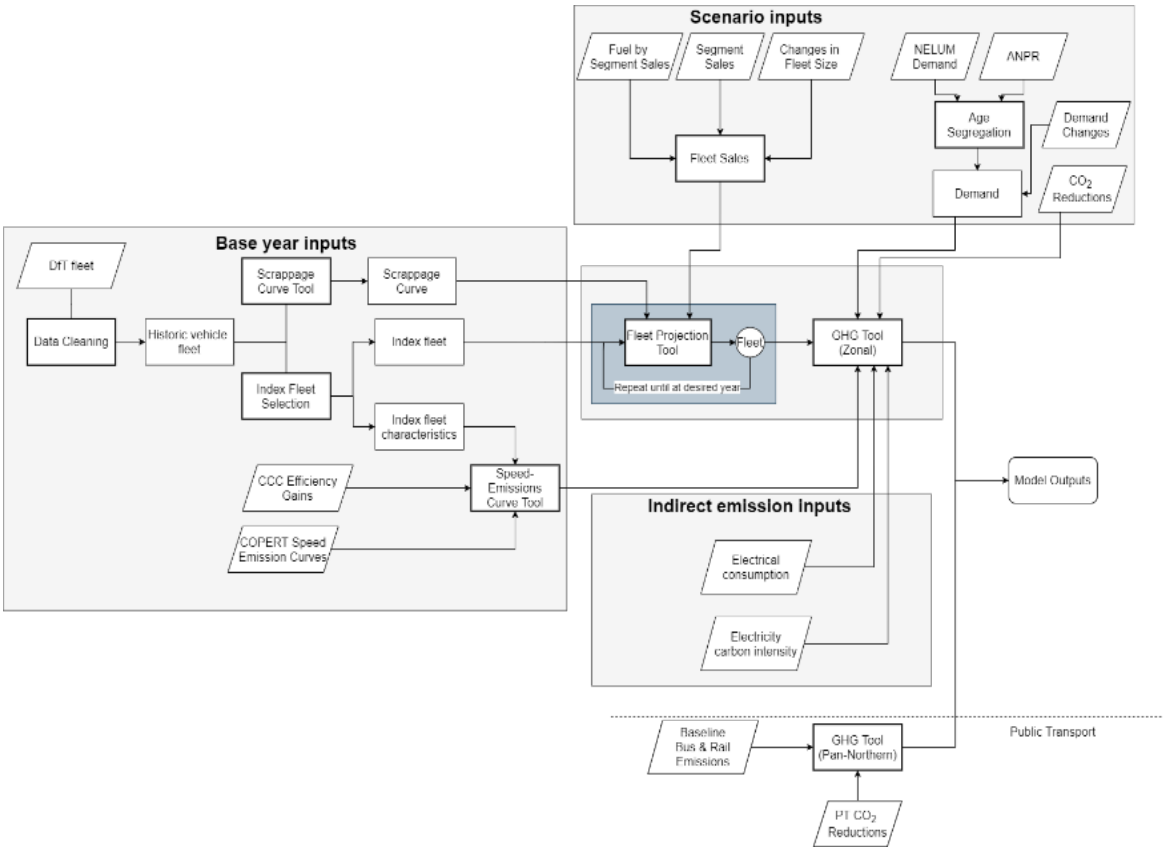


Figure 4 NoCarb Model Architecture

[12] https://es.catapult.org.uk/case-studies/consumers-vehicles-and-energy-integration/.
[13] Road Freight Model - https://es.catapult.org.uk/reports/decarbonising-road-freight

In essence, ESC applied 5 key steps:

1. Acquire, process and format data (multiple sources as detailed in Table 1);
2. Alter area specific files to match the TE study area;
3. Use insights from the ESC's work to compile scenario inputs & refine assumptions;
4. Run the NoCarb Model to deliver draft outputs;
5. Refine, re-run and validate the required outputs.

2.2.1. Scenarios

Essentially to deliver the required outputs, ESC ran the model according to 4 scenarios; the details of these are presented below in Figure 5 and are elaborated upon in the specific scenario sections.

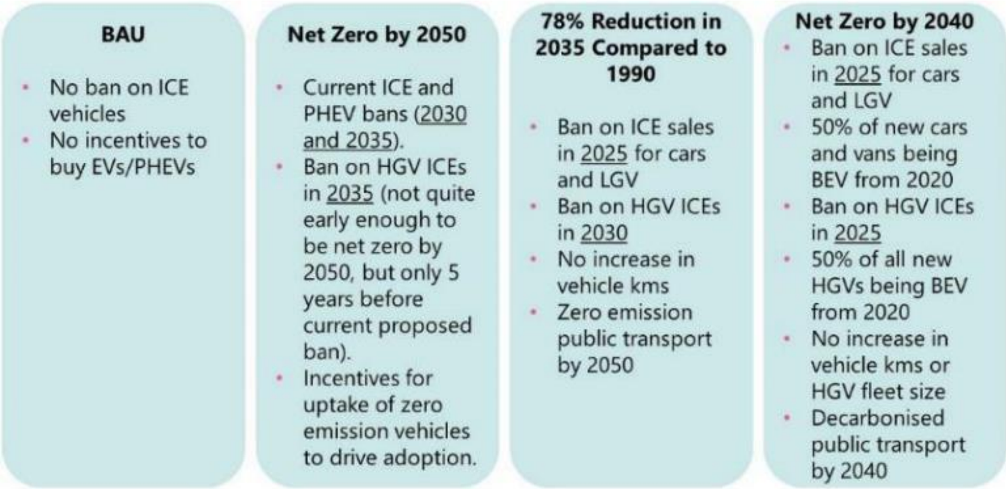
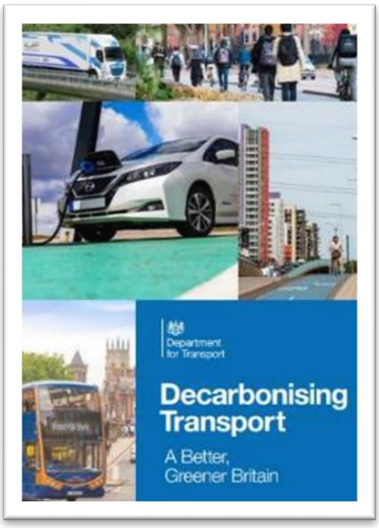


Figure 5 Scenario Definition

The BAU scenario is based on ESC's CVEI project[14] and assumes an organic change and move towards low emission transportation. The reduced CO_2 scenarios relate to prevailing government policy - as announced in July 2021 in their seminal publication "Decarbonising Transport"[15] which details transport decarbonisation delivery plans, including the phasing out of petrol and diesel vehicles[16] and the decarbonisation of rail and aviation. Notable points include:



- A commitment to end the sale of new petrol and diesel vehicles by 2030, and that all new cars and vans will be required to be fully zero emission at the tailpipe by 2035.
- The Government has recently ended a consultation governing HGV's and when to end the sale of new non-zero emission heavy goods vehicles (HGVs) in the UK. Proposed dates include:

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[14] https://es.catapult.org.uk/reports/consumers-vehicles-and-energy-integration/

[15] https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1009448/decarbonising-transport-a-better-greener-britain.pdf

[16] https://www.gov.uk/government/publications/transitioning-to-zero-emission-cars-and-vans-2035-delivery-plan and

    - End the sale of new non-zero emission HGVs (under 26t) by 2035.
    - End the sale of new non-zero emission HGVs (above 26t) by 2040.
- In July 2021, The UK government announced how they would support an electrification programme for the rail industry as well as the development of battery and hydrogen trains to achieve net zero by 2050. This also stated an ambition to remove all diesel trains from the network by 2040.
- The scenarios also take account of changes in mobility and as personal vehicle economics change, it is expected that we will see the rise of active mobility and mobility as a service (MaaS). Both of which contribute to declining emissions.

3. Modelling Results

3.1. Baseline Emissions

The modelling draws on 2018 data which constitutes the most complete data sets available. In totality, the total vehicle distance travelled in the TE region was 22,617million kms which resulted in a total CO_2 footprint of:

- **5.35 Mt** CO_2 broken down by the following components and represented in Figure 6 below:
  - Car - 2.44 Mt CO_2
  - HGV - 1.89 Mt CO_2
  - LGV - 0.50 Mt CO_2
  - Bus - 0.3 Mt CO_2
  - Rail - 0.22 Mt CO_2

96% of CO_2 emissions are derived from on-road activity with a broad split of It is notable that these figures do not account for the behavioural and related transport impacts arising from the Covid19 pandemic, which will of course have substantially impacted the emissions in 2020.

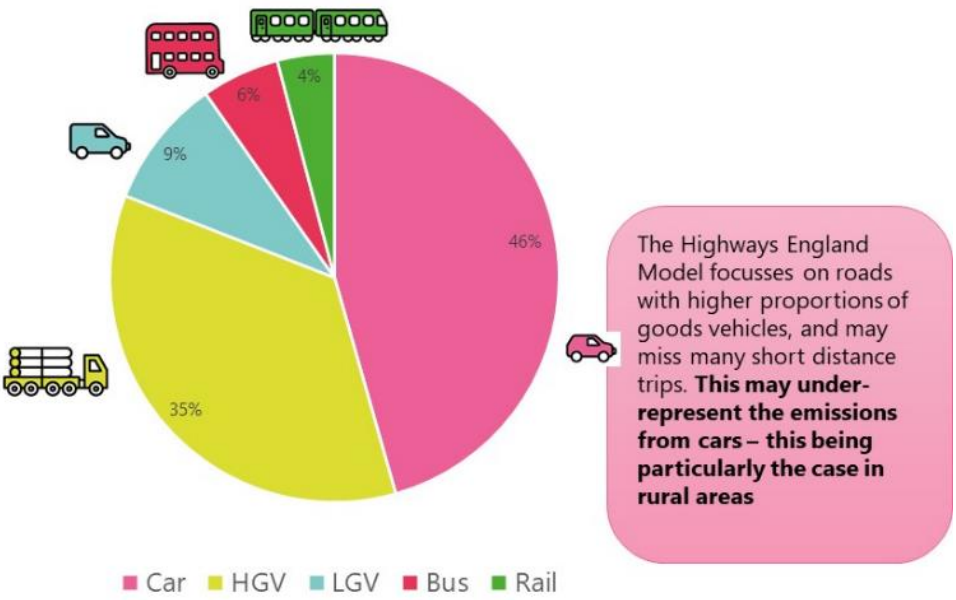


Figure 6 Transport East Baseline Emissions

To give a scale of this impact, provisional data for the UK's domestic GHG emissions from the transport sector for 2020 have been released. These data suggest that domestic transport CO_2 emissions have fallen 19.6% since 2019, to 97.1 million tonnes in 2020. This is associated with reductions in transport usage during the personal and work-related restrictions introduced in response to the COVID 19 pandemic. These estimates also suggest that domestic transport CO_2 emissions were 23% below the 1990 figure.

Given that on road transport emissions related to cars and taxis is the dominant category of domestic UK emissions (see Figure 1 UK Transport Emissions by Mode (1990 & 2017) on page 1), it is not yet clear whether there will be a wholescale return to previous trends (marginal home working / large scale work related commuting) which will negate these reductions. Initial findings suggest that car travel is returning to pre-pandemic levels[17] but there are unknowns around the journey types and vehicle usage patterns.

This is a factor that TE will need to consider when reflecting on the data and it is difficult to presently model how the behavioural trends will stabilise across the region. A scenario based approach would be suitable to understand the impact from reduced car travel reliance.

Figure 7 indicates the distribution of the emissions across the region.

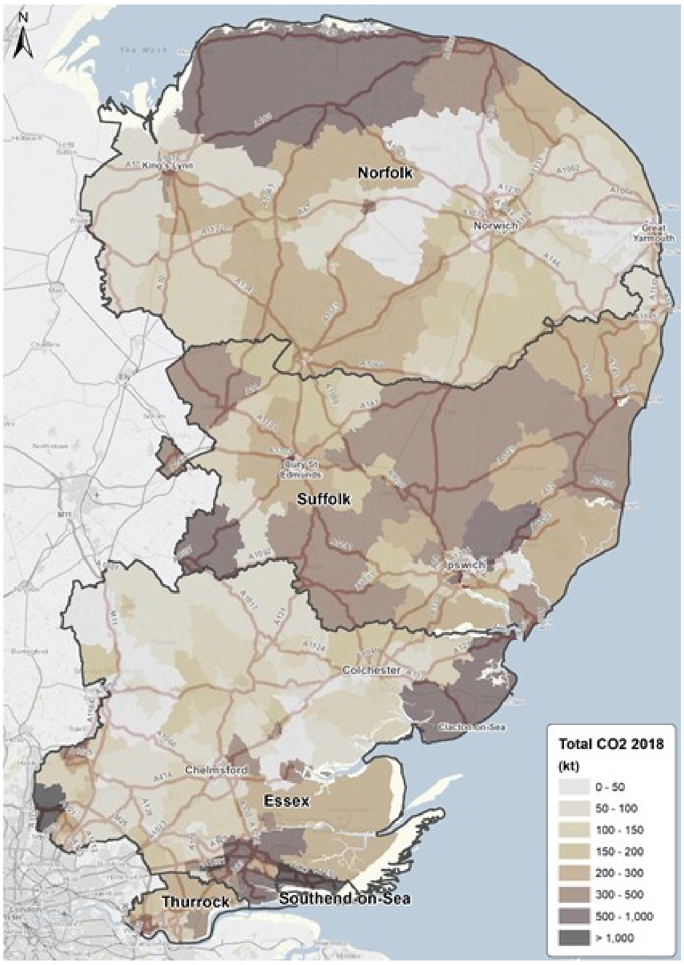


Figure 7 Total CO_2 per zone in 2018

Key areas of intensity are located in, and around:

- Southend on Sea and the main A127 artery;
- Romford and North London, with key motorway intersections with the M25;
- Colchester extending through to Harwich which includes the main thoroughfare for HGVs to Harwich along the A12 and A120;
- Ipswich which is partly bounded the main dual carriageways of the A14 and A12; and
- North Norfolk which is predominantly rural in nature which presents the dual impact wherein most trips will be made via private transport and will be made with greater frequency.

The CO_2 intensity can be broadly categorised by either:

[17] https://www.gov.uk/government/statistics/transport-use-during-the-coronavirus-covid-19-pandemic

- Impacts where the CO_2 is higher due to the presence of primary motorways or dual carriageways which pose the double aspect of greater vehicle flow and the greater carriage of vans and HGV's which have an increased CO_2 footprint per vehicle; and
- Rural areas where there is a greater propensity to travel by private vehicle due to the lack of public transport and the need to travel longer distances to get to a desired location.

This second point is particularly pertinent for the TE area wherein 45% of the population live in a rural location[18] (which is the dominant designation across the TE region – see Figure 10).

Location	Total Population	%
Urban	1,094,000	35%
Market Town / Coastal Town / Large Rural Town	629,000	20%
Rural	1,406,000	45%

Table 2 Population distribution according to region

As a further related point, it should be noted that the Highways England Model focusses on roads with higher proportions of goods vehicles, and for this reason it is possible short journeys are not represented in the modelling. Therefore, it is likely that **there is an underestimation in CO_2 emissions and that this will be particularly marked in rural areas which are less frequented by goods vehicles**.

It is not possible to assign a value to this underestimation due to the nature of the HE data. An alternative methodology would need to be deployed to capture short journeys in the region and account for their associated emissions. Mobile phone data could be processed to understand trip patterns in more detail and be able to identify short journeys but presently this is out of scope due to the complexity of modelling this aspect.

In terms of the emission distribution by population, the results are indicated in Figure 8 below. Here it is evident that key areas of concentrations are located in and around:

- The Dartford Crossing extending to Tilbury Docks which feature both the M25 and the A13;
- North and South of the River Stour and the River Orwell as a consequence of the main ports of Harwich and Felixstowe;
- Large town concentrations surrounding Bury St Edmunds and Kings Lynn; and finally
- Mid Norfolk with the main arteries of the A11 and the A47 dual carriageways.

[18] Populations figures are based on SERTM population figures by model zone. These zones cover a large area and therefore the population figures by specific location may differ to any more detailed studies using smaller areas for classification and greater data granularity, e.g. adjacent TE reports.

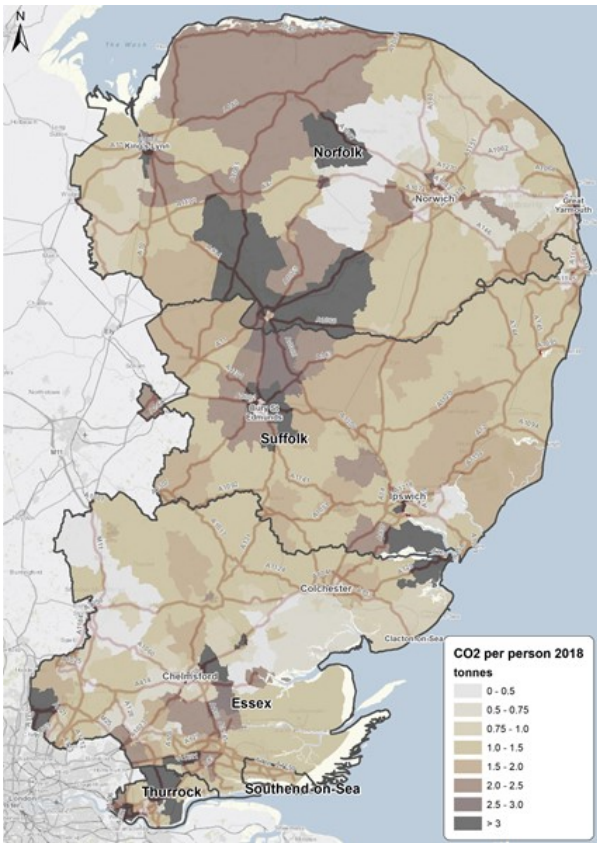


Figure 8 Total CO_2 per person in 2018

3.1.1. Cross Region Comparisons

To understand how the TE region performs compared to other regions, ESC explored the CO_2 footprint of differing regions with respect to on road transport. Government figures are presented in Figure 9 below which detail transport emissions for roads falling under the influence of local authorities (LA) (and which do not include motorways) and transport emissions for all roads by region (which do include the motorway network).

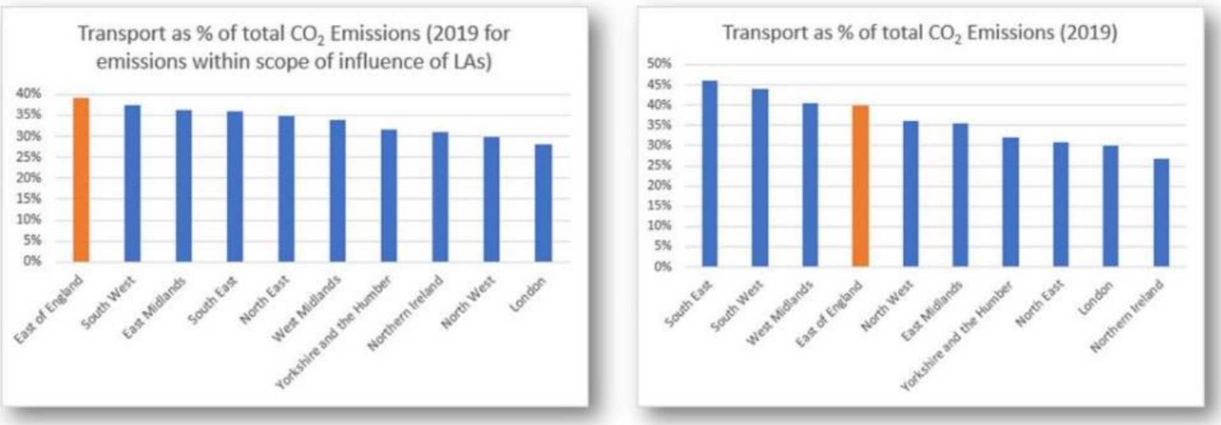


Figure 9 Transport Emissions as a % of the Total Regional Footprint across Regions[19]

[19] https://www.gov.uk/government/collections/uk-local-authority-and-regional-carbon-dioxide-emissions-national-statistics

It is evident that if one accounts for LA controlled roads only, then the TE region has the highest CO_2 footprint of all regions but falls to 4th place once motorways are also included in the analysis. When motorways are included, then the South-East, with motorway rich transit links (M25, M3, M1, M4, M40) rises to first position and encompasses the highest CO_2 emissions. The TE region is largely devoid of motorways and so one could argue that the large movement of goods from the ports of Harwich and Felixstowe significantly impact the area's carbon emissions, as it is a main transit thoroughfare for goods coming into and out of the country for forward distribution.

