Department for Transport

Road Traffic Forecasts 2018

Moving Britain Ahead

July 2018

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2 The forecasts provide the Department's strategic view of future road travel demand under a number of plausible scenarios that reflect the uncertainty in the key drivers of road traffic demand. The forecasts have been disaggregated by vehicle type, road type and region and are presented in this document, accompanying spreadsheets and in the interactive Road Traffic Forecasts 2018 Visualisation Tool[1].

3 This publication follows a substantial update to our modelling suite since Road Traffic Forecasts 2015 (RTF15), with a recalibration of the NTM to a new base year of 2015 and an updated National Trip End Model (NTEM) extending the forecast horizon to 2050.

4 Understanding future demand for road travel is essential to shape the policies we implement and the investments we make. However, forecasting future demand is complex and there is significant uncertainty about the extent to which existing trends and relationships will carry on into the future. We need to ensure that we understand and communicate this uncertainty.

5 Within these forecasts, a scenarios approach has been taken to construct a number of different plausible future outcomes. This provides a strategic view of key uncertainties that might impact on future road traffic and supports the design of strategies and policies that are resilient to these uncertainties.

6 These forecasts are not definitive predictions about the future, or desired futures, but show how demand for road travel may evolve assuming no change in government policy beyond that already announced. These forecasts have been produced using a broad range of research, evidence and data focusing on:

- Our understanding of how people make travel choices
- The possible paths of key drivers of travel demand

Improvements to the Forecasts

7 The NTM has been updated to take into account the most recent traffic data and trends in travel behaviour. The update rebases the model from 2003 to 2015, requiring a full recalibration, and takes all relevant up-to-date evidence and input data, whilst retaining the same functionality as the previous model.

[1] http://maps.dft.gov.uk/rtf18-vis

8 Since the publication of our last forecasts in RTF15, we have also comprehensively updated the National Trip End Model (NTEM) to reflect more recent evidence. NTEM brings together exogenous projections of population, employment and housing supply and combines these with projections of car ownership and trip rates to forecast future numbers of trips by person type at a detailed spatial level.

9 In preparing RTF18 we have developed a new set of scenarios which aim to improve on RTF15 by considering a wider variety of uncertainty and combining multiple issues to create plausible future states of the world.

10 As part of this process we have reviewed the evidence on road demand and the uncertainty around a number of key drivers of road traffic, including:

- Population growth
- Trip rates
- GDP & Income
- Costs of driving
- Young people's driving patterns and licence holding
- Demand for goods: freight
- Technology

11 After assessing the uncertainty around these key drivers of demand, we have combined assumptions related to these issues where possible to create a set of seven plausible, internally consistent scenarios. Further discussion of these scenarios is set out in section 3.

12 Finally we have developed an interactive visualisation tool to allow users to easily navigate through our model outputs and fully explore the forecast results. This can be found at http://maps.dft.gov.uk/rtf18-vis

What the Forecasts Show

13 Traffic in England and Wales is forecast to increase across all scenarios, but the size of that growth depends on the assumptions made about the key drivers of future road demand. From 2015 traffic is forecast to grow by between 17% and 51% by 2050.

14 The growth in traffic levels is predominately driven by the projected growth in population levels (and thus the number of trips) and changes to vehicle running costs. Extrapolated Trip Rates (scenario 6), which explores the impacts of extrapolating recent trip rate trends, has the lowest forecast growth of 17% by 2050.

15 Traffic growth on the Strategic Road Network (SRN) is forecast to be strong and positive in all scenarios, ranging between growth of 29% and 59% by 2050, driven by forecast increases in the number of car trips and trip distances, as well as increasing Light Goods Vehicle (LGV) traffic. Forecast growth on principal roads and minor roads is lower than the SRN, between 10%-44% and 11%-48% respectively.

16 Car traffic is forecast to grow between 11% and 43% by 2050, whilst LGV traffic is forecast to continue growing significantly in all scenarios (between 23% and 108%). Strong LGV traffic growth has a significant impact on total traffic growth, particularly in Extrapolated Trip Rates (scenario 6). In this scenario although car traffic is forecast to grow by just 11%, overall traffic growth still reaches 17% with LGV traffic accounting for 19% of total traffic. HGV traffic growth is forecast to be lower than

other vehicle types, with growth ranging from 5% to 12% by 2050.

17 Congestion is forecast to grow as a result of increases in traffic. The proportion of traffic in congested conditions in 2050 is forecast to range from 8% to 16% depending on the scenario, compared to 7% in 2015. The average speed during all periods is forecast to fall from 34mph in 2015 to as low as 31mph in 2050 in Shift to ZEVs (scenario 7). The average delay per vehicle mile during all periods is forecast to increase by up to approximately 11 seconds per mile (69%) by 2050, although Extrapolated Trip Rates (scenario 6) specifically sees smaller increases (5%).

18 There is great uncertainty around the possible impact of transport technology on road traffic demand and it is unclear how far our existing understanding of the drivers of demand will continue to apply. In an attempt to address this, we have undertaken some initial exploratory analysis of how the introduction of Connected Autonomous Vehicles (CAVs) may impact on demand through examining levers in existing models. The purpose of the analysis presented is not to make forecasts about how CAVs will impact on demand, but to better understand which aspects of these new technologies traffic levels might be most sensitive to, thus informing future research priorities. The range of traffic growth by 2050 in these tests is between 5% and 71% driven principally by uncertainty around possible changes to car occupancy levels, alongside possible changes to the perceived values of time and mobility.

Forecast Performance & Next Steps

19 We have reviewed the performance of RTF15 and the findings emphasise:

- that the forecasts performed well at the aggregate level
- the importance of keeping the base year and assumptions up-to-date
- the amount of uncertainty around road traffic demand (even in the short term).
- that the model is likely to overstate the level of traffic growth in London.

20 Important elements to note given this:

- The base year of the NTM has been updated to 2015 for RTF18.
- In RTF18 we have reflected a broader range of factors in our scenarios, including exploring the possible impacts of changes to population levels.
- The NTM is a national strategic transport model and therefore has difficulties replicating travel patterns at local levels where travel behaviour is substantially different from the national picture. This is particularly apparent in London where the relationship between income and car ownership differs. Whilst this is a known feature of the NTM and is not considered to have a material impact on the performance of our forecasts at the national level, it should be considered if looking at London outputs.

21 We recognise that our understanding of the drivers of road traffic demand continue to evolve and there is uncertainty around travel behaviour. We will continue to work on developing the evidence base and forecasting approach to improve the transparency and robustness of our strategic modelling capability.

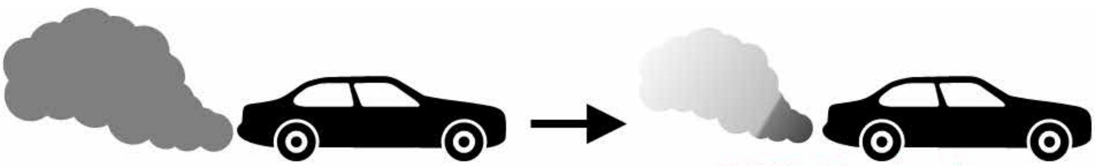
22 Whilst we believe the technology-focused tests have explored some key features of CAVs that may impact road traffic demand in the future, these developments present a significant challenge to any forecasting activity. We shall explore ways in which models may be used more effectively to forecast the impacts in more detail.

Traffic levels are forecast to rise by between **17% and 51%** by 2050.
The key drivers of growth are **increases** in **population** and **decreases** in **vehicle running costs**

By 2050, on the Strategic Road Network

an **additional 1 to 2 vehicles** forecast for every 3 cars currently using these roads

Without further action congestion and delays are expected to increase.
The average car journey taking 17 minutes in 2015 could increase to 20 minutes in 2050



Despite a 17% to 51% increase in traffic, tailpipe CO_2 Emissions from road vehicles are expected to **reduce by between 17% to 76%**

New vehicle technology has the potential to transform road traffic and congestion.

However there is great uncertainty as to what effects this will have. How behaviour is affected by new business models is likely to be a determining factor.

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1. Introduction, Use of Forecasts & How the Model Works

Introduction

1.1 Road Traffic Forecasts 2018 (RTF18) presents the latest forecasts of traffic demand, congestion and emissions in England and Wales produced using the Department for Transport's National Transport Model (NTM).

1.2 The forecasts provide the Department's strategic view of future road travel demand under a number of plausible scenarios that reflect the uncertainty in the key drivers of road traffic demand. The forecasts have been disaggregated by vehicle type, road type and region and are presented in this document and in the interactive Road Traffic Forecasts 2018 Visualisation Tool. This can be found at http://maps.dft.gov.uk/rtf18-vis.

1.3 This publication comprises 6 core sections:

1. How the forecasts are used and an overview of the approach to forecasting and the modelling suite
2. An evaluation of how the forecasts have performed in the past and how they have been updated since the last set of published forecasts
3. Summary of the key drivers of road traffic demand and descriptions of our scenarios based approach with specific detail on the narrative and core assumptions of each scenario
4. Presentation of results
5. Description of the technology-focused tests and results
6. Summary and next steps

Use of the Forecasts

1.4 The Road Traffic Forecasts are used to:

- inform the Department's roads strategy. The challenges which transport strategy and policy aim to overcome are strongly influenced by current and future trends in transport demand over the long term;
- understand how uncertainty around the key drivers of travel demand in the long term could impact on future traffic growth;
- provide a sense-check of Highways England analysis in support of the 2nd Roads Investment Strategy (RIS2) and provide LGV and HGV forecasts. RIS2 analysis is primarily to be developed by Highways England using, amongst other tools, their Regional Traffic Models (RTMs).

1.5 Given the strategic, high-level nature of the NTM, the forecasts are not used to appraise individual road schemes, nor are they intended to be used to consider the right level of capacity on a specific road or solutions to specific local issues.

How the NTM Works

1.6 Forecasting travel demand requires an understanding of the factors that influence it. The interactions between these factors and the nature of their relationship with travel demand make traffic forecasting a complex process. The NTM takes a four-stage multimodal approach to modelling travel behaviour which provides a robust way of taking account of this complexity. However it is worth noting any model is by definition a simplified representation of a complex reality.

1.7 Our modelling splits travel-making choices across four key decisions following the classic 4-stage transport model approach:

1 Whether to travel (Trip Generation) – whether a trip needs to be made (e.g. to work, the shops or to visit friends). The total number of trips are calculated by determining the frequency of productions and attractions in each zone by trip purpose. The choice of where to travel to is determined and constrained by the distribution of destinations to travel to i.e. the location of jobs, schools and shops.

The National Trip End Model (NTEM) dataset and suite of models provides an initial forecast of travel demand based on:

- Households by size in the study area for each forecast year;
- Population by gender and age for each control area in each forecast year; and
- Employment (jobs) by industry, gender and working status in the control area for each forecast year.
- Car Ownership (NATCOP, see Figure 1) by household type based on licence holding, income, population, car costs and employment

2 Where to travel to (Trip Distribution) - the demand model (PASS1 - see Figure 1) matches productions with attractions determining where trips start and end and the distance of the trip.

3 Which mode to travel by (Mode Choice) – taking into account the time and monetary costs of travelling by different modes to distribute the trips from NTEM to different modes of transport in the demand model in NTM.

4 Which route to be assigned to (Highway Assignment) – taking into account the time and monetary costs relating to using each route. This is handled in FORGE (see Figure 1) based on road capacity, forecast demand levels, costs of different modes as a result of congestion, speed flow curves (see Annex A) and a comprehensive database of actual traffic data.

1.8 Analysing decisions using these four aspects helps explain the aggregate travel patterns observed, identify where changes are occurring and where the main uncertainties are. A diagrammatic representation of each of the above stages as well as key inputs to the model can be seen in Figure 1.

1.9 A more comprehensive description of how the NTM works can be found at the NTM webpages[2].

[2] https://www.gov.uk/government/collections/transport-appraisal-and-modelling-tools#the-national-transport-mode

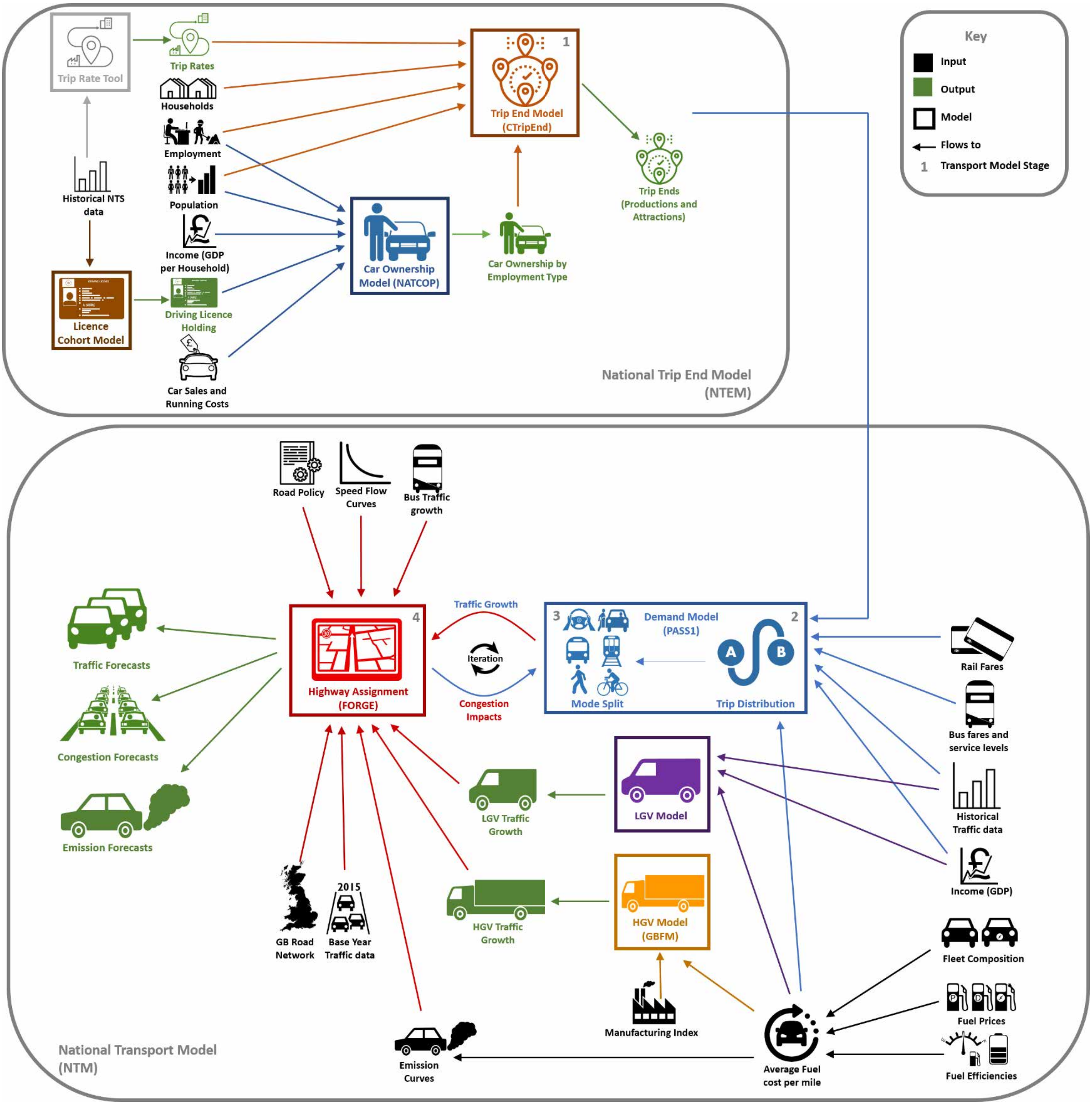

Figure 1: Diagram of the National Transport Model & National Trip End Model

HGV & LGV Forecasting

1.10 Heavy Goods Vehicle (HGV) traffic and Light Goods Vehicle (LGV) traffic is generated by two separate sub-models within the NTM suite (see Figure 1). These take into account the key drivers of demand that affect these vehicle types. Traffic growth from these models is fed into the NTM at the highway assignment stage (FORGE) to assess the impact of these vehicles on congestion.

1.11 The GB Freight Model (GBFM) is a freight transport demand model forecasting HGV traffic growth based on assumptions around future HGV fuel efficiencies and future growth of manufacturing (captured in the manufacturing index).

1.12 The manufacturing index is produced by the Department for Business, Energy and Industrial Strategy (BEIS) in their Energy Demand Model which forecasts manufacturing outputs by industry sub-sector based on GDP and terms of trade.

1.13 LGV traffic growth is projected by the LGV Model, a regression based model that forecasts LGV traffic using three main inputs:

1. LGV lagged traffic (past two years' traffic figures for LGVs)
2. GDP per capita
3. Average Fuel cost of an LGV (accounting for fuel prices, fuel efficiencies and fuel makeup of the LGV fleet)

Public Transport & Active Modes

1.14 While this publication presents the Department's road traffic forecasts, the NTM takes account of the choice between walking, cycling, rail and bus as well as car. The purpose of the representation of other modes in the NTM is to ensure the relative attractiveness of those modes are accounted for in the demand model in response to changing costs, levels of congestion or policy changes. The Department has specialist models that are more detailed and appropriate for forecasting demand for those specific modes.

1.15 As relationships describing the impact of cycling and motor cycling on road capacity and traffic congestion are unavailable, these modes are not assigned to the NTM road network and motor cycles are not modelled in the NTM.

NTM Recalibration & Update

1.16 This publication follows a substantial update to our modelling suite. The NTM has been recalibrated to a new base year of 2015 and the National Trip End Model (NTEM) has been updated to version 7.2 allowing us to forecast out to 2050.

1.17 A key objective for DfT was to update the NTM to ensure it continued to remain fit for the purposes of strategic policy analysis and the quality assurance methods and frameworks that have been used for the project reflect that aspiration.

1.18 The NTM has been updated to take into account the most recent traffic data and trends in travel behaviour. The update rebases the model to 2015, requiring a full recalibration, and takes all relevant up-to-date evidence and input data, whilst retaining the same functionality and structure as the previous model. This is distinct from the project of developing a new National Transport Model.

1.19 The update includes using latest travel and cost data to re-estimate the parameters which are used to allocate trips for different journey purposes across:

(i) Modes; (options are, walk, cycle, bus, car driver or passenger and rail)

(ii) Distance bands; (from less than 1 to over 200 miles) and

(iii) Attraction zones. (Different urban & rural area types)

1.20 Key highlights of the data updates are as follows:

- Updated behavioural parameters and costs based on the National Travel Survey (NTS) up to 2014
- Up-to-date traffic data from Roads Traffic Statistics and Highways England to update the model's traffic database, which is used to provide inputs to the model on road length and kilometres travelled by road type, area type and sub region
- Updated forecasting assumptions, based on demand inputs from National Trip End Model (NTEM) 7.2, which includes updated assumptions on trip rates and reflects the latest evidence from the NTS on the current trip-making behaviour (see NTEM 7.2 update for more details).
- The latest local policy assumptions for roads, public transport and active modes where relevant.
- Up-to-date WebTAG[3] parameters such as value of time, fuel price and GDP forecasts
- Updated LGV model, providing more dis-aggregated forecasts

1.21 Since the model structure is unchanged, features of the model which are identified in section 2 regarding RTF15 remain pertinent to interpreting the forecasts in RTF18.

1.22 For more information on the NTM recalibration and update, please see the reports published on the NTM webpages[4].

Future Development of NTM

1.23 DfT is continuing to enhance its analytical tools through development of a new NTM. This will provide the capability to analyse national transport policies and road strategies at a more granular geographic level, as well as providing the potential to test a wider range of emerging issues and policies. The new model is expected to offer the following enhancements:

- a highly detailed spatial resolution, sufficient to distinguish travel between cities and larger and medium-sized towns, whilst continuing to provide a flexible platform for analysing national transport policy through representation of personal travel demand by six modes of transport;

[3] WebTAG (Web Transport Analysis Guidance) is the guidance on the conduct of transport studies and analysis. This includes the WebTAG databook which contains a number of parameters and values that should be used in transport studies and appraisal - https://www.gov.uk/guidance/transport-analysis-guidance-webtag

[4] NTMv2R demand model calibration and validation report produced by Rand and NTMv2R demand model implementation by Aitkins https://www.gov.uk/government/collections/transport-appraisal-and-modelling-tools#the-national-transport-mode

- a more detailed network model, representing route choice through the major road network and major competing routes, allowing traffic, congestion and emissions to be analysed more reliably and precisely;
- development within a software package which should maximise flexibility and efficiency of future development of the model as the priorities for transport analysis and computing power evolve.

NTEM7.2 Update

1.24 Since the publication of our last forecasts in RTF15, we have also comprehensively updated the National Trip End Model (NTEM)[5] to reflect more recent evidence. NTEM brings together exogenous projections of population, employment and housing supply and combines these with forecasts of car ownership and trip rates to forecast future numbers of trips at a detailed spatial level and for different segments of the population[6].

1.25 The forecasts provide an initial estimate of all-mode travel demand for input into bespoke transport models used by the Department, Local Authorities and other organisations. These transport models then translate these initial estimates of the number of trips into traffic forecasts. More specifically, NTEM provides inputs into the NTM, which forecasts traffic taking into account other factors such as income, fuel costs and network capacity.

1.26 NTEM version 7.2 incorporates data from the 2011 Census as well as updated projections for all the planning data (set out in Box 1 below). In addition to planning data we have updated elements of the model that relate to travel behaviour of households and individuals: trip rates and car ownership have been updated.

Box 1: Summary of updates to the National Trip End Model

- 2011 Census
- ONS 2014-based population projections
- Dwellings projections - updated using local authority plans and annual monitoring reports
- Employment projections - updated using UKCES 2012-based employment projections (“Working Futures”) project
- The distribution of employment and workers by region in the base year 2011 (and hence in all years) - updated using Workforce jobs statistics and the Labour Force Survey
- A comprehensive update and re-estimation of the National Car Ownership Model
- Re-estimated trip rates based on the National Travel Survey

1.27 Further details can be found in the NTEM FAQ[7].

[5] For further information on how NTEM works and an overview of the updates for NTEM 7.2 see the NTEM Planning Data Guidance Note - https://data.gov.uk/dataset/11bc7aaf-ddf6-4133-a91d-84e6f20a663e/national-trip-end-model-ntem
[6] It is worth acknowledging that, as projections themselves, there is uncertainty around the inputs to the NTEM projections.
[7] https://www.gov.uk/government/publications/tempro-downloads

2. Evaluating Past Performance

Background

2.1 Evaluating the past performance of the Road Traffic Forecasts informs future improvements to the forecasting process and whilst does not guarantee future performance, helps ensure the forecasts remain fit for purpose.

2.2 Furthermore, evaluating forecast performance gives the Department an understanding of the strengths and weaknesses of the NTM, and as a result a view of whether it is suitable for providing traffic forecasts. Monitoring performance is an ongoing process and results of a similar exercise were shared in Road Traffic Forecasts 2015 (RTF15). Further objectives of evaluating past forecasts are:

- Improving trust in the Department's modelling and forecasts by being transparent about how our forecasts compare to outturn data at a granular level;
- Informing an assessment of risks, limitations and uncertainties associated with the use of forecasts; and
- Assisting in guiding priorities for future evidence gathering and model development.

2.3 Figure 2 shows the previous 4 iterations of the Road Traffic forecasts going back to 2009 (all with a base year of 2003) compared with road traffic statistics. There are differences from road traffic statistics which could come from two sources:

- Shifts in the transport system (i.e. changing relationships between travel and its key drivers, or emergence of new drivers not captured in the model which affect travel behaviour).
- Input over/under-forecasting (i.e. difference in outturn statistics from forecasts for key drivers such as GDP, population, fuel costs): when historic levels were input into the model, the forecasts were found to be within 1% of total traffic in 2010.

2.4 We have evaluated the performance of the RTF15 forecasts[8] by comparing outputs with road traffic statistics between 2010 and 2017[9]. The measure of performance was whether road traffic statistics[10] fell within the range of scenario forecasts. However the range of scenario forecasts is not considered to represent extremes.

2.5 The forecasts were produced in five year increments from 2010 and thus analysis of individual years has been conducted by linearly interpolating outputs. Although interpolated year results will not give the same forecast as if the NTM was run for that year, comparing these results gives a more rounded picture as to how the forecasts

[8] https://www.gov.uk/government/publications/road-traffic-forecasts-2015
[9] Despite RTF15 being published in 2015, forecasts were produced for 2010 onwards from a base year of 2003.
[10] Road Traffic Estimates 2016, https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/611304/annual-road-traffic-estimates-2016.pdf

are performing (but not necessarily the NTM). The comparison with statistics for non-forecast years is provided for context of general trends in the outputs.

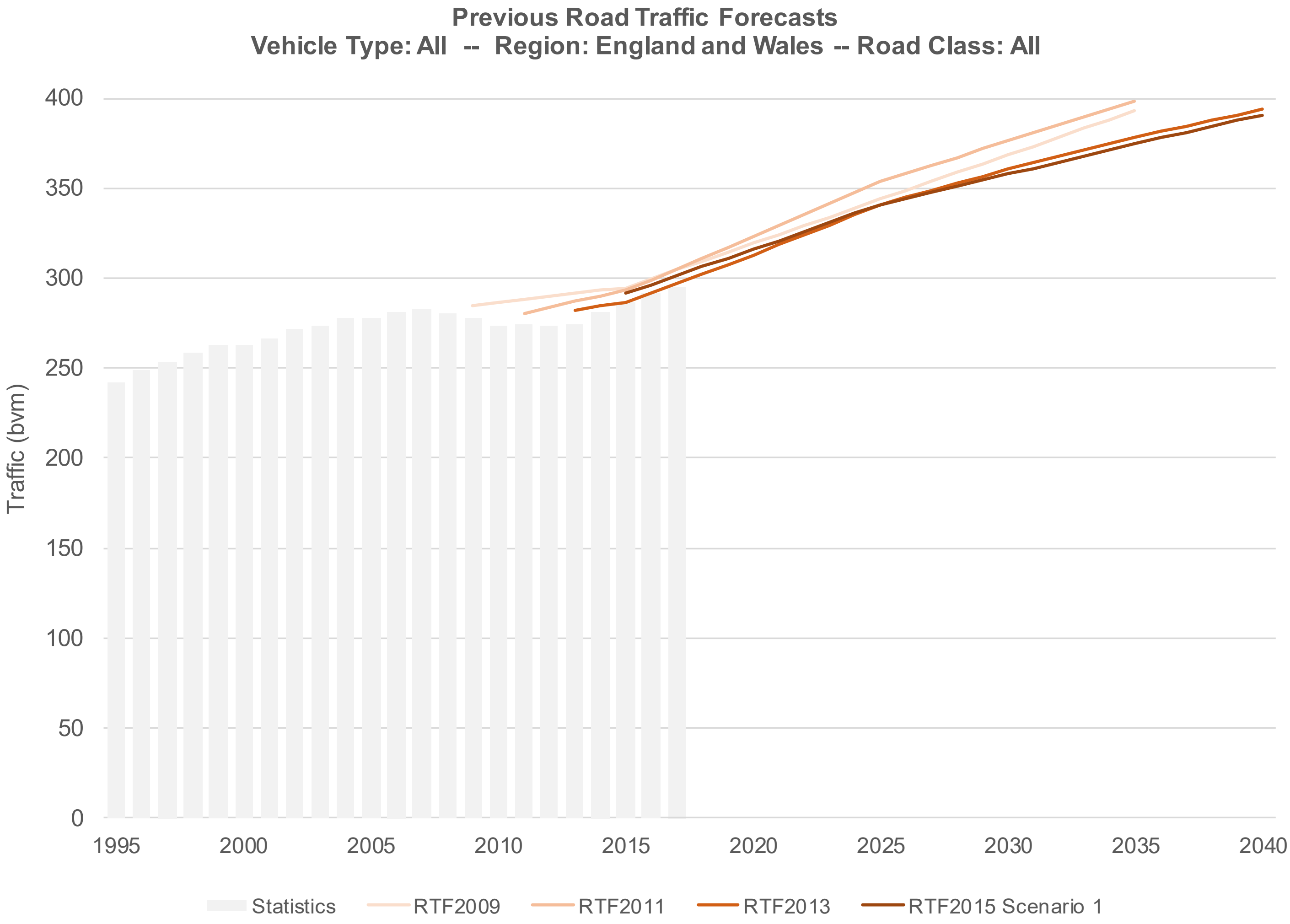

Figure 2: Previous Road Traffic Forecasts

Summary of Results

2.6 At the aggregate level the forecasts perform well with Figure 3 showing that for 6 out of the 8 years post-2010 the statistics were within the range of the scenario forecasts. Scenarios 1, 2 and 5 consistently over forecast traffic from 2010 through to 2017. In 2017 scenario 2 was closest to outturn statistics (+1.4%), with scenario 5 the furthest away (+6.8%).