3.1.2. Current On Road Emissions by Zone

Assessing zones more broadly, Figure 10 overleaf denotes the categorisation of the TE region area according to "place". As noted in Table 2 on page 10, 49% of the TE population reside in rural areas. This is a point visually reinforced by, Figure 10 , wherein the graphic shows that the extent of the rural designation. This factor could present challenges for TE in terms of the decarbonisation practices such as public transport, MaaS, and active travel.

There are a number of large rural/coastal and market towns (such as Dereham, Thetford, Lowestoft, Clacton on Sea, West Thurrock, Chingford etc) and c. five large urban clusters.   Clacton on Sea encompasses a couple of designations and for this reason it is marked separately.

Points of note are:

- The rural area is the dominant designation, accounting for 45% of the total population within the TE region. In CO_2 terms, the associated footprint mirrors the population footprint and accounts for 48% of the emission footprint with an impact of 2.3$MTCO_2$/annum;
- The large towns account for a total population of 20%, and similarly, the associated emission footprint accounts for 1.03$MTCO_2$/annum;
- The urban areas account for 35% of the population and incurs a CO_2 footprint of 1.5$MtCO_2$/annum.

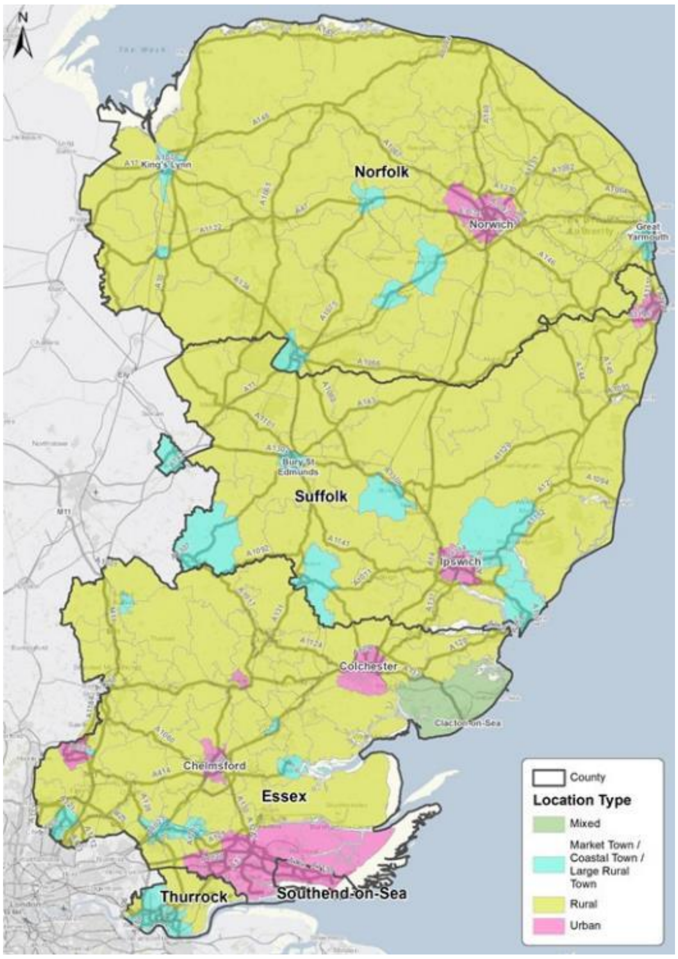


Figure 10 Location Type / Category

As one would expect, individuals living within a rural designation have a high personal CO_2 footprint (1.6 tCO_2/pp), though this is slightly outpaced by parties living in the larger towns. See Figure 11 overleaf. The reasons for this are twofold:

- Due to population density, the overall denominator when calculating emissions per person is lower. This also reflects the fact that the footprint associated with the rural designation, doesn't just relate to the impact derived from parties living in that designation. It equally relates to all main arteries passing through that locale. Consequently, with the higher impact associated with dual carriageways and motorways, it is inevitable that the rural/town designations will have a higher personal footprint.
- Secondly, it is certainly the case that parties living in rural areas or towns where public transport is less prevalent are more reliant upon their own private vehicle journeys and therefore, they are likely to have a higher personal CO_2 impact given that journeys are more frequent in nature, are potentially longer in terms of mileage and are in private vehicles.

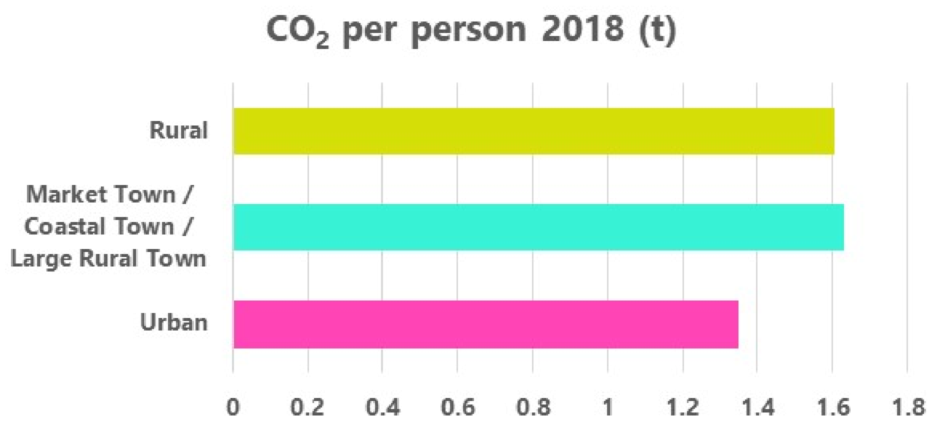


Figure 11 Total Emissions Per Person by Location (MTC0_2)

As denoted in Figure 11, the associated impact by person of those living in rural designations and those in towns is broadly similar, whilst the footprint of an urban resident is almost 20% lower. This naturally reflects the prevalence of public transport and active travel given the denser nature of the environment. Similarly, Figure 12 again reflects this trend, where it can be seen that the overall miles travelled per person in an urban setting are14% and 10% lower than those travelled by parties in a town and a rural environment respectively. Though it should be noted that the modelling structure will underestimate the non-urban footprint and so the overall miles travelled may be significantly more than what can be reported from the current available data.

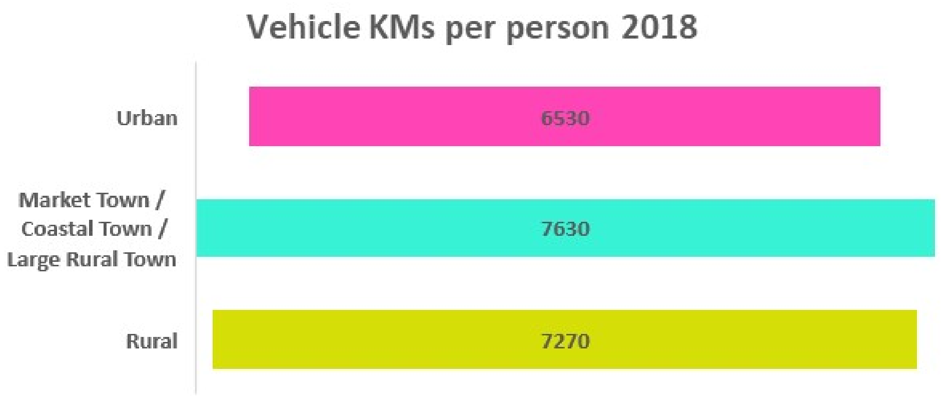


Figure 12 Total vehicle kms per person by location (MTC0_2)

Accordingly, this will present particular challenges for TE in the decarbonisation of transport and encouraging behavioural change.

3.1.3. Conclusions from the Baseline Analysis

Key points of note from the baseline analysis are:

- There is roughly a 50%:50% split between cars and goods vehicles (both heavy and light). This results from the fact that:
- The figures for the rural CO2 emission footprint are likely to be under-reported due to the granularity of the data available.
- The region is rural in nature and is likely to have a high car dependency – this will be particularly challenging for TE and consideration needs to be given to wider demographic metrics in terms of a decarbonisation strategy;

- 78% of working commuters in the Transport East region elect private transport which is the most polluting form compared to others. This may be a particularly pernicious factor given that the East of England is the fastest growing area for new homes;
- Over half of the on-road car emissions are derived from trips in non-urban areas;
- Major transit corridors to and from ports have a significant impact on regional emission levels, this includes 13 ports including 2 freeports identified by name;
- There are transit corridors to 3 international airports which again increase local on road emissions.
- The TE region compares poorly with other regional transport emission footprints, this is attributable to the points noted above.
- The on-road car and taxi footprint is underestimated due to HE model architecture. There are no regional models available to unpick this level of granularity and this is applicable to all "place" designations but the impact may be more pronounced in rural settings.

Consequently, TE's focus cannot solely feature urban concentrations; a more nuanced approach is required across "place" and this will play into the other tenets of the TE strategy.

- Solutions are going to be varied and nuanced in nature according to:
  - Place
  - Journey type
  - Demographics and behaviours
  - Commercial business models

3.2. Business As Usual Scenario to 2050

Against this backdrop, ESC modelled the expected emission footprint in a Business As Usual (BAU) scenario. This broadly reflects ESC's perspective on BAU as described in section 2.2.1 (Scenarios).

Business as Usual (BAU)

- No interventions
- No behavioural change
- No ban on ICE vehicles
- No incentives to buy ultra low emission vehicles

In this scenario, it is expected that there will be an increase in CO_2 in the short term due to an expected increase in vehicle kms travelled[20]. However, this trend in CO_2 emissions falls post 2030 due to increased number of EVs and PHEVs on the road after 2030. This is due in large part due to the changing economics of vehicles, wherein the falling costs of batteries transforms EV and PHEV competitiveness with the ICE counterfactual. As battery costs fall and with car OEM's achieving significant increases in EV economies of scale, the overall total costs of ownership (TCO) for EV's and PHEV's is predicted to be 14% below that of an ICE after 2045.

As a consequence of this gradual transition to EV's and PHEV's across on-road transport, the overall BAU scenario is predicted to feature:

- A **180 Mt CO_2** footprint over the whole period with a significant proportion of ICE based vehicles on the road by 2050;
- Drastically reducing emissions from the transport sector is unlikely to happen until the end of this century;
- LGVs & HGVs and cars continue to dominate source emissions;
- Emissions from public transport (rail and bus) remain broadly static across the time period.

[20] DfT projections on vehicle service demand were used for the purposes of this work.

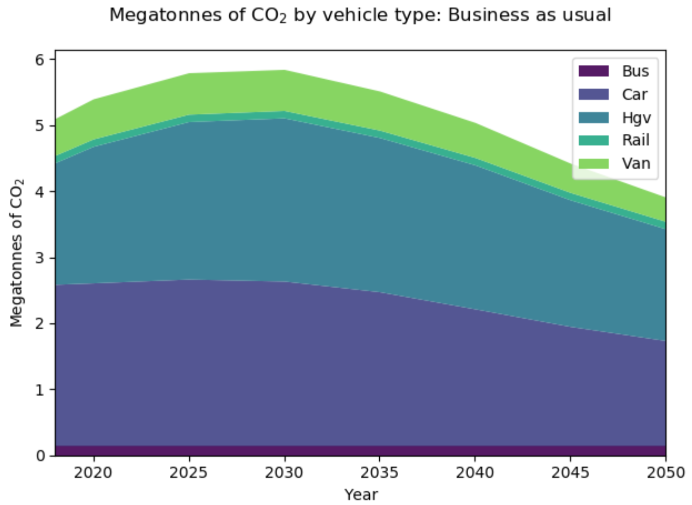


Figure 13 CO2 Footprint (MTC0$_2$) by vehicle type – BAU scenario

Low carbon vehicle uptake is assumed to be organic, driven largely by falling battery costs, improvements in range, and a better driver experience. These factors are coupled with increased access to charging points, as public destination and rapid charging points are built incrementally by commercial entities and utilities respond to the changing consumer market in the domestic sector.

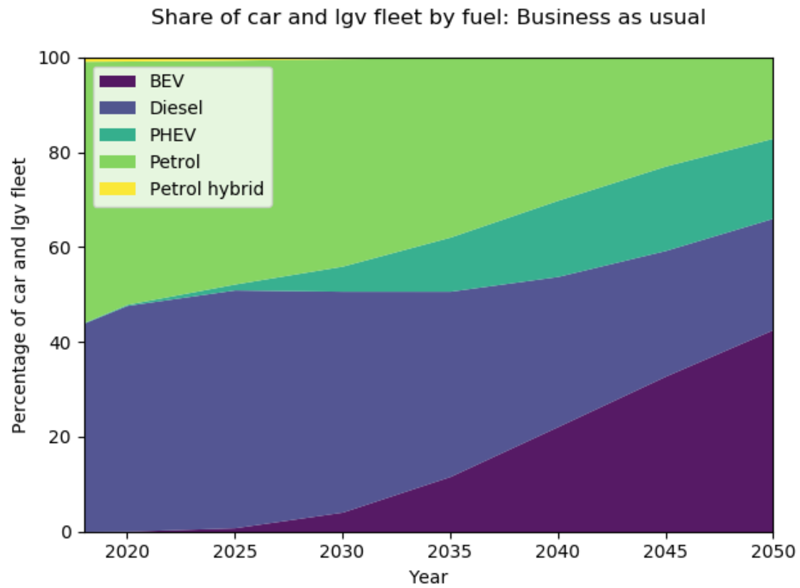


Figure 14 Percentage spread of vehicle types within a BAU scenario)

Figure 14 indicates the distribution of vehicles across the BAU time period to 2050. Whilst there is a gradual uptake of EV's and PHEV's, petrol and diesel vehicles still constitute c.50% of the on-road vehicles by 2050. The primary cause of this slow adoption is the:

- Lack of financial intervention supporting the adoption of EV's;
- Lower level of financial support for infrastructural "build out" for charging facilities; and
- Reduced "push" for infrastructure deployment by central government.

These factors have the combined effect of slowing uptake. This is a similar feature of the HGV fleet forecast, wherein there is an increase in zero emission HGVs, but a high percentage of diesel remains (>50%) as indicated in Figure 15 below.

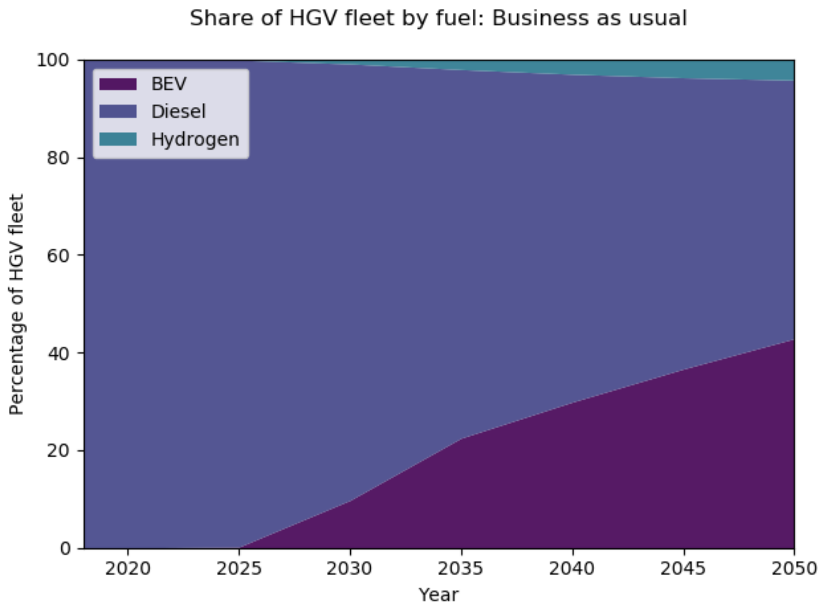


Figure 15 Percentage spread of HGV's by fuel type within a BAU scenario)

3.3. Net Zero Scenario to 2050

ESC modelled the expected emission footprint in a "Net Zero" scenario. This broadly reflects the ESC's perspective on Net Zero as described in section 2.2.1 (Scenarios). Explicitly, net zero[21] refers to the legislation, which was passed in June 2019, requiring the UK government to reduce the UK's net emissions of greenhouse gases by 100% relative to 1990 levels by 2050.

Net Zero by 2050

- Current ICE and PHEV phase out of sales (2030 and 2035).
- Phase out of HGV ICEs by 2035 (ESC assumption based on previous work – in consultation to bring forward from 2040).
- Incentives for uptake of zero emission vehicles to drive adoption.

This net zero target recognises that there will be some residual emissions from industrial processes and hard to decarbonise sectors (such as aviation) by 2050.

Therefore, there will be a need to fully offset these residual emissions via natural carbon sinks through land-based carbon sequestration, geological sequestration and through other forms of atmospheric CO_2 removal such as Direct Air Carbon capture (DACCS). For this reason, there is a drive to lower emissions as far as possible to reduce the reliance on CO_2 sequestration solutions.

It is the UK Government's firm belief that the UK can decarbonise all road and rail transport. Therefore, key elements in the modelling scenario

[21] The Climate Change Act 2008 (2050 Target Amendment) Order 2019 is available at www.legislation.gov.uk/uksi/2019/1056/contents/made

reflect a very determined focus on driving down transport emissions across on-road and rail modes. Key elements underlying the modelling in this scenario assume that:

- Current ICE and PHEV bans are implemented in 2030 and 2035 respectively – as suggested in "Decarbonising Transport"22 the UK Government's proposed commitments to transport decarbonisation.
- There is a ban on HGV ICE sales in 2035 (5 years before current proposed ban).
- Incentives to promote the uptake of zero emission vehicles to drive adoption are deployed. Specifically, these relate to:
    - Infrastructure – centrally planned roll out of infrastructure that allows adoption of smart charging for home charging and the provision of on-street charging for consumers without access to off-street parking.
    - Vehicle – further vehicle grants beyond the current incentives.
    - Fiscal / Tax incentives – applied to vehicles and electricity/hydrogen[23] as a transport energy source. Equally our scenarios include the adoption of a carbon tax on liquid fuels (in addition to fuel duty).
- The scenario assumes that there are no incentives for zero emission HGV uptake.

The overall forecast of emissions by mode is presented in Figure 16 below.

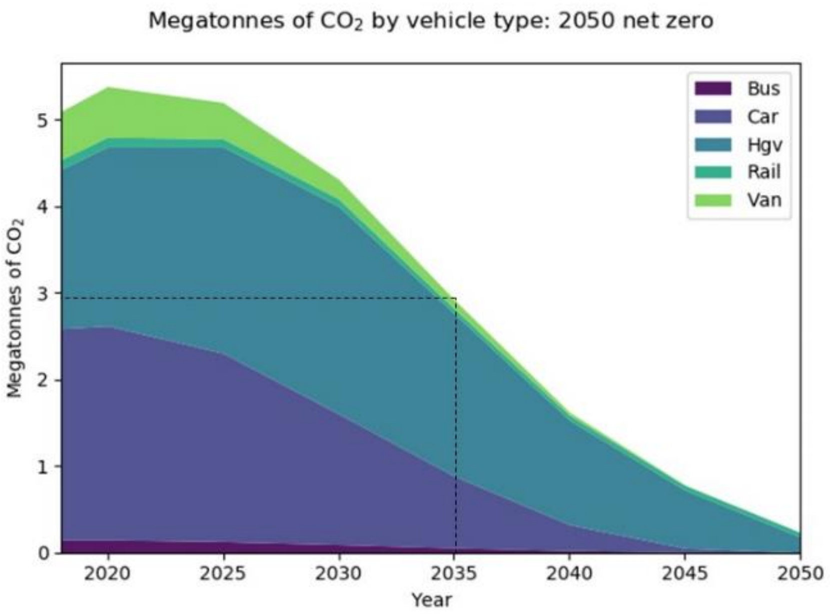


Figure 16 Emissions by transport mode within a Net Zero by 2050 scenario

In total, the overall CO_2 footprint across the transition would result in a total emission of **106 Mt CO_2** over whole period, and this is a 41% reduction on a BAU scenario. For further comparison with the 6th Carbon Budget, the timeframe for emission reduction and level of reduction is marked on the scenario.

Our analysis predicts that achieving a net zero position 2050 will be challenging. Whilst on road cars and taxis will approach a net zero position by c. 2045, a number of high mileage HGVs are still part of the population in 2050. Our modelling approach takes a more conservative approach and

22 https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1009448/decarbonising-transport-a-better-greener-britain.pdf

[23] Assumed to be zero carbon – either blue or green.

considers vehicle uptake from the position of fleet operators, accounting for both TCO[24] driven purchase decisions and the likely lack of incentives for zero emission HGVs. Therefore, selecting an earlier year for banning HGVs (2035) is more in line with this conservative approach.

As the ban of ICE HGVs is still under consideration by Government and the mechanism for delivering this ambition is not yet defined, incentive mechanisms have not been considered here.

In the net zero scenario, car and LGV fleets achieve 100% transition by 2050 and this is helped by a quick uptake in EVs from 2025. This would largely be driven by lower TCO purchase decisions as discussed previously and good access to charging infrastructure – both of which are accelerated by a central Government push to deploy public charging infrastructure especially to support consumers that will not have access to off-street parking. .

As Figure 17 indicates, the car and the LGV sector are able to fully transition from fossil fuel-based fuels by 2050. Indeed, there is significant ownership of low carbon vehicles by 2035, (c.80%).

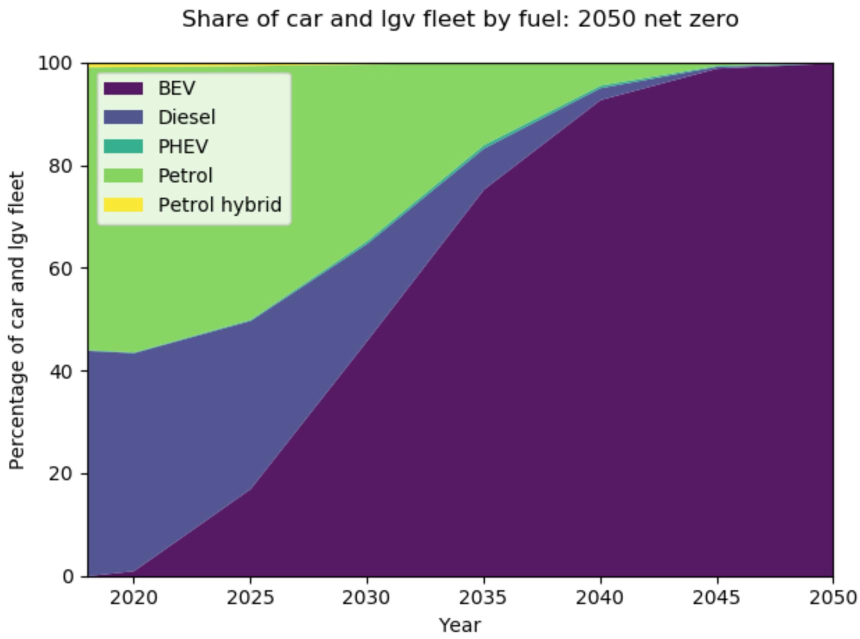


Figure 17 Percentage spread of on road vehicles by fuel in a Net Zero by 2050 scenario

With respect to HGV's there will similarly be a high uptake of zero emission HGVs leading to 2050. BEV / fuel cell vehicle (FCV) split is based on current projections on vehicle cost, although it should be acknowledged that there is high uncertainty around future vehicle prices and performance due to the limited number of options available at present. Until more options emerge in the next 5-10 years, our analysis is based on limited projections about these vehicles' classes and fuel types.

This point underlines Figure 17, wherein projections predict that by 2050, zero emission vehicles will dominate the HGV sector. Based on current vehicle and infrastructure data BEVs are predicted to be used in most freight vehicle categories. With increasing capacity and range and with reducing costs, BEV vehicles are generally preferred over hydrogen fuel cells in the HGV sector. However, it is expected that longer distance and heavier vehicles will transition to hydrogen. In the net zero scenario, HGV's all but transition by 2050, with diesel fuel making only a marginal showing.

[24] Total Cost of Ownership

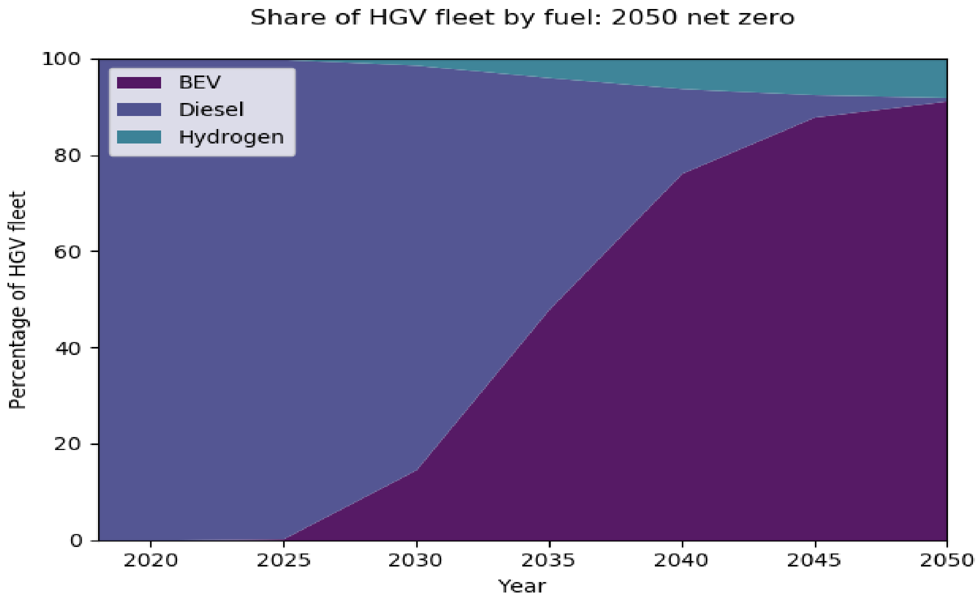


Figure 18 Percentage spread of HGV fleet by fuel in a Net Zero by 2050 scenario

3.3.1. Key Conclusions from the 2050 Net Zero Scenario

- The net zero position is achieved a little after 2050, which is slightly counter to the national picture. The reason for this is that there is a slight difference of approach in modelling architecture between the national and regional approach:
- National modelling architecture at national level.
- More behavioural reality applied to TFN analysis which has been used for TE.
- **The pathway would produce c.106 Mt CO_2** over the period - a 41% reduction on BAU.
- The TE region encompasses main freight corridors to and from ports resulting in a much heavier HGV traffic impact than other regions as previously noted.
- Based on the presumption of current financial interventions, further measures will be needed for HGVs to achieve net zero by 2050.
- Due to the heavy HGV footprint, TE may have to push harder on other decarbonisation activities to compensate for this HGV impact to achieve Net Zero by 2050.
- TE could explore options to encourage much quicker turn around in power trains in tandem with the port operators and logistic companies serving the port freight.

3.4. 78% Reduction in 2035 Compared to 1990 – The Sixth Carbon Budget

The scenario wherein the deployment plan achieves a 78% reduction of CO_2 emissions by 2035 reflects the UK Government's ambitions with respect to its **Sixth Carbon Budget**. In April 2021, the UK government stated its intent to write into law the UK's commitment to reduce emissions by 78% by 2035 compared to 1990 levels. This falls in line with the recommendation from the independent Climate Change Committee, regarding its sixth Carbon Budget which limits the volume of greenhouse gases emitted over a 5-year period from 2033 to 2037. This would take the UK more than three-quarters of the way to reaching net zero by 2050.

Aligning with this commitment would ensure that the UK remains on track to end its contribution to climate change while remaining consistent with the Paris Agreement temperature goal to limit global warming to well below 2°C and pursue efforts towards 1.5°C

Our modelling forecast within this scenario relies upon the following assumptions:

- There is a ban on ICE sales in 2025 for both cars and LGV – which would require the UK Government to announce that it is advancing its proposed bans on each vehicle type by 5 and 10 years respectively.
- There is a ban on HGV ICEs in 2030 which is 10 years before previous commitments.
- There is no further increase in vehicle kms/per person.
- That there are incentives for the uptake of zero emission vehicles to drive adoption. Specifically, these relate to:
    - Infrastructure – centrally planned roll out of infrastructure that allows adoption of smart charging for home charging and the provision of on-street charging for consumers without access to off-street parking.
    - Vehicle – further vehicle grants beyond the current incentives.
    - Fiscal / Tax incentives – on vehicles and electricity/hydrogen as a transport energy source. Adoption of a carbon tax on liquid fuels (in addition to fuel duty).

Key findings under this scenario are that a Net Zero position is achieved by 2050 and due to the quicker uptake of low carbon vehicles, there is a steeper reduction in CO_2 compared to the Net Zero 2050 scenario. This translates to an overall larger savings in CO_2. There is a total of **82 $MtCO_2$** emissions over the whole period and this is a 23% reduction in CO_2 levels against the Net Zero 2050 scenario.

Figure 19 presents the distribution of CO_2 emissions by travel mode. In this scenario, public transport (buses and rail) has achieved a net zero position between 2035-40. All cars and LGV's have transitioned to 100% BEV by 2045 and HGV's have also achieved a net zero position by 2050.

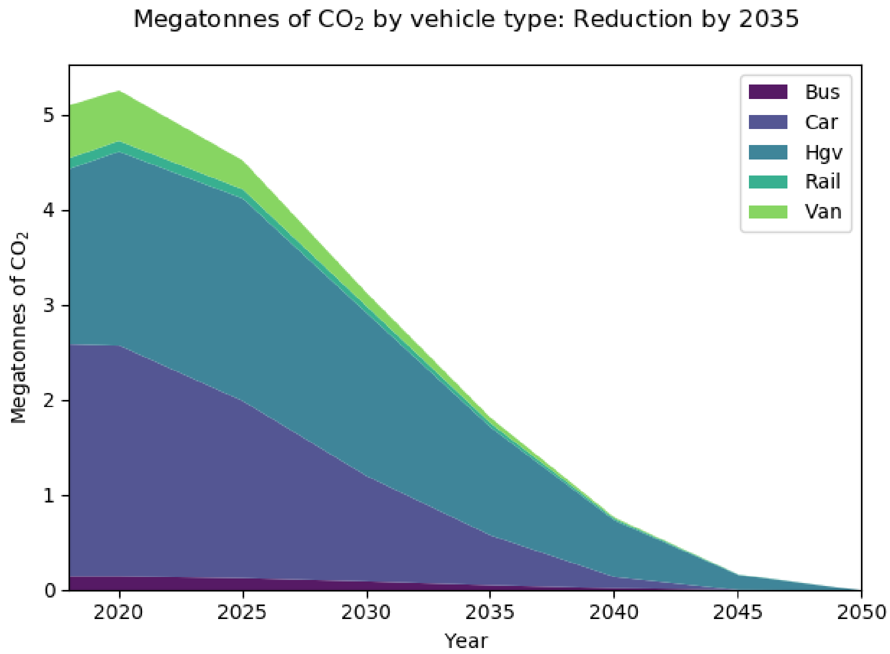


Figure 19 Emissions by Vehicle Type in a 2035 Scenario (MTCO2)

In particular the decarbonisation of the car and van segment accelerates to meet emission targets with an accelerated adoption of BEV between 2020 and 2035 (see Figure 20). This rapid adoption, would, by necessity, require the requisite charging infrastructure to support uptake and this would need to be widely deployed earlier than the net zero by 2050 scenario.

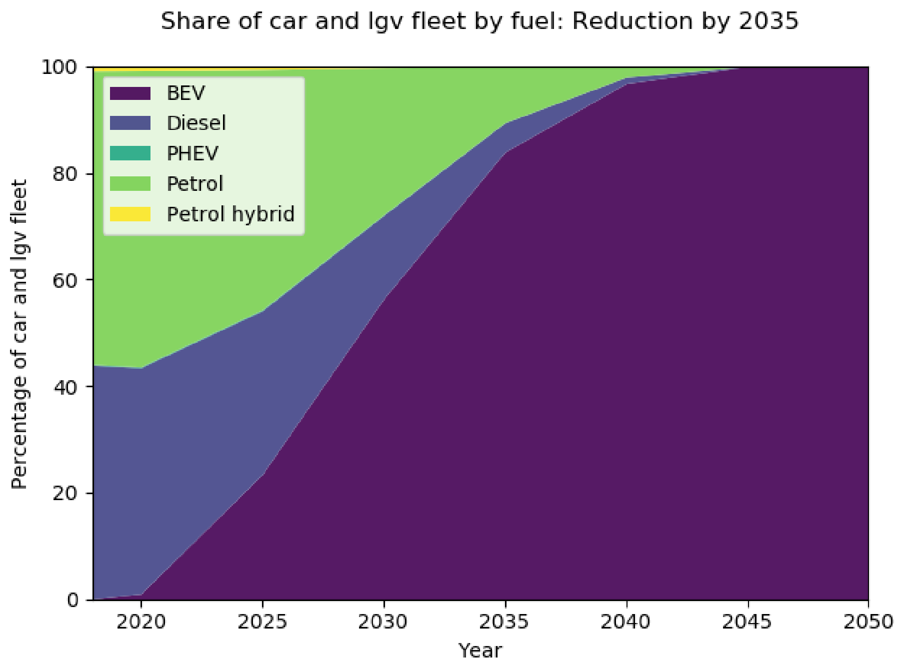


Figure 20 Percentage spread by on road vehicle type in a 2035 scenario

In this scenario, the HGV segment is predominately decarbonised by 2045, with a sharp increase in sales of zero emission vehicles in earlier years driven by the earlier ban (2030). In this scenario, it will be essential to deploy public refuelling/charging infrastructure to mirror vehicle adoption.

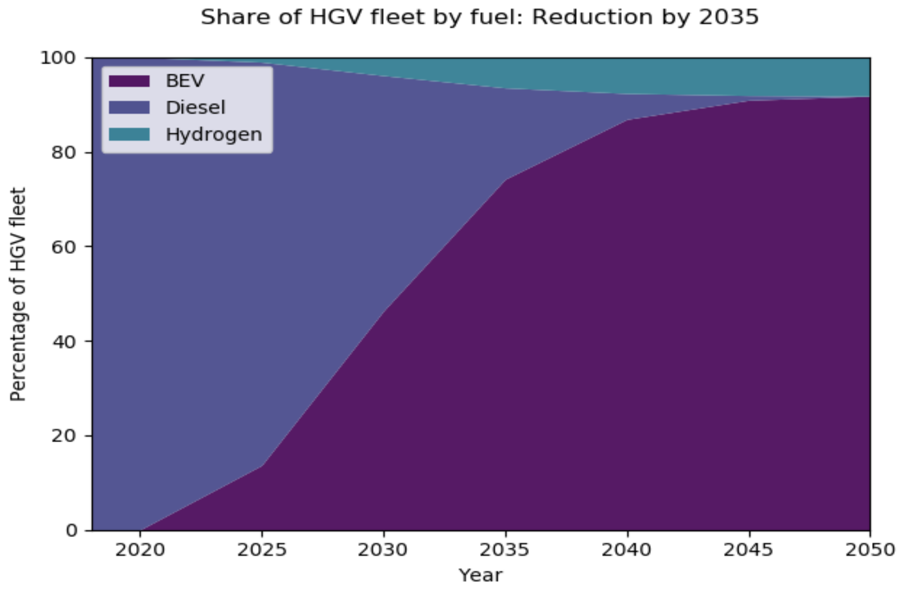


Figure 21 Percentage spread of HGV by fuel type in a 2035 scenario

3.4.1. Key Conclusions from the Sixth Carbon Budget Scenario

- If TE were to adopt this target, they would need to secure c.1MtCO_2 saving compared to 2050 target by 2035. This would require <u>**aggressive**</u> regional intervention over and above the net zero scenario.
- TE <u>**would need to complement**</u> national policies with regional initiatives:
  - Comprehensive public transport offer;
  - Encourage a shift in transport behaviour (reducing kms);
  - Modal shift for freight, commercial transport needs and people;
  - Transport East and its respective LA members will require adjacent public authority initiatives to complement sustainable transport strategy (e.g. planning policy / rural broadband provision/ town regeneration etc).
  - This scenario presents a much steeper reduction in CO_2 compared to 2050 scenario and results in **82 MtCO_2** over whole period (saving **24MtCO_2** against 2050 target).

3.5. Net Zero Scenario by 2040 – Paris 10 Years Early

Our last scenario reflects an ambitious target which explores whether a net zero position could be achieved by 2040. This mirrors the "Climate Pledge"[25] made by many organisations and agencies to be net zero across their operations by 2040. It is an ambitious target which is the most challenging of all scenarios to achieve. Key tenets underlying the scenario included:

- A ban on ICE sales in 2025 for cars and LGVs – 5 and 10 years ahead of current proposals (respectively).
- A ban on HGV ICEs sales is implemented in 2025 – this is 15 years ahead of the current proposal.
- Miles travelled per annum remain static in terms of vehicle kms or HGV fleet size.

[25] https://www.theclimatepledge.com/

- A decarbonised public transport system is fully operational by 2040.
- That there are incentives for the uptake of zero emission vehicles to drive adoption. Specifically, these relate to:
  - *Infrastructure* – centrally planned roll out of infrastructure that allows adoption of smart charging for home charging and the provision of on-street charging for consumers without access to off-street parking.
  - *Vehicle* – further vehicle grants beyond the current incentives.
  - *Fiscal / Tax incentives* – on vehicles and electricity/hydrogen as a transport energy source. Adoption of a carbon tax on liquid fuels (in addition to fuel duty).

Operationally, these are difficult market features to implement given the range of models on the market, their associated range and operational performance. Moreover, this is aside from the infrastructural challenges of realising the supporting charging and fuelling networks which would be required to dovetail with adoption rates and timescale on this scale. In parallel with policy decisions, financial incentives and a central Government push towards zero emission mobility will be required to accelerate the market and achieve earlier adoption of zero emission vehicles. As well as vehicle uptake, other implications, such as impact on the electricity network should be considered alongside vehicle uptake and infrastructure rollout.

Key findings within this analysis predict that:

- The proposed interventions and market dictates are insufficient to achieve net zero by 2040. At this point, Figure 19 indicates that there will still be residual emissions from the HGV fleet post 2040 and equally there will still be levels of CO_2 arising from the residual petrol and diesel car inventory.
- ICE based HGVs and vehicles will still be part of the mix post 2040, primarily due to the lifetime that vehicles are on the road prior to scrappage. This is on average c.14 years for cars and 15 for HGV's. Therefore, it is possible that vehicles bought up to 2025 may still be in use in 2040 and will be the primary provenance of CO_2 emissions.
- Overall, the total emission footprint in this scenario is predicted to be **65 Mt CO_2** over whole period and this is a 39% reduction on the Net Zero by 2050 scenario.

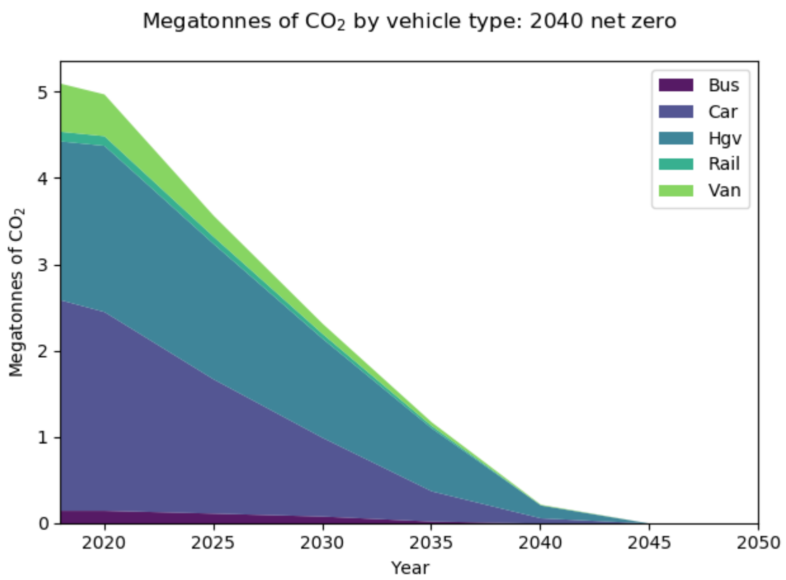


Figure 22 Percentage spread of HGV by fuel type in a 2040 scenario

In this scenario, the car and LGV fleet is fully decarbonised by 2045 but not 2040 and this being a similar conclusion for HGV's. Figure 23 indicates that there would be sharp increases in BEV adoption between 2020 and 2035 with diminishing ratios of petrol and diesel powered vehicles, and this is equally mirrored in HGV fleet predictions (Figure 24).