2.7 In 2017, the latest modelled year for which we have outturn data, actual traffic levels were within the range generated by these scenarios.

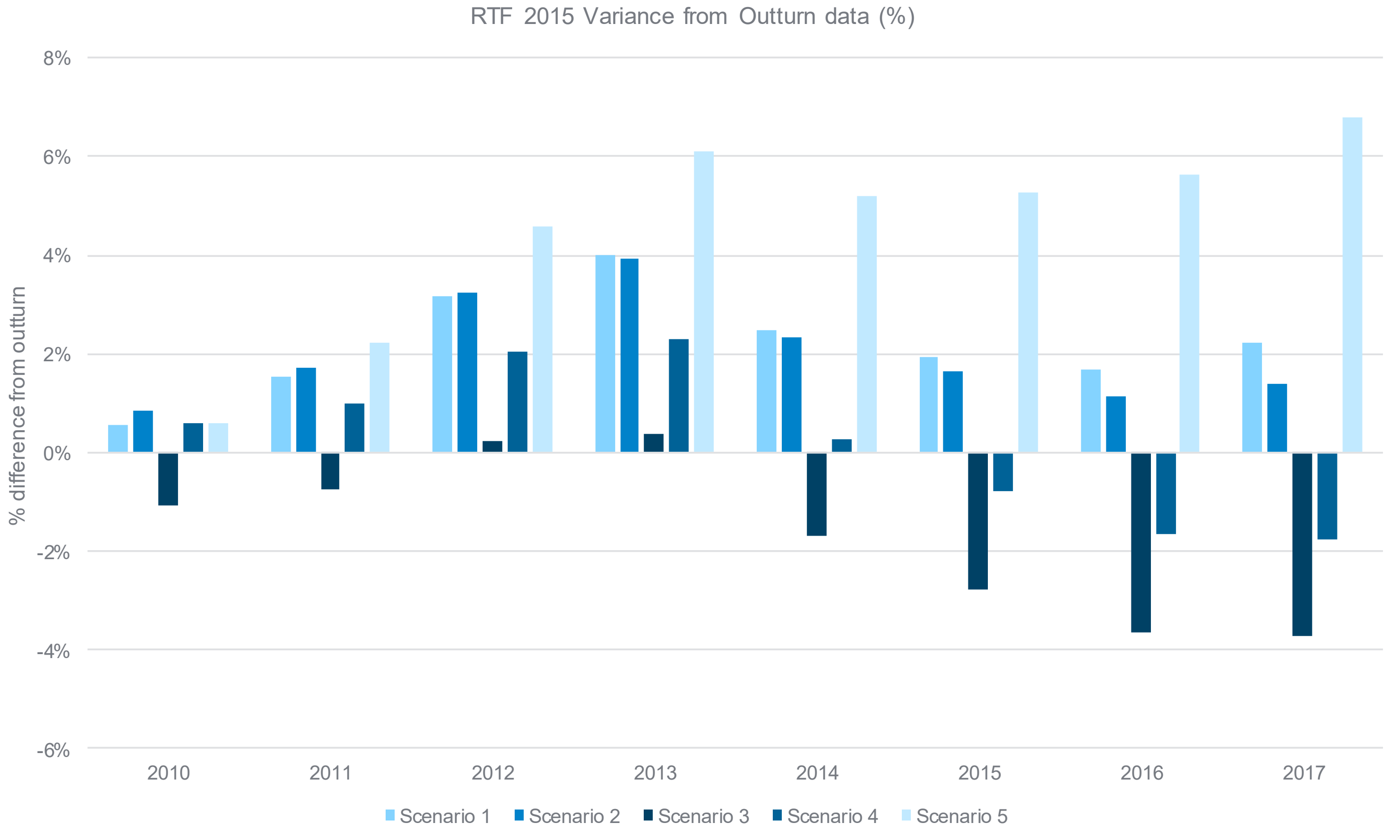

Figure 3: % Difference between forecasts & statistics – All Vehicles (2010-2016)[11]

- **Scenario 1** - uses central projections of GDP, fuel price and population and assumes that the number and type of trips per capita remains constant over time.
- **Scenario 2** - uses central projections of fuel price and population but removes the link between income and car travel. It assumes that the number and type of trips per capita remains constant over time.
- **Scenario 3** - uses central projections of GDP, fuel price and population but assumes that the number and type of trips made by individual's changes over time based on the trend between 2003 and 2010.
- **Scenario 4** - uses a low forecast of GDP, a high forecast of the fuel price and a central projection of population. It assumes that the number and type of trips per capita remains constant over time.
- **Scenario 5** - uses a high forecast of GDP, a low forecast of the fuel price and a central projection of population. It assumes that the number and type of trips per capita remains constant over time.

2.8 The forecasts performed well within some regions but less well in others (Figure 4).

- For 3 out of the 10 regions in the NTM the forecasts performed well with (East Midlands, Eastern England, Yorkshire & Humber) traffic statistics falling within the range of the forecasts for all years from 2010 to 2016.
- For 4 of the other regions the forecast performed reasonably well (North West, South West, West Midlands and Wales) with outturn traffic slightly outside the range of the forecasts (generally by approx. 1%) for the forecast years between 2010 and 2013 and within the range for the 2015 forecasted year and beyond.
- London had the largest variance of outturn data outside the forecast range, with over-forecasting of traffic of 2-6% (for both cars and LGVs) for all forecasting years regardless of the trend in the other geographical areas.
- The South East and North East were the other two regions where outturn data were outside our forecast range, although the gap was below 1% for the forecast year of 2015 and within the range of the interpolated 2016 result.

2.9 To reduce over forecasting in London analysis for RTF15 included updating the modelled speeds and capacity of the London road network using the latest observed data from Transport for London. However, this led to only a 1.7% reduction in London's forecast traffic levels in 2030[12] and did not solve the over forecasting issue.

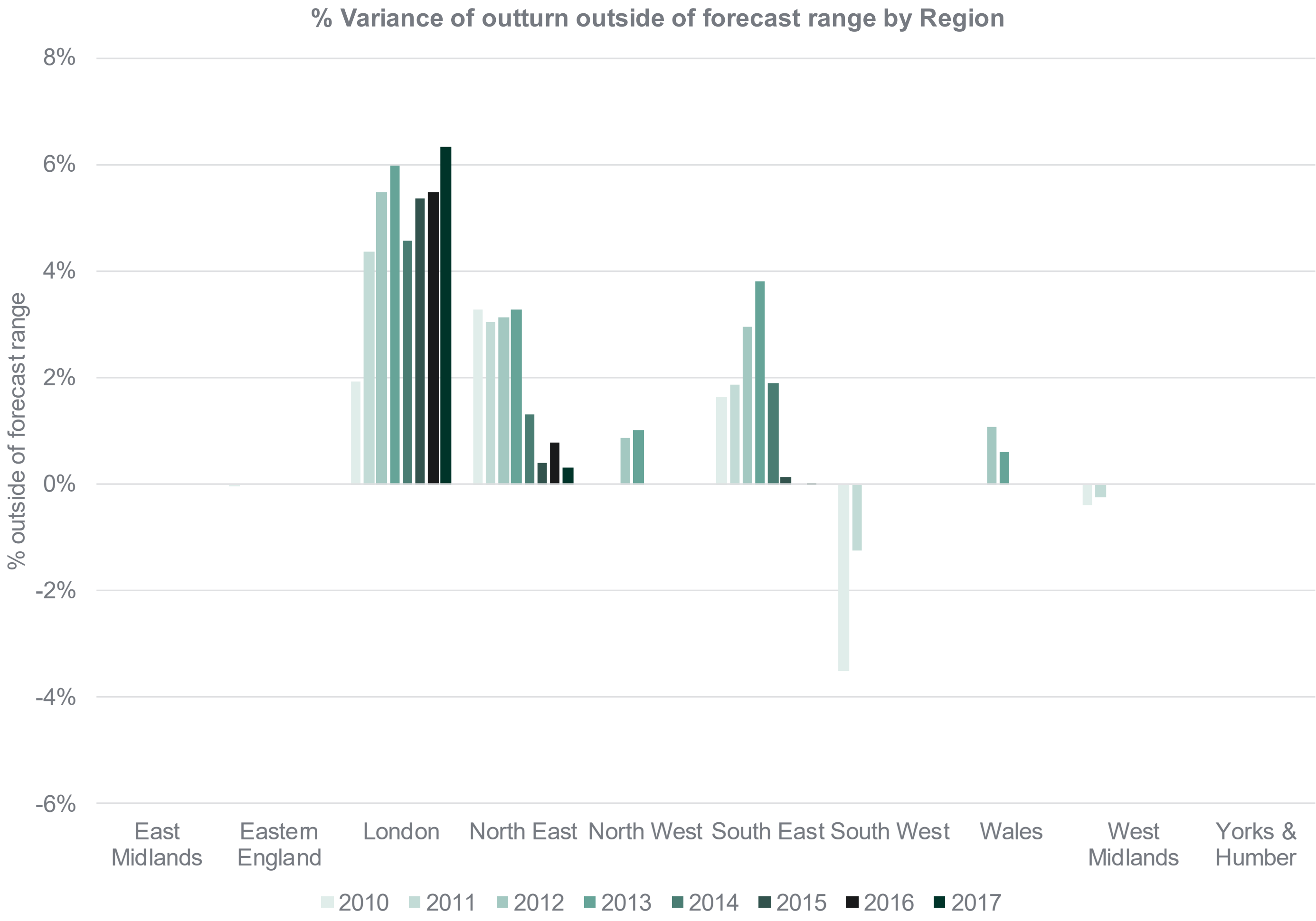

Figure 4: % Variance of outturn outside of forecast range by Region

[12] DfT, Road Traffic Forecasts 2015, 2015

2.10 The forecasts performed well for cars but less well for LGV and HGVs (Figure 5). The forecast for car traffic was within the range of the scenarios for all years between 2010 and 2017. LGV forecasts were outside the range for some years (2010-2012) and HGVs for multiple years and by as much as 6% in 2012. At the aggregate level, however, the impacts of over-forecasting HGVs on total traffic will not be as significant as HGVs only makes up approximately 5% of total vehicle miles.

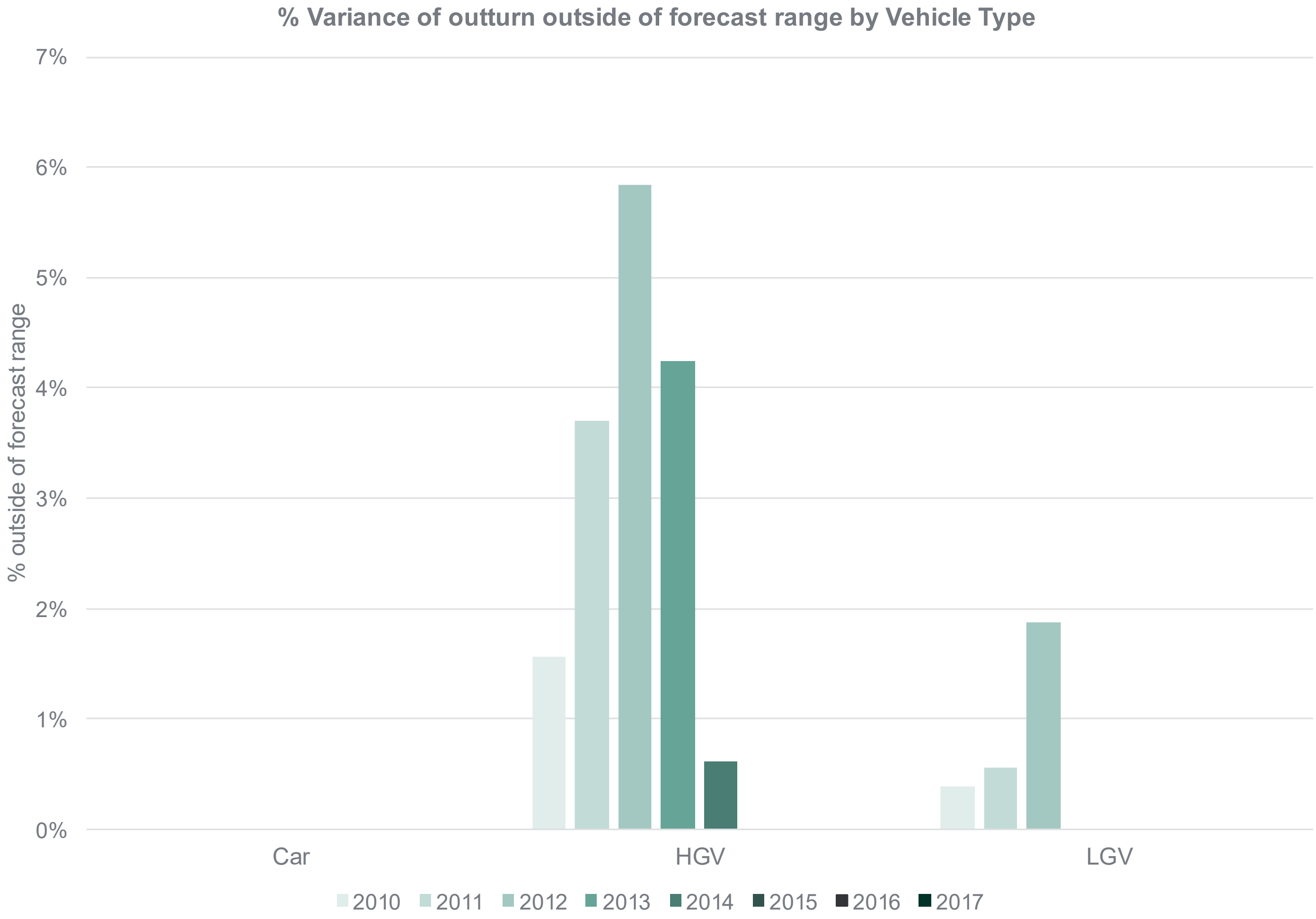

Figure 5: Variance of outturn outside of forecast range by Vehicle Type

2.11 In terms of road type, the forecasts performed best on Principal A roads, with the forecasts falling within the range for all years post-2011 (Figure 6). However, the forecasts consistently allocated too little traffic on Motorways throughout 2010-2017 and too much on Trunk Roads.

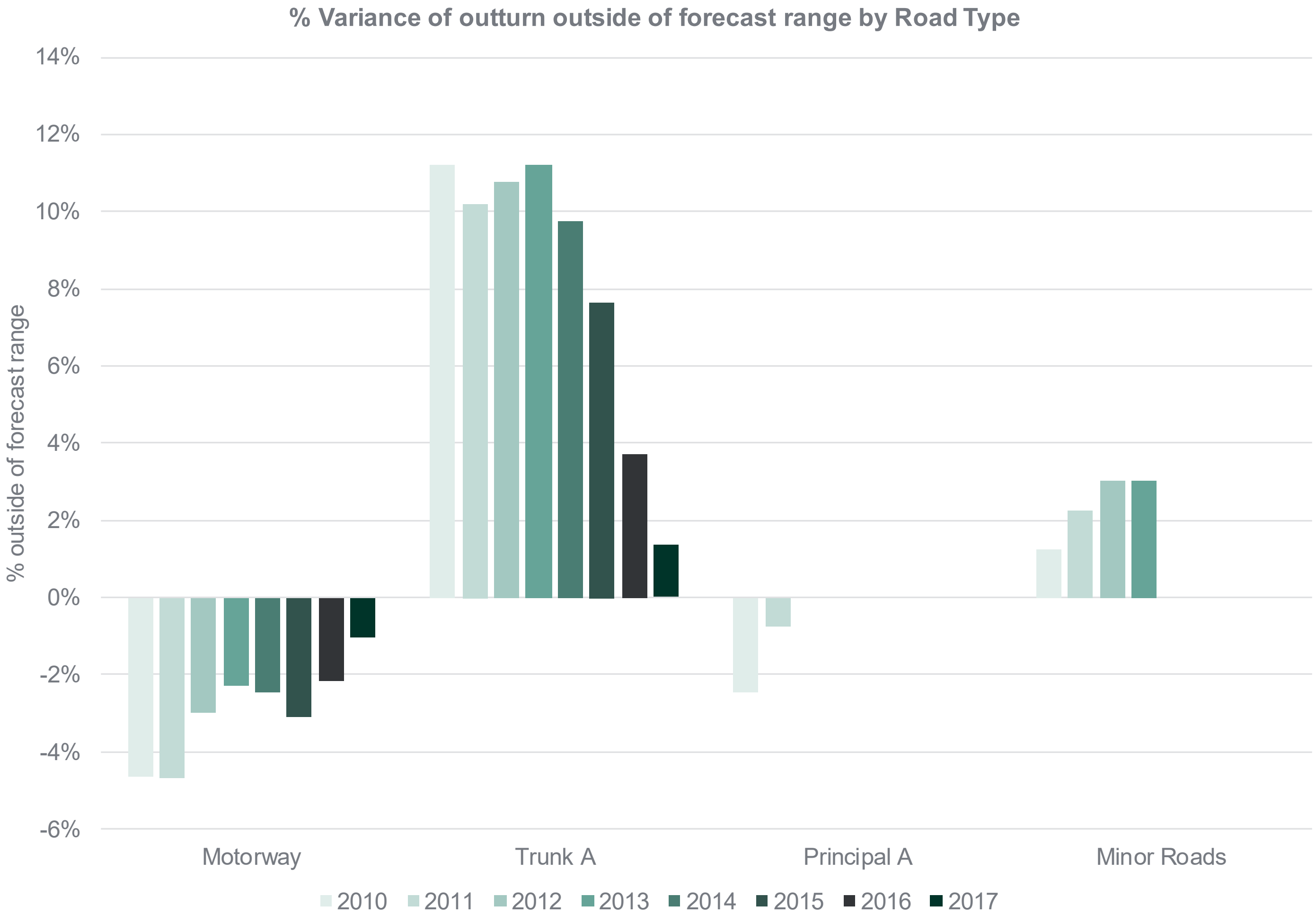

Figure 6: % Variance of outturn outside of forecast range by Road Type

2.12 Investigating the over forecasting on Trunk roads further, we can see (in Figure 7) the outturn data was significantly lower than forecast. As a general trend this occurred to a greater or lesser extent across a lot of the forecasts at different levels of disaggregation. RTF15 was produced from a 2003 base year (12 years previous to when the forecasts were published). Our expectation is that updating the base year of the model should address the divergence in forecasts traffic levels on trunk roads and motorways.

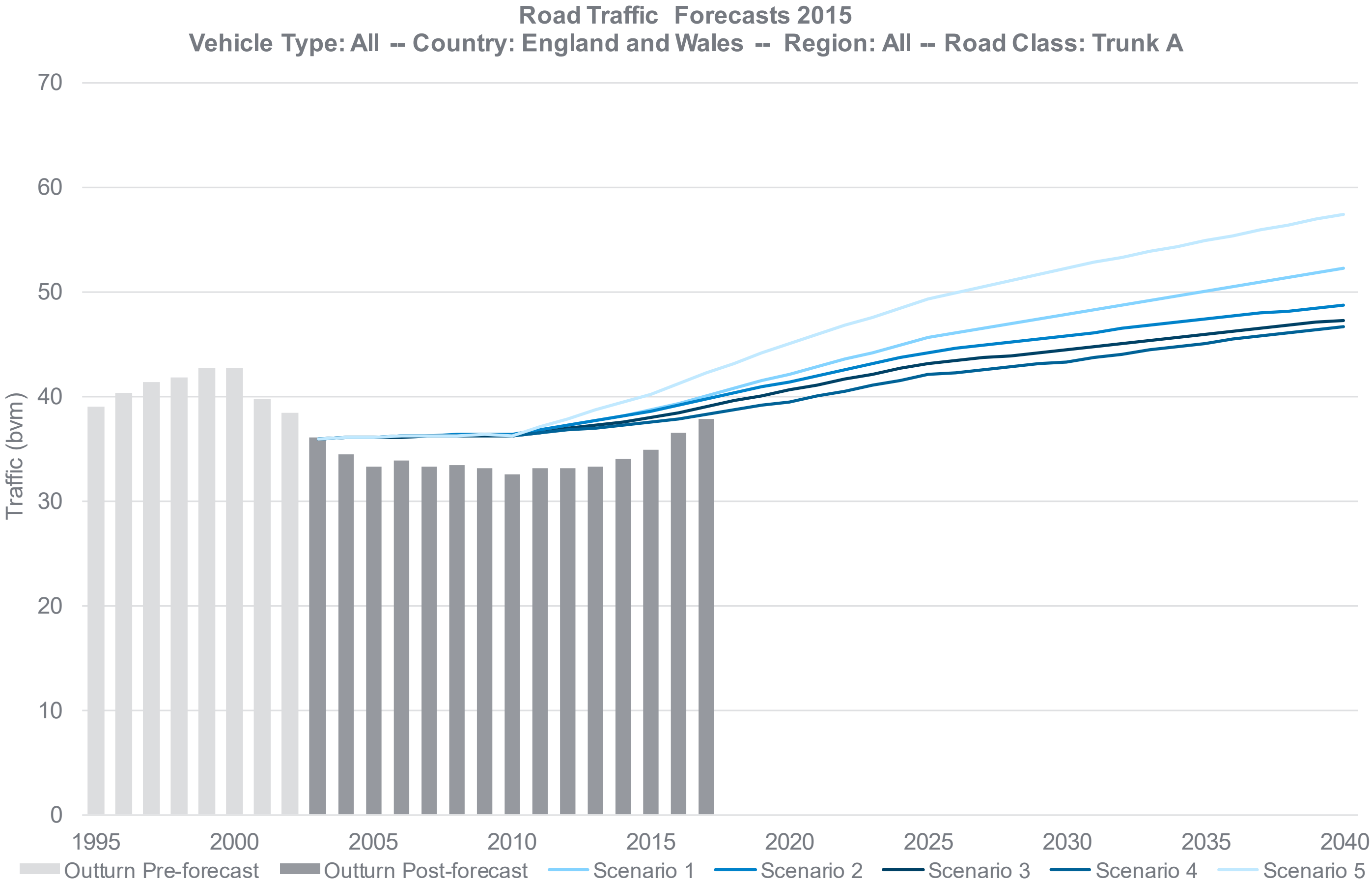

Figure 7: Trunk Roads RTF15 Forecasts & Outturn Data - The Impact of a 2003 Base Year

Implications of Results

2.13 The results outlined above show that the forecasts perform well as they are within the range of outturn statistics at the aggregate level. At more granular levels, this is not always the case and this highlights some issues with the NTM that we have attempted to rectify in the updated model used to produce the new forecasts.

2.14 Given that the forecasts perform well at an aggregate level and most breakdowns are within the range of outturn statistics, we conclude that the NTM is a fit for purpose and suitable model for producing road traffic forecasts. While improvements can be made, it is felt that the NTM produces reliable and robust forecasts provided the most up to date evidence is used, the model is calibrated to a recent year and government quality assurance procedures are followed.

2.15 In particular, the findings emphasise:

- the importance of keeping the base year and underpinning assumptions up-to-date
- the amount of uncertainty around road traffic demand (even over the relative short term).
- that the model is likely to overstate the level of traffic growth in London.

2.16 Given these findings:

- The base year of the NTM has been updated from 2003 to 2015.
- In RTF18 we have reflected a broader range of factors in our scenarios, including exploring the possible impacts of changes to population levels.
- The NTM is a national strategic transport model and therefore has difficulties replicating travel patterns at local levels where travel behaviour is substantially different from the national picture. This is particularly apparent in London where the relationship between income and car ownership differs. Whilst this is a known feature of the NTM and is not considered to have a material impact on the performance of our forecasts at the national level, it should be considered if looking at London outputs.


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3. Scenarios - Uncertainty and the Drivers of Demand

Introduction

3.1 Forecasting future traffic demand is complex and as with any forecast, there will always be uncertainty. While uncertainty in road traffic demand has always existed, it is perhaps now more uncertain than ever given the changes that are currently being experienced in the system and the changes that could lie ahead. Even as our understanding of the underlying evidence on the drivers of road travel demand continues to improve, there will always be uncertainty about the extent to which existing trends and relationships will continue into the future.

3.2 It is important that we understand and communicate this uncertainty. The use of scenarios is one method for capturing and presenting uncertainty in order to make our future policies more resilient and robust.

3.3 Within this context, demand scenarios allow us to construct a number of different plausible futures and examine what their impact on road traffic might be.

3.4 DfT has developed scenarios for previous RTF publications and has modelled scenarios developed by the National Infrastructure Commission (NIC) to support their 2017 publication consulting on a National Infrastructure Assessment[13]. The new set of scenarios for RTF18 aims to improve on RTF15, and draw on the evidence collected by the NIC to support their scenarios, by considering a wider variety of uncertainty and combining multiple issues to create multiple plausible future states of the world. This is expected to be an iterative learning process, repeated for future publications.

3.5 From a long-list of factors considered, we have developed scenarios based around those that have been judged to have most impact on demand for road travel and/or are most uncertain. The shortlist shown in Figure 8 was based on the consideration of the level of uncertainty associated with these drivers and their impact on travel demand. In developing these scenarios we have considered how different factors may work together.

3.6 Future technological developments such as the use of Connected and Autonomous Vehicles (CAVs) and Ultra Low Emission Vehicles (ULEVs) could have a significant effect on road traffic levels. A future where fully autonomous CAVs make up a large proportion of the fleet is likely to be fundamentally different from the current state of the world. We have significantly less evidence on the potential impacts of CAVs and the assumptions and key relationships that we should model to understand those

[13] https://www.nic.org.uk/wp-content/uploads/Congestion-Capacity-Carbon_-Priorities-for-national-infrastructure.pdf

impacts. Therefore their impacts are not considered in this section or presented alongside the forecasts and are instead discussed separately as exploratory tests in section 5.

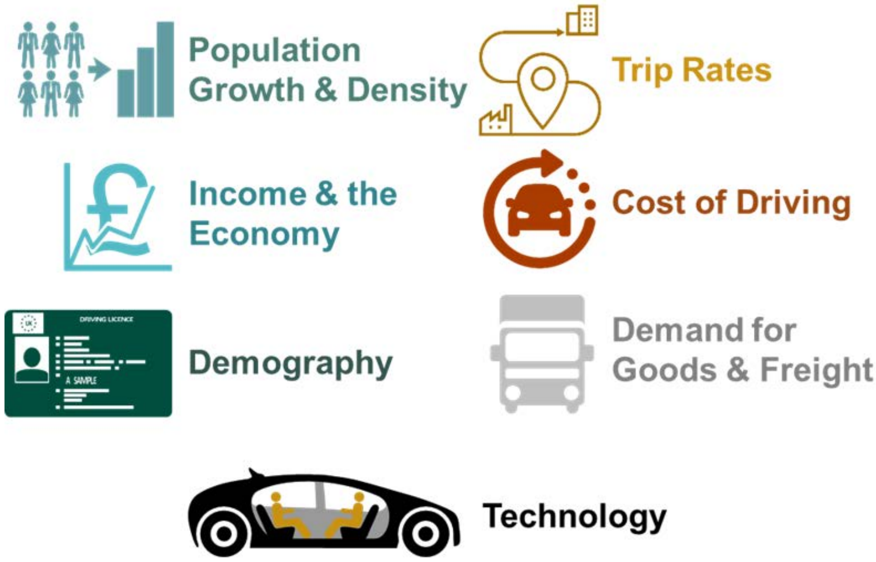

Figure 8: Short-listed issues for scenario development

3.7 In order to develop scenarios for RTF18 which reflect the wide range of uncertainty in road traffic demand, it was critical to assess a wide range of factors that drive road traffic. However, the scenarios and forecasts presented here are not intended to reflect a definitive or extreme range for traffic demand. This section gives a brief overview of these factors, the uncertainty associated with them and how they feed into the NTM.

3.8 There are a number of variables with an impact on road travel demand that are not explicitly mentioned here. These include developments in land use and the use of company cars. These variables are not included in the forecasts as they were deemed to be of less significance than the key variables presented in Figure 8.

3.9 For a more comprehensive review of the factors, those listed above and others, see Latest Evidence on Factors Impacting Road Traffic Growth report by RAND[14] that was commissioned by DfT. This report presents the findings of a rapid evidence assessment review of peer-reviewed papers, reports and other 'grey' literature to provide a better understanding of traffic growth trends and factors driving these trends for the strategic road network in Britain.