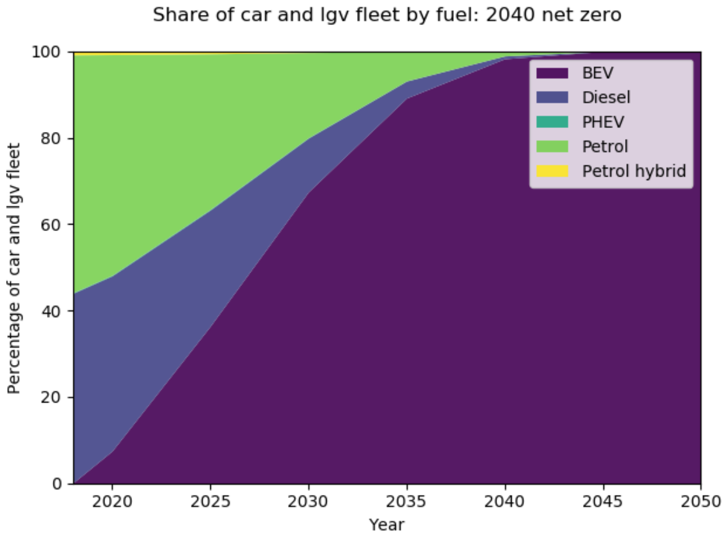


Figure 23 Percentage spread of on road vehicles by fuel type in a 2040 scenario

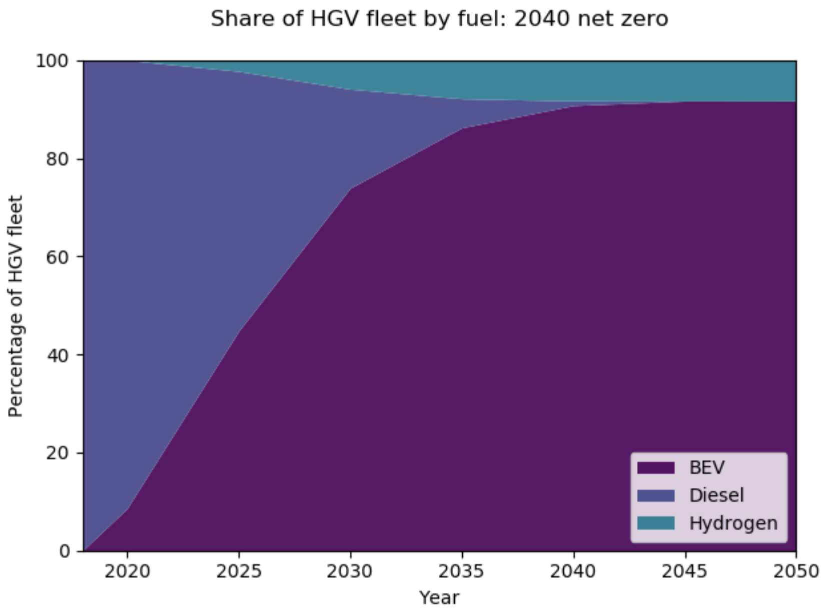


Figure 24 Percentage spread of HGV's by fuel type in a 2040 scenario

In the case of HGV's, it is predicted that BEV will be the dominant vehicle type with hydrogen fuel cells accounting for less than 10% of on road vehicles. As stated earlier, there is high uncertainty around zero emission vehicle techno-economic data, therefore a firm conclusion on the type of powertrain that will be used for HGVs cannot be drawn.

Of all scenarios, the 2040 scenario is the most ambitious and is broadly seen to be difficult to achieve given the nature of:

- Proposed government interventions and timings;
- The array of OEM models coming to the market;

- The difficulties in deploying the requisite levels of fuelling / charging infrastructure within the timescales suggested and at scale.

3.5.1. Key Conclusions For Net Zero by 2040

- Accelerated national policies will be insufficient to achieve a 2040 Climate Pledge;
- This scenario would need a proactive pursuit of adjacent measures- a switch to EV's is not enough. The TE strategy would require a full-scale assault on the reduction in vehicle kms travelled, a modal shift, MaaS offerings across the region and wider cross-LA initiatives to enable an environment promoting those objectives;
- In short there are still too many older ICE vehicles still part of transport fleet post 2035 – in particularly HGVs. There would need to be a proactive pursuit of switching powertrains across the HGV sector due to the impact that they pose in the region.
- Success would require accelerated ULEV adoption rates now (2020-25).
- This scenario would secure **65 Mt CO_2** over whole period and would save **41Mt CO_2** compared to Net Zero 2050.
- Across all the measures that TE could apply, TE would need to understand the degree to which these measures would drive down CO_2 (Phase 2 work).

3.6. Scenario Comparisons

Figure 25 and Figure 26 provide a comparison across all 3 scenarios and indicates the level of CO_2 emissions that would be associated with each scenario. This is identified more fully in Table 3 below, wherein the figures depict the possible reductions that could be achieved against a BAU counterfactual.

Scenario	Total Mt CO_2 over the period	Reduction from BAU scenario
BAU	180	
Net Zero by 2050	106	-41%
78% Reduction in 2035 Compared to 1990	82	-54%
Net Zero by 2040	65	-64%

Table 3 Total CO_2 emissions across Scenarios

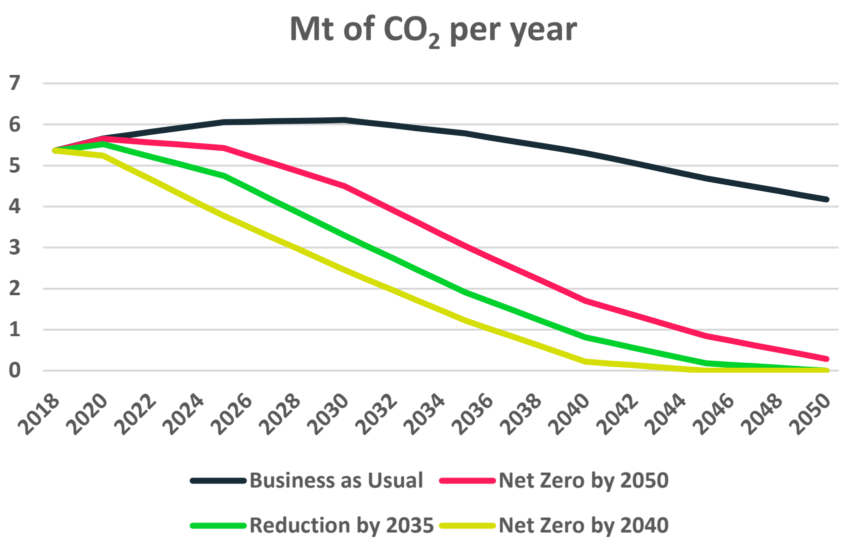


Figure 25 Total CO_2 emissions per annum ($MTCO_2$) by scenario to 2050

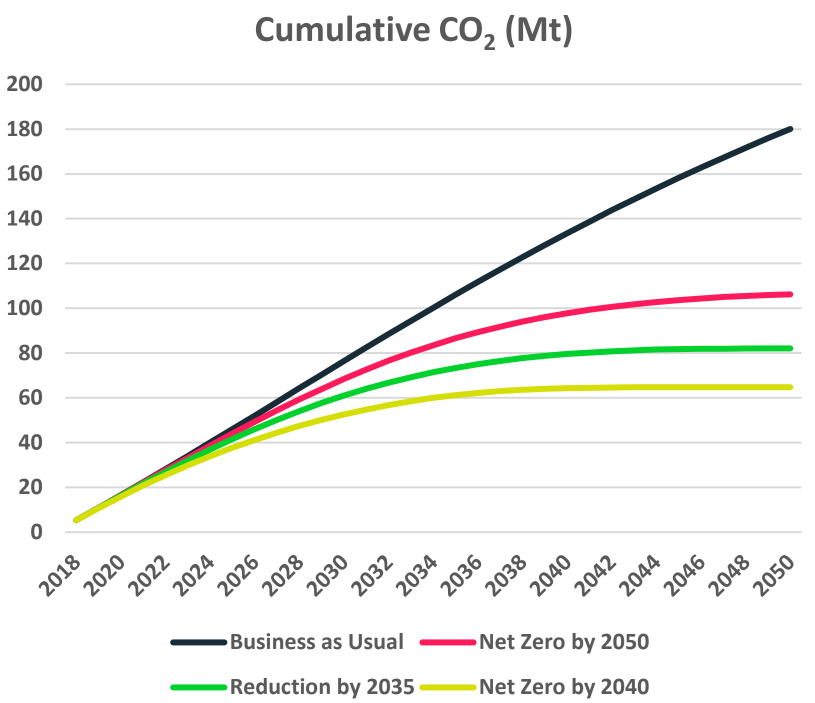


Figure 26 Total cumulative CO_2 emissions (MTCO2) by scenario to 2050

4. Conclusion

The ESC was commissioned to establish a current baseline of carbon emissions from transport modes within the TE region area and to map possible emission reduction pathways to achieve environmental goals between now and 2050.

The emission reduction pathways are also intended to accord with TE's adjacent economic and social goals. Therefore, the modelling of baseline emissions has been disaggregated according to geographic groupings which will enable TE's strategic alignment going forward for Phase 2 of the intended work programme (Identification of Decarbonisation Pathways)

4.1. Carbon Baseline

ESC's modelling has set out a carbon baseline across the region, covering "on road" and rail transport modes. In sum, total vehicle kms travelled in the TE region were 22,617million in 2018 which resulted in a CO_2 footprint of:

- **2.44 Mt** CO_2 from cars & Taxis; and
- **2.39 Mt** CO_2 from LGVs & HGVs.

This relates to a total emission footprint of 5.35MtCO_2 in 2018 once public transport and rail are also accounted for. The car and good vehicle footprint can be disaggregated by area designation, wherein it can be seen that rural areas account for the dominant share of emissions at 47%.

Location	CO_2 Mt (2018)	%
Urban	1.5	31%
Market Town / Coastal Town / Large Rural Town	1.04	22%
Rural	2.29	47%
Total	4.83	

Table 4 Total car and good vehicle CO_2 emissions across locations

Mapping the CO_2 intensity across regions highlights that there are a number of key areas of consideration in terms of how emissions manifest across the TE region. Points of intensity relate to:

- Intersection points between main motorway arteries (e.g. M25) and A road infrastructure;
- Rural area designation is the dominant category within the TE region. Transport emissions are significant across this category because most trips will be made via private transport and will be made with greater frequency – moreover the figures are conservative and are possibly an underestimation due to data availability. Moreover 45% of the population of the TE region reside in rural areas which compounds the effect.
- Main transport corridors featuring dual carriageways – particularly out to the ports of Harwich and Felixstowe or around urban conurbations such as Ipswich and Norwich.

The impact related to personal travel of those living in rural designations and those in smaller towns is broadly similar and quite different to those in urban settings where miles travel, and CO_2 pp is much lower. This naturally reflects the prevalence of public transport and active travel given the denser nature of the environment. Overall miles travelled per person in an urban setting are14% and 10% lower than those travelled by parties in a smaller town and a rural environment respectively. This of course will present challenges for the design of public transport across the region in achieving net zero and similarly it will influence the nature of charging infrastructure and smart enabled grid infrastructure where it can be assumed that home charging will be the dominant trend.

Following the analysis of the existing carbon footprint associated with transport trends in the TE region, ESC modelled a number of scenarios to explore whether a net zero position could be achieved across certain scenarios, which were then compared with the BAU counterfactual. The scenarios are:

- Business As Usual (BAU)
- Net Zero by 2050 – which aligns with UK Government Strategy
- The Sixth Carbon budget with a 78% reduction in emissions by 2035
- Paris 10 years Early – A net zero position by 2040

4.2. Business as Usual

Within the BAU trend, it is expected that there will be an increase in CO_2 in short term due to an expected increase in vehicle kms travelled. However, this trend in CO_2 emissions falls post 2030 due to increased number of EVs and PHEVs on the road after 2030. This is due in large part due to the changing economics of vehicles, wherein the falling costs of batteries transforms EV and PHEV competitiveness with the ICE counterfactual.

As a consequence of this gradual transition to EV's and PHEV's across on-road transport, the overall BAU scenario is predicted to result in a footprint of **180 Mt CO_2** over the period out to 2050. Emissions from public transport (rail and bus) will remain broadly static across the time period and whilst there is a gradual uptake of EV's and PHEV's post 2030, petrol and diesel vehicles still constitute c.50% of the on-road vehicles by 2050.

In this scenario, full decarbonisation of the transport sector is unlikely to be achieved until late in the century.

4.3. Net Zero by 2050

In totality, the overall CO_2 footprint related to the transition of a net zero scenario is predicted to be **106 Mt CO_2** over whole period, and this is a 41% reduction on a BAU scenario.

Our analysis predicts that achieving a net zero position 2050 will be challenging. Whilst on road cars and taxis will approach a net zero position by c. 2045, a number of high mileage HGVs are still part of the population in 2050 making a total transition "*marginal*". In the net zero scenario, car and LGV fleets achieve 100% transition by 2050 and this is helped by a quick uptake in EVs from 2025. In the net zero scenario, HGV's all but transition by 2050, with diesel fuel making only a marginal showing.

Therefore, to achieve a complete net zero position, TE will have to go further to try and encourage the HGV sector which impacts the region to switch powertrains quicker than national policy alone.

4.4. 78% Reduction of CO_2 Emissions by 2035 – Sixth Carbon Budget

The scenario wherein the deployment plan achieves a 78% reduction of CO_2 emissions by 2035 reflects the UK Government's ambitions with respect to its sixth carbon budget. Key findings under this scenario are that a Net Zero position is achieved by 2050 and due to the quicker uptake of low carbon vehicles, there is a steeper reduction in CO_2 compared to the Net Zero 2050 scenario. This translates to an overall larger savings in CO_2. which sums to **82 $MtCO_2$** over whole period and this is a 54% reduction in CO_2 levels against the BAU scenario. In this scenario, public transport (buses and rail) have achieved a net zero position between 2035-40. All cars and LGV's have transitioned to 100% BEV by 2045 and HGV's have also achieved a net zero position by 2050. Overall, if TE were to adopt this target, they would need to secure c.1$MtCO_2$ saving compared to 2050 target by 2035. This scenario presents a much steeper reduction in CO_2 compared to the 2050 scenario and results in **82 $MtCO_2$** over whole period (saving **24$MtCO_2$** against the 2050 target).

Achieving this will require aggressive intervention by TE.

- TE regions **would need to complement** national policies with regional initiatives:
  - This scenario would need a proactive pursuit of adjacent measures- a switch to EV's is not enough. A comprehensive public transport offer is required;
  - Encourage a shift in transport behaviour (reducing kms);
  - Modal shift for freight, commercial transport needs and people;
  - Transport East and its respective LA members will require adjacent public authority initiatives to complement sustainable transport strategy (e.g. planning policy / rural broadband provision/ town regeneration etc).

4.5. Net Zero by 2040 – Paris 10 years Early

ESC also modelled the most ambitious scenario wherein a net zero position is achieved in 2040. In this scenario, the proposed interventions and market dictates are insufficient to achieve net zero by 2040. At this point, there will still be residual emissions from the HGV fleet and equally there will still be levels of CO_2 arising from the residual petrol and diesel car population.

Despite an early ban on ICE vehicles, ICE based HGVs and vehicles will still be part of the mix post 2040, primarily due to the lifetime that vehicles are on the road prior to scrappage. This is on average c.14 years for cars and 15 for HGV's. Therefore, it is possible that vehicles bought up to 2025 may still be in use in 2040 and will be the primary provenance of CO_2 emissions in this scenario.

Overall, the total emission footprint in this scenario is predicted to be **65 Mt CO_2** over whole period and this is a 39% reduction on the Net Zero by 2050 scenario and a 64% reduction on a BAU scenario.

In terms of TE activities, this scenario would be the most challenging and would require a proactive and aggressive pursuit of adjacent measures- a switch to EV's is not enough.

The TE strategy would require a full-scale assault on the reduction in vehicle kms travelled, a modal shift, MaaS offerings across the region and wider cross-LA initiatives to enable an environment promoting those objectives.

In short there are still too many older ICE vehicles still part of transport fleet post 2035 – in particular the issue of HGV bias. In this scenario, TE would need to encourage the switching of power trains now (2020-2025) to reduce the level of ICE from being in the transport population by 2040.

4.6. Final Comments

The above analysis of transport emissions and possible pathways provides oversight of what can be realistically achieved across transport modes within the TE region. Equally, the scenario assumptions provide signposting to the type of measures that may be required to achieve those pathways (both via public and private means) and the current emission footprint and the cumulative footprint over the duration of the decarbonisation pathway.

It should be noted that the figures do not account for the behavioural and related transport impacts arising from the Covid19 pandemic, which will of course have substantially impacted the emissions in 2020 and 2021. This is a factor that TE will need to consider when reflecting on the data and how the behavioural trends will stabilise across the region.

In essence, the analysis can be broadly split in terms of the key messages:

The Analysis

- The composition of the area poses **different challenges across the region** (rural / smaller town / urban) and the nature of the intervention will be slightly different for each "place";
- The TE region bears the **dual impact of being significantly rural in nature and having major freight corridors**. Rural emissions could actually be worse due to a national lack of data & modelling capability to address the shorter trips across rural areas;
- The above point however does not mean that there is not a problem to solve in urban areas too and urban decarbonisation will be part of the mix of solutions in meeting net zero (e.g. active travel, reducing travel need, effective zero emission public transport and new transport business models for short urban trips (e.g. MaaS)). Indeed, resolving these issues will be as hard, as there is likely to be a greater proportion of homes in these areas without access to off street charging. Consequently, the solutions in these settings may be different, but they require no less attention.
- A further point with respect to the analysis across all places, is that the granularity of the SERTM model is poor for all areas in capturing traffic flows on the smaller roads. However, the impact is likely to be more pronounced in rural areas. There are no regional models that offer full granularity.
- Earlier intervention saves more CO_2 over time – a "**<u>sooner the better</u>**" approach is required;
- Analysis presents a compelling **strategic case for more investment** to decarbonise:
    - Nearly half of emissions are from freight (national average is c.30% for HGV's and vans) – much of which is enroute to and from major port infrastructure;
    - These are "national routes" for which TE could be perceived to be "taking a hit";
    - Success will require- a modal shift to rail freight and cleaning out of ICE based road freight;
    - C. 50% of emissions are derived from non-urban areas and this is potentially under-estimated. The situation presents a particular challenge given the high use of private vehicles and there will need to be an accelerate shift to affordable EV alternatives.
- TE must strongly advocate for a re-appraisal of the business case for public transport in rural areas. Need to shift towards outcome based policy (less CO_2 / Air Quality / reduced road deaths / less congestion) rather than financial metrics to tackle this challenge.

What this means for TE

- **Co-ordinated measures are needed** to supplement national policy if more ambitious targets are to be achieved and requires a 360^{O} perspective:
- Co-ordinating **upward** with respect to national policy, advancing timelines and funding – particularly in relation to freight and HGV's arising from the regional ports / airports. Assistance here may allow regional transport initiatives to be more palatable.
- **Sideways** with respect to adjacent public authority policy which must aligns with sustainable transport objectives and behavioural change (planning / digital roll out etc.).
- Downwards so that individual local authority transport strategies align with the regional position, ensuring that parties work collectively to find solutions across county boundaries and "place".
- The TE strategy will need to compliment national policies and draw on the intervention "levers" that are available to the public authorities to achieve regional ambitions – TE need "everything in the tool bag":
    - MaaS business models;
    - Advocating and supporting behaviour change to shift towards active travel and reduced kms travelled;
    - Available low carbon infrastructure and promoting fuel switching;
    - Addressing affordability.

In conclusion, we understand that this baseline modelling exercise forms the first of two stages of work being pursued by TE and will help inform the development of a regional carbon reduction strategy which will rely upon various interventions (alternative fuels, modal shift and enabling infrastructure) to enable the realisation of their chosen target.