3.10 After assessing the key drivers of demand, we have combined assumptions related to these issues where possible to create plausible, internally consistent scenarios. All scenarios are considered to represent plausible futures and thus all scenarios should be taken into account when using the forecast results. A high-level summary of the assumptions made in our scenarios can be found in Table 1. Compared to RTF15 these scenarios cover a wider range of issues, specifically the uncertainty around future population levels and future fleet penetration of ZEVs. Note that whilst the uncertainty around CAV technology is not covered in these scenarios, possible technology impacts have been explored further in section 5. Unless otherwise stated all other assumptions for the scenarios are the same as the reference scenario.

[14] Latest Evidence on Factors Impacting Road Traffic Growth: An Evidence Review, RAND for DfT, 2018

Scenario	Assumptions
1 (Reference)	NTEM7.2 (incl. constant trip rates) Updated central forecasts for GDP (OBR) BEIS Central Forecasts for Fuel Central projection for Population (ONS) WebTAG Value of Time 25% of car and LGV mileage powered by zero emission technologies by 2050
2 (High GDP, Low Fuel)	High GDP Growth (+0.5pp Growth on OBR) Low Fuel Cost Projection (Fossil Fuel Price Assumptions 2017, BEIS)
3 (Low GDP, High Fuel)	Low GDP Growth (-0.5pp Growth on OBR) High Fuel Cost Projection (Fossil Fuel Price Assumptions 2017, BEIS)
4 (High Migration)	High Migration population variant (ONS) No Relationship between Income and Car Ownership in London High LGV Growth High HGV Growth
5 (Low Migration)	Low Migration population variant (ONS) Low LGV Growth Low HGV Growth
6 (Extrapolated Trip Rates)	Extrapolation of recent trip rate trends until 2050 Extrapolation of recent decreases in young person licence holding
7 (Shift to ZEVs)	97% of car and LGV mileage powered by zero emission technologies by 2050 (Assumes all car and LGVs sold are zero emission by 2040)

Table 1: Detailed Scenario Assumptions

Reference (Scenario 1) - Context, Assumptions & Inputs

3.11 In this scenario we assume the number of trips per person declines from 2011 to 2016 and then remains constant to 2051. We also assume that historic relationships between incomes, costs and travel choices continue into the future. We use Office for Budget Responsibility (OBR) and Department for Business, Energy and Industrial Strategy (BEIS) central forecasts for future changes in incomes and fuel prices. This scenario includes implemented, adopted or agreed policies only. This is broadly in line with the assumptions used in scenario 1 in RTF15 with updates to more recent data and evidence.

3.12 The main inputs/assumptions for the reference scenario are:

1 NTEM 7.2, which includes:
   a. ONS projections for population
   b. Licence holding and car ownership projections
   c. Declining trip rates from 2011 to 2016 and held constant from 2016 onwards.
   d. Employment projections
   e. Household and dwelling projections

2 Central OBR forecasts for GDP – updated recently using OBR's long-term economic determinants[15]
3 BEIS central forecasts for fuel prices (as stated in WebTAG[16])
4 BEIS Manufacturing Index (Energy Demand Model)
5 WebTAG Values of Time[17]
6 Assumptions around electric vehicle mileage split in line with WebTAG[18]
7 Vehicle fuel efficiency forecasts[19]
8 The modelled road network has been updated to include all fully committed schemes being implemented as part of the 1st Roads Investment Strategy (RIS1).

With regards to Ultra Low Emission Vehicles (ULEVs):

1 These forecasts include implemented and adopted policies only. These do not include future policies or Government ambitions that have not been legislated, for example it does not include future car and van CO2 regulations.
2 The proportion of zero emission mileage is modelled as if these were electric vehicles. It captures distances driven by both battery electric and plug in hybrid electric cars and LGVs.
3 Our forecasts assume existing taxation policies are maintained. Fuel costs for ULEVs are significantly cheaper than for petrol and diesel cars.

[15] http://obr.uk/supplementary-forecast-information-release-9/
[16] https://www.gov.uk/government/publications/webtag-tag-data-book-may-2018
[17] https://www.gov.uk/government/publications/webtag-tag-data-book-may-2018
[18] WebTAG assumptions reflect impact of current committed policy and equate to 25% fleet penetration by 2050
[19] Taken from DfT's Fleet Fuel Efficiency Model

High GDP, Low Fuel & Low GDP, High Fuel (Scenarios 2 & 3) – Context, Assumptions & Inputs

3.13 These scenarios capture uncertainties around GDP growth and fuel price.

Income and the Economy

3.14 One of the drivers of road traffic demand is income. There are two principle mechanisms through which higher incomes lead to increased traffic in the NTM. The higher the income of an individual the more likely they are to own a car, to travel and travel further. Income affects how people perceive time with those on higher incomes happier to pay more to travel in comfort and get to a destination more quickly.

3.15 Within the NTM, income growth is represented by growth in GDP per capita. GDP per capita is a measure of average income per person in the UK and is a key input to the NTM that affects how the 'average' person perceives and values their time. Real GDP is also a key input into the car ownership model (NATCOP), the LGV model and in the HGV model (via the manufacturing index).

3.16 Growth in GDP is influenced by many factors including productivity and employment. Historic GDP forecasts against outturn data (Figure 9) show how difficult GDP is to forecast and the uncertainty associated with this variable. In particular, over the last 10 years productivity growth has been significantly below trends observed pre-2008. There is currently a high level of uncertainty around assumptions of future productivity growth (see paragraphs 3.17-3.18 of OBR's Economic and Fiscal Outlook[20]) and the OBR have recently revised their forecast of future productivity.[21]

3.17 Given this uncertainty around GDP growth, specifically around productivity, it is appropriate to evaluate the sensitivity of the forecasts to variations in GDP growth.

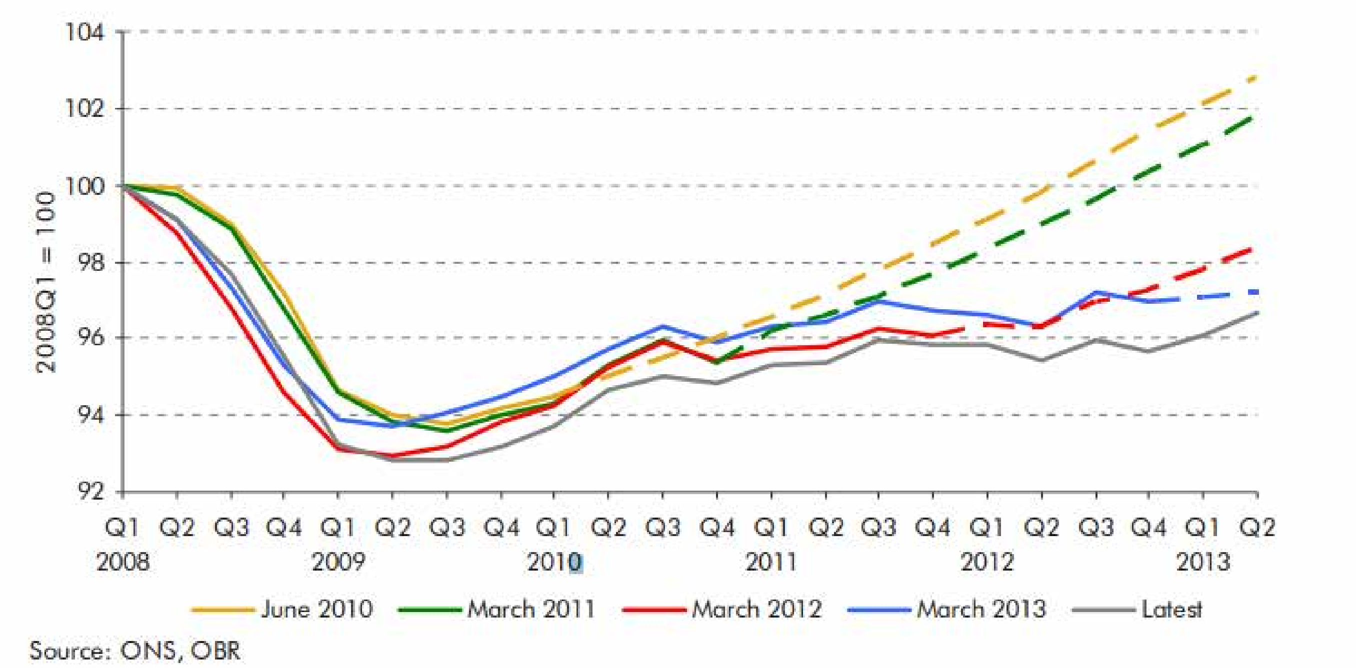

Figure 9: OBR historic forecasts of real GDP (OBR Forecast evaluation report)

[20] http://cdn.obr.uk/EFO-MaRch_2018.pdf
[21] http://obr.uk/supplementary-forecast-information-release-9/

3.18 Additionally, there is evidence to suggest the relationship between income and car ownership is changing. Ownership of cars has become more widespread across society as the relative purchase cost of cars has decreased as incomes have increased. For example NTS data shows the proportion of those in the lowest income groups with no car has dropped from 62% since 1995/97[22] to 44% in 2016 while the proportion of those in the highest income groups with no car has increased from 8% in 1995/97 to 12% in 2016. In the forecasts income is typically represented by:

- People being more likely to own a car
- People being more likely to use a car and travel further as their household income rises. In the NTM the choice of mode is influenced by how much an individual values their own time. This is assumed to increase in line with income, and people with higher values of time prefer faster modes of transport - i.e. car and rail.
- Impacts on forecast of light and heavy goods vehicle traffic

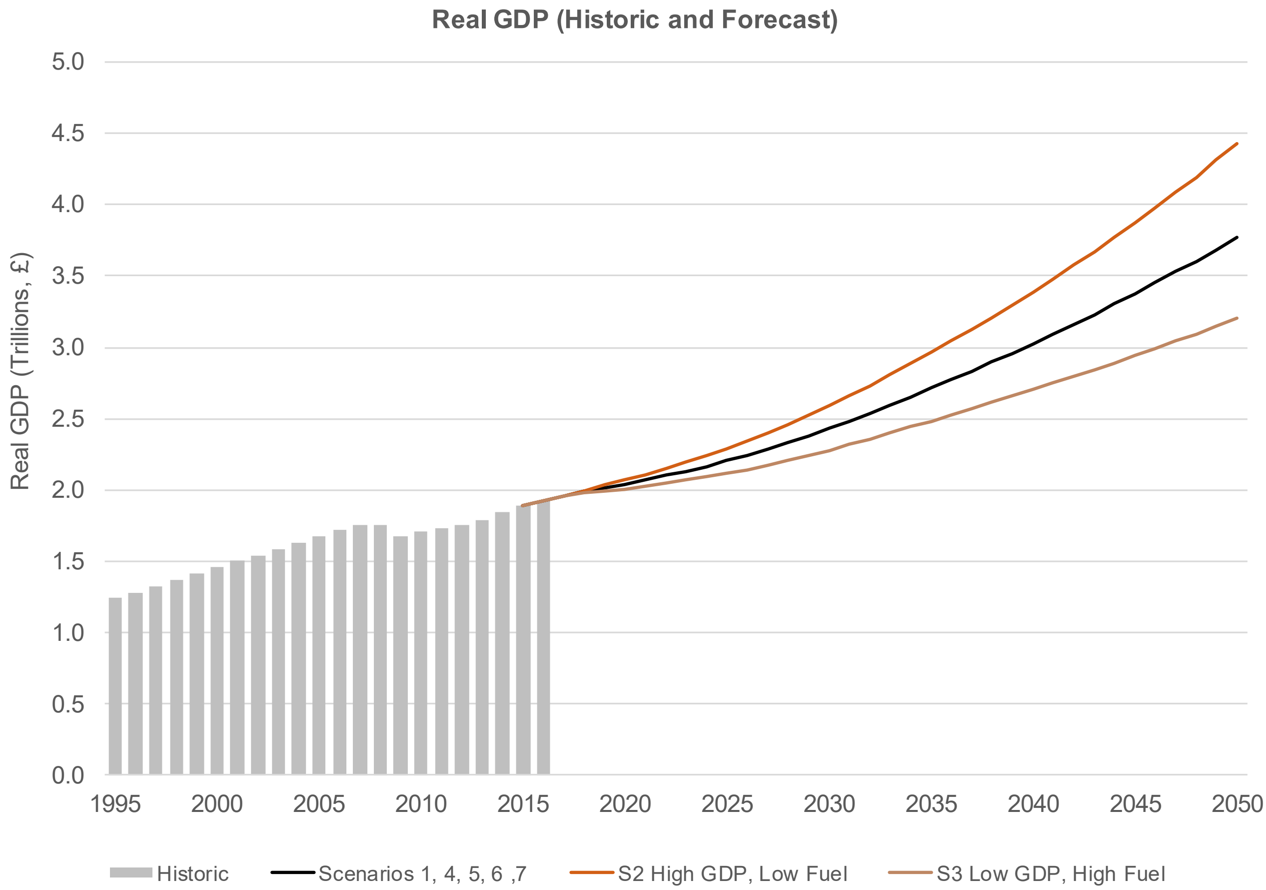

Figure 10: Real GDP (Historic and Forecast)

3.19 For High GDP, Low Fuel & Low GDP, High Fuel (scenario 2 and 3), we have applied +/- 0.5 percentage points per annum to the growth rates in the reference scenario from 2017 onwards. This is fed into the NTM, affecting the values of time. The GDP inputs for High GDP, Low Fuel & Low GDP, High Fuel (scenario 2 and 3) are displayed in Figure 10. The range for real GDP by 2050 is £3.2tn in Scenario 3 (Low GDP, High Fuel) to £4.4tn in Scenario 2 (High GDP, Low Fuel) – a range of 38%.

[22] https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/633077/national-travel-survey-2016.pdf

Costs of Driving

3.20 The cost of making a trip influences road traffic levels, informing an individual's choice of whether to make a trip, how far they are willing to travel and what mode they will use to make a trip. Within the NTM, costs primarily influence the trip distribution and mode choice stages of the model. Costs can be broken down into fuel and non-fuel costs. Non-fuel costs, which include oil, tyres, maintenance and depreciation, are in line with WebTAG and are the same for all scenarios.

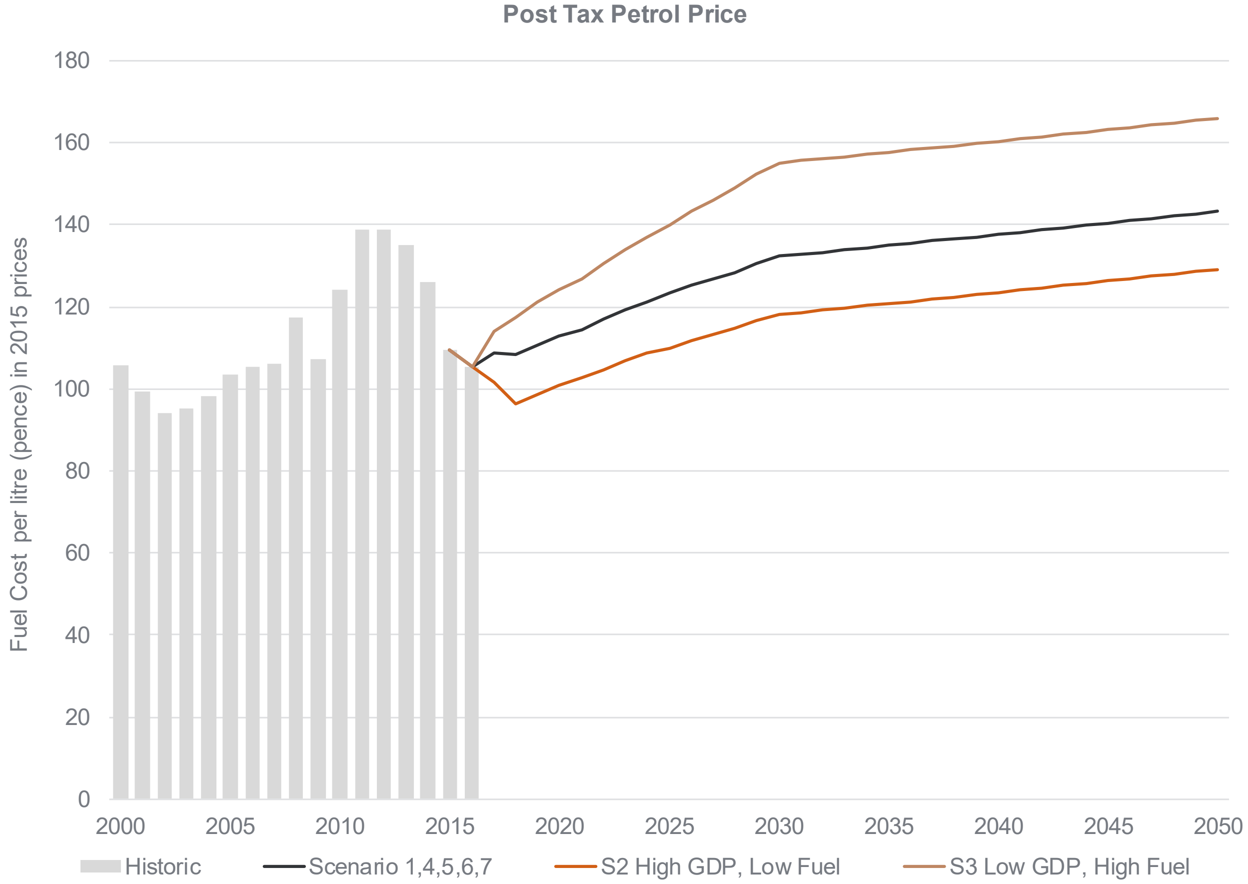

Figure 11: Post-Tax Petrol Price (Historic and Forecast)

3.21 There is uncertainty around future fuel prices (volatility in oil price), represented in the Fossil Fuel Price Assumptions (FFPA) published by BEIS[23]. We have used the high and low projections for road transport fuel prices in the FFPA to produce the post-tax petrol price and diesel price. Post-tax petrol price can be seen in Figure 11 with forecasts following a similar trend for diesel prices

3.22 Fuel costs combine the direct cost of fuel (per litre or per kilowatt hour (kWh) of petrol, diesel or electricity) and the fuel efficiency of a vehicle. Fuel costs change over time due to assumed improvements in fuel efficiency and forecast changes in fuel prices.

3.23 High GDP, Low Fuel (scenario 2) takes the low fuel price projection. Low GDP, High Fuel (scenario 3) takes the high fuel price projection. The range around the central forecast in the FFPA for real petrol and diesel costs by 2050 will be approximately 29% and 32% respectively. The price of electricity does not vary in these scenarios.

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[23] https://www.gov.uk/government/publications/fossil-fuel-price-assumptions-2017

Demand for Goods & Freight

3.24 The demand for goods is calculated using a forecast of the manufacturing index (see Figure 12), a key input to the GBFM and the main driver of HGV traffic in the model. In general the higher the demand for goods, the more goods need to be transported and the higher HGV traffic on the roads. The manufacturing index is correlated with GDP growth of the economy. Other key inputs include fuel prices and HGV fuel efficiency forecasts.

3.25 The manufacturing index is produced by BEIS for energy demand and emissions projections and forecasts manufacturing outputs based on lagged terms of the series, GDP and terms of trade. Terms of trade are held flat at the last outturn and are an ONS statistic. Therefore the main driver of the forecast series is GDP which varies in these scenarios.

3.26 The forecasted manufacturing index has changed substantially since RTF15 and has resulted in a lower forecast of HGV traffic growth. This has occurred for two reasons. Firstly, BEIS, in conjunction with University College London have rebuilt their Industry Growth Model (a regression model based entirely on historical correlation between UK industrial growth, GDP and terms of trade). Secondly, RTF18 uses GDP projections from the OBR which were updated in January 2018 following lower productivity revisions.

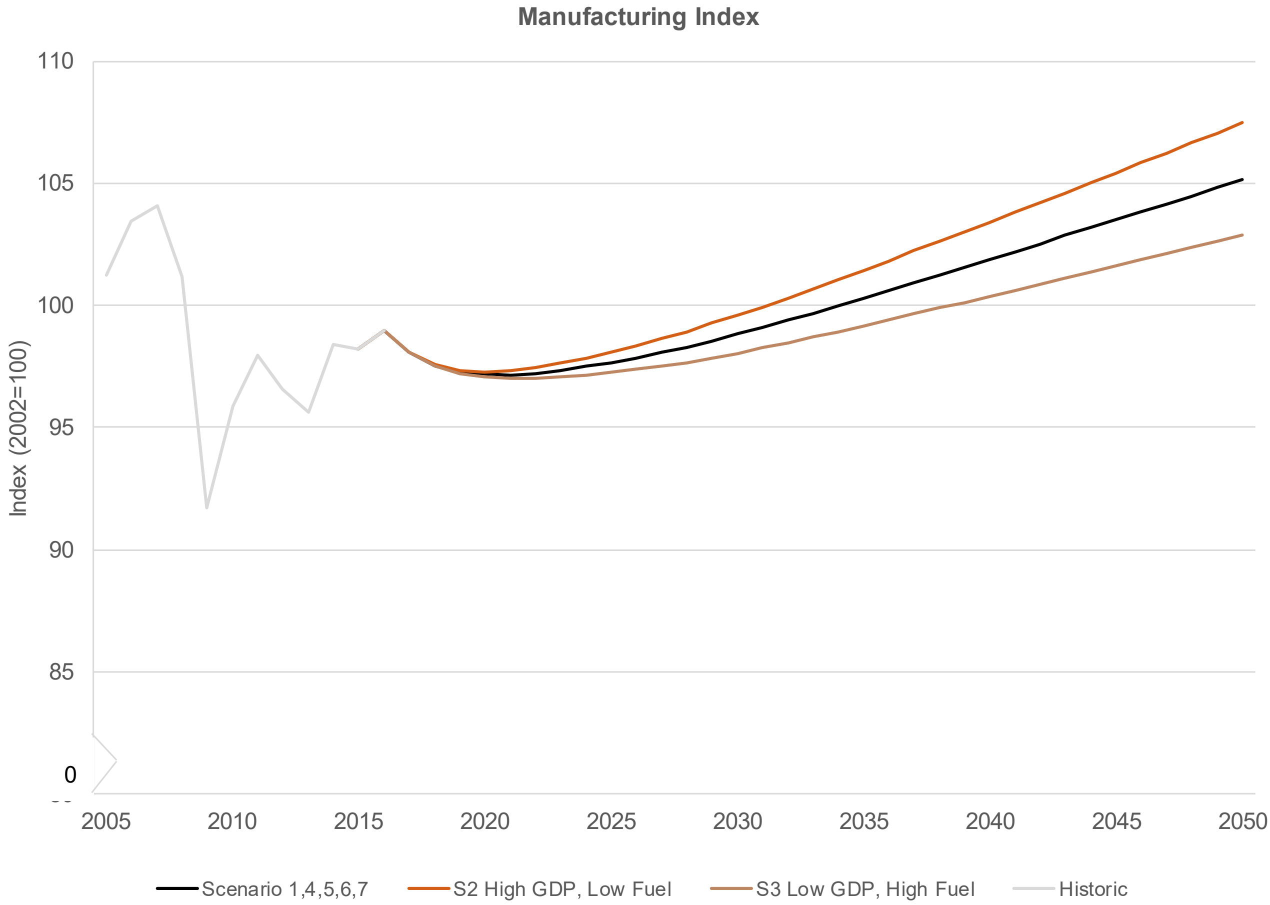

Figure 12 Manufacturing Index (Historic and Forecast)

High Migration & Low Migration (Scenarios 4 & 5) – Context, Assumptions & Inputs

3.27 These scenarios explore the uncertainty around population growth and distribution as well as the relationship between car ownership and income for London.

Population Growth & Density

3.28 Population is another key driver of road traffic demand. As population continues to increase there is a logical link to an increase in the aggregate level of road traffic. Furthermore, the age and distribution of the population impacts on trip rates.

3.29 There has been a steady growth in population over the last 20 years which has increased the overall demand for travel[24]. Population is fed into the model via NTEM. The current version of NTEM uses ONS 2014 population projections.

3.30 Population growth is highly uncertain and difficult to predict. Figure 13 shows how variable ONS population projections have been over the past 50 years and gives an indication of the uncertainty surrounding population growth[25].

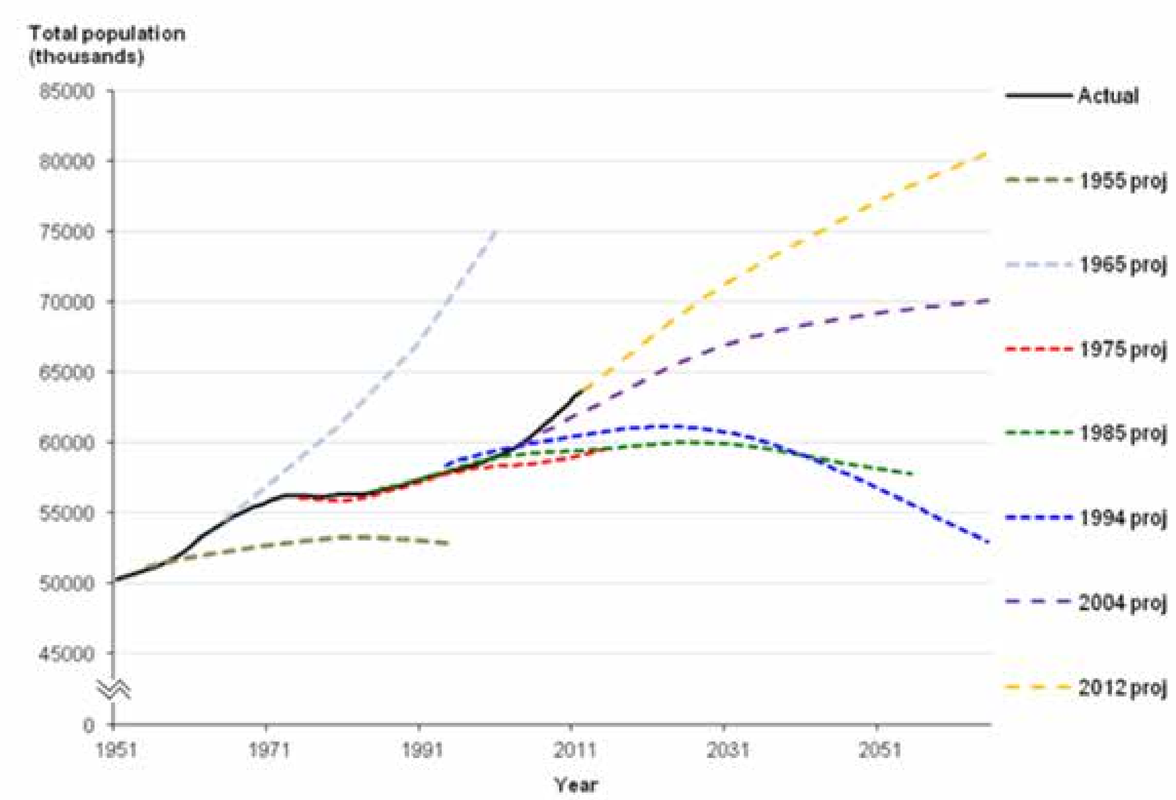

Figure 13: Actual and projected UK population, 1951 to 2065, selected projections by base year (ONS)

3.31 Although there has been a clear upward trend in the UK population and this is expected to continue, the magnitude of this increase is uncertain and influenced by a number of factors such as migration and number of births and deaths. Many of these factors are difficult to predict themselves and can be altered dramatically by unforeseen events. These often result in clear step changes in population growth.

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[24] https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/611304/annual-road-traffic-estimates-2016.pdf

[25] ONS National Population Projections Accuracy Report, 2016

3.32 Population projections become even more uncertain if broken down geographically as other variables such as the number of houses available, availability of jobs and migration between areas have a greater influence at this level. The spatial distribution of population growth is a key factor in traffic growth particularly at regional and local levels.

3.33 The 2015 National Travel Survey showed that those living in rural hamlets and villages travel 90% further than those in urban conurbations[26]. In recent years, there has been a trend towards more people living in urbanised areas where trips are often shorter and public transport more likely to be used, but it is unclear as to whether this trend will continue.

3.34 Modified ONS population projections are embedded within the NTEM dataset[27]. While the spatial and demographic disaggregation of these is critical to producing robust forecasts of traffic, understanding aggregate population changes is important in understanding the overall trend in car use.

3.35 A key driver of road freight is consumer demand for goods[28]. Consumer demand is related to the size of the population and so it is consistent to adjust freight traffic in-line with any population changes.

3.36 Scenarios 4 and 5 use the 2014 ONS high/low migration population variants as a tool for addressing both population growth and distribution uncertainty, allowing for a practical way of manipulating the population between urban and rural areas given migration tends to be focused in urban areas. This allows us to explore the possible impacts of changes to trends regarding urbanisation.

3.37 High Migration (scenario 4) makes the following assumptions:

- An increase in net international migration, in line with the national high migration variant produced by the ONS. This is distributed appropriately to the local authorities with the highest migration to simulate urbanisation[29].
- Decoupling of income to car ownership relationship in London
- HGV and LGV traffic increases in line with regional population assumptions, so freight traffic increases more in urban areas and less in rural areas.

3.38 An increase in population in the model could lead to unrealistically high levels of car ownership in London, where there is traditionally a higher proportion of public transport usage. In order to mitigate this, we have assumed a decoupling of the relationship between income and car ownership in London.

3.39 Decoupling refers to completely removing the link between income and a household's decision to purchase a car, meaning higher income people are no more likely to own a car than people with lower incomes.

3.40 Historically, research has indicated that income levels positively influence road demand but more recent studies are more mixed with some indicating the strength and nature of this relationship may be changing[30]. Although higher income groups still drive significantly more than those with lower incomes, the recent decline in car

[26] Road Traffic Estimates 2016,
[27] http://assets.dft.gov.uk.s3.amazonaws.com/tempro/version7/guidance/ntem-planning-data-guidance.pdf
[28] Riet O, Jong G and Walker W (2007). 'Drivers of Freight Demand and Their Policy Implication'.
[29] ONS only produce high migration projections at the national level while they produce central migration projections at the local authority level. To calculate the regional impact of high migration the national level increase has been distributed appropriately to the local authorities which are projected to have the largest net migration under the ONS central migration projection.
[30] Bastian, Anne, Maria Borjesson and Jonas Eliasson. 2016. "Explaining "peak car" with economic variables." Transportation Research Part A: Policy and Practice 88pp 236-250.

use amongst higher income groups may suggest there are other factors which are offsetting the effect of rising incomes on demand.

3.41 Low Migration (Scenario 5) makes the following assumptions:

- A decrease in net international migration, in line with the national low migration variant produced by the ONS. This decrease has been distributed appropriately to the local authorities with the least migration to simulate de-urbanisation[31].
- HGV and LGV traffic reduces in line with these regional population assumptions, so freight traffic reduces more heavily in urban areas and reduces less heavily in rural areas.

3.42 No assumption has been made in either scenario about how the level of distribution of housing supply could differ from Reference (Scenario 1) in the future.

3.43 Figure 14 shows the location and magnitude of differences in the population from 2016 to 2050 in both High Migration (scenario 4) and Low Migration (scenario 5). It is worth highlighting the assumptions are more or less symmetric given the symmetry of the ONS international migration components of the high and low migration scenarios. As a consequence of increased (reduced) levels of international migration the largest increases (decreases) in population tend to be in urban areas and London specifically.

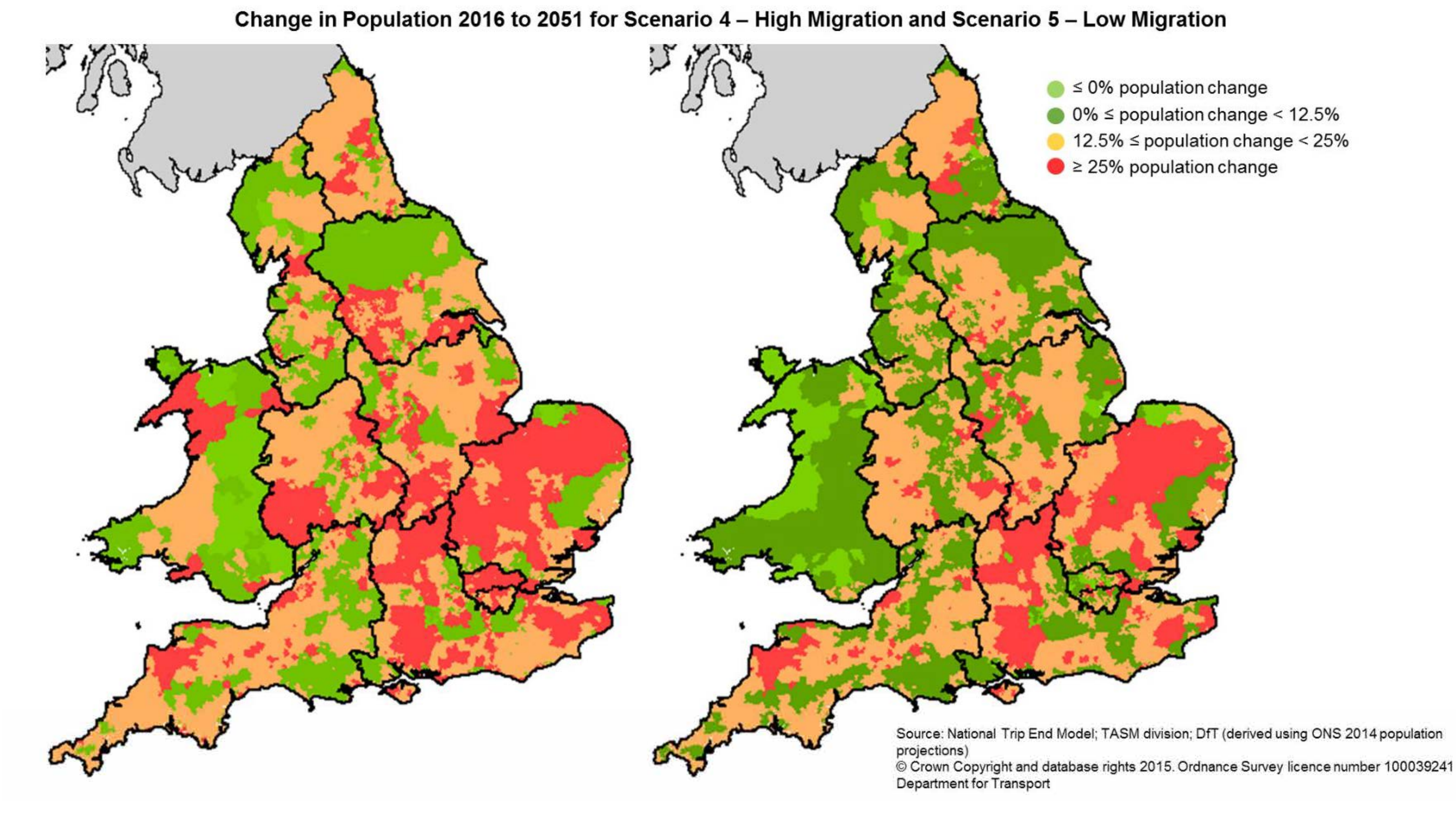

Figure 14: Change in Population for High Migration (left) and Low Migration (right) (2016-2051)

[31] ONS only produce low migration projection at the national level while they produce central migration projection at the local authority level. To calculate the regional impact of low migration the national level increase has been distributed appropriately to the local authorities which are projected to have the smallest net migration under the ONS central migration projections.

Extrapolated Trip Rates (Scenario 6) – Context, Assumptions & Inputs

3.44 This scenario captures uncertainty around trends in both trip rates and licence holding in young people.

Trip Rates

3.45 Trip rates are the average number of trips people make for different journey purposes and thus capture key aspects of travel behaviour. Evidence from the National Travel Survey (NTS) suggests trip rates have been declining over the last 20 years, with a reduction in trip rates of 13% since 2002[32]. Figure 15 shows the national average trips per person across all journey purposes and modes. Figure 16 shows there have been different trends for different trip purposes over the past 20 years, with long downward trends in shopping, visiting friends and commuting and business trips, while average trip rates for holidays have gone up and education has been relatively constant.

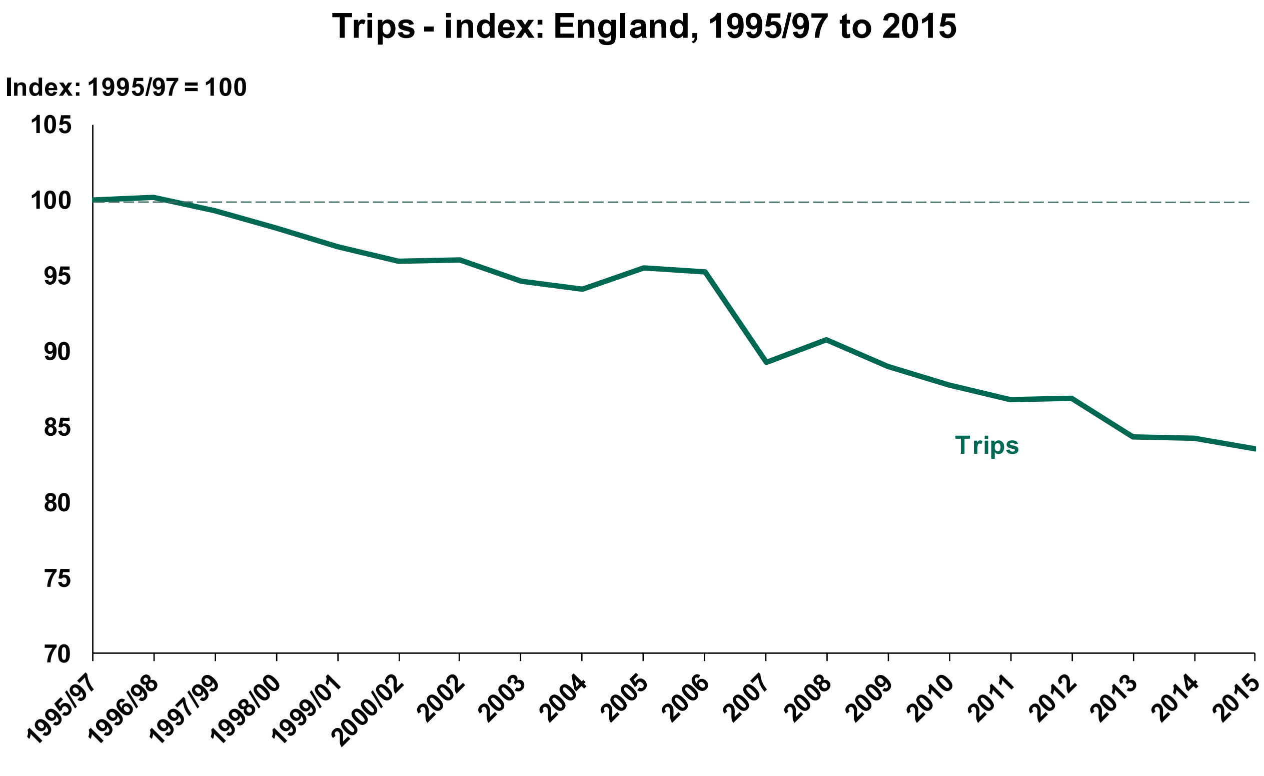

Figure 15: Trips per Person – index[33]

3.46 In 2015, in conjunction with the Independent Transport Commission (ITC), DfT commissioned comprehensive research into the factors that determine today's trip rates and may be influencing trends over time[34]. Based on NTS data the research

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[32] NTS2016, Chart 1A, https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/674568/analysis-from-the-national-travel-survey.pdf

[33] Table NTS0102, https://www.gov.uk/government/statistical-data-sets/nts01-average-number-of-trips-made-and-distance-travelled#table-nts0102

[34] https://www.gov.uk/government/publications/trip-rates-research-for-a-range-of-journey-types

explored factors that influence total trip rates for a range of journey types (commute, business and a range of personal and leisure purposes).

3.47 The research thoroughly investigated the key factors that influence travel behaviour such as age, employment status, gender, area type and car ownership.

3.48 In addition, the research tested the impact of changes in three additional factors: income after housing costs, frequency of internet shopping, and migration. The analysis used contemporary econometric techniques to explore methods and models that could improve estimates of trip rates.

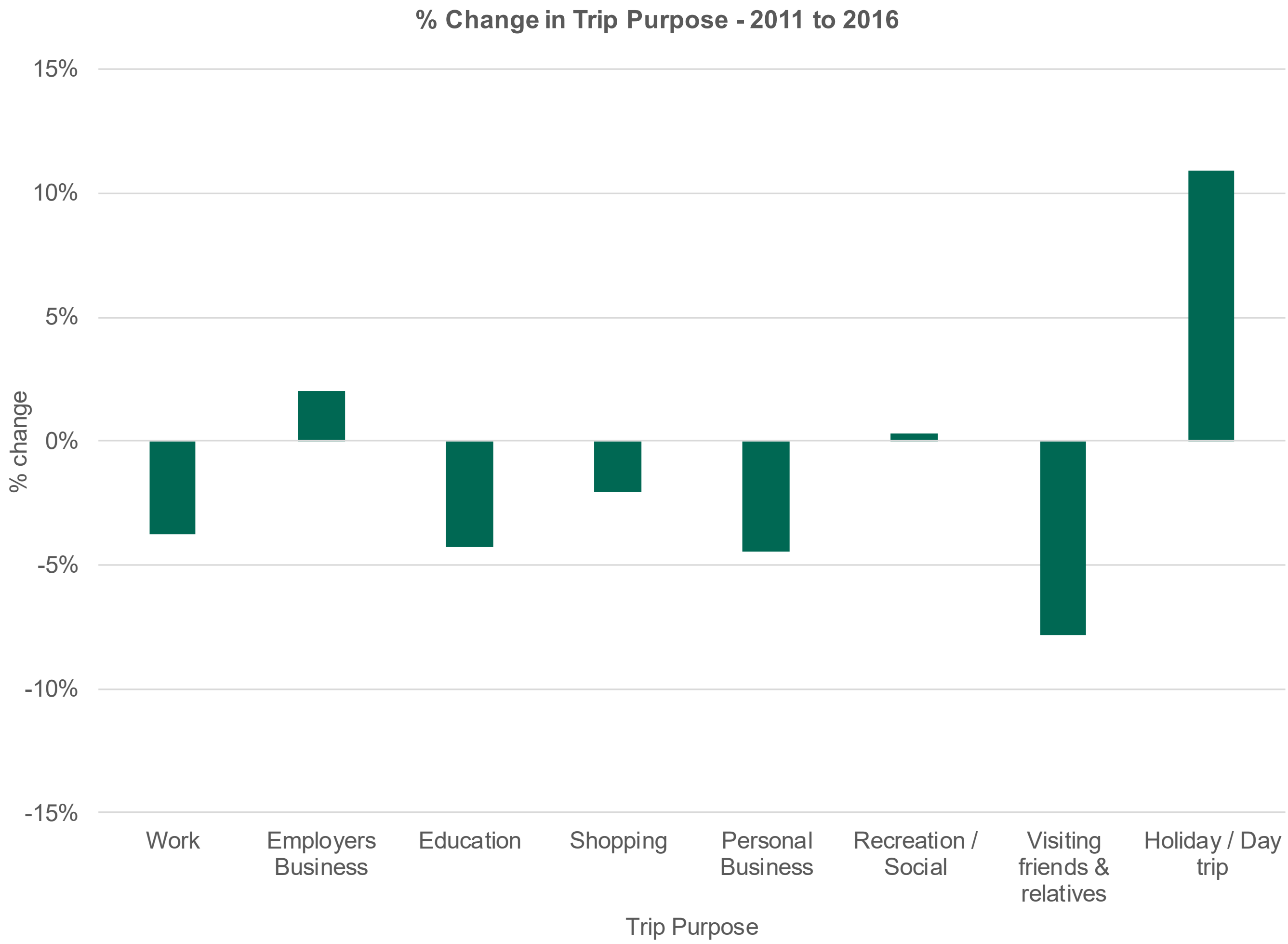

Figure 16: Trips by purpose percentage change between 2011 and 2016 (NTEM)

3.49 The reported changes were complex and varied by mode, journey purpose and distance: rail trips rates had increased, walking trip rates (the shortest of trips) decreased at the fastest rate, and changes in car trip rates varied by distance and area type. Figure 16 shows that work, shopping and visiting trips have reduced between 2011 and 2016, whilst holiday and business trips increased.

3.50 The research allowed the estimates of trip rates to be refined by adding in new factors and delivering improved representation of trip rates for different population segments and different areas of the country. This is a significant step forward in estimating trip rates of today's travellers. However, the research was unable to provide an explanation for the reduction in average trip rates over time, leading to significant uncertainty about the future trajectory of trip rates.

3.51 NTEM7.2 which underpins Scenario 1 assumes that trip rates continue to decline between 2011 and 2016 and that from 2016 trip rate are held constant.

3.52 Extrapolated Trip Rates (scenario 6) recognises the uncertainty in future trip rates and extrapolates this recent trend (2011 to 2016) in trip rates to 2050 to understand how this might impact on traffic growth.

3.53 DfT will continue to monitor the evidence on trip rates in the coming years and monitor the developments of the National Travel Survey aimed at improving the method of collection of data on walking trips, which are believed to be under-represented[35].

Demography

3.54 Road traffic levels are also influenced by a number of demographic variables such as age and gender. The driving population has seen some significant changes over time. For example females are now more likely to hold a licence than they were 20 years ago with the percentage of females that hold a licence increasing at a greater rate than male licence holders[36] (Figure 17).

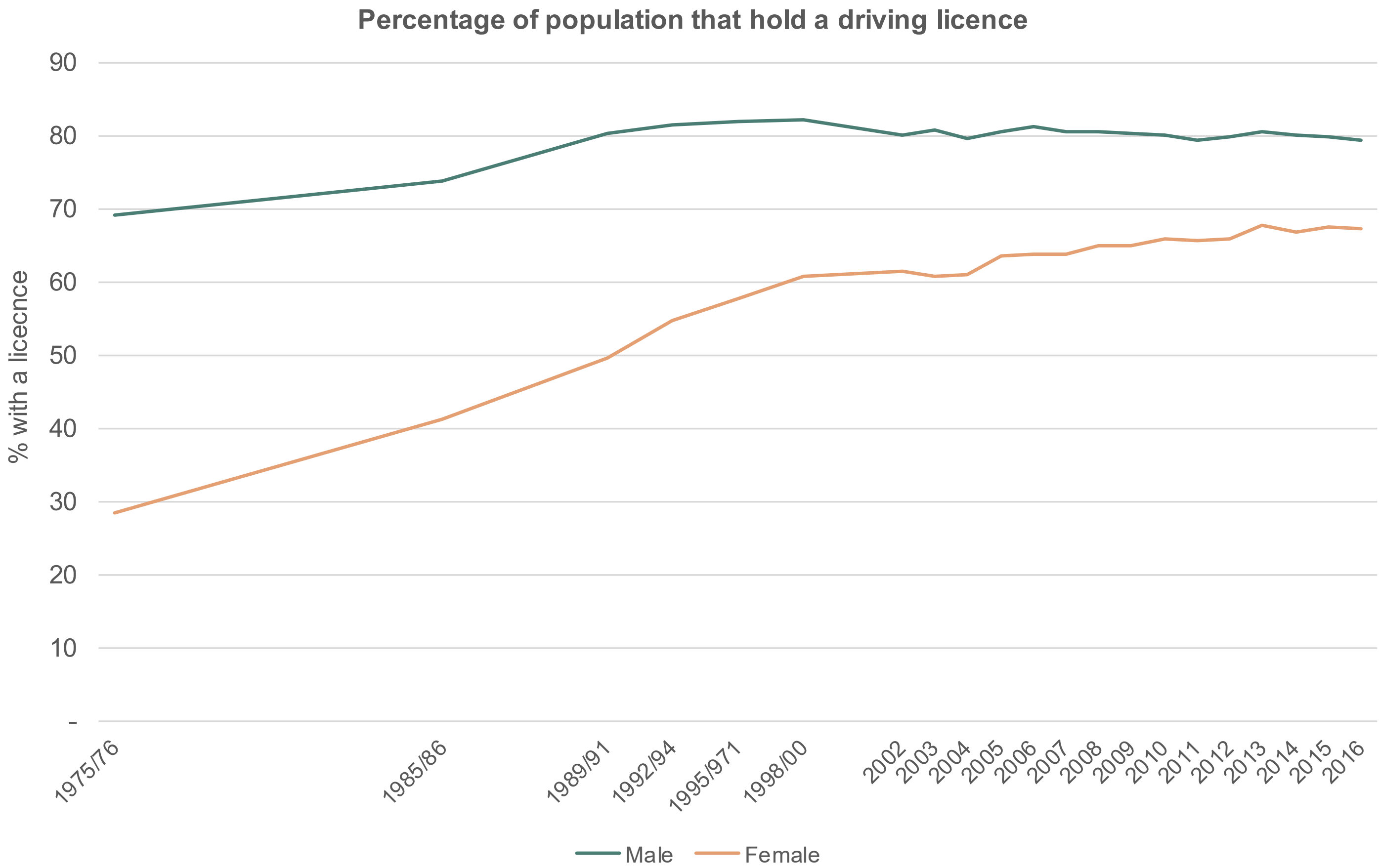

Figure 17 Percentage of Population Holding a Licence (NTS - Table 0201)[37]

3.55 The make-up of the population is important here as well as the different travel behaviours of different age groups and genders. For example given we have an ageing population, changes in travel behaviour of older people could have a significant effect on the road traffic.

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[35] https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/484923/short-walk-weighting.pdf
[36] Road Traffic Estimates 2016, https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/611304/annual-road-traffic-estimates-2016.pdf
[37] https://www.gov.uk/government/statistical-data-sets/nts02-driving-licence-holders#table-nts0201

3.56 Additionally, evidence from NTS data shows younger people (17-20) are now less likely to hold a licence than 20 years ago. A recent DfT study on young people's travel behaviour[38] suggested reduced licence acquisition amongst younger people could have a lasting impact into their later life travel behaviours. The extent to which this trend will continue is unclear and therefore is a significant area of uncertainty for the licence holding assumptions that go into the model.

3.57 Thus for this scenario we have assumed further that young people reduce their licence holding acquisition compared to current levels. We have extrapolated the trend in young people's licence holding up until 2050.

3.58 This has been applied to both males and females in the age cohort between 17 and 29. Note this will have an impact as this cohort ages throughout the forecasts, an example is shown below for females in Inner London but the results will be similar across regions and gender (Figure 18).

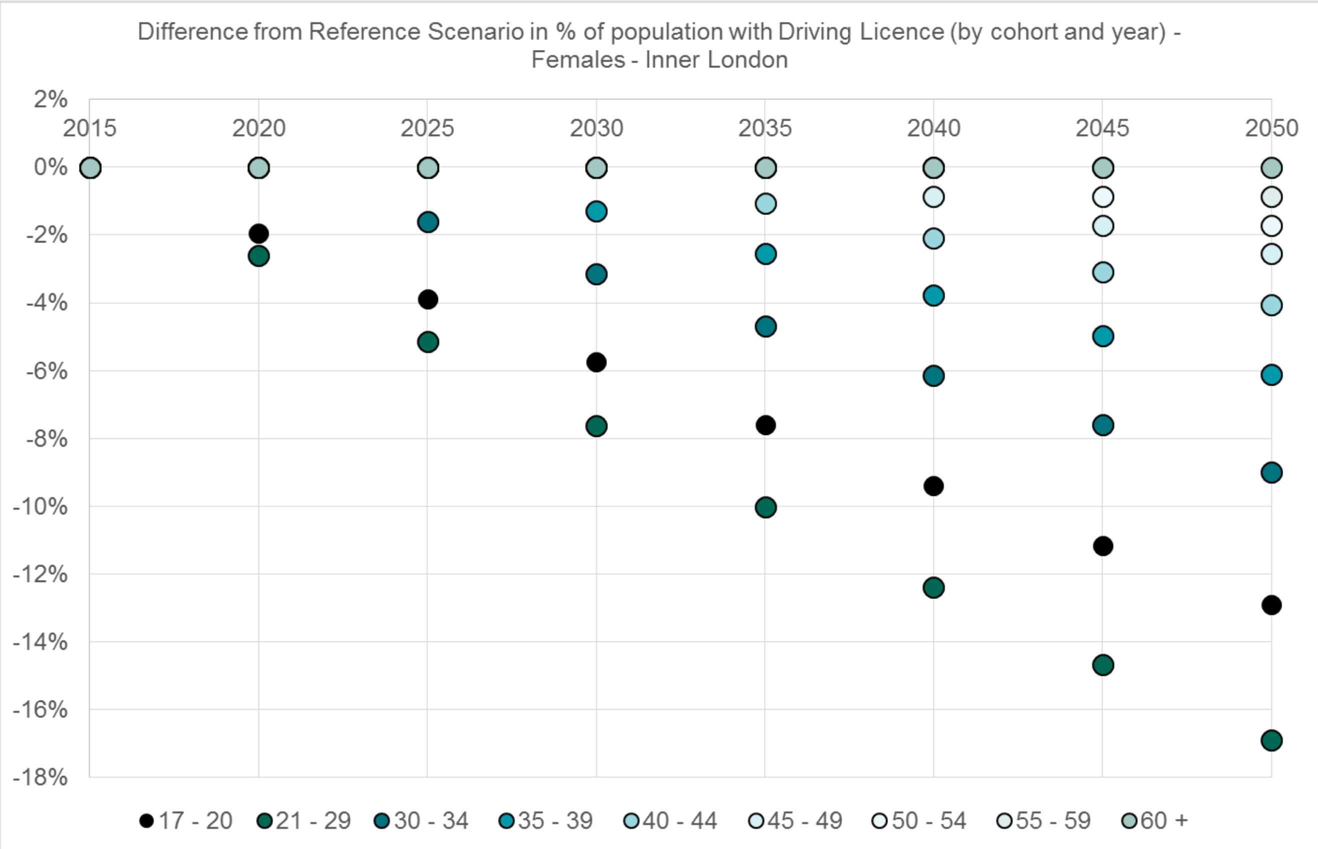


Figure 18: Difference from Reference scenario of population with Driving Licence (Females - Inner London)

[38] https://www.gov.uk/government/publications/young-peoples-travel-whats-changed-and-why

Shift to Zero Emission Vehicles (ZEVs) (Scenario 7) – Context, Assumptions & Inputs

3.59 This scenario forecasts demand and emissions based on a fast uptake rate for zero emission vehicles (ZEVs), for cars and LGVs.

3.60 Currently ULEVs makeup only around 0.4% of cars and LGVs in the UK. In scenarios 1-6 this is assumed to rise, so that by 2050 25% of miles are travelled by ZEVs. For this scenario we assume 100% of sales of cars and LGVs are zero emission by 2040, resulting in approximately 97% of miles travelled by ZEVs by 2050. Figure 19 shows how the fuel composition for cars is forecast to change over time in this scenario. The HGV fleet is assumed to remain powered by diesel.

3.61 The shift to zero emission vehicles is modelled assuming that all of these are electric vehicles. In reality there could be a mix of technologies, including for instance hydrogen vehicles. The decision to model this using electric vehicles reflects better data availability on electric vehicle performance.