Appendix A - Glossary

Acronym	Description
AM	AM Peak: average hour 07:00-10:00
BAU	Business As Usual
BEV	Battery Electric Vehicle
CVEI	Consumer, Vehicles and Energy Integration
DfT	Department for Transport
DNO	Distribution Network Operator
ESC	Energy Systems Catapult
EV	Electric vehicle
FCV	Fuel Cell Vehicle
GHG	Greenhouse Gas
HGV	Heavy Goods Vehicle
ICE	Internal Combustion Engine
kW	Kilowatt
IP	Inter Peak: average hour 10:00-16:00
LA	Local Authority
LGV	Light Goods Vehicles
MaaS	Mobility as a Service
MW	Megawatt
MWh	Megawatt-hour
OEM	Original Equipment Manufacturer
OP	Off Peak: average hour 19:00-07:00
PHEV	Plug-in Hybrid Electric Vehicle
PiV	Plug-in Vehicle
PM	PM Peak: average hour 16:00-19:00
STB	Sub regional Transport Body
RFM	Road Freight Model
TfN	Transport for the North

Appendix B
Report Presentation to TE Transport Forum 12th Nov 2021

CATAPULT Energy Systems

Transport East Carbon Baseline

Thalia Skoufa & Hayley Myles
Transport Practice Manager / Advisory

12th November 2021

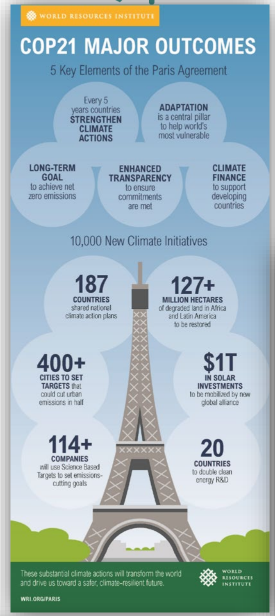
@EnergySysCat   LinkedIn

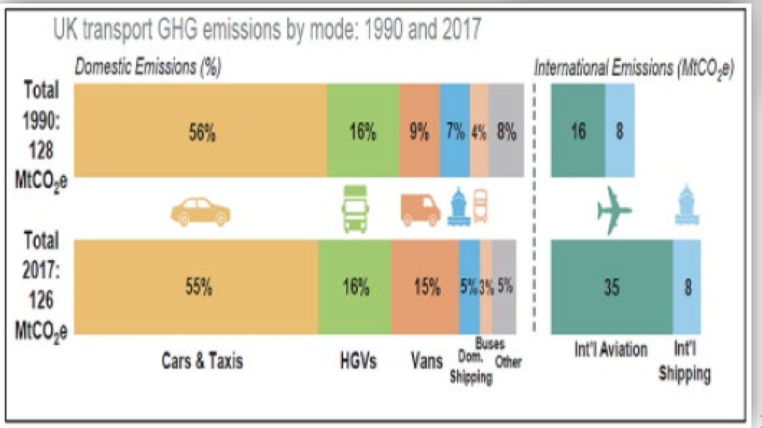
Agenda

- Setting the Context
- Baseline Emissions
- Emission Reduction Assessment
- Key Messages
- What Next

Transport East Against a National Backdrop

- UK ratified the Paris Agreement – treaty to limit emissions to keep mean global temperatures below 2ºC and preferable within 1.5ºC;
- In 2019, UK was first major economy to pass laws to end its contribution to global warming by 2050 – effectively legislating to adhere to legal targets;
- Transport emissions are estimated to be responsible for c.1/4 of CO2 emissions – higher than power generation since 2016.
- Transport emissions in the East of England (E of E) are the largest source of CO_2 – comprising 42% of total emissions (compared with an average of 28% in other regions).
- East of England worst than the UK average





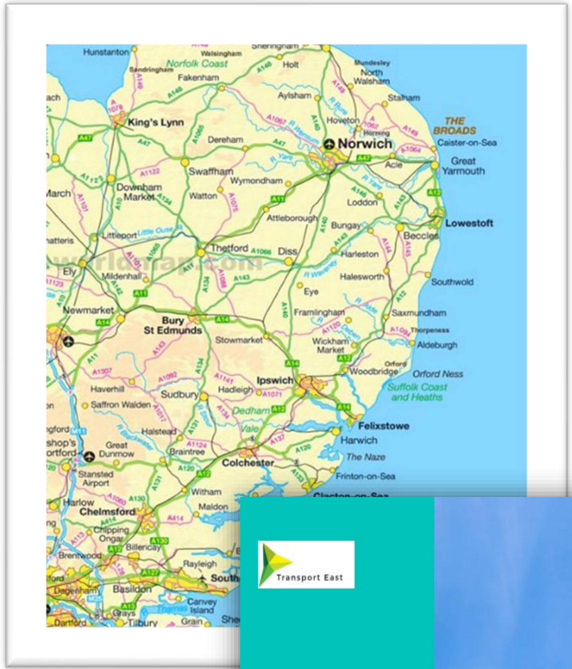
The Importance of the TE Transport Strategy

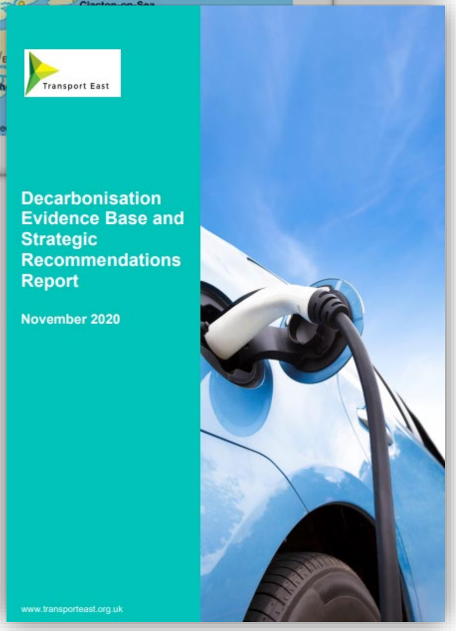
- **96% - of E of E emissions are on-road**. Roughly 50% : 50% split between cars and freight vehicles. Dual hit of:
  - Rural in nature = high car dependency.
  - 78% of commuters to work elect private transport – the most polluting;
  - Over half of the on-road car emissions are derived from trips in rural areas (possibly an underestimate as a result of available data);
  - Major transit corridors to and from port;
  - Transit corridors to 3 international airport (several smaller airfields).

- Decarbonisation is core pillar of TE's transport strategy - strong ambition to be first.

- Need to understand baseline CO_2 position and its composition – recognising slight underestimation for shorter journeys in rural areas (due to HE data).

- Recognise what "levers" the regional transport board has at its disposal to complement national policies.





Decarbonisation – Alignment with Broader Aims

CATAPULT Energy Systems

TRANSPORT EAST

Unlocking Global Gateways

42% of the region's carbon emissions come from transport. If we are to tackle our contribution to climate change and reach net zero emissions we need to act quickly.

Multi-Centred Growth

Better links between our fastest growing places and business clusters. This helps the area function as a coherent economy and improves productivity.

Energising Coastal & Rural Communities

A reinvented, sustainable coast for the 21st century which powers the UK through energy generation. Supporting our productive rural communities and attracting visitors all year round.

Decarbonising to Net Zero

Better connected ports and airports to help UK businesses thrive. Boosting the nation’s economy through greater access to international markets and Foreign Direct Investment.

Determining Regional Baseline Emissions

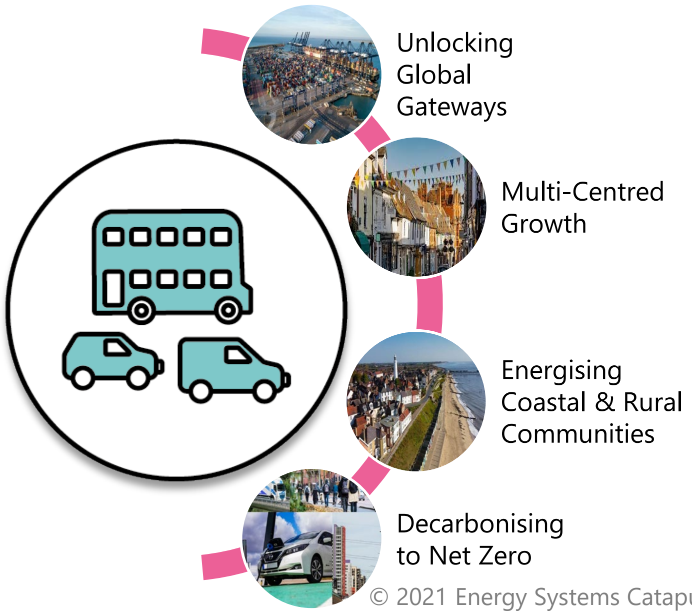
CATAPULT Energy Systems

To support the development of Transport East's inaugural transport strategy, ESC has:

1. Established a baseline of CO_2 emissions. This will inform the strategic assessment of the transport investment required to achieve TE's economic, social and environmental goals;

2. Estimated the reduction in emissions required to achieve emission reduction targets in 2035, 2040 and 2050 without deploying any additional measures such as modal shifts.

3. Disaggregated the data to identify:
   a) Source emissions from different on road and rail sources:
      - Cars,
      - Buses,
      - Vans,
      - HGV,
      - Rail.
   b) How the baseline and projections change for different place types:
      - Urban;
      - Market/Coastal/ Lge Rural Towns
      - Rural



Baseline Emissions

Total Baseline Emissions

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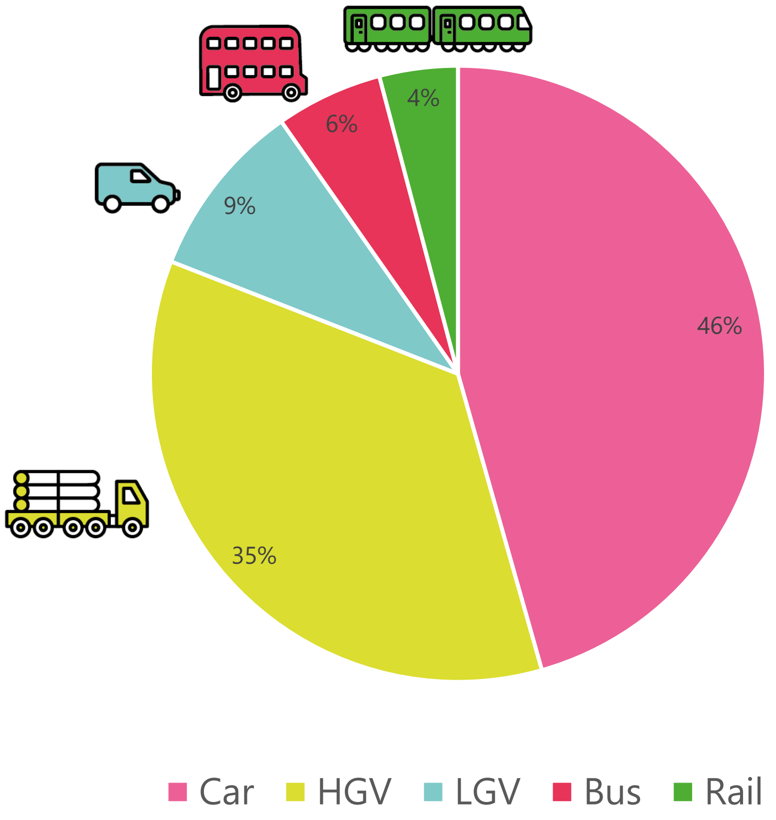
In 2018 the total emissions were:

5.35 Mt CO_2

This was broken down as:

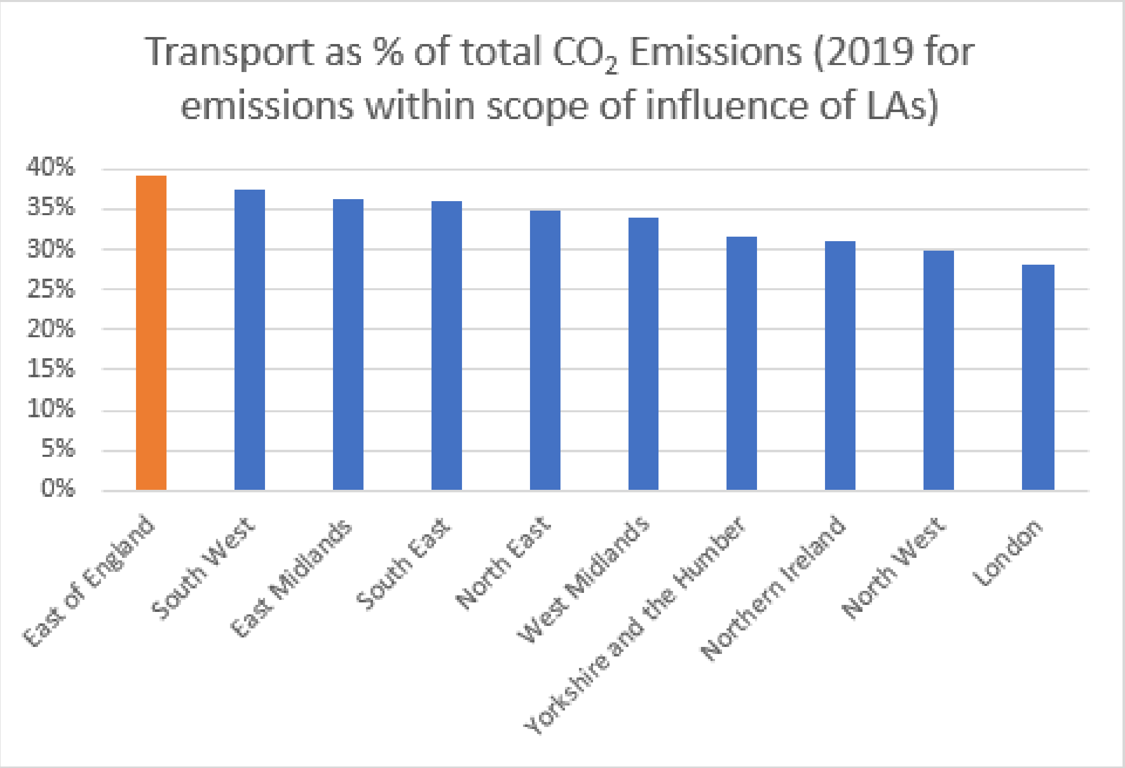
Car - 2.44 Mt CO_2
HGV - 1.89 Mt CO_2
LGV - 0.50 Mt CO_2
Bus - 0.3 Mt CO_2
Rail - 0.22 Mt CO_2

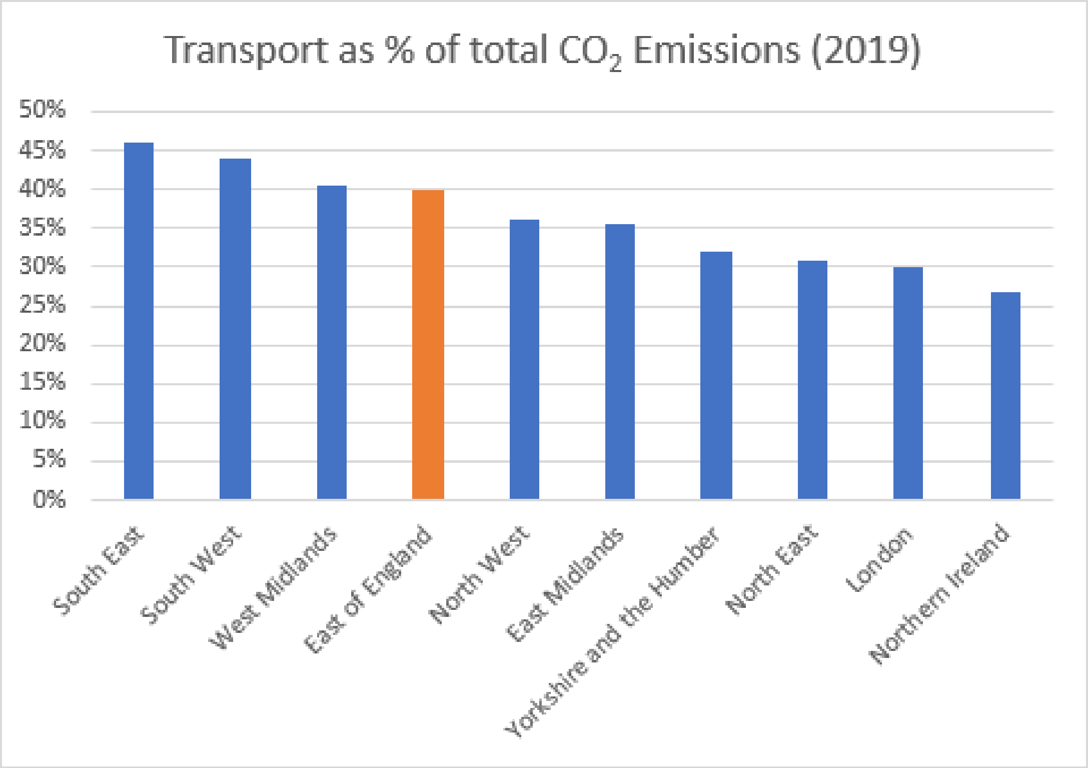
- East of England is in X place in terms of its transport emissions compared to other regions.



The Highways England Model focusses on roads with higher proportions of goods vehicles, and may miss many short distance trips. **This may under-represent the emissions from cars – this being particularly the case in rural areas**

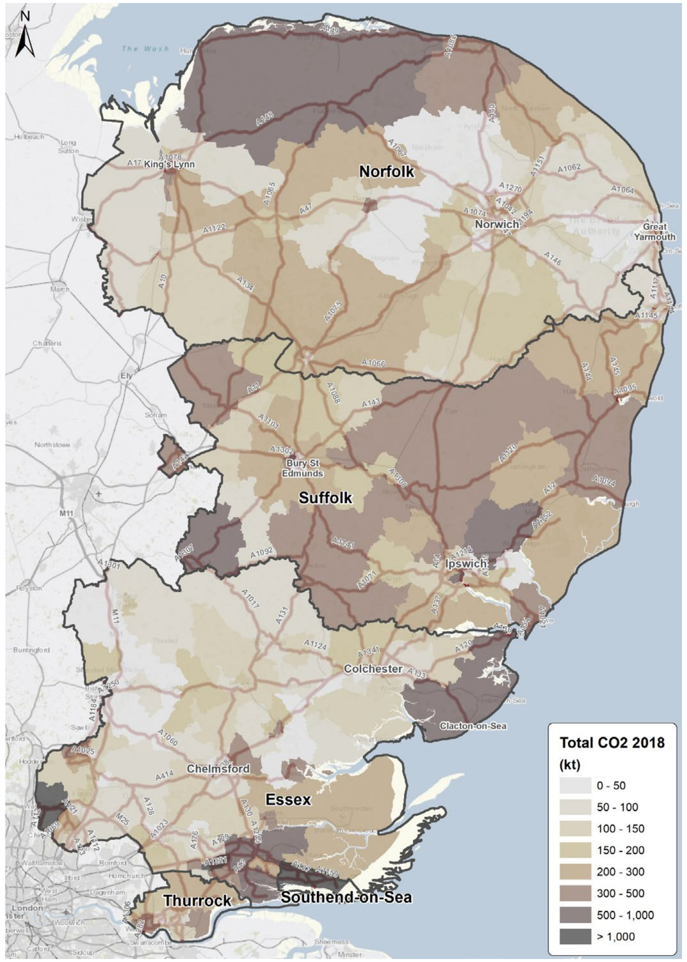
Regional Transport Comparisons – the Motorway Differential