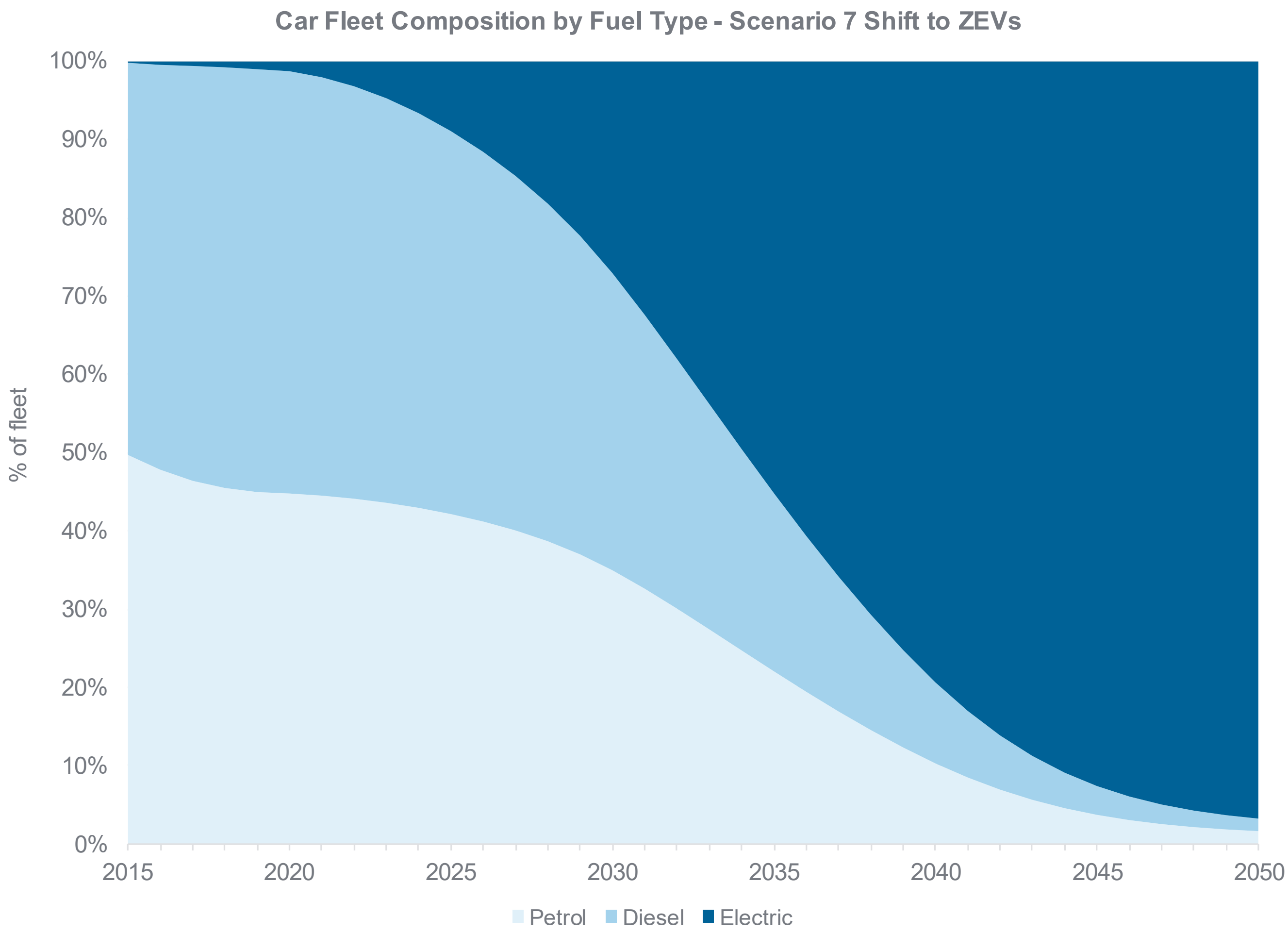


Figure 19: Car Mileage Splits by Fuel Types for S7 Shift to ZEVs

3.62 The NTM considers the average fuel cost of a car across petrol, diesel and electric. As a result of this increased take-up, fuel costs decline by approximately 63% in this scenario by 2050 for cars, whilst for LGVs, the average fuel cost decreases by approximately 53%. There are no assumed changes to government policy (e.g. tax changes on electricity).

Trips (All Scenarios)

3.63 The relevant assumptions for each scenario (trip rates and inputs relating to car ownership such as GDP and population - see Figure 1) have been fed into NTEM to produce trip forecasts for the NTM. The impact of each scenario on forecast numbers of trips is shown below in Table 2, the range in trips across the scenarios is approximately 35 percentage points by 2050. Note that Shift to ZEVs (scenario 7) has the same number of trips as the reference scenario.

3.64 High GDP, Low Fuel (scenario 2) and Low GDP, High Fuel (scenario 3) show a similar number of trips to each other and the reference scenario. Although GDP feeds into NTEM through the car ownership model, the main impact of different GDP assumptions is on traffic levels as a result of changes in mode of travel and trip distance in the NTM itself. The Extrapolated Trip Rates scenario shows a decline in the total number of trips with approximately 11% fewer trips in 2050 than in 2015.

Scenario	**Growth in Trips (relative to 2016)**						
	2021	2026	2031	2036	2041	2046	2051
Reference	4%	6%	9%	11%	14%	16%	19%
High GDP, Low Fuel	4%	7%	9%	12%	14%	17%	19%
Low GDP, High Fuel	4%	6%	9%	11%	14%	16%	19%
High Migration	4%	8%	11%	14%	17%	21%	24%
Low Migration	3%	5%	7%	9%	10%	12%	14%
Extrapolated Trip Rates	-1%	-3%	-5%	-7%	-9%	-10%	-11%
Shift to ZEVs	4%	6%	9%	11%	14%	16%	19%

Table 2: Growth in Forecasted Trips (total)

3.65 Growth in trips and population largely mirror each other (see Figure 20 and Figure 21), showing the strong relationship between size of the population and number of trips. Figure 20 shows the highest growth rate between 2016-2021, declining growth rates until 2036 and similar rates thereafter.

3.66 Average car trip distances vary across the scenarios with Extrapolated Trip Rates showing the most growth out to 2050 (see Figure 27 in section 4) due to the change in the distribution of trips over time. Costs of driving impact on distances for car trips, shown with the shortest car trip distances in the Low GDP, High Fuel scenario.

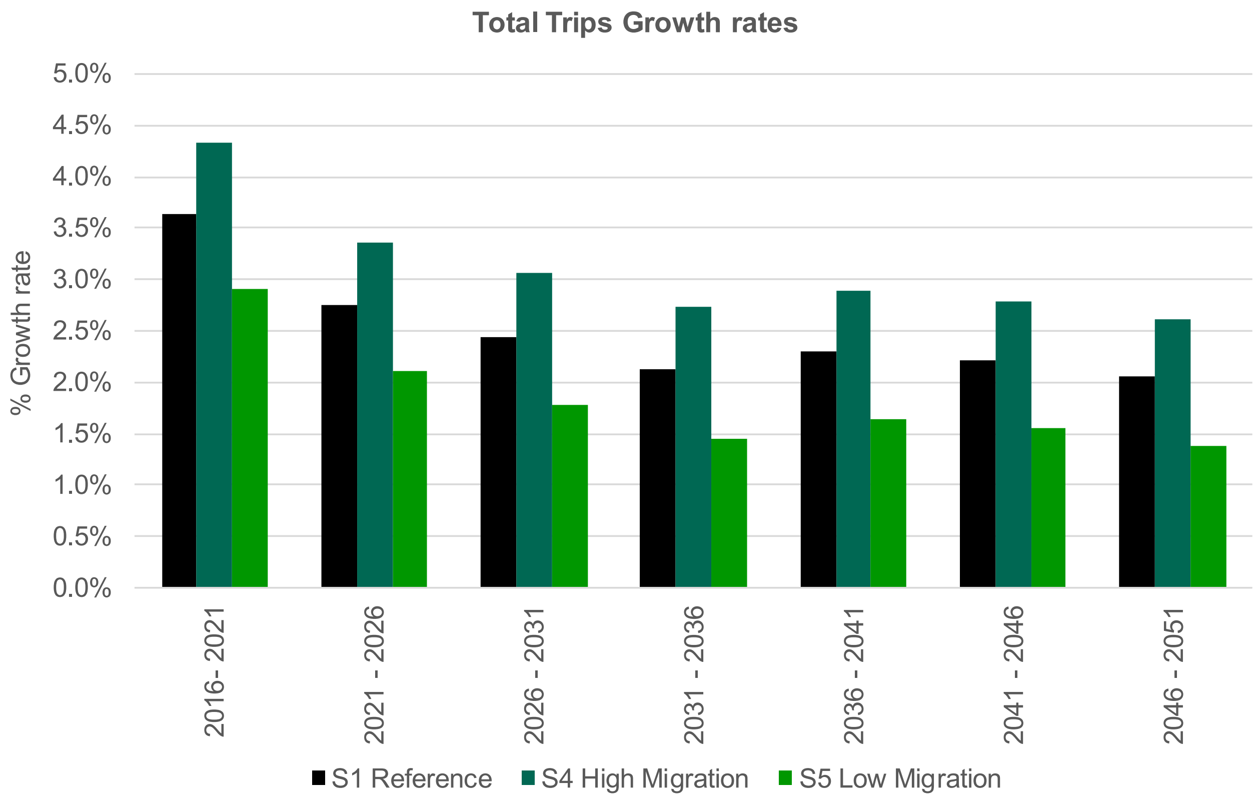


Figure 20: Trip Growth Rates

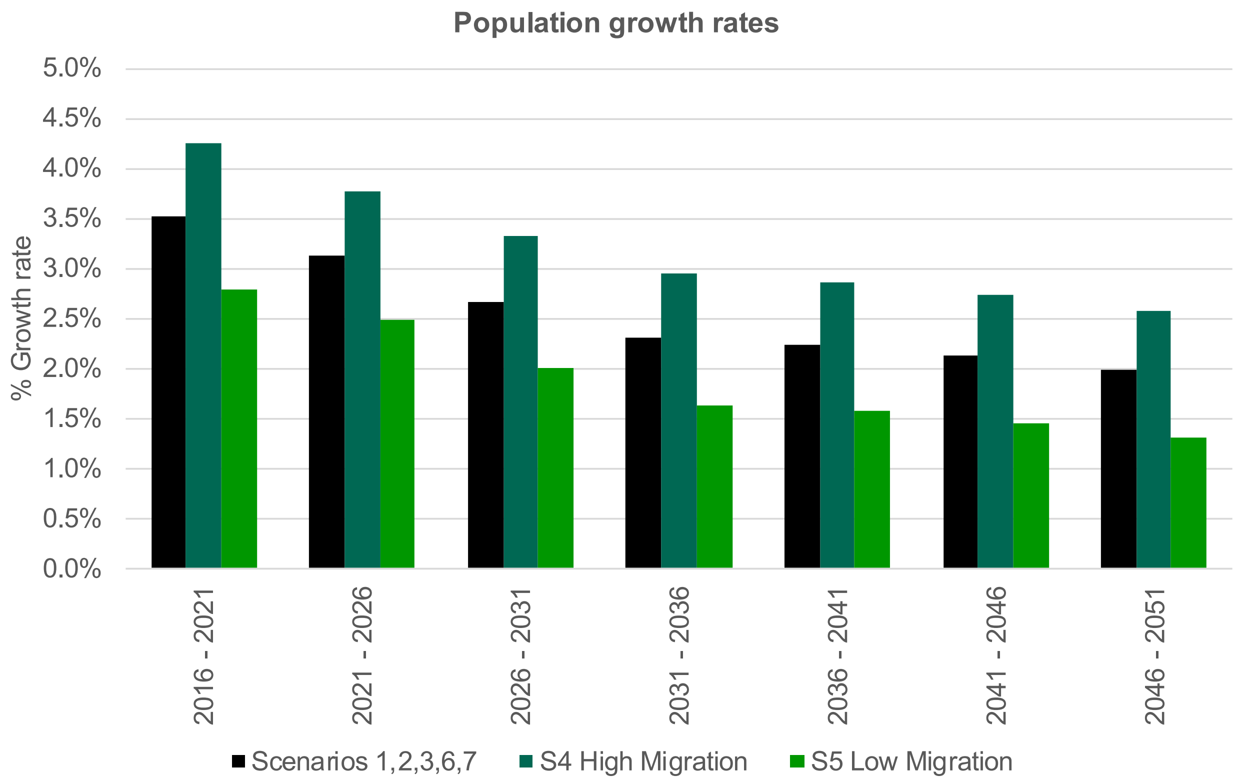


Figure 21 Population Growth Rates

Car Ownership (All Scenarios)

3.67 Car ownership in England and Wales is forecast to grow from approximately 29m in 2015 to between 38m and 42m in 2050, which equates to growth of between 30% and 45% over 35 years (Figure 22).

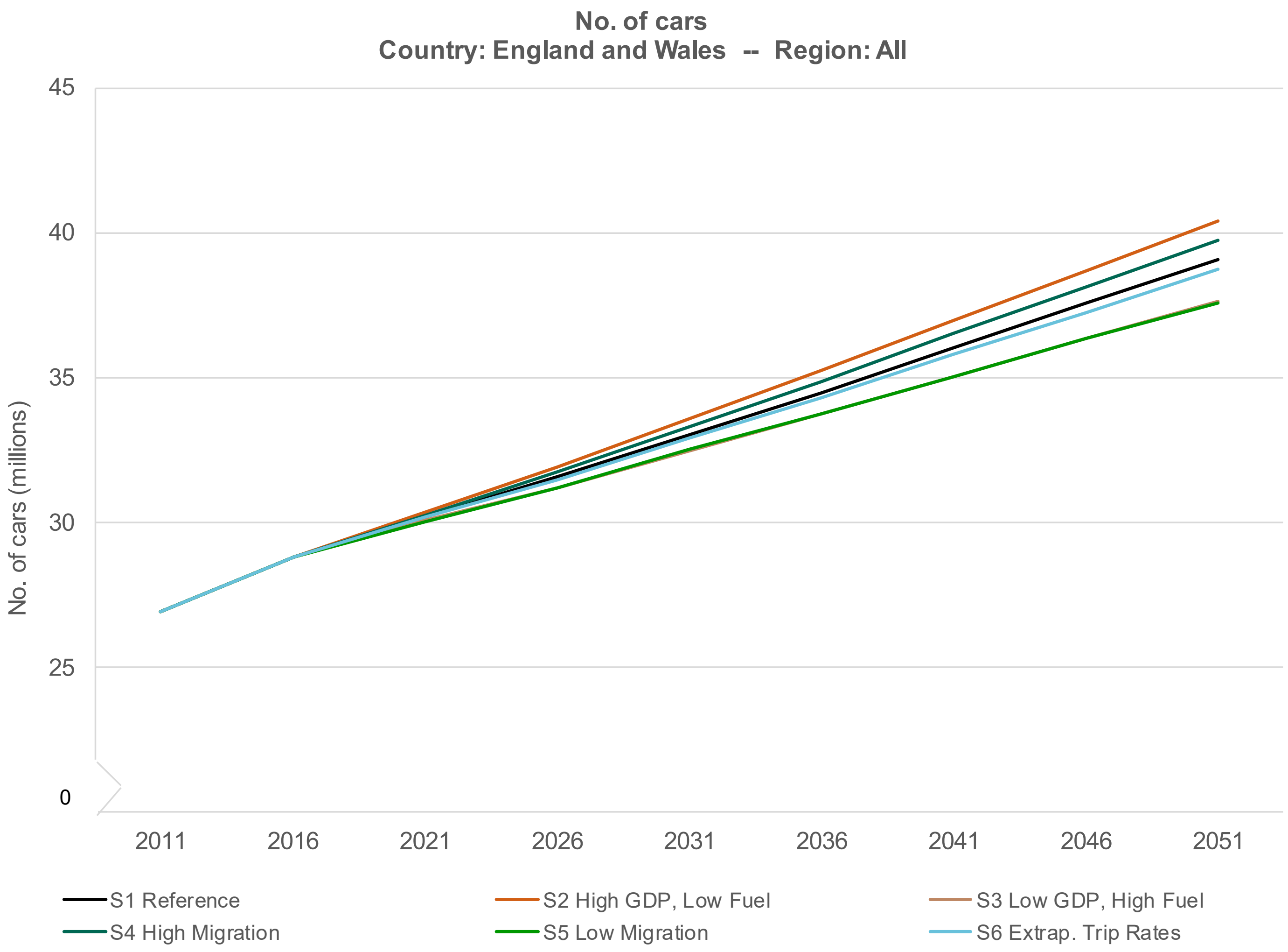


Figure 22: Car Ownership Forecast (NATCOP)

3.68 This has been driven by forecast increases in GDP, employment and population. Figure 23 shows that by 2051 households owning 1, 2 and 3+ cars increase in all scenarios from the 2015 base year. There are only relatively minor changes to the number of zero car households forecast, although in some scenarios there is a decrease. These changes are caused by changes in GDP and employment, as the population becomes more affluent and households effectively transition to having access to a greater number of cars.

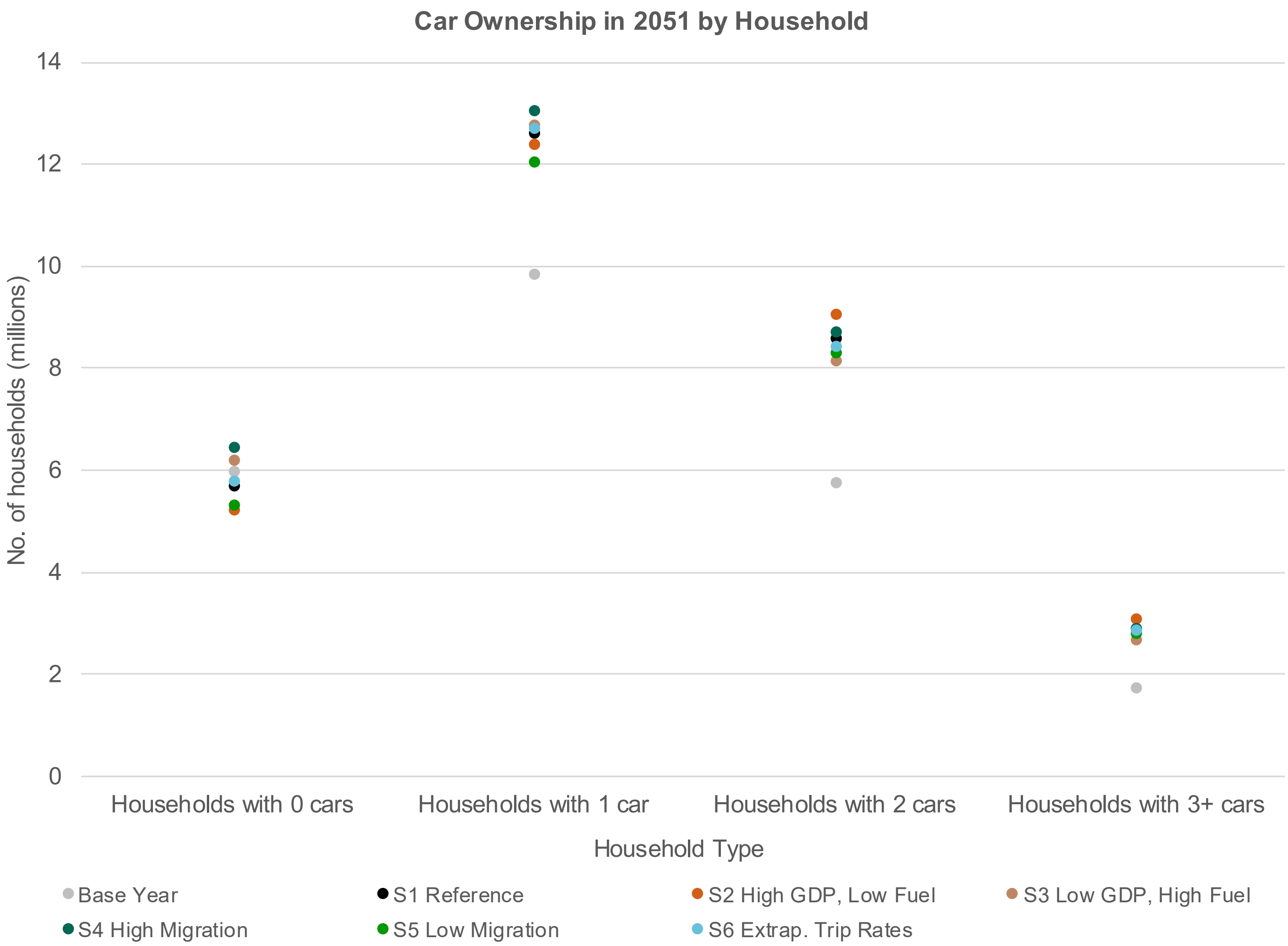


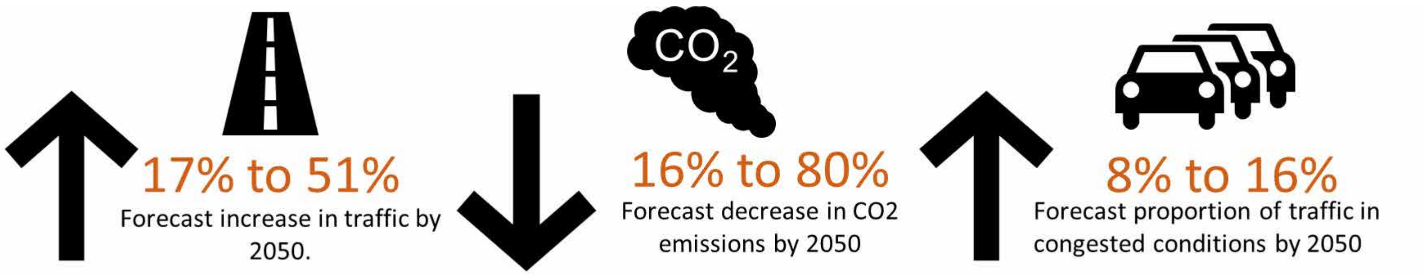
Figure 23: Car Ownership Forecast in 2051 by Household Type

4. Summary of Results

Summary

4.1 Traffic in England and Wales is forecast to increase in all our scenarios, but the size of growth varies.

- From 2015 traffic is forecast to grow between 17% and 51% by 2050.
- CO2 emissions from road transport are forecast to fall by between 16% and 80% by 2050.
- The proportion of traffic in congested conditions is forecast to increase from a level of 7% in 2015 to between 8% and 16% by 2050.



What Drives the Growth?

4.2 The growth in national traffic levels is predominantly driven by projected growth in population levels (and thus the number of trips) and changes to vehicle running costs. Extrapolated Trip Rates (scenario 6) shows lowest forecast growth with 17% by 2050.The highest forecast growth of 51% by 2050 is seen in Shift to ZEVs (scenario 7).

4.3 Figure 24 shows the actual growth rate (5-yearly) back to 2000 compared with the forecast growth rates in the forecasts. In the reference scenario, growth in traffic is higher in earlier years and then declines over time. The biggest growth (approx. 7%) can be seen between 2015 and 2020 before broadly levelling off from 2025 until 2035 and then declining.

4.4 This larger increase in earlier years is driven by strong growth in some key inputs. In particular there is higher growth in trips between 2016 and 2021 compared with later years (see Figure 20 in section 3) this is driven by projected increases in population growth rates (see Figure 21 in section 3) and car ownership. Furthermore there is a bigger decline in fuel costs between 2015 and 2020 than in later years, this is driven by fuel efficiency improvements.

4.5 With the exception of the period in the immediate aftermath of the 2008 financial crisis, our scenario forecasts are broadly in line with these historical growth rates (see Figure 24).

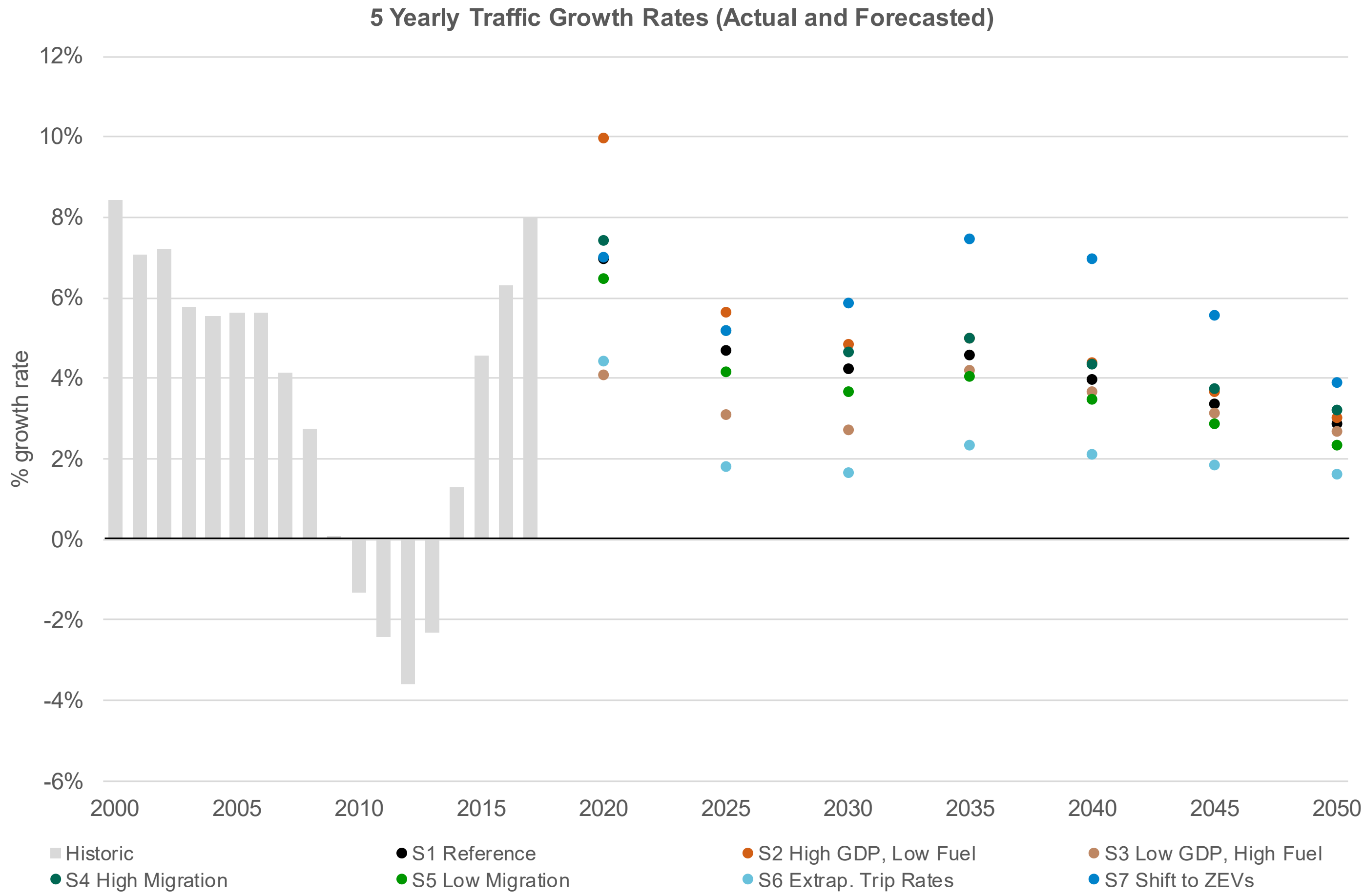


Figure 24: 5 Yearly Traffic Growth Rates (Historic & Forecast)

4.6 Increased growth is partly driven by the low running costs of increased numbers of ULEVs in the car and van fleets. This is most evident in Shift to ZEVs (scenario 7) where the growth rates are strongest as ULEVs become a larger part of the fleet.

Comparisons with RTF15

4.7 For the purposes of comparing these results with RTF15, the focus has been on comparing the reference scenario from RTF18 and scenario 1 from RTF15 given these are the scenarios with most comparable assumptions.

4.8 At the aggregate level, traffic forecasts (vehicle miles) in RTF18 are approximately 6% lower than RTF15 in 2040. Decreases relative to RTF15 have largely been a result of recalibrating the model to a base year of 2015 and lower projected growth to key inputs such as GDP and population.

- Slight declines of approximately 5% can be seen in car traffic.
- Differences in LGV traffic change over time growing from a small increase of 2% in 2020 to a decrease of 10% in 2040. This is partially due to lower forecast of GDP and higher forecast of fuel costs compared to RTF15.
- HGV traffic as a whole shows a decrease of 12% by 2040. This is partially due to a lower forecast of the manufacturing index.

4.9 When comparing the forecasts across road type, RTF18 forecasts approximately 5% more traffic on motorways than in RTF15, but a reduction in growth on all other road types. An increase in the forecast of motorway traffic seems reasonable given past under-forecasting (see section 2). Trunk roads see a 12% decrease (again reasonable given findings in section 2), principal roads see a 7% decrease and minor roads a 10% decrease.

4.10 CO2 emissions forecasts are greater for RTF18 in earlier years compared to RTF15. This is largely due to the recalibration of emissions to more recent outturn data. Fuel efficiency assumptions have also been updated to better reflect the gap between test cycle and real world emissions which will cause some variation particularly in earlier years.

4.11 In RTF18 CO2 emissions continue to decline over time whereas in RTF15 post 2030 emissions began to rise in line with traffic. This is due to the inclusion of a higher proportion of ULEVs after 2030 which outweighs the impact of increasing traffic.

4.12 In line with the traffic forecast, congestion forecasts have declined relative to RTF15 with the percentage of vehicles in congested conditions in 2040 falling from between 8% and 17% in RTF15 to between 7% and 12% in RTF18.

4.13 The NTM’s response to GDP has changed since RTF15. The previous version of the model took account of non-fuel vehicle operating costs (VOCs) for all journeys. The new assumption, aligned with WebTAG, is that these costs are only perceived during work time. As GDP affects travel through the monetary component of travel costs, and this component has decreased, the sensitivity of car travel to GDP has diminished since RTF15.

4.14 The range in growth across the scenarios is similar (34 percentage points in RTF18 compared with 36 percentage points in RTF15). We recognise there is additional uncertainty around the impact of technology on road traffic which is discussed in section 5.

Results

4.15 This section outlines the results of the Road Traffic Forecasts in more detail looking at all key outputs for traffic, emissions and congestion broken down in different ways. For more breakdowns, please view the Road Traffic Forecasts 2018 Visualisation Tool at http://maps.dft.gov.uk/rtf18-vis.