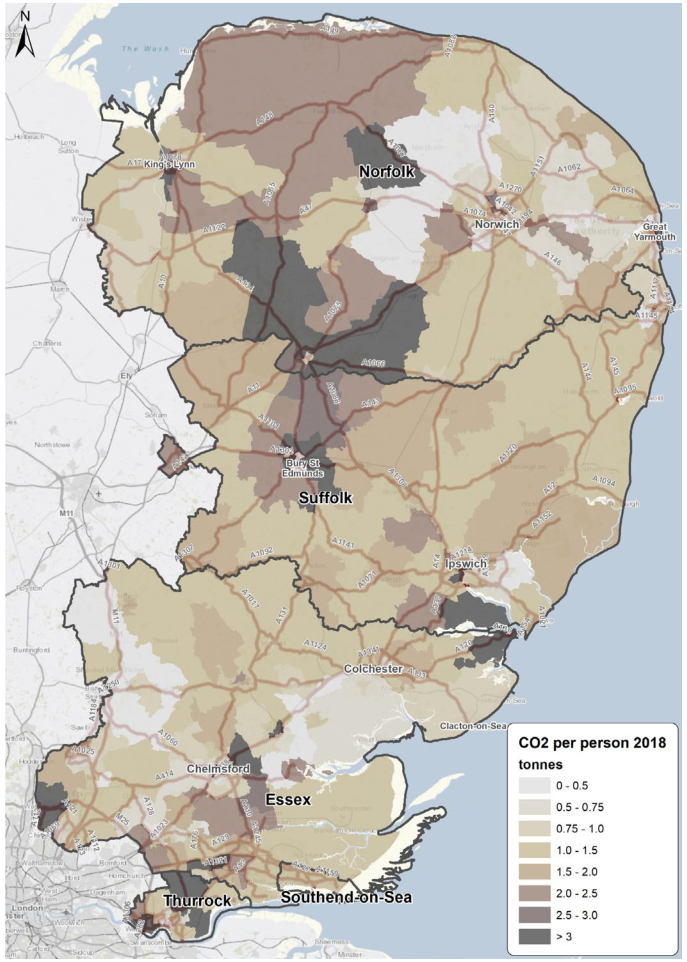


Current Car, LGV and HGV Emissions - by Area and by Population

Total CO_2 per zone in 2018



Total CO_2 per person in 2018



In 2018 the on road emissions were:

2.44 Mt CO_2 from cars and taxis

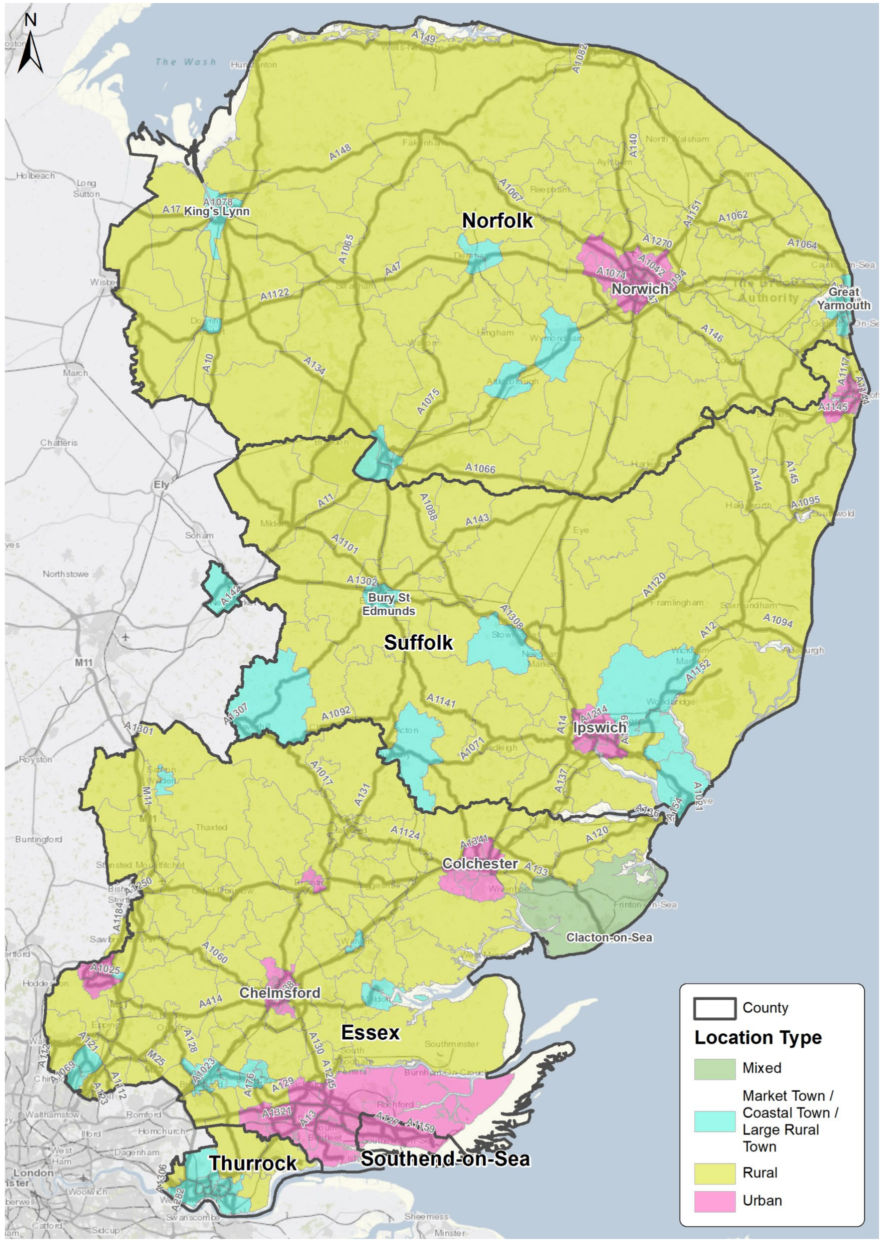
2.39 Mt CO_2 from LGVs & HGVs

22,617m total vehicle kms

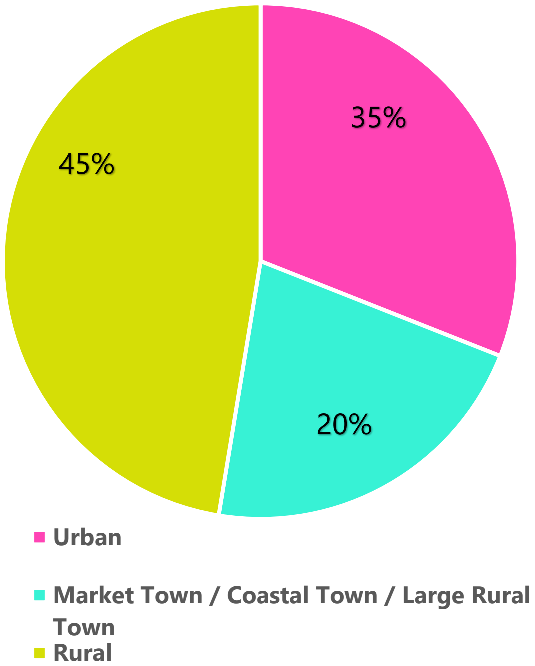
Bus and rail figures are not available by model zone.

(N.B. The Highways England Model focusses on roads with higher proportions of goods vehicles, and may miss many short distance trips. **This may under-represent the emissions from cars.**)

Current Car, LGV and HGV Emissions - by Location

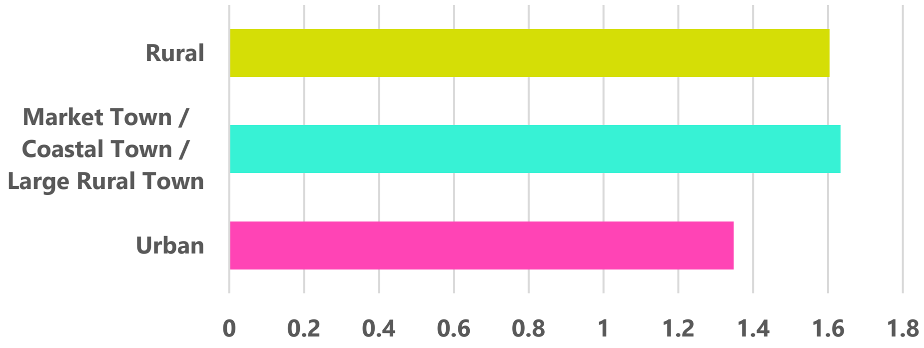


Total CO_2 2018 = 4.8MtCO_2

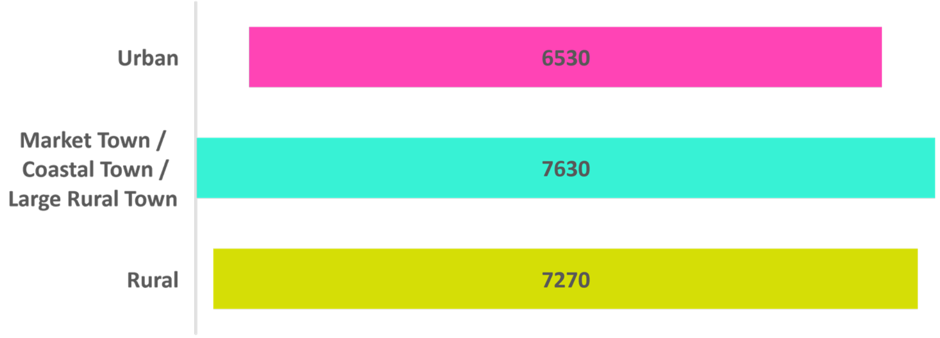


Definitions governed by population density and TE member guidance. Some areas merge due to the proximity of parishes and their populations.

CO_2 per person 2018 (t)



Vehicle KMs per person 2018



Key Points from the Baseline Analysis

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- EoE compares poorly with other regional transport emission footprints – attributable to:
  - Rural characteristics
  - Heavy HGV impact
- Car footprint is underestimated due to HE model architecture – No models available to give the required granularity at local level.
- Can't focus decarbonisation strategy on urban concentrations – required a more nuanced approach across "place" and this will play into the other tenets of the TE strategy.
- Solutions are going to be varied and nuanced in nature according to:
  - Place
  - Journey type
  - Demographics and behaviours
  - Commercial business models

One size does not fit all

Emission Reduction Assessment

Core Scenario Factors

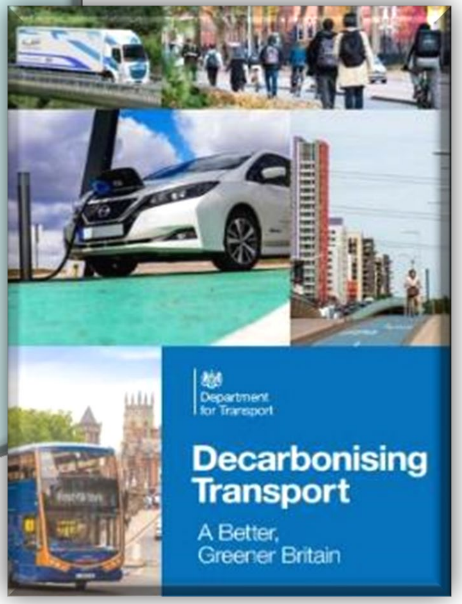
CATAPULT Energy Systems

Business as Usual (BAU)

- No interventions
- No behavioural change
- No ban on ICE vehicles
- No incentives to buy ultra low emission vehicles

Net Zero by 2050

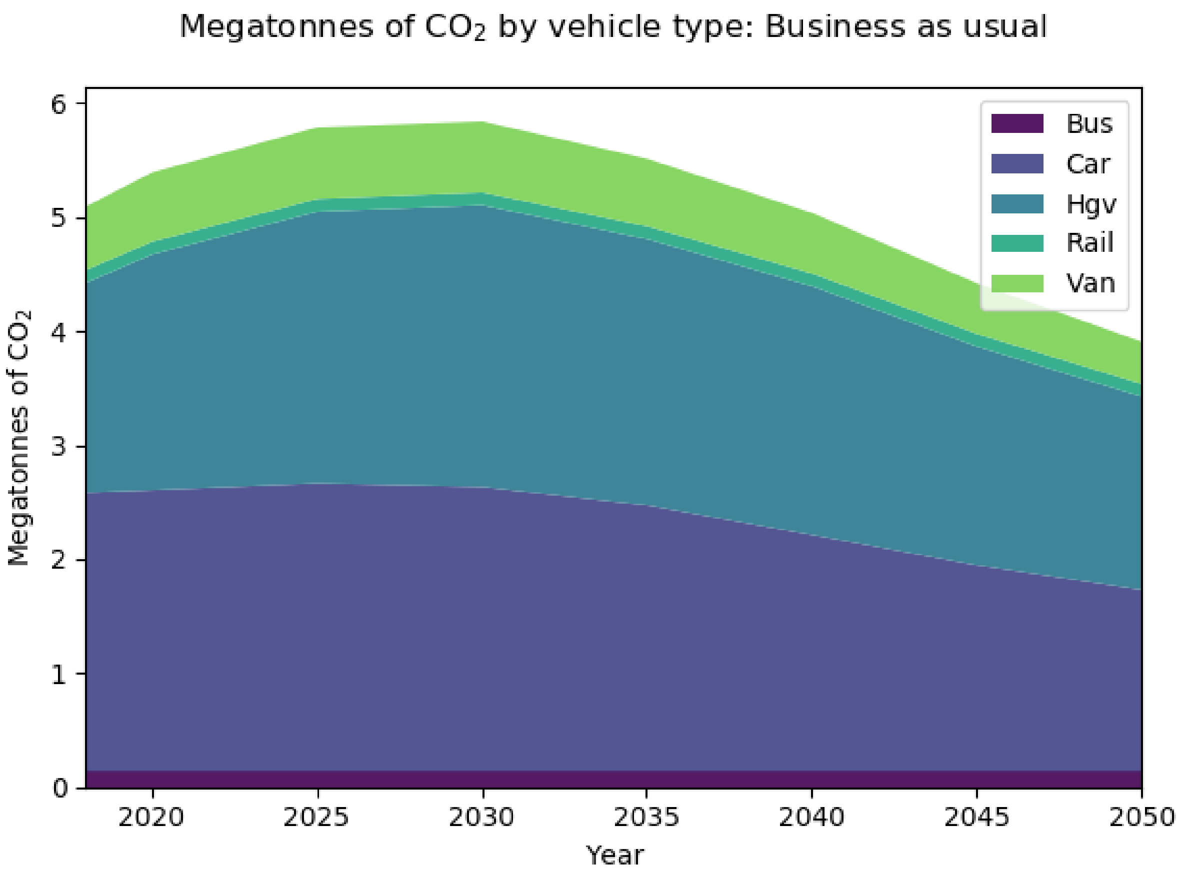
- Current ICE and PHEV phase out of sales (2030 and 2035).
- Phase out of HGV ICEs by 2035 (ESC assumption based on previous work – in consultation to bring forward from 2040).
- Incentives for uptake of zero emission vehicles to drive adoption.



BAU – Will not achieve emission targets by 2050

- Increase in CO_2 in short term due to forecast for increase in vehicle kms.
- Decrease between 2030 and 2050 due to increased number of EVs and PHEVs on the road – changing vehicle economics.
- **180 Mt CO_2** over whole period with a significant proportion of ICE based vehicles on the road.
- Trend continues late into this century

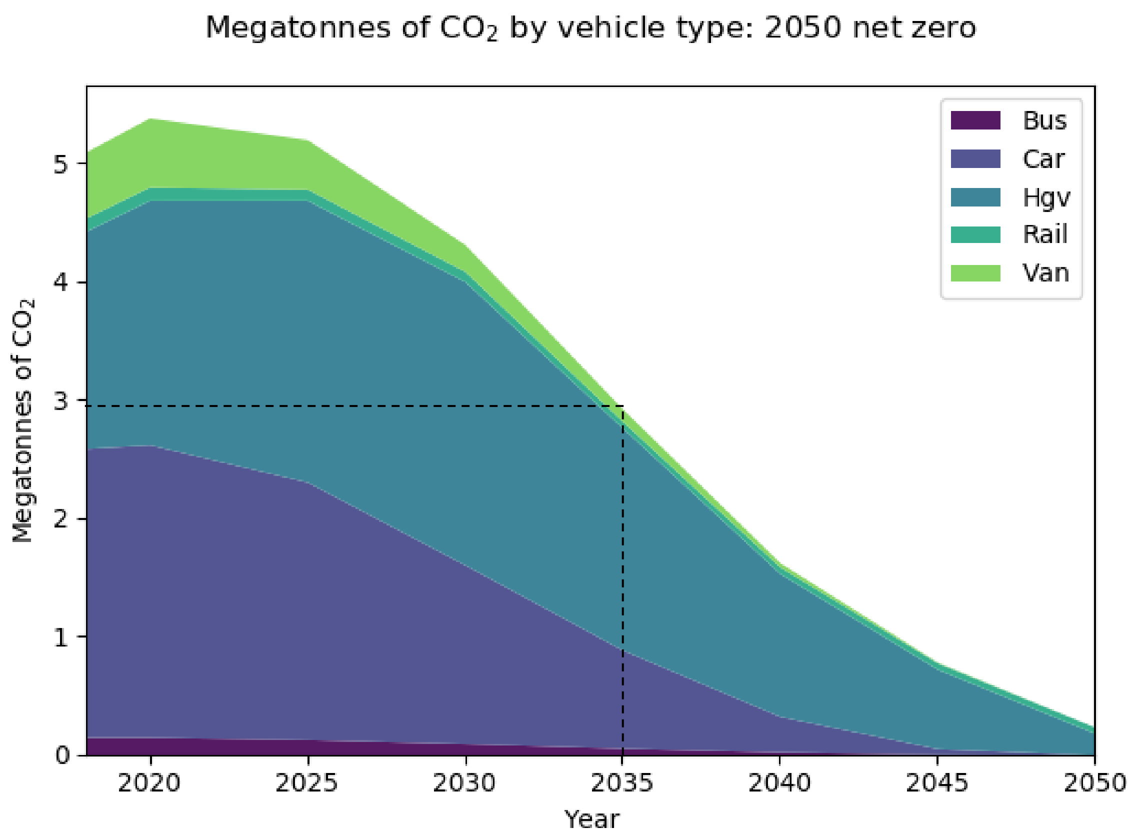
BAU Scenario
- Organic change and lack incentives slow down zero emission vehicle adoption.
- Decarbonisation not achieved until late in the century.



No ban on ICE vehicles
No incentives to buy EVs/PHEVs

Relying on National Policy - Achieving Net Zero will be Challenging

- Net zero position achieved a little after 2050 – slight difference of approach in modelling architecture between national /regional modelling.
    - ESME architecture at national level.
    - More behavioural reality applied to TFN analysis.
- **The pathway would produce c.106 Mt CO_2** over the period – 41% reduction on BAU.
- TE region encompasses main freight corridors to and from port - heavier HGV traffic than other regions as previously noted.
- Based on the presumption of current financial interventions - further behavioural measures needed for HGVs to achieve net zero by 2050.
- Explore options to encourage much quicker turn around in power trains.