Traffic

4.16 The forecasts show an overall upward trend in traffic levels (Figure 25). The range of traffic growth forecast is 17% to 51% between 2015 and 2050 with vehicle miles ranging from 340Bvm to 430Bvm. Extrapolated Trip Rates (scenario 6) shows the lowest growth with the declining trip rates suppressing the rate of growth but increases in trip distance and total population generating an overall increase in car miles. Shift to ZEVs (scenario 7) shows the highest growth due to the effective low fuel cost in the scenario.

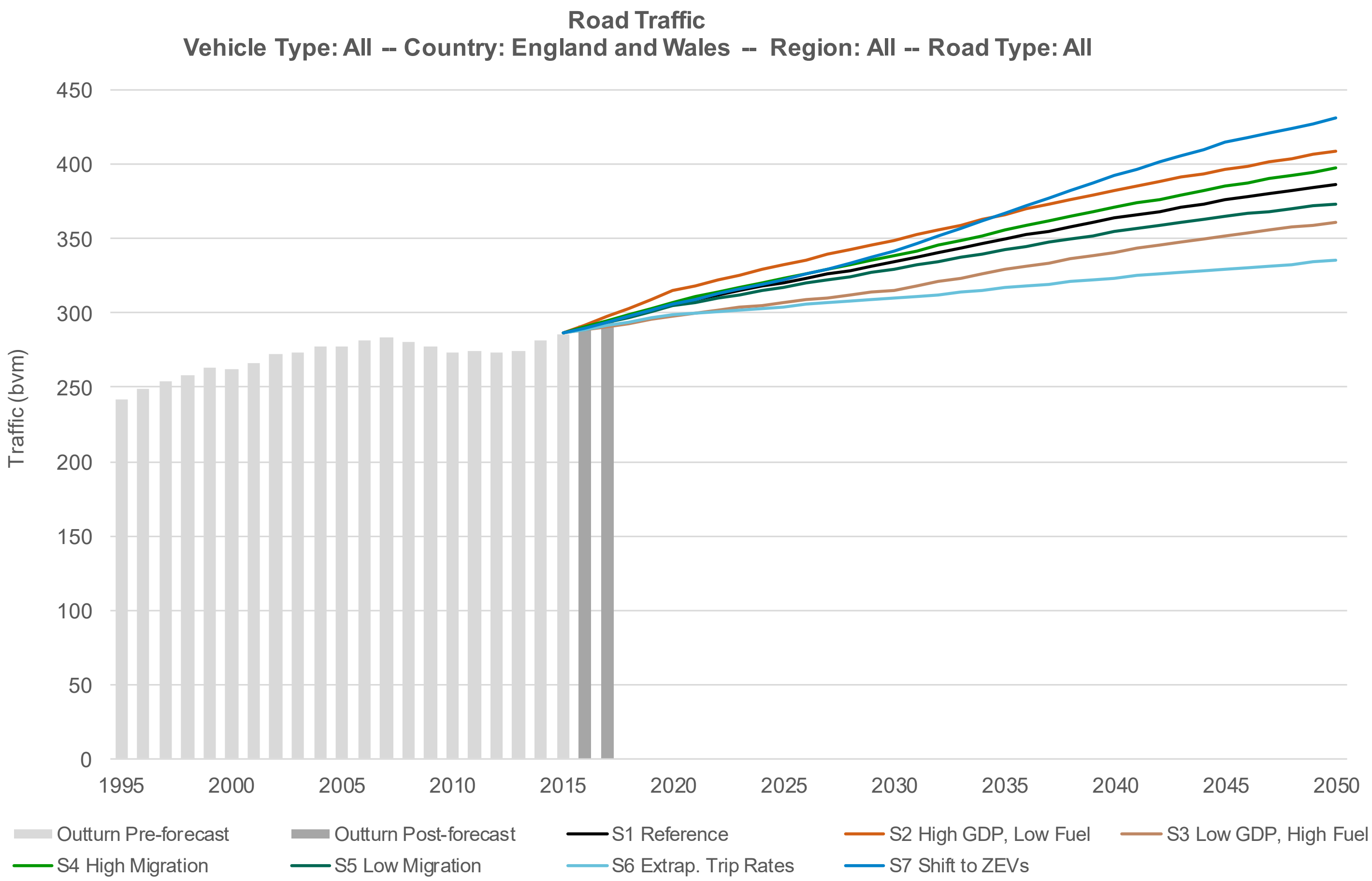


Figure 25: Vehicle miles forecasts for England & Wales

4.17 High GDP, Low Fuel and Low GDP, High Fuel forecasts show a wider range of uncertainty compared to the population based scenarios. The impact on road traffic demand in these scenarios is dominated by the impact of fuel costs, which impact trip distances and the total cost of driving causing switching to or from other modes.

Scenario	Traffic Growth (2015-2050)
1 - Reference	35%
2 - High GDP, Low Fuel	43%
3- Low GDP, High Fuel	26%
4 - High Migration	39%
5 - Low Migration	31%
6 - Extrapolated Trip Rates	17%
7 - Shift to ZEVs	51%

Table 3: Traffic Growth for England & Wales (2050)

Vehicle Type

4.18 Car traffic is forecast to grow between 11% and 43% by 2050 (Figure 26), whilst LGVs are forecast to continue growing significantly in all scenarios (between 23% and 108%). The strong growth predicted for LGV traffic (Figure 28) means even when car traffic growth is at its lowest level (11% by 2050) in Extrapolated Trip Rates (scenario 6), overall traffic growth is 17% with LGV traffic accounting for 19% of traffic, up from 15% in 2015. HGV traffic growth is forecast to be lower than other vehicle types, with growth ranging from 5% to 12% by 2050 (Figure 29).

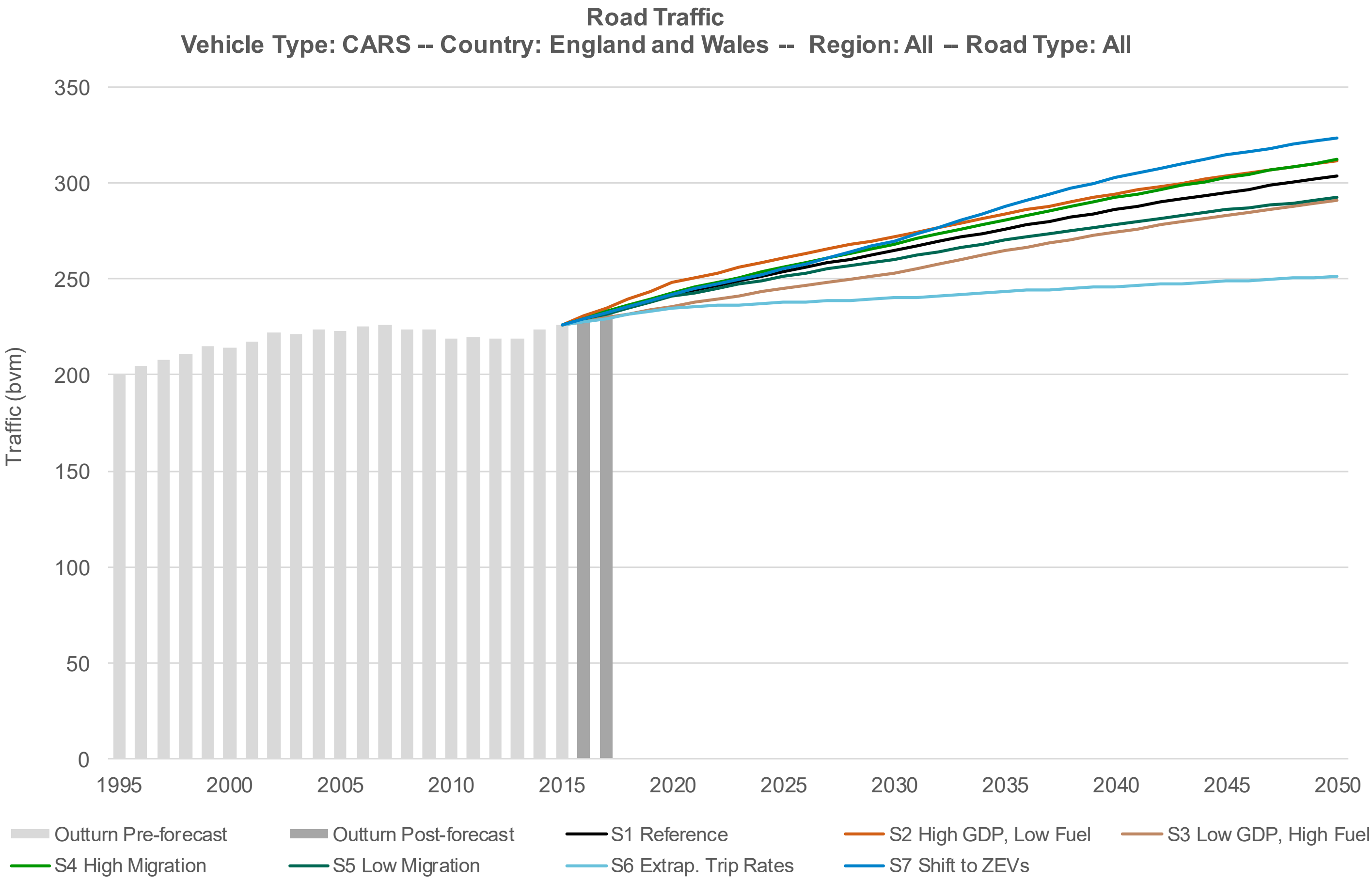


Figure 26: Car vehicle miles forecasts for England & Wales

4.19 Average car trip distances are increasing across all scenarios due to falls in vehicle running costs. The cost impacts on average car trip distances can clearly be seen as shorter trip distances can be found in Low GDP, High Fuel Scenario (Scenario 3) where running costs are more expensive and longer trip distances can be seen in Shift to ZEVs (Scenario 7) and High GDP, Low Fuel (Scenario 2) where running costs are cheaper. Extrapolated Trip Rates (Scenario 6) shows the most growth out to 2050 (see Figure 29) due to the change in the distribution of trip purposes over time. In particular in this scenario while many trip purposes decrease, trip purposes that are normally associated with longer trips such as holiday trips increase.

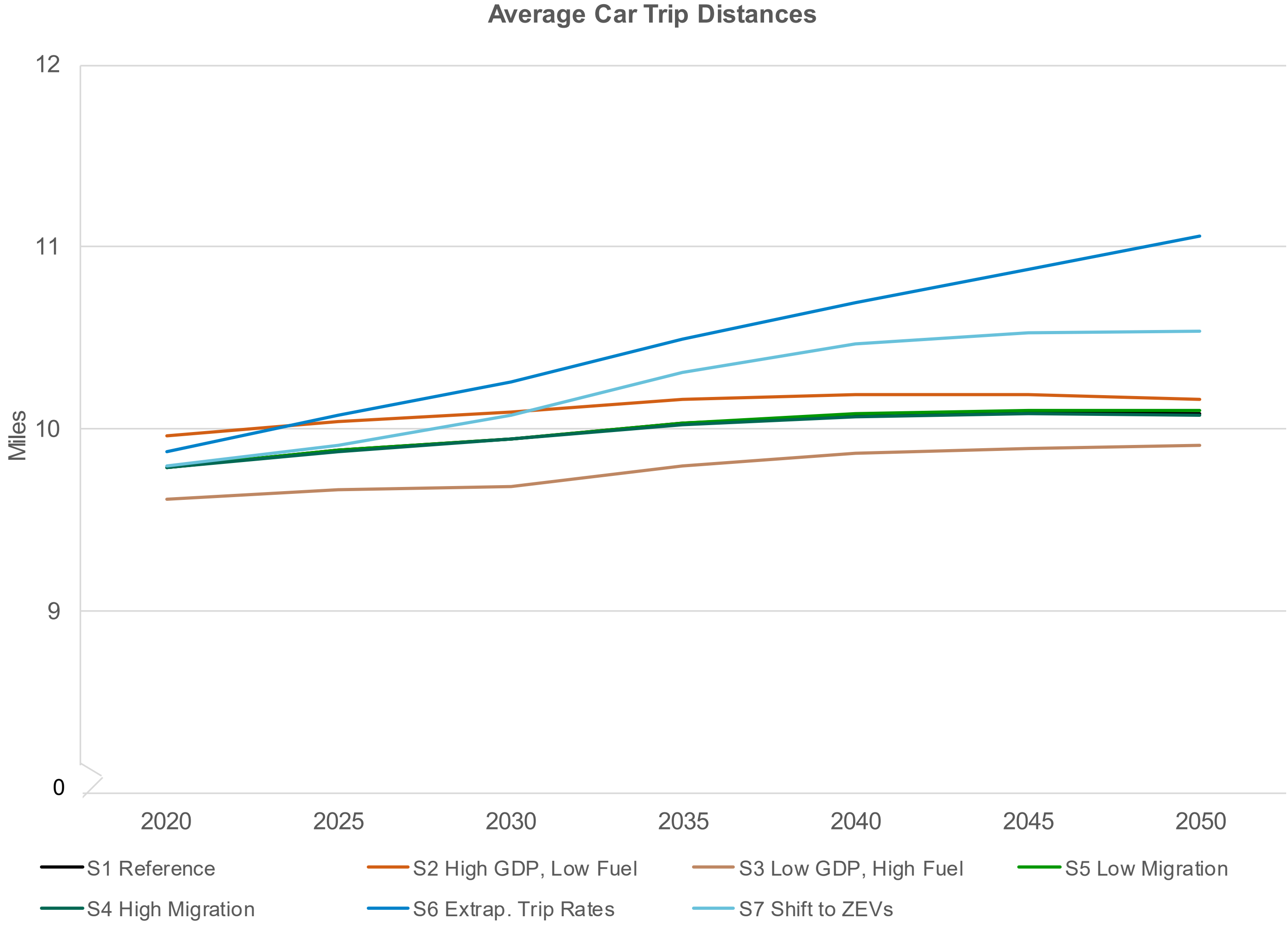


Figure 27: Average Car Trip Distance

4.20 Cars are the dominant mode of road transport and are forecast to remain so.

- Cars made up approximately 79% of traffic in 2015 and are forecast to make up between 75% and 81% of traffic mileage by 2050.
- LGVs made up approximately 15% of traffic in 2015 and this is forecast to be in the range 14% to 21% by 2050.
- HGVs made up approximately 5% of traffic in 2015 and this is forecast to be similar in 2050, between 4% and 5% depending on the scenario.

4.21 The HGV and LGV forecasts are unaffected by the trip rates assumption in Extrapolated Trip Rates (scenario 6) as this only relates to personal travel.

4.22 Long term growth of LGVs in the model is driven by forecast GDP growth and fuel cost assumptions in all scenarios, but particularly by fuel costs in Shift to ZEVs (scenario 7) where a high level of ZEVs are forecast to enter the fleet.

4.23 LGV traffic has seen significant growth of approximately 67% over the last 20 years, following changes in the economy closely.[39] This relationship is represented in the analysis where High GDP, Low Fuel (scenario 2) and Low GDP, High Fuel (scenario 3) forecast the most (51%) and least (10%) growth respectively by 2035.

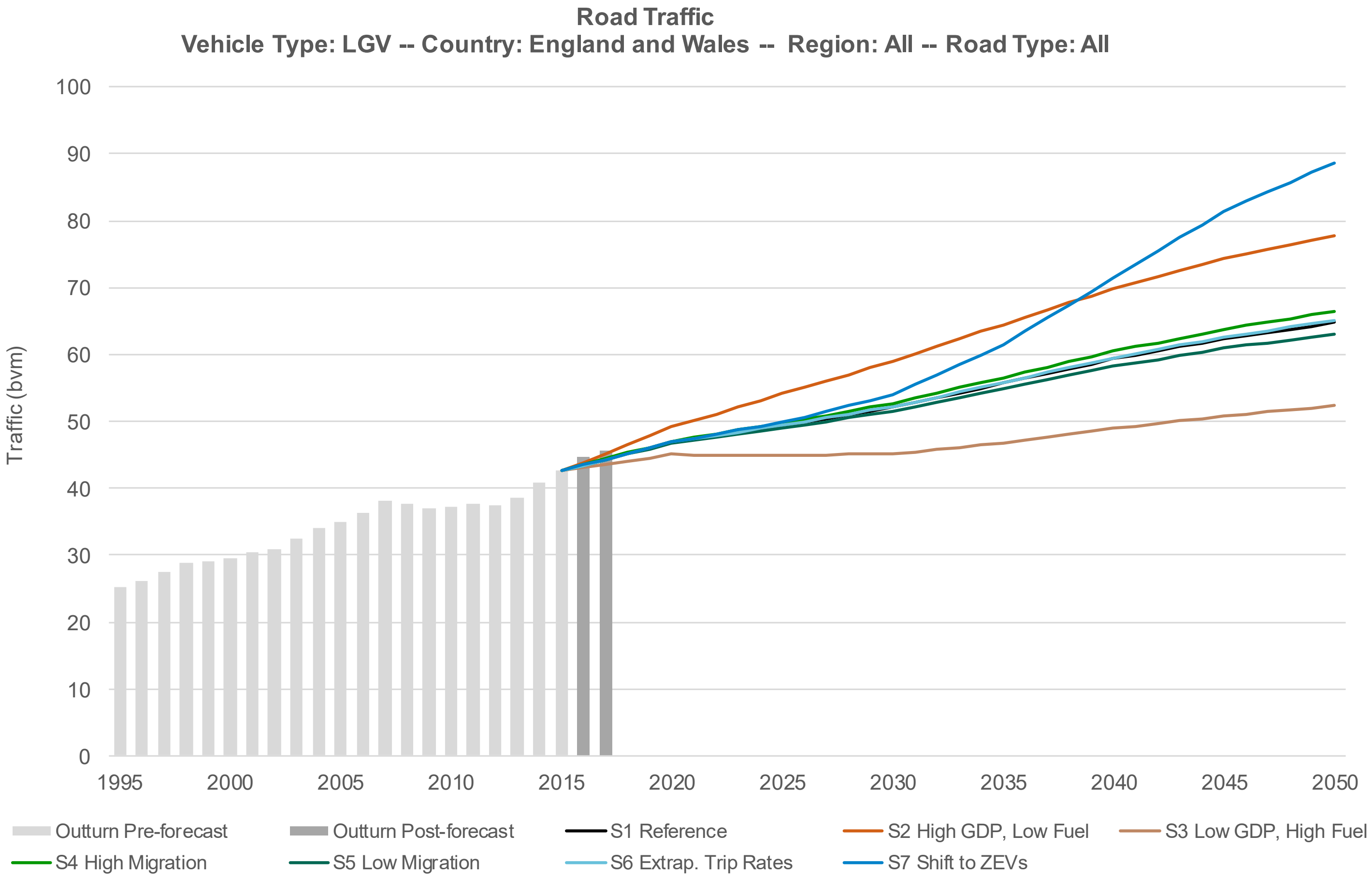


Figure 28: LGV vehicle mile forecasts for England & Wales

4.24 The HGV forecasts have the smallest forecast range of any vehicle type, however this does not imply greater certainty in the forecast. Whilst growth in HGV traffic has been relatively flat over the last few years and is forecast to remain so, other factors such as the split between articulated and rigid vehicles[40], distribution of freight centres and external factors affecting demand for goods could have a significant impact on HGV traffic.

4.25 Greatest growth in HGV traffic is expected on motorways where growth by 2050 is forecast to be between 9% and 18%. Total vehicle miles travelled by HGVs are forecast to be 12% lower in 2040 when comparing the reference scenario in RTF18 with scenario 1 from RTF15 (Figure 29). This is driven by the manufacturing index forecasts which, as discussed in section 3, have been updated since RTF15.

[39] https://www.gov.uk/government/statistics/road-traffic-estimates-in-great-britain-2017

[40] Articulated HGVs tend to be heavier with more axles. They also have a semi-trailer that is attached to the front of the HGV. Rigid HGVs tend to be lighter with less axles and will have a single rigid chassis.

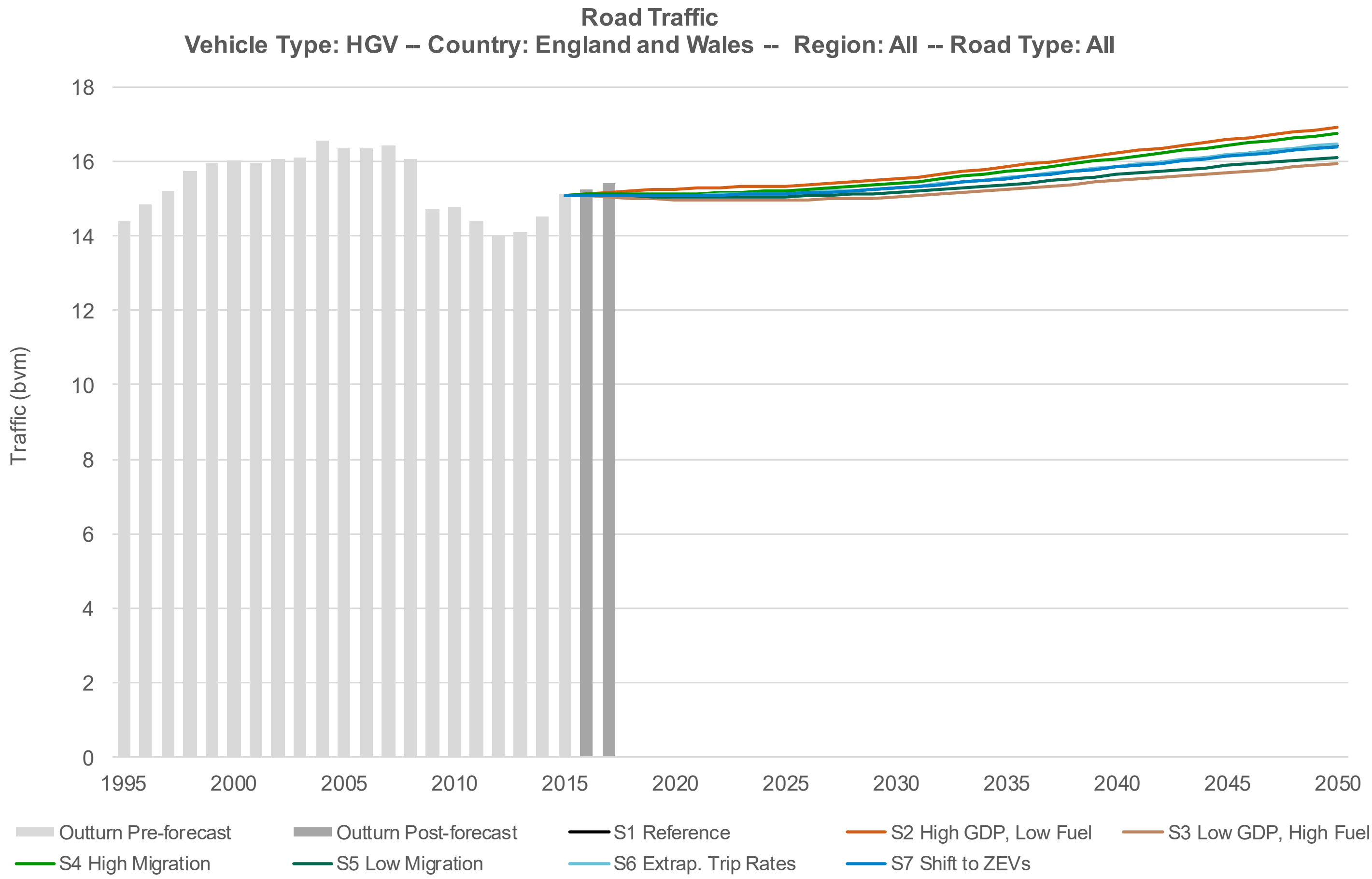


Figure 29: HGV vehicle mile forecasts for England & Wales

Road Type

4.26 The NTM produces traffic forecasts for all roads disaggregated across 7 road types. For the purpose of clarity in the analysis these have been grouped into:

- Strategic Road Network (SRN) - comprised of Motorways and Trunk roads managed by Highways England in England and the National Assembly for Wales in Wales
- Principal A roads - managed by local authorities
- Minor roads - all other roads (B, C and unclassified)

4.27 Traffic growth on the SRN (Figure 30) is forecast to be strong and positive in all scenarios (ranging between growth of 29% and 59%) driven by increases in the number of car trips and trip distances, as well as rising LGV traffic. This follows recent growth of approximately 11% on the SRN between 2012 and 2017.

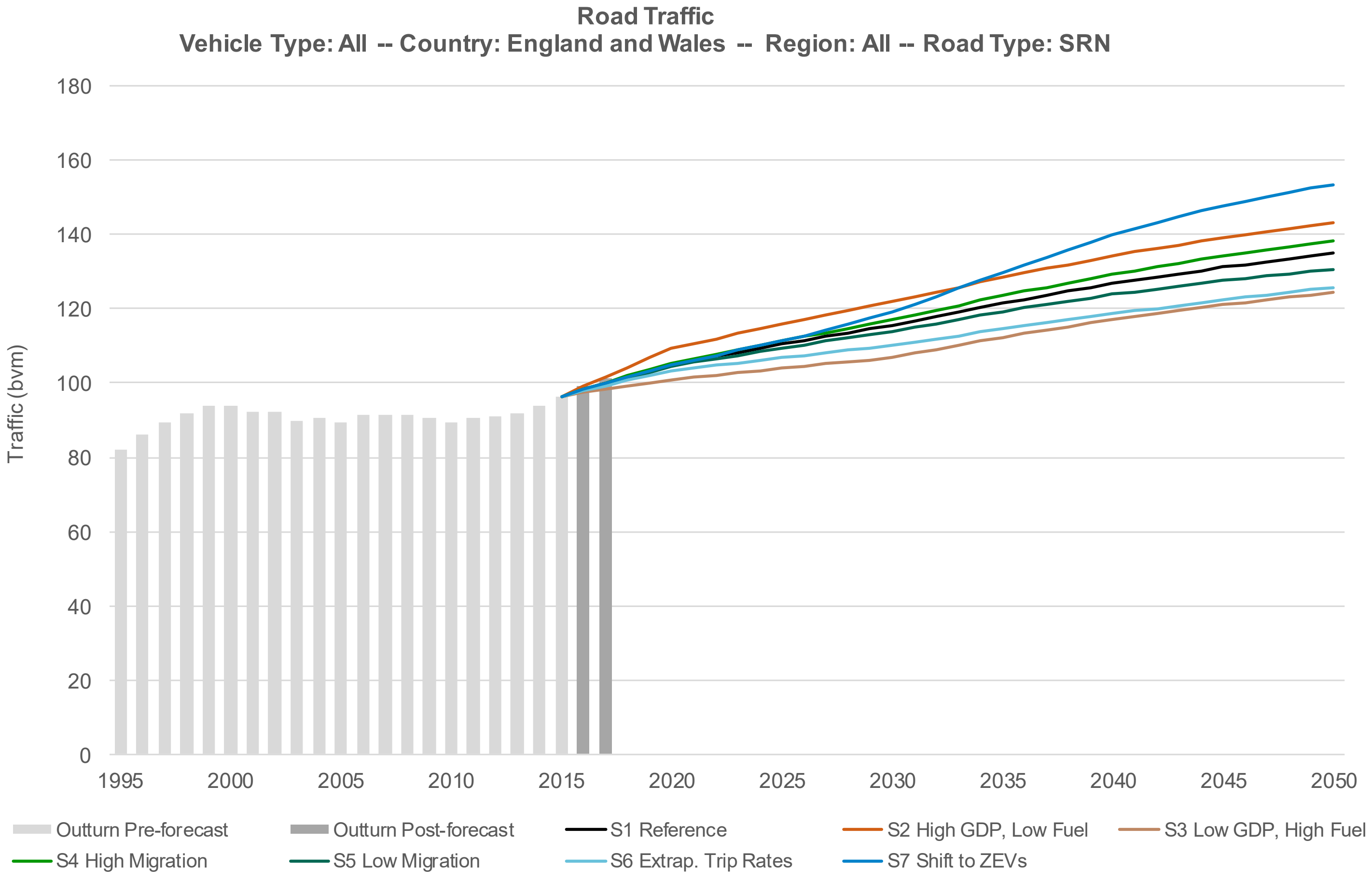


Figure 30: Vehicle miles for England & Wales on the SRN

4.28 In Extrapolated Trip Rates (scenario 6), where overall road traffic is forecast to grow more slowly on other roads, growth on the SRN by 2050 is still forecast to be strong (30%) and in line with Low GDP, High Fuel (29%) and only slightly lower than the Reference scenario (40%). The extrapolation of trip rates in this scenario has led to trip rates for the majority of trip purposes declining. However, holiday trips have more than doubled by 2050 resulting in longer average distance car trips as shown in Figure 27. In the NTM longer trips are more likely to be routed on the SRN as journeys are faster on these roads meaning the generalised cost of the journey is lower. Thus the forecast for Extrapolated Trip Rates (scenario 6) is for reasonable growth on the SRN.