- Current ICE and PHEV bans (2030 and 2035).
- Ban on HGV ICEs in 2035
- Incentives for low emission vehicles

Stretch Targets……

Net Zero by 2040

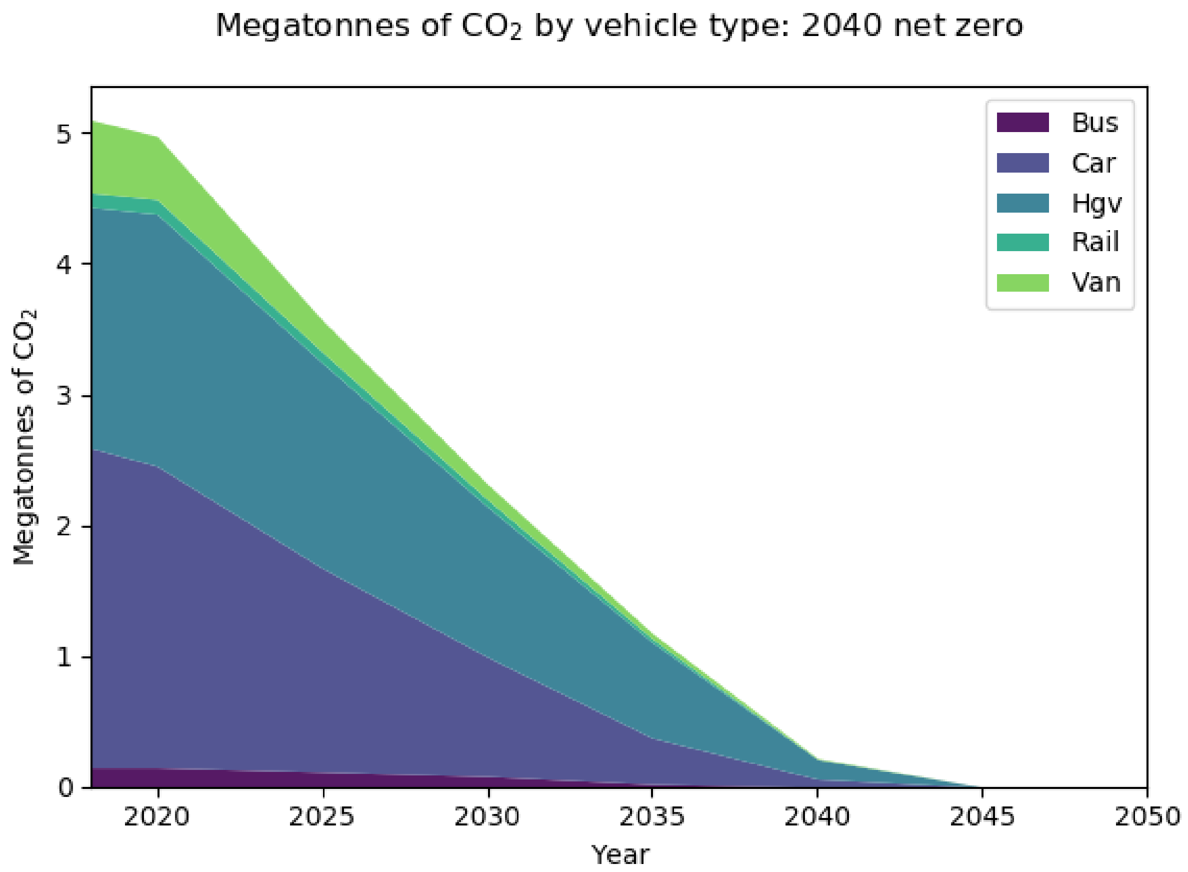
- Phase out sale of ICE cars and LGVs by 2025
- Phase out of HGV ICEs by 2025
- No increase in vehicle kms or HGV fleet size
- Decarbonised public transport by 2040

78% Reduction in 2035 Compared to 1990

- Phase out sale of ICE cars and LGVs by 2025
- Phase out of HGV ICEs by 2030
- No increase in vehicle kms
- Zero emission public transport by 2050

"Paris 10 Years Early "– A Climate Pledge Requires Aggressive Intervention

- Accelerated national policies are insufficient to achieve a 2040 Climate Pledge.
- Needs proactive pursuit of adjacent measures- switch to EV's not enough (reduction in vehicle kms, modal shift, MaaS etc.) to achieve a 2040 Climate Pledge.
- Too many older ICE vehicles still part of transport fleet post 2035 – in particular issue of HGV bias.
- Success would require accelerated ULEV adoption rates now (2020-25).
- **65 Mt CO_2** over whole period – would save **41Mt CO_2** compared to Net Zero 2050.
- Need to understand the degree to which these measures would drive down CO2 (Phase 2 work).



- Phase out of ICE sales by 2025 for cars, LGVs and HGVs.
- Very quick increase in BEV new cars, vans and HGV sales, with an average of 50% of new vehicles being BEV between 2020 and 2035.
- No increase/reduction in vehicle kms or HGV fleet size.
- Decarbonised public transport by 2040.

78% Reduction in 2035 - Legally Binding Target (UK 6th Carbon Budget)

CATAPULT Energy Systems

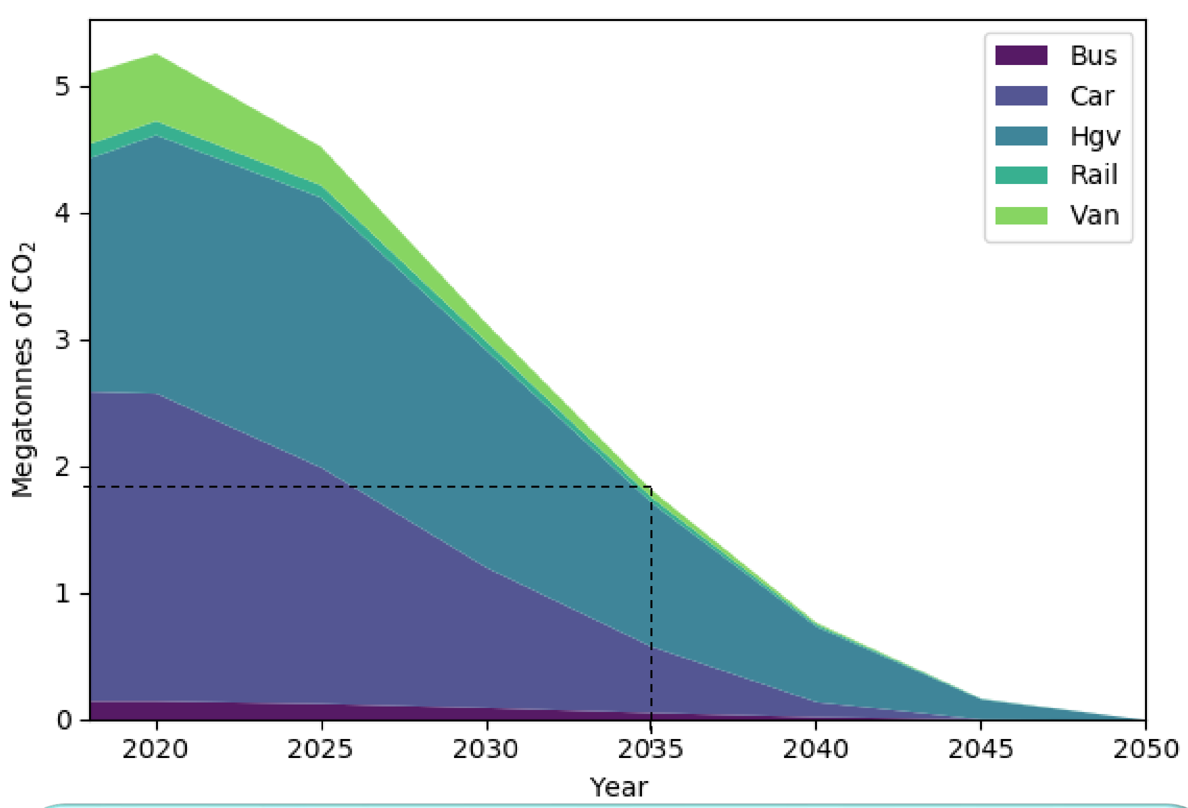
- Target needs to secure c.1MtCO_2 saving compared to 2050 target by 2035. Requires aggressive regional intervention.

- TE **<u>must complement</u>** national policies with regional initiatives:
  - Comprehensive public transport offer;
  - Shift in transport behaviour (reducing km's);
  - Modal shift for freight, commercial and people;

- Requires adjacent public authority initiatives to complement sustainable transport strategy (e.g. planning policy / rural broadband provision).

- Steeper reduction in CO_2 compared to 2050 scenario results in **82 MtCO_2** over whole period (saving **24MtCO_2** against 2050 target)

Megatonnes of CO_2 by vehicle type: Reduction by 2035



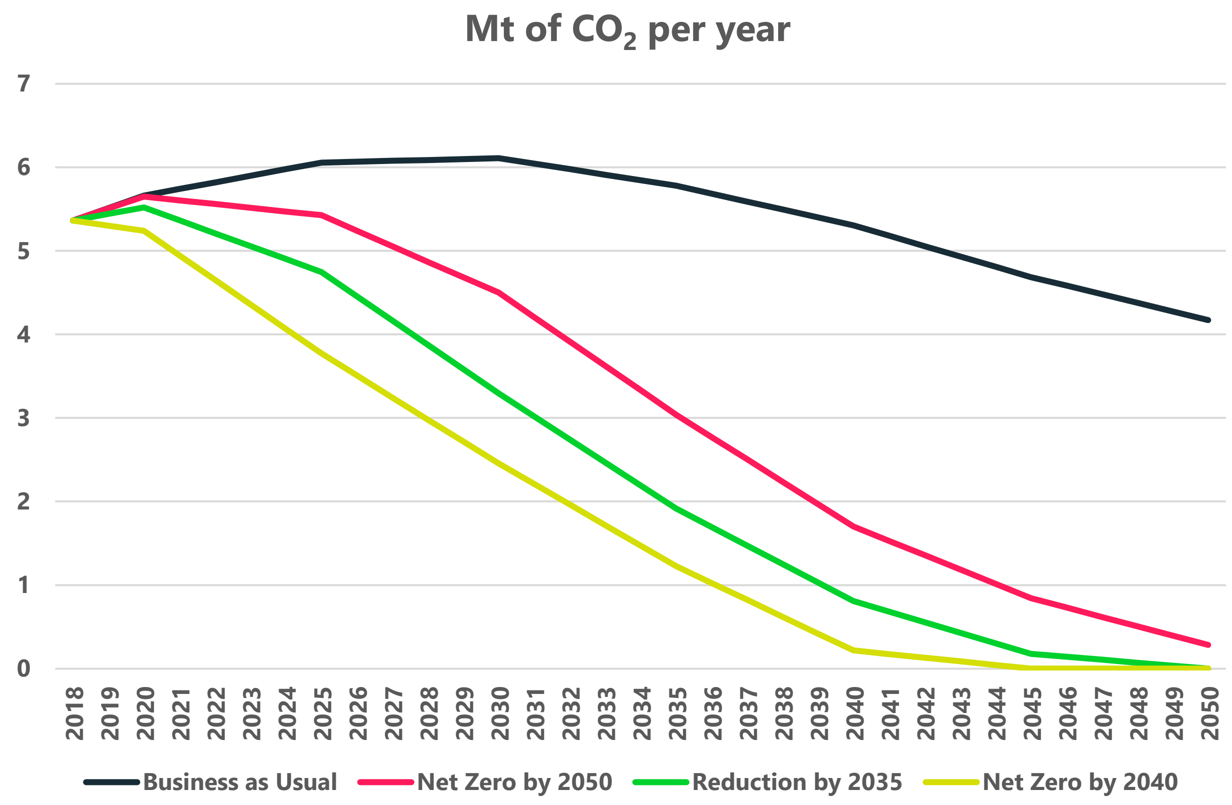
- Ban on ICE sales in 2025 for cars, LGVs.
- Ban on HGV ICEs in 2030.
- No increase/reduction in vehicle kms / HGV fleet
- Zero emission public transport by 2050 and so assumes that TE has implemented a comprehensive public transport offer that is low carbon in nature.

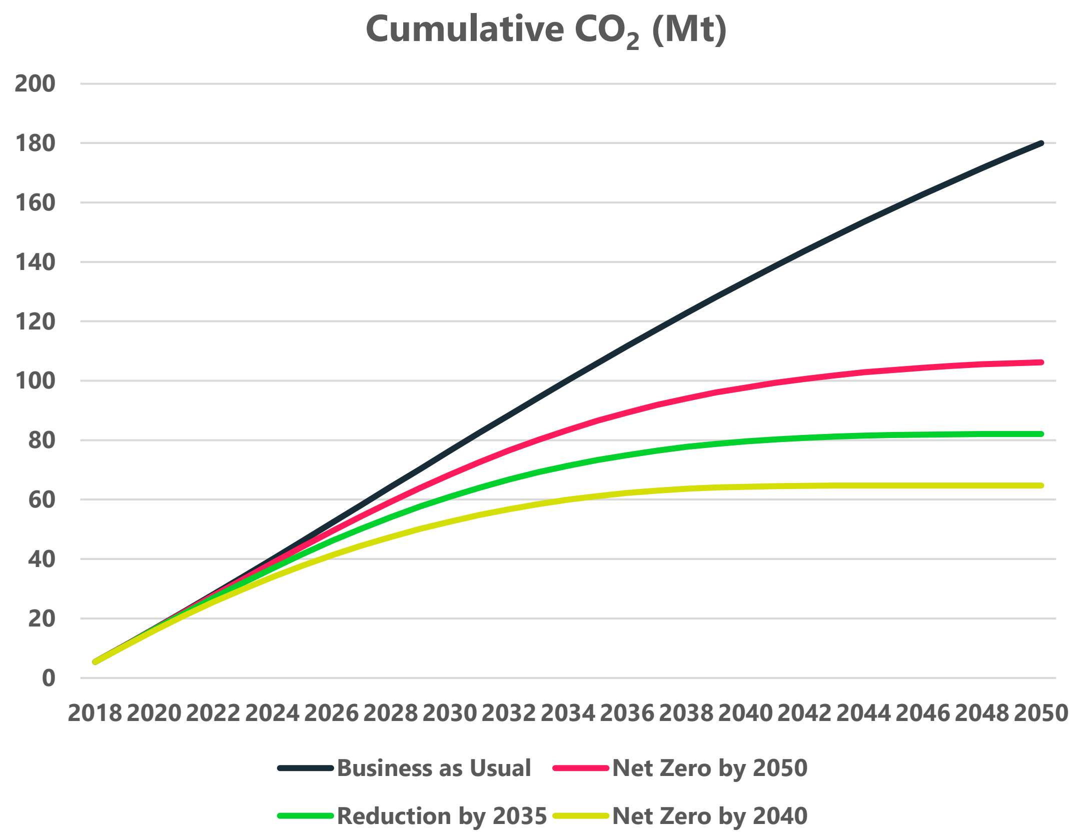
*78% reduction calculated using BEIS figure of 39% reduction in CO_2 between 1990-2018

What do stretch targets mean for TE Strategy.

- BAU will not move the dial and a significant change will not happen until the latter part of this century;
- National policies may not achieve net zero by 2050 due to the disproportionate impact of HGV vehicles. The STB needs to be exploring adjacent activities to complement national policies to ensure a 2050 target could be achieved.
- Stretch targets will require proactive interventions to achieve earlier ambitions and these need to span
  - Public transport offer;
  - Shift in transport behaviour (reducing km's);
  - Modal shift for freight, commercial and people;
- Targets are challenging and TE need to start sooner rather than later due to mitigate the steep incline that manifests as the window for change reduces.

Scenario Comparison – Per annum and cumulatively





Key Messages – The Analysis

- The composition of the area poses **different challenges across the area** (rural / town / urban) and the nature of the intervention will be slightly different for each "place".

- TE region bears the **dual impact of being significantly rural in nature and having major freight corridors**. Rural emissions could actually be worse due to a national lack of data & modelling capability to address the shorter trips across rural areas.

- Earlier intervention saves more CO_2 over time – a "**<u>sooner the better</u>**" approach is required.

- Analysis presents a compelling **strategic case for more investment** to decarbonise:
  - Nearly half of emissions are from freight (national average is c.30% for HGV's and vans) – much of which is enroute to and from major port infrastructure:
    - These are "national routes" for which TE is "taking a hit".
    - Success will require- a modal shift to rail freight and cleaning out of ICE based road freight.
  - C. 50% of emissions are derived from rural areas and this is potentially under-estimated. Situation presents a particular challenge given the high use of private vehicles – accelerate shift to an affordable EV alternative.
  - TE must strongly advocate for a re-appraisal of the business case for public transport in rural areas. Need to shift towards outcome based policy (less CO_2 / Air Quality / reduced road deaths / less congestion).

Key Messages – What Does This Mean for the Region

- **Co-ordinated measures are needed** to supplement national policy if more ambitious targets are to be achieved and requires a 360^{O} perspective:
  - Co-ordinating **upward** with respect to national policy, advancing timelines and funding – particularly in relation to freight and HGV's arising from the regional ports / airports. Assistance here may allow regional transport initiatives to be more palatable.
  - **Sideways** with respect to adjacent public authority policy which must aligns with sustainable transport objectives and behavioural change (planning / digital roll out etc.).
  - **Downwards** so that individual local authority transport strategies align with the regional position, ensuring that parties work collectively to find solutions across county boundaries and "place".

- TE strategy will need to compliment national policies and draw on the intervention "levers" that are available to the public authority to achieve regional ambitions – TE need "everything in the toolbag":
  - Mobility as a Service (MaaS) business models.
  - Advocating and supporting behaviour change to shift towards active travel and reduced kM's travelled.
  - Available low carbon infrastructure and promoting fuel switching.
  - Addressing affordability.

What Next

- TE is intending to use the analysis to inform the TE Decarbonisation Strategy, composed of:
  - Alternative power trains and fuels
  - Strategic planning
  - Reducing the need to travel
  - Mode shift
- Must act at pace to understand the extent to which regional and local intervention activities can move the dial.
  - Support BSIP's.
  - Accelerate active travel and reducing kms travelled.
  - Increasing provision of public transport services.
- Next phase of work will contribute to TE's bid to DfT for additional STB funding this financial year.
- Demand management must be considered to drive down the kM's travelled.
- Need to consider public / private collaboration to drive infrastructure roll out and adoption.

Energy Systems

Thalia Skoufa / Hayley Myles

Thalia.Skoufa@es.catapult.org.uk
Hayley.myles@es.catapult.org.uk

Appendices - Methodology

Methodology - Establish a baseline of carbon emissions from transport and map emission reduction pathways - Methodology

Catapult Energy Systems

Review existing studies by Transport East authorities, Highways England, National Rail and neighbouring STBs

Create a carbon baseline disaggregated by:
Type of place
Transport mode
Trip length
Time period
Type of place

Provide an estimate on emissions for the following cases:

- Business as Usual for 2050
- Net zero by 2040
- Net zero by 2050
- Reduced emissions by 2035

Deliverables:

1. Visualisation of data modelling with underlying commentary
2. Modelling User Guide

Methodology - Data, Tools and Insights

Models

TfN's NoCarb model

Data*

* Where data is not available assumptions will be agreed between ESC and TE

Vehicle registration data: DfT vehicle licensing data by MSOA.

Demand data: derived from Highways England's Region Traffic Model outputs, using processing Python scripts from TfN.

Emission data: NAEI emissions factors.

DfT Automatic Number Plate Recognition data: if available data from TfN will be used.

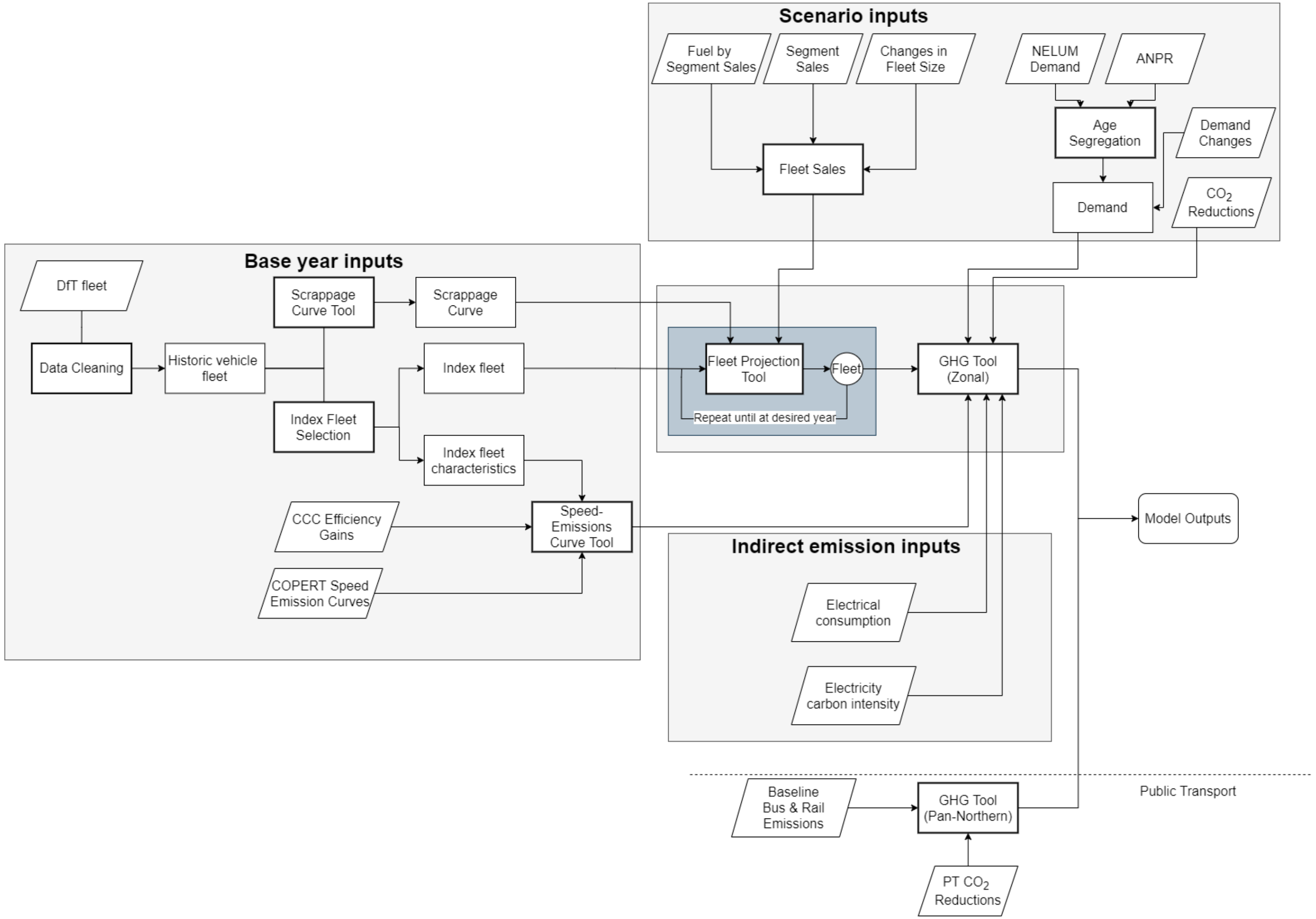
Methodology - Process using TfN's NoCarb Model

Acquire and format data (multiple sources)

Alter area specific files to match study area

Use insights from the ESC's work to compile scenario inputs & refine assumptions

Run NoCarb Model



Objective - Determine Regional Baseline Emissions

The modelling has been achieved by:

- Building upon work by TE authorities, Highways England, National Rail & neighbouring STBs.
- Establishing an estimate for the "business as usual" carbon emissions out to 2050 which is disaggregated by:
- Developing modelling and outputs for specific carbon targets in 2035, 2040 and 2050.