4.29 There are forecast growth rates of between 10% and 44% for Principal roads (Figure 31), whilst for minor roads growth is forecast to be between 11% and 48% (Figure 32). The slightly lower growth rates for principal roads and minor roads, relative to total traffic, reflect a slight shift in traffic to the SRN. This trend is even more significant when considering car traffic on principal roads and minor roads. Car traffic growth by 2050 ranges between 4% and 36% on principal roads and between 2% and 37% on minor roads as opposed to 33% and 61% on motorways and 23% and 52% on trunk roads. Again this reflects the forecast change in average trip distances (Figure 27).

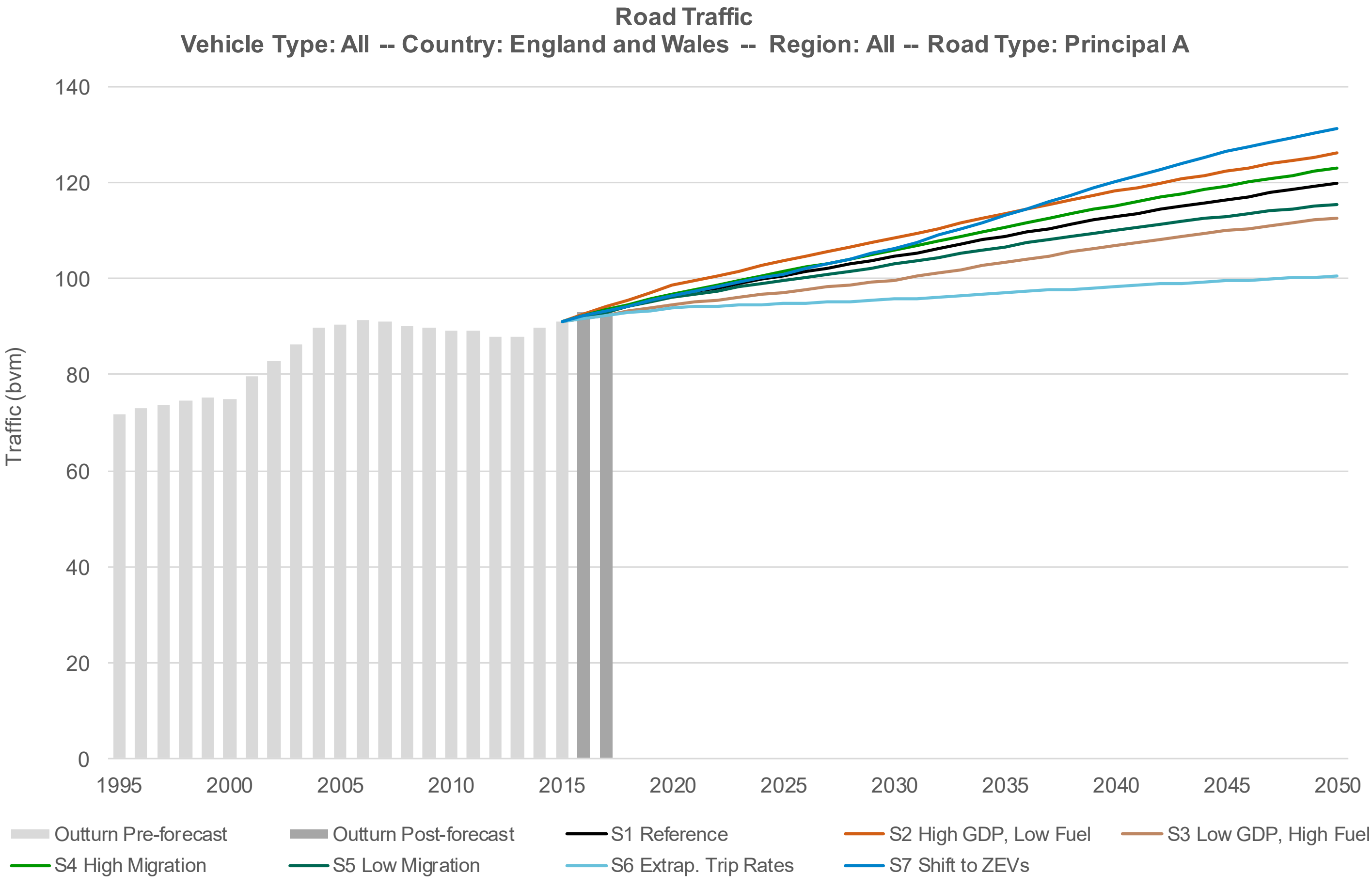


Figure 31: Vehicle miles for England & Wales on Principal Roads

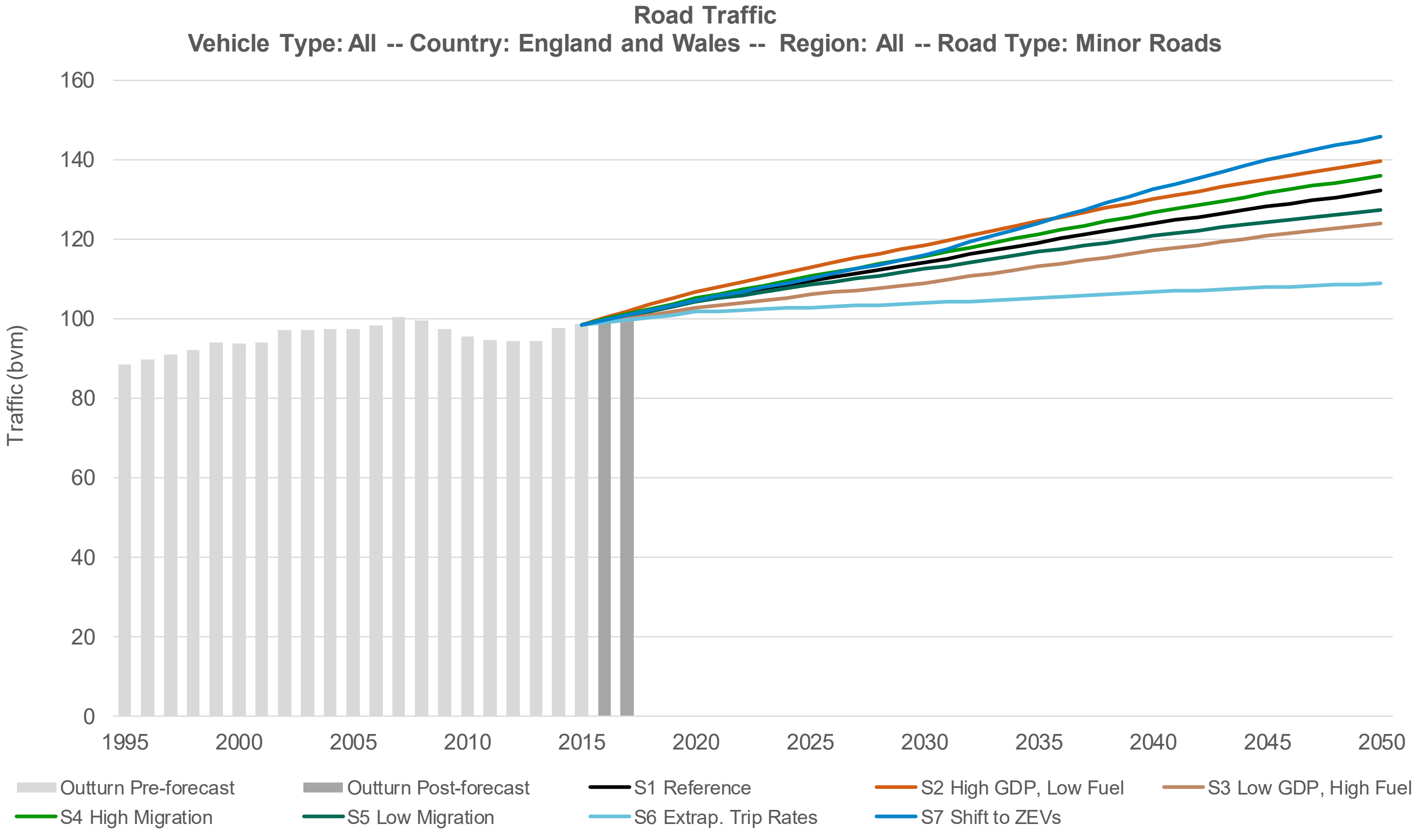


Figure 32: Vehicle miles for England & Wales on Minor Roads

Region

4.30 Figure 33 shows regional growth rates for all scenarios over the 2015 to 2050 period. These results are driven largely by the distribution of road type in each region, but additionally by projected regional population growth. The lowest rates of traffic growth are forecast for the regions with the lowest projected increases in population, particularly the North East.

4.31 The variation in national traffic growth forecast across the scenarios is broadly mirrored in each of the regions, although the assumption of decoupling between income and car ownership leads London to have the lowest growth of any region in High Migration (scenario 4).

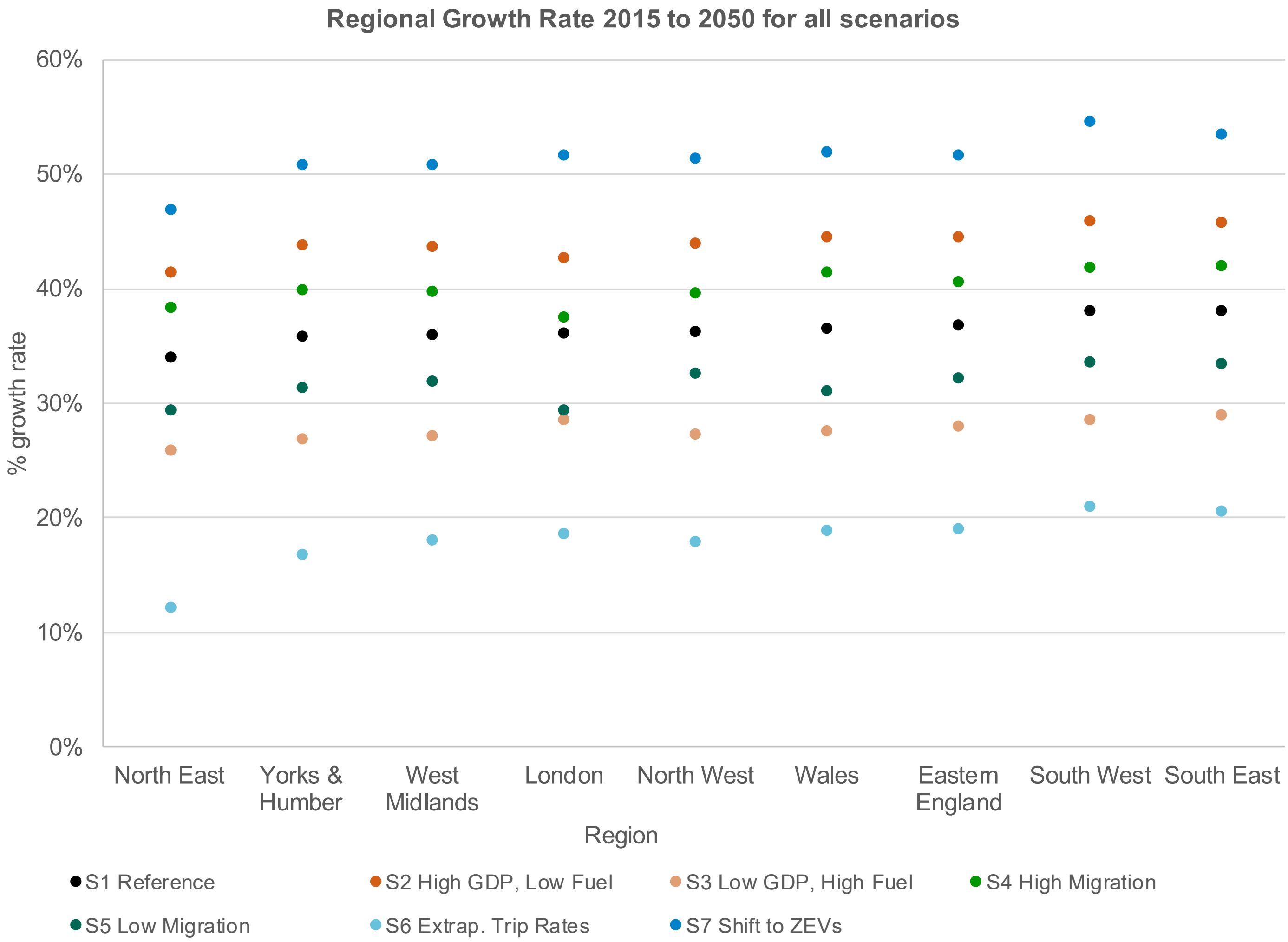


Figure 33: % Growth Rates in Traffic for England & Wales by Region

4.32 Whilst at the aggregate level the forecast 5-yearly traffic growth rates are within historical ranges, comparing the 5-yearly growth rates for London outturn data and forecasts (Figure 34) shows, particularly for earlier forecast years, that we are likely to be over forecasting traffic growth in London.

4.33 The reason for this likely over-forecasting is that the NTM applies the same weight to drivers of road traffic to all areas of the country. Travel behaviour in London and relationships between key variables and road traffic demand can be different to the rest of the country, due to a high use of the public transport network and significantly higher congestion on roads. Therefore it is unlikely transport users will react to changes in the same way as in other parts of the country. This is a known issue with the NTM and although it does not have a material effect on the forecasts at a national level, it is an issue which we will look to address in the future.

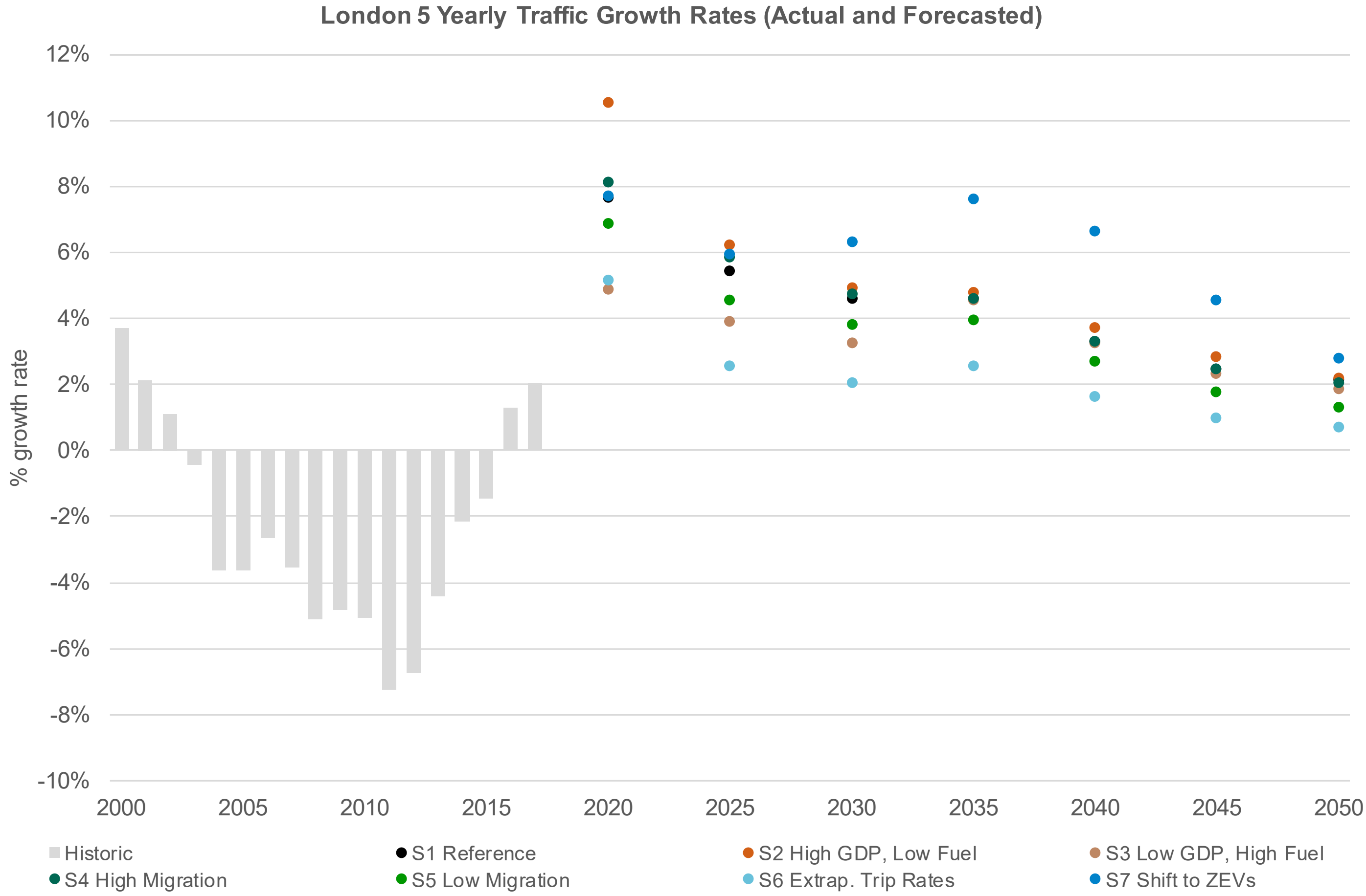


Figure 34: Traffic Growth Rates for London (Historical & Reference Scenario)

Congestion

4.34 Congestion in the NTM can be measured as the proportion of traffic travelling in congested conditions[41] (Figure 35), changes in average speed (Figure 36) or in average delay per mile (Figure 37).

4.35 For a given change in traffic the change in congestion should be broadly consistent across all three measures. Figure 35 shows that, when measured at an aggregate level, the percentage of vehicles in congested conditions is forecast to grow at a similar rate to traffic demand, with higher congestion in those scenarios which forecast higher demand growth. Congestion is dependent on the overall level of traffic relative to road capacity and should be expected to increase as traffic grows provided capacity does not change. However, growth in congestion will vary depending on where and when traffic growth occurs. Traffic growth concentrated in already congested areas and times of days will naturally have a greater impact than growth that is spread more evenly.

	Bn Vehicle mile	Lost Seconds per Vehicle mile	Average Speed (mph)	% of Traffic in Congested Conditions
2015	286.2	16.4	33.7	7%
Scenario 1	386.9	23.1	31.9	11%
Scenario 2	408.9	25.3	31.3	13%
Scenario 3	361.3	20.8	32.5	9%
Scenario 4	397.6	24.1	31.6	12%
Scenario 5	373.7	21.5	32.4	10%
Scenario 6	335.2	17.3	34.2	8%
Scenario 7	430.8	27.7	30.8	16%

Table 4 : Congestion measures (Lost seconds, Average Speed, % in Congested Conditions) in 2050

[41] Congested conditions are considered to be where the Volume over Capacity Ratio (V/C) is over 0.8. V/C is the ratio that describes the 'Level of Service' (LOS) of a road, where Volume is the total number of vehicles (total traffic volume) on a road in an hourly period and Capacity is the maximum designed capacity of a road (based on geometrical characteristics; width, number of lanes etc.) expressed in number of vehicles per hour.

4.36 The proportion of traffic in congested conditions[40] (Figure 35) in 2050 is forecast to range from 8% to 16% depending on the scenario, with the most congested periods being the weekday peak period. This is compared to 7% of traffic in congested conditions in 2015.

4.37 Figure 35 shows that the growth of traffic in congested conditions increases post 2025 with the forecasts getting steeper at this point. Excluding Shift to ZEVs (scenario 7), where this change is due to increased traffic as higher uptake of ZEVs reduces running costs, this does not match the growth in traffic. The growth in congestion from 2025 onwards is due to no further planned improvements to the road network. This impact is seen more strongly when looking at the SRN in isolation and demonstrates that the improvements made to the roads as a result of RIS1 are likely to contribute to lower growth in congestion in the years before 2025, despite high forecasted traffic demand. Furthermore, this suggests that future investment will be required beyond this point to maintain the current level of congestion experienced by road users.

Figure 35: % of Traffic in Congested Conditions (All Periods)

4.38 The average speed during all periods (Figure 36) is forecast to fall from 34mph in 2015 to as low as 31mph in 2050 in Shift to ZEVs (scenario 7). Average speeds during the weekday AM peak are lower, with an average speed of 32mph in 2015 declining to as low as 29mph in Shift to ZEVs (scenario 7).

4.39 Increases in average speed can be seen in Extrapolated Trip rates (scenario 6) however this does not mean that congestion is easing in this scenario. Average speed is increasing as there is a shift to vehicles using the SRN, where vehicles travel more quickly. Vehicles shift to the SRN due to the higher increase in average trip distances (Figure 27) in this scenario. As a higher percentage of trips are made on the faster SRN this leads to an increase in average speed.

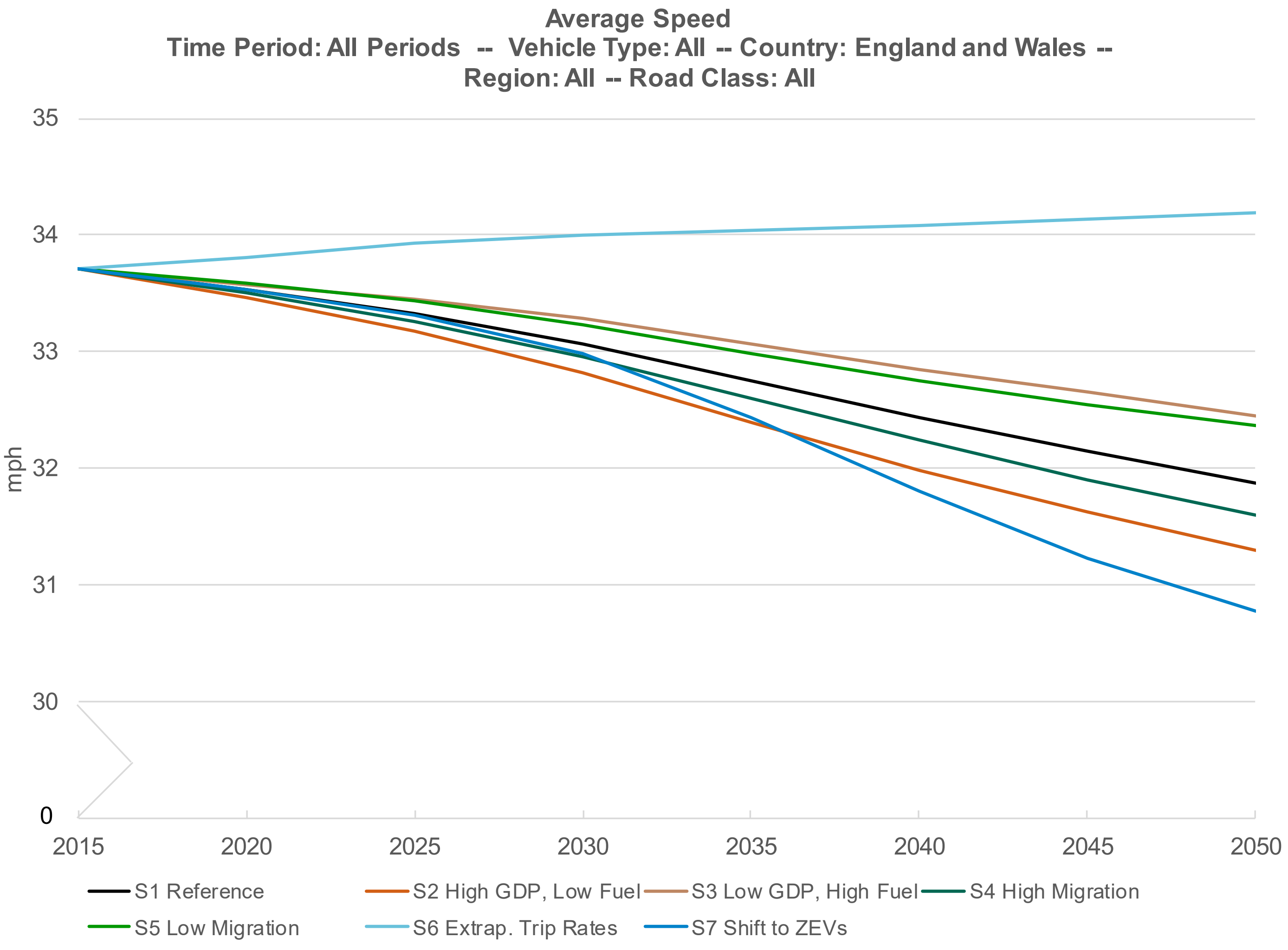


Figure 36: Average Speed (All Periods)

4.40 The average delay per vehicle mile (Figure 37) during all periods is forecast to increase by a wide range of up to approximately 11 seconds per mile (69%) by 2050, although Extrapolated Trip Rates (scenario 6) only sees minor increases (5%) in average delay per vehicle mile. The increase across the scenarios equates to an average delay of between 3 minutes 10 seconds and 4 minutes 50 seconds on the average journey in 2050 compared with an average delay of 2 minutes 40 seconds on the average journey in 2015. This is an increase of between 30 seconds and 2 minutes on current levels.

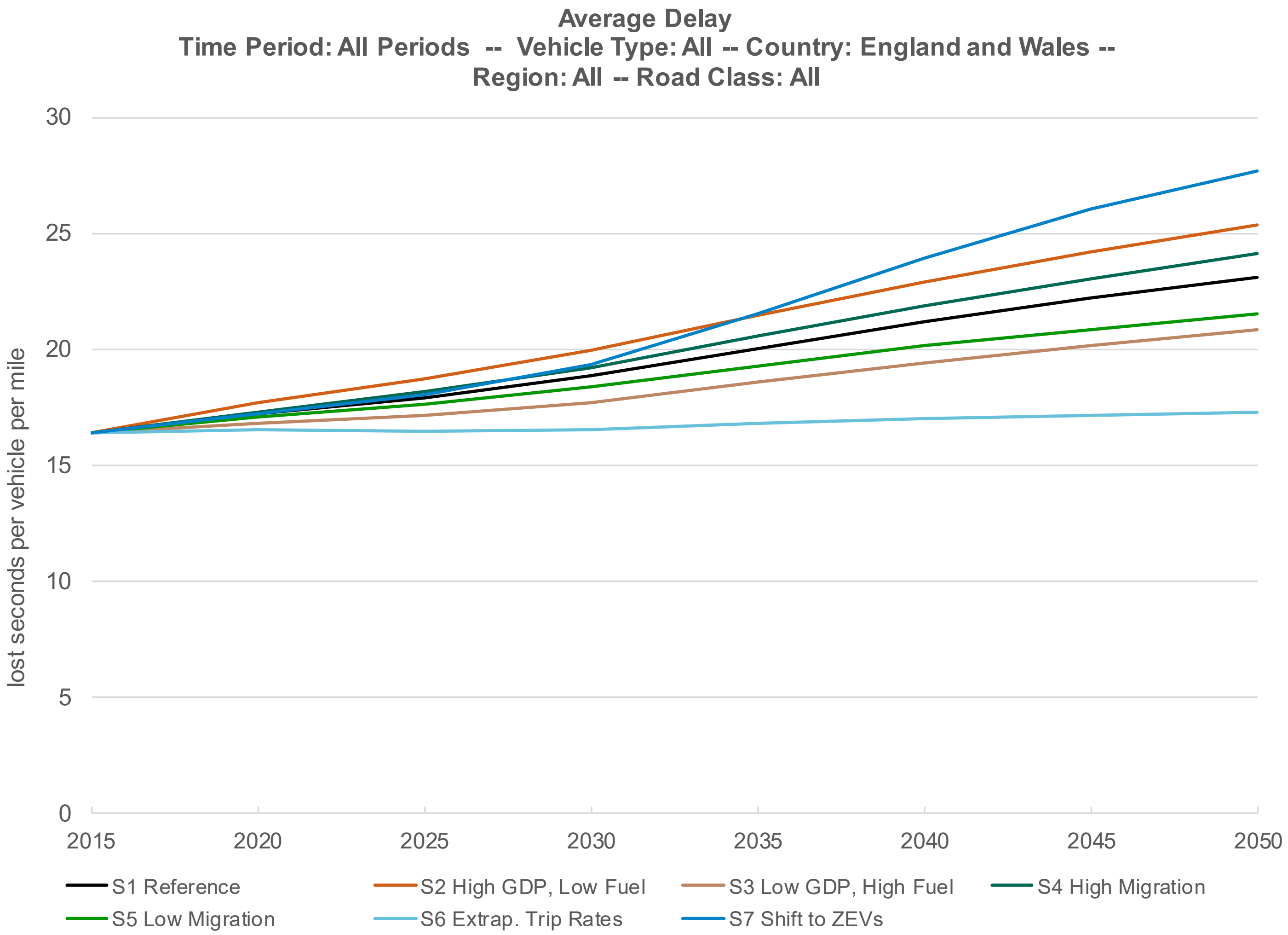


Figure 37: Average Delay in Lost Time per vehicle per mile (All Periods)

4.41 Congestion is forecast to vary with road type and time of day. Despite the percentage of traffic forecast to be in congested conditions being lowest in Extrapolated Trip Rates (scenario 6) at the aggregate level for all time periods, this is not the case when broken down by road type and specific period. For the SRN at the weekend for example, the forecast percentage of traffic in congested conditions in Extrapolated Trip Rates (6%) is higher relative to the Low GDP, High Fuel scenario (4%) and similar to the Low Migration scenario (7%), reflecting the higher number of longer, holiday type trips forecast on the SRN at the weekend.