1. Type of place (cities, market towns and rural locations)
2. Time period (AM, IP, PM, OP)
3. Mode (car, van, HGV and rail)
4. Trip length
5. Purpose (commute, business or other)

Tools - Determine Regional Baseline Emissions -

The main datasets and tools that were used included:

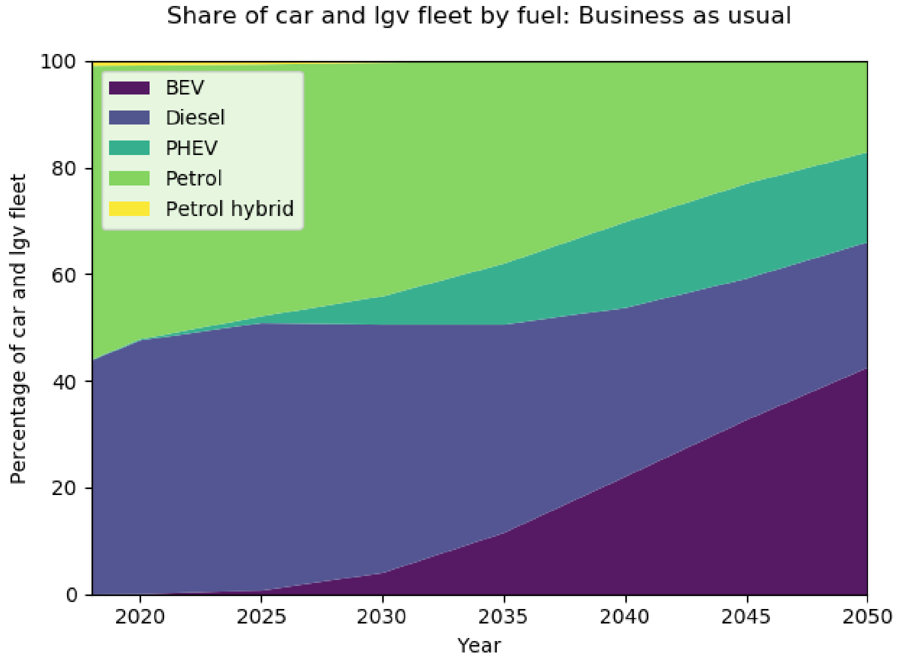
- Transport for North's (TfN's) NoCarb model
- Highway England's Region Traffic Model
- NAEI emissions factors
- DfT vehicle licensing data
- DfT ANPR data (if available); and
- Energy Systems Catapult's CVEI and ESME models.

The underlying assumptions to all the modelling was informed by ESC's deeper insight gathered from:

- Significant consumer engagement drawn from our prevailing transport work
- A comprehensive understanding of the policy support landscape driving the net zero transition and what these means for adoption rates.
- Technical insight gathered during regional trials (relating to DNO activities and V2G trends) which informs the distribution of charging infrastructure;
- ESC's whole energy system focus.

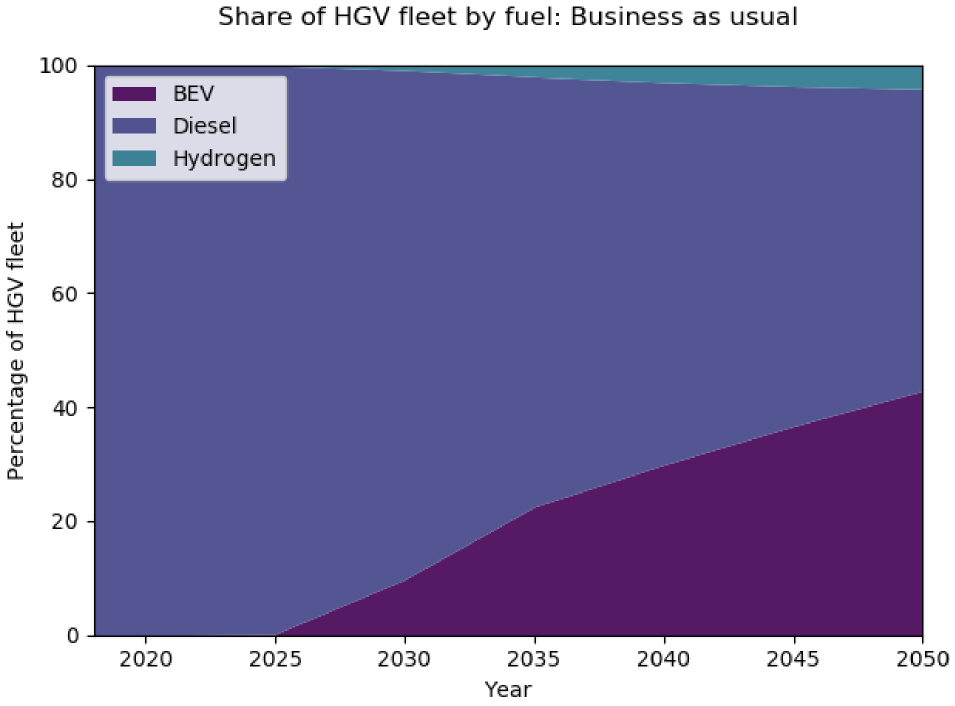
Business as Usual Scenario to 2050

BAU Scenario involves:
No ban on ICE vehicles
No incentives to buy EVs/PHEVs

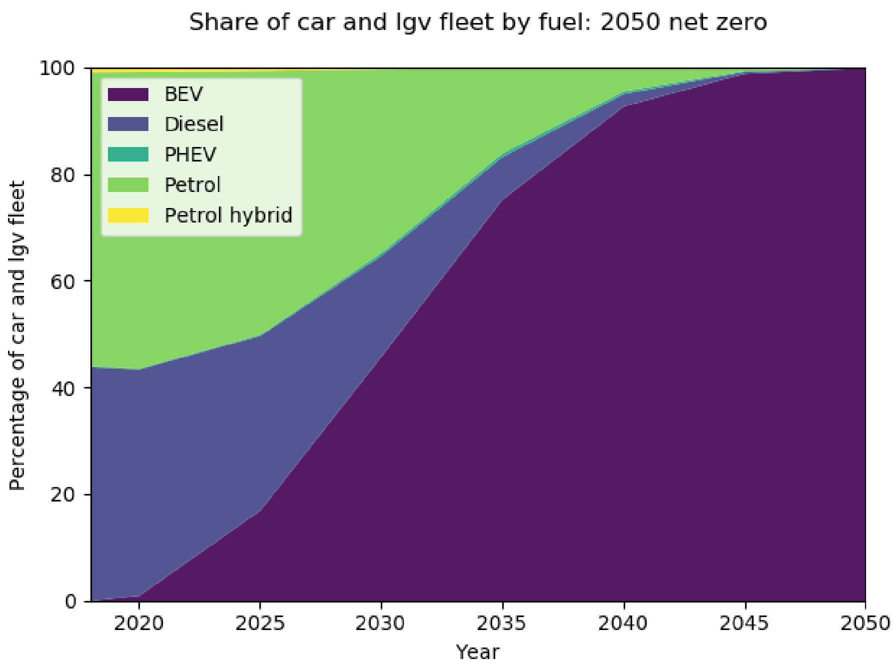


- Still an increase in EV cars and LGVs, but a slower uptake due to the lack of vehicle incentives in the BAU scenario. Diesel and petrol constitute c.50%.

- Still an increase in zero emission HGVs, but a high percentage of diesel remains (>50%).

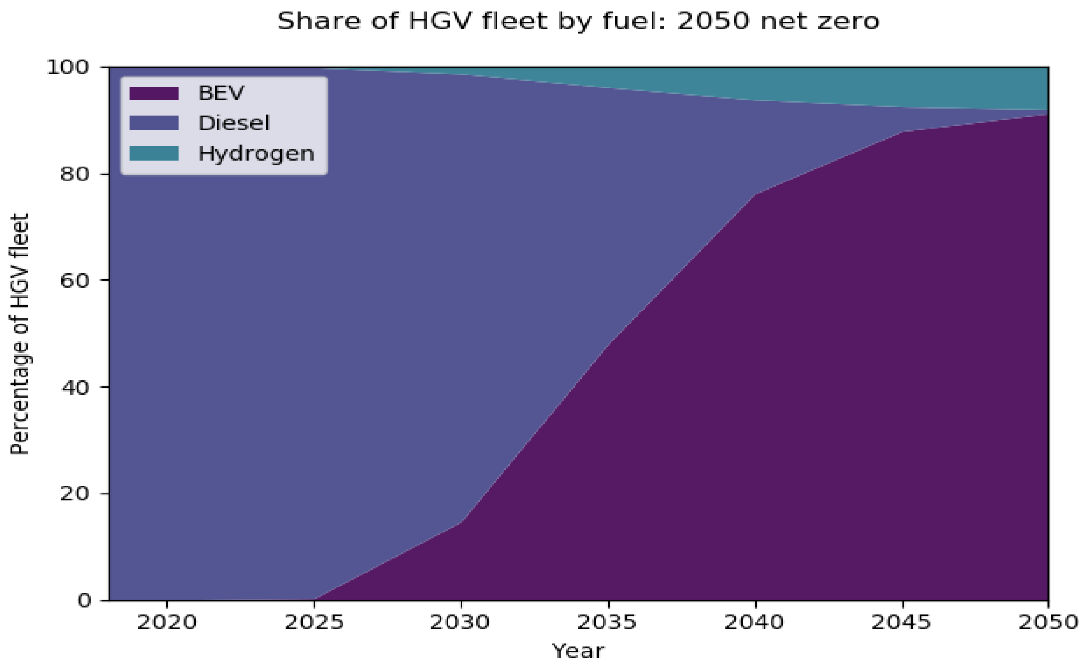


'Net Zero' Scenario by 2050



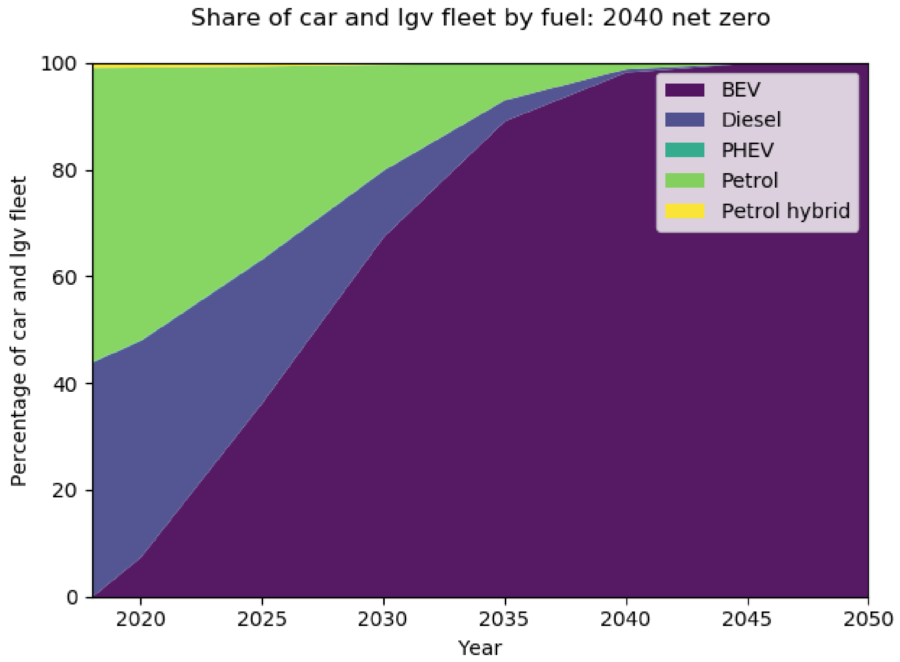
- Car and LGV fleet 100% BEV in 2050
- Quick uptake in EVs from 2025 driven by lower Total Cost of Ownership (TCO) and good access to charging infrastructure
- Significant low carbon ownership by 2035 (c.80%).

- High uptake of zero emission HGVs leading to 2050.
- BEV / FCV split is based on current projections on vehicle cost*.



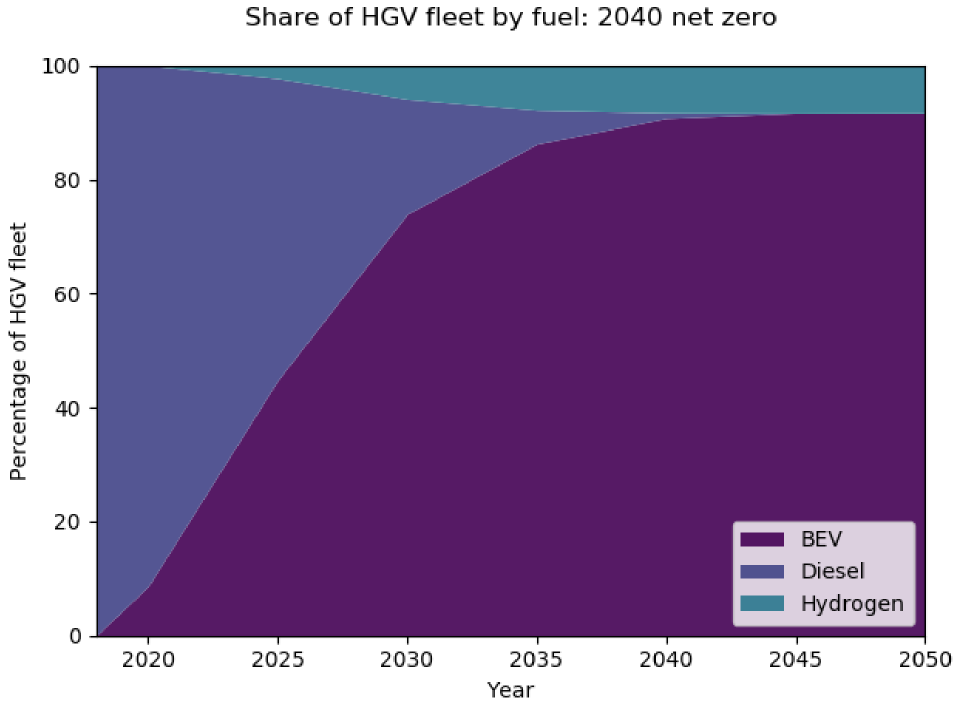
*There is high uncertainty around future vehicle prices / performance as not much data presently available for these vehicles classes / fuel types.

Net Zero by 2040



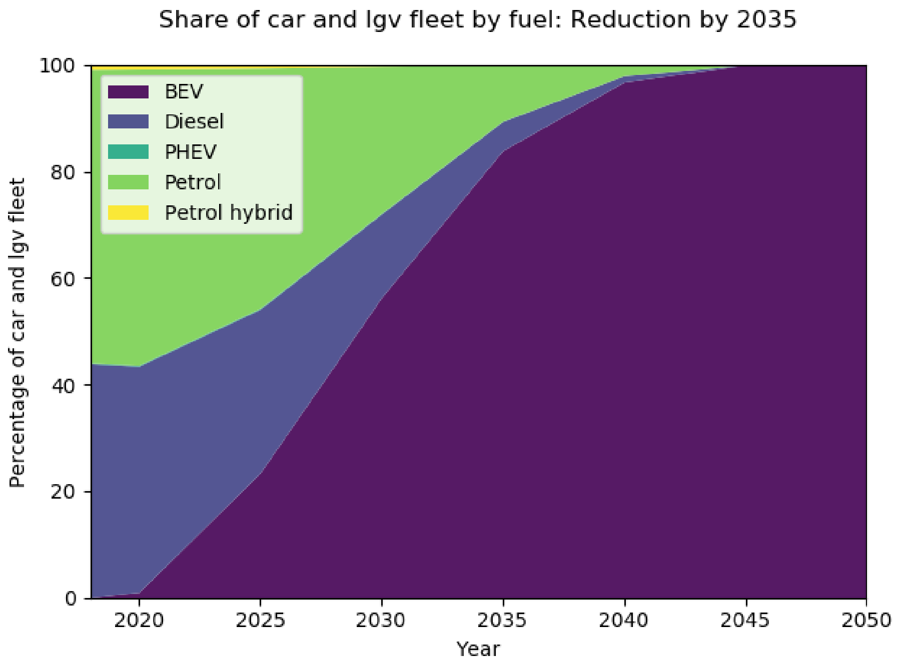
- Car and LGV fleet fully decarbonised in 2045
- Steep increase in BEVs from 2020-2030

- Steep increase in zero emission HGVs from 2020-2030



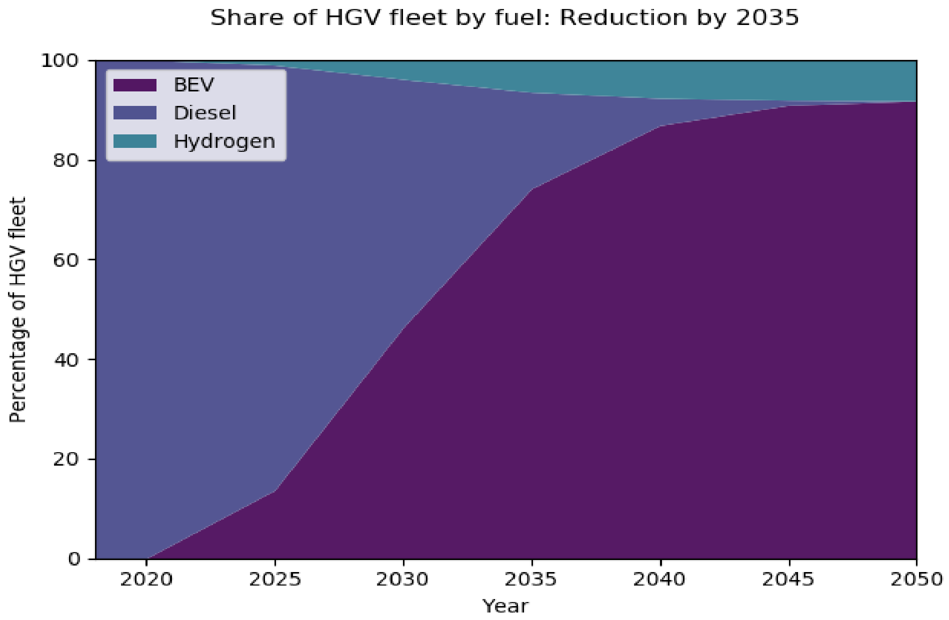
For cases with more aggressive decarbonisation targets, public charging/refuelling infrastructure roll out would need to be considered to support zero emission vehicle uptake

78% Reduction in 2035 Compared to 1990



- Car and LGV fleet are 100% BEV in 2045.
- Decarbonisation of the car and van segment accelerates to meet emission targets.
- Charging infrastructure to support uptake would need to be in place earlier than the net zero by 2050 scenario.

- The HGV segment is predominately decarbonised by 2045, with a sharp increase in sales of zero emission vehicles in earlier years driven by the earlier ban (2030).
- Public refuelling/charging infrastructure would need to be in place to support deployment of zero emission vehicles.



Energy Systems Catapult supports innovators in unleashing opportunities from the transition to a clean, intelligent energy system.

Energy Systems Catapult
7th Floor, Cannon House
18 Priory Queensway
Birmingham
B4 6BS
es.catapult.org.uk
info@es.catapult.org.uk
+44 (0)121 203 3700