4.42 Congestion impacts[42] in the AM peak are shown in Figure 38. It is clear that a greater percentage of the road network is expected to be congested by 2050 in all scenarios other than Extrapolated Trip Rates (scenario 6) where congestion is expected to largely remain unchanged from 2015 other than on the SRN as discussed above. Figure 39 shows High Migration (scenario 4) compared to the base year in a congestion map and here we can see increases in congestion focused around urban areas when compared with base year (2015) congestion.

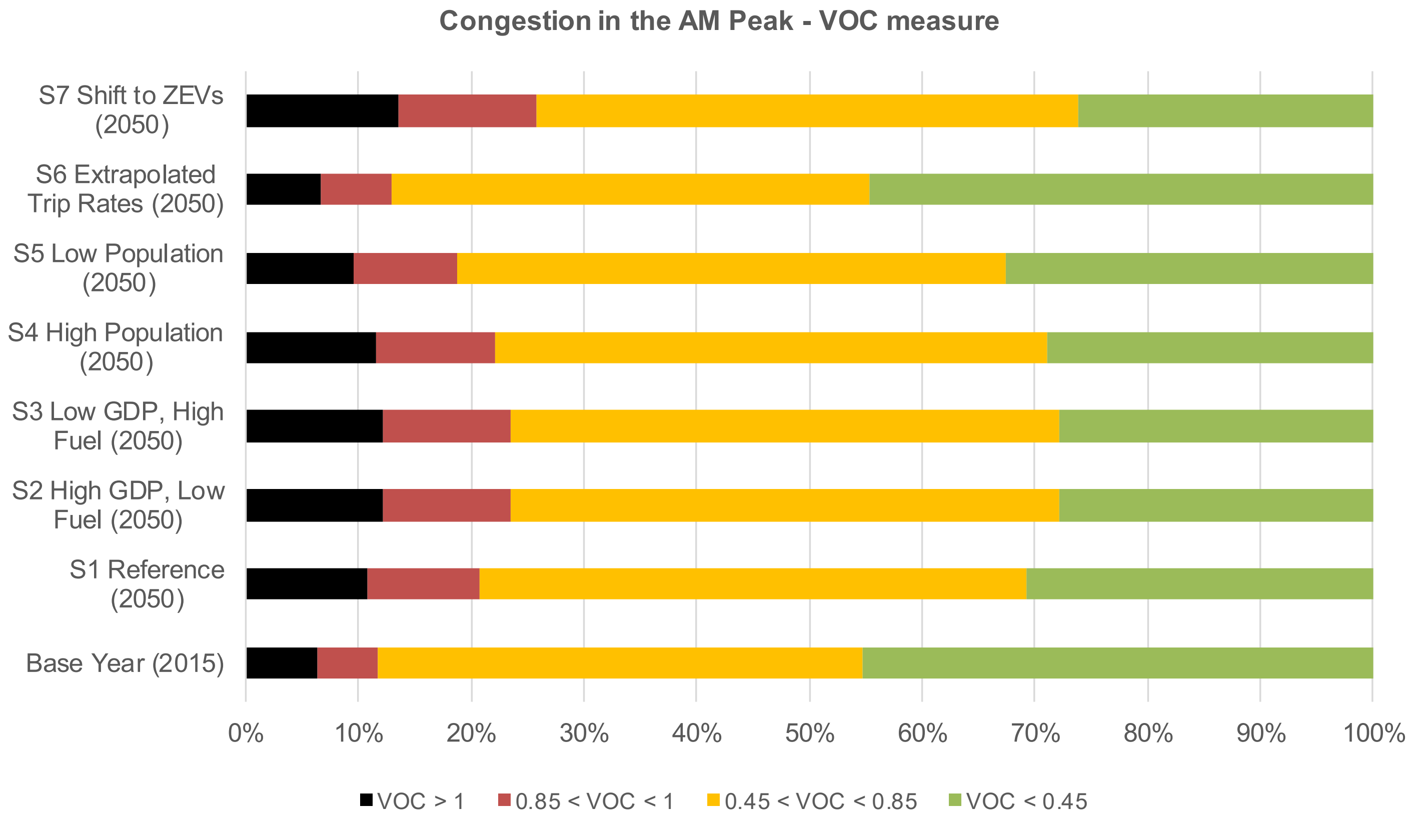


Figure 38: Congestion in the AM Peak - Volume over Capacity

[42] Congestion impacts are measure in congested conditions using the Volume over Capacity Ratio (V/C). V/C is the ratio that describes the 'Level of Service' (LOS) of a road, where Volume is the total number of vehicles (total traffic volume) on a road in an hourly period and Capacity is the maximum designed capacity of a road (based on geometrical characteristics; width, number of lanes etc.) expressed in number of vehicles per hour.

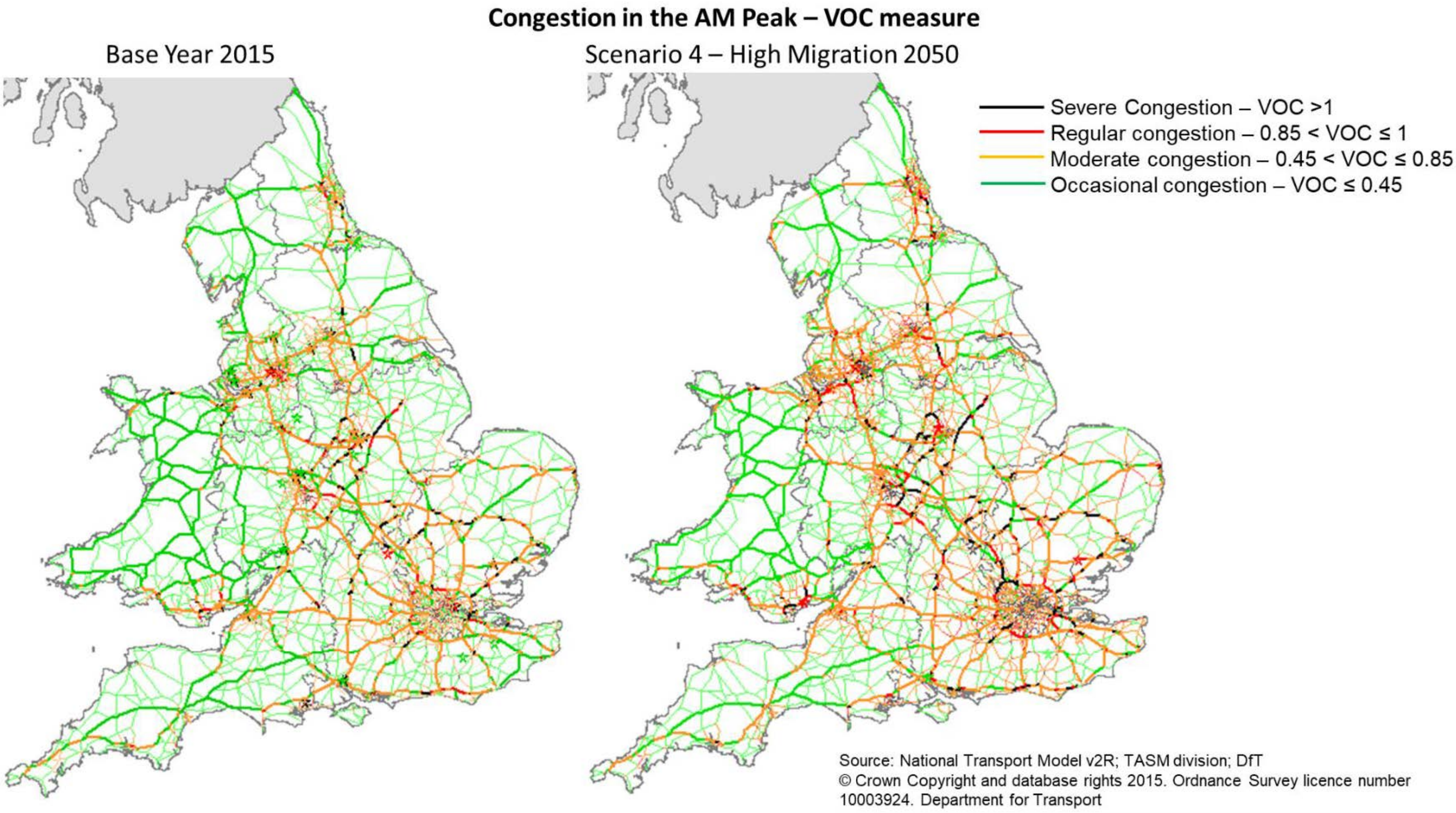


Figure 39: Congestion Maps for the AM Peak period (Base Year 2015 and High Migration 2050)

Emissions

4.43 The NTM produces forecasts of emissions of CO_2 (Carbon Dioxide), NOx (Nitrogen Oxides) and PM10 measured at the tailpipe and does not capture any upstream emissions produced. For example it excludes indirect emissions, such as those from electricity generation. The model calculates an estimate of aggregate emissions from the volume of traffic, the speed of the traffic and assumptions of improved fuel efficiency in the vehicle fleet that reduce emissions for a given speed. Speed emissions curves (see Annex) are applied to the traffic forecasts from the NTM, and the results aggregated up to give emissions at the national level.

4.44 The estimates of emissions produced here are dependent on the input assumptions, which have been explained in section 3. They are not official forecasts showing progress towards meeting the UK's Carbon Budgets. Progress towards the UK's carbon budgets is forecast by taking account of policy across all sectors of the economy and published in Energy and Emissions Projections (EEP)[43] produced by BEIS.

4.45 Scenarios 1-6 take account of the impact of committed transport policies to reduce emissions from road travel (Figure 40). Shift to ZEVs (scenario 7) assumes a higher level of ULEV uptake, assuming 97% of cars and LGVs are ZEVs by 2050 and almost all cars and LGVs sold from 2040 have zero emissions at tailpipe.

4.46 The main drivers behind the forecast changes in CO_2 emissions are the levels of traffic for each vehicle type and assumptions on the future fuel efficiency of the vehicle fleet. For cars and LGVs fuel efficiency is forecast to improve due to technological developments.[44]

4.47 Based on these assumptions, CO_2 emissions in scenarios 1-6 are forecast to fall by between 16% and 30% from 2015 to 2050. As would be expected the scenarios which result in greater levels of traffic result in higher emission forecasts.

4.48 The largest reduction in CO_2 emissions (80% by 2050) occurs in Shift to ZEVs (scenario 7) where we have assumed approximately 97% of the car and LGV fleet will be powered by electricity by 2050. The scenario shows it is possible to deliver substantive reductions in tailpipe emissions against a backdrop of rising GDP and traffic growth. In the other scenarios, where only committed policy is taken into account in forecasting emissions, the largest fall is expected to be 30% in Extrapolated Trip Rates (scenario 6) reflecting lower levels of traffic growth. .

4.49 After initial falls, emissions largely level off after 2030 as future car and LGV regulations to improve efficiency are not modelled. After 2030 the impact of rising traffic is offset by the increasing numbers of ULEVs in the fleet. In Shift to ZEVs (scenario 7), emissions continue to decline to 2050, with greater numbers of ULEVs.

[43] https://www.gov.uk/government/collections/energy-and-emissions-projections

[44] Our forecasts assume average fuel efficiency improves by 28% for petrol cars, 19% for diesel cars and 19% for electric cars. 32% for petrol LGVs, 14% for diesel LGVs and 13% for electric LGVs between 2015 and 2050. For rigid and articulated HGVs fuel efficiency improves by 12% and 21% respectively by 2050

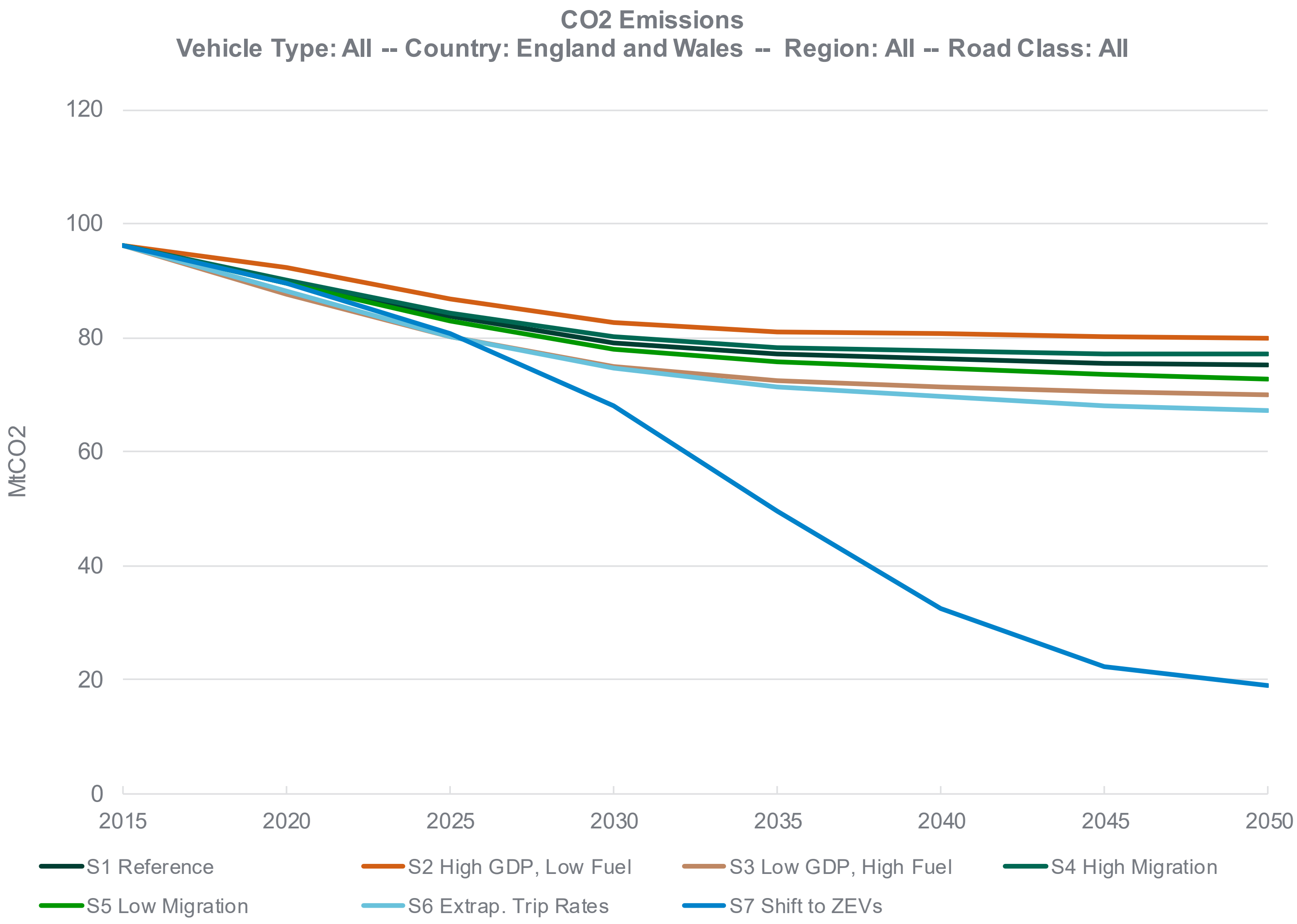


Figure 40: CO2 Road Traffic Emissions for England & Wales (Mt)

4.50 The forecast for NOx emissions (Figure 41) shows a decline of between 60% and 95% by 2050. The lower end of the range relates to Shift to ZEVs (scenario 7). Outside of this scenario, the steep downward path is relatively insensitive to the different range of traffic levels we forecast - the assumptions for declining emissions per vehicle mile expected to be achieved through vehicle standards are much more important, and more than offset the increases in demand projected over most of the forecast period.

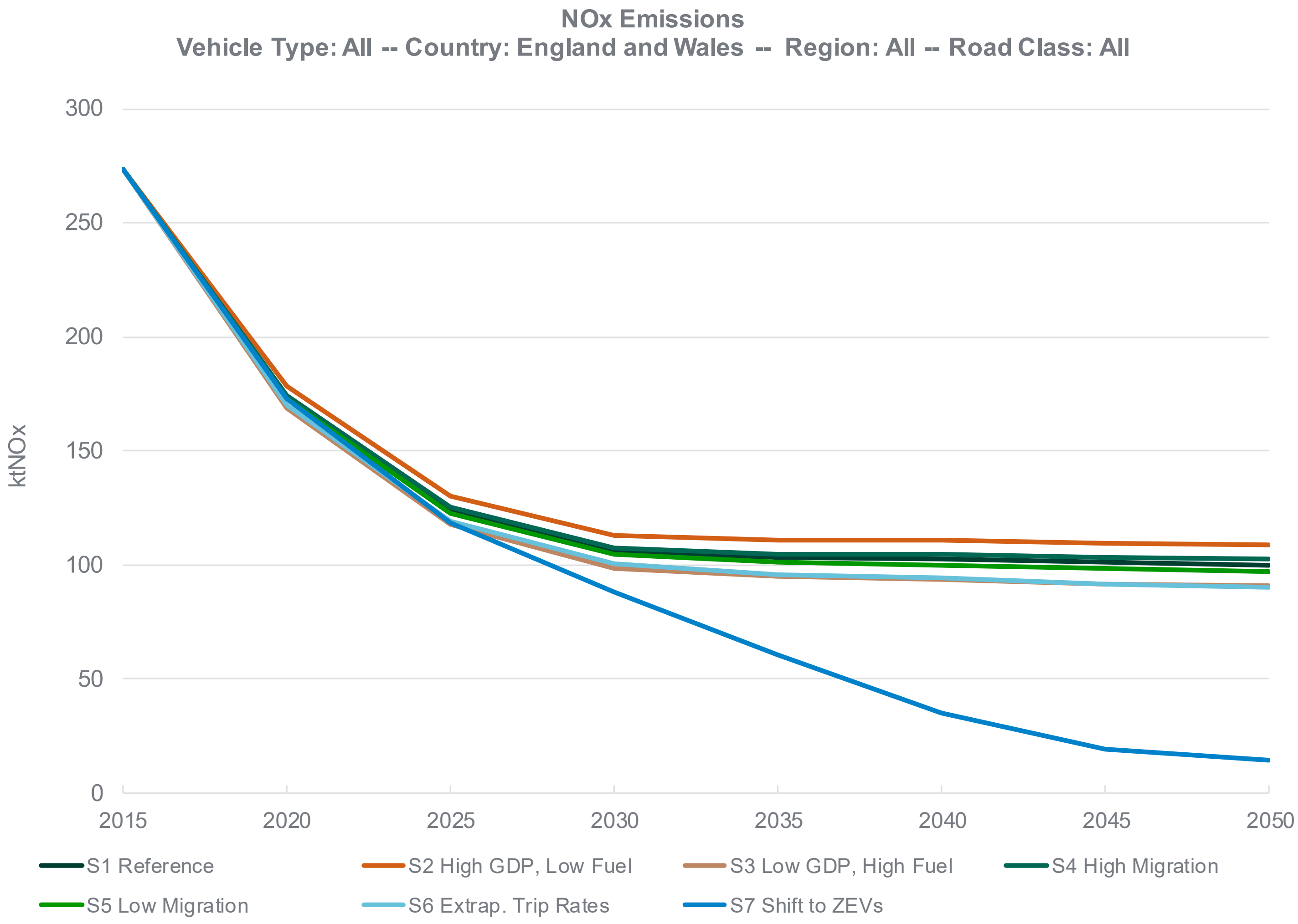


Figure 41: NOx Road Traffic Emissions for England & Wales (kt)

4.51 PM10 emissions (Figure 42) are forecast to reduce by 86% to 98% between 2015 and 2050. Again, the assumption of improvements in vehicle PM10 emissions through vehicle standards dominates increases in demand, and the results are insensitive to our different forecast levels of traffic.

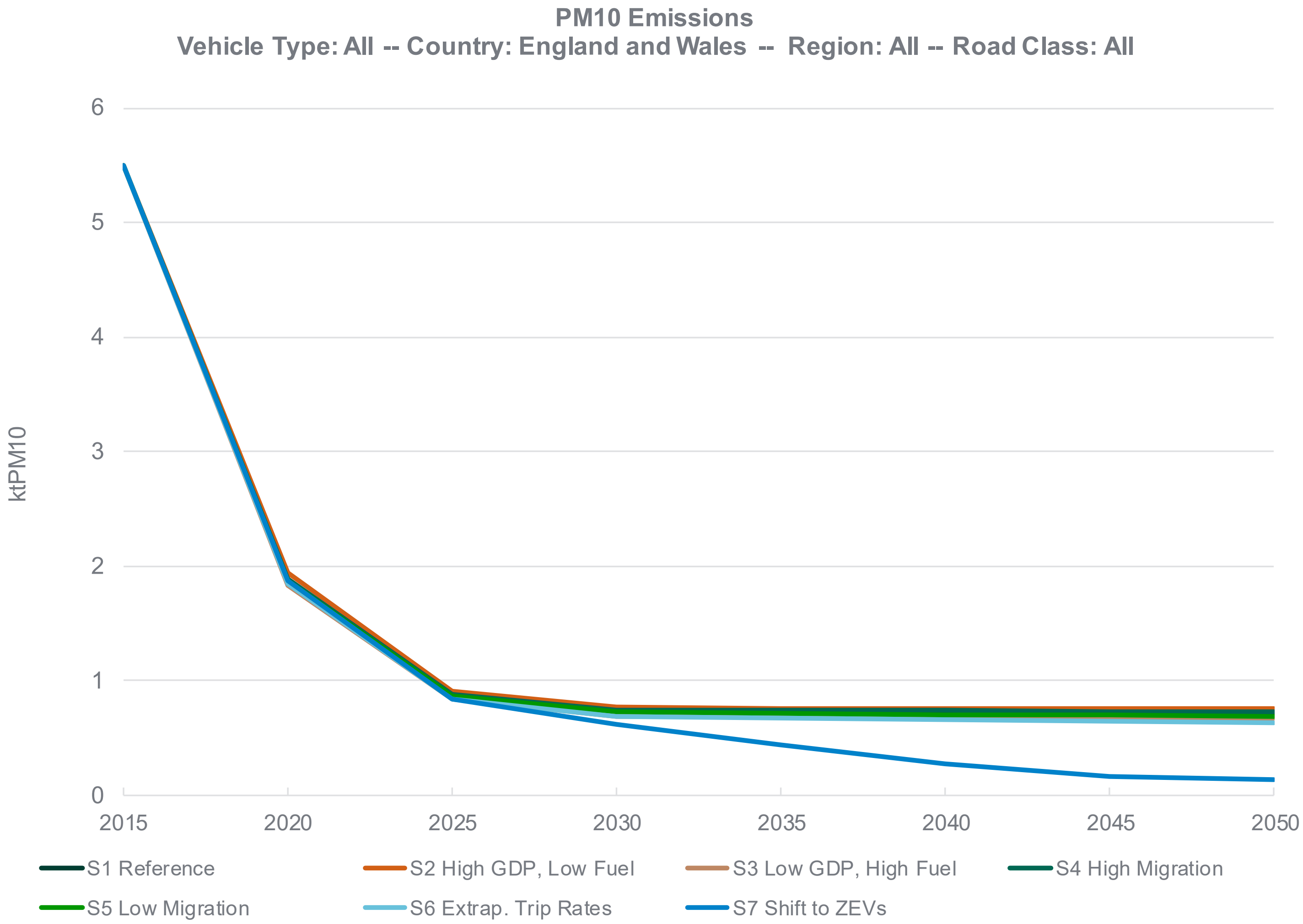


Figure 42: PM10 Road Traffic Emissions for England (kt)

Motorway Traffic is forecast to grow by

33% to 61%

by 2050

Car Traffic is forecast to grow by

11% to 43%

from 2015 to 2050.

Key drivers of road traffic are increases in population, increasing car ownership and decreases in car running costs

23% to 108%

LGV traffic is forecast to increase and has the potential to **double** from 2015 to 2050

5% - 12% increase

in HGV Traffic by 2050.

Modest increases in demand for goods and a forecasted higher proportion of larger Articulated HGVs mean less growth than other vehicles

Traffic on Principal Roads is forecast to grow by

10% to 47%

by 2050

Traffic levels vary by scenario and depend on key inputs such as population, GDP, fuel price and trip rates

Shift to ZEVs Scenario has highest traffic levels by 2050 due to high uptake of EVs

Extrapolated Trip Rates Scenario has lowest traffic levels by 2050 due to lower trip rates per person

CO2 Emissions are forecast to decrease by

16% to 80% by 2050

ZONE

This decrease is mainly driven by a more fuel efficient fleet and higher proportion of vehicles on the road being zero emission

34 → 31 to 34

2015 Average Speed

2050 Average Speed

Average Speed is forecast to **decrease** across all scenarios except Extrapolated Trip Rates where average speeds remain the same, due to more traffic travelling on faster roads

Without further action, delays are expected to increase. The average car journey taking

17 minutes in 2015

could increase to

20 minutes in 2050

Queues likely

Percentage of vehicles in **congested conditions** is forecast to increase from

7% in 2015

up to

8% to 16% in 2050

5. Transport Technology

Introduction

5.1 We are potentially at the start of profound change in how we move people, goods and services around. This is driven by innovation in engineering, technology and business models. New market entrants and business models, such as ride-hailing services, ride sharing and mobility as a service are challenging our assumptions about how we travel. There is limited evidence to enable us to understand the impacts this is having and could have on the nature, patterns and volumes of road traffic demand.

5.2 It is unclear how far our existing understanding of the drivers of demand will continue to apply. In an attempt to address this, we have undertaken some initial exploratory analysis of how the introduction of Connected Autonomous Vehicles (CAVs) may impact on supply and demand through examining the levers in existing models.

5.3 While we have focused on transport technology in this analysis, it is plausible that substitution technology (enabling an individual to opt out of making a trip), technology which indirectly affects travel demand through influencing social behaviour or other (as yet unknown) technological innovations will emerge that may also significantly impact upon road traffic demand.

5.4 The purpose of the analysis presented here is not to forecast how CAVs will impact on demand, but to better understand what aspects of these new technologies traffic levels might be most sensitive to. This will be used to inform the priorities for our future research.

5.5 This analysis also forms a part of our wider thinking on the developments in question, which are the subject of the Future of Mobility Grand Challenge, which was launched as part of the Government's Industrial Strategy[45]. The Future of Mobility programme aims to establish the UK as a world leader in transport innovation. As part of that, a Future of Urban Mobility Strategy will be published by the end of 2018.

5.6 When analysing the potential impacts of technology on transport, the effects can be split into:

- Demand Side Impacts: when technology causes changes to the nature, patterns or volumes of travel demand. For example, transaction costs associated with hailing a taxi, sharing a car or a sharing a long-distance ride, are being radically changed by new mobility services, which can also impact road travel demand and variables that affect the network such as vehicle occupancy rates.
- Supply Side Impacts: when technology affects the transport options that are available to people, how much they cost or their quality. For example, CAV technologies could enable smoother driving dynamics, reducing traffic waves and improving overall traffic flow. This would have the effect of increasing the effective

[45] https://www.gov.uk/government/publications/industrial-strategy-building-a-britain-fit-for-the-future

capacity of the network. There are also potential second order impacts on demand if a reduction in congestion improves journey times and journey ambience, which in turn causes users to travel more and creates more demand.

Possible Impacts

5.7 CAV technologies are the source of potentially significant but uncertain impacts on road traffic demand.

- Connected Vehicles - A connected vehicle is able to communicate wirelessly with other vehicles or with the infrastructure. Connected vehicles are already on our roads, and they have the potential to improve overall network performance.
- Autonomous Vehicles – Figure 43, based on definitions from the Society of Automotive Engineers (SAE), categorises 6 different levels of automated vehicle technology.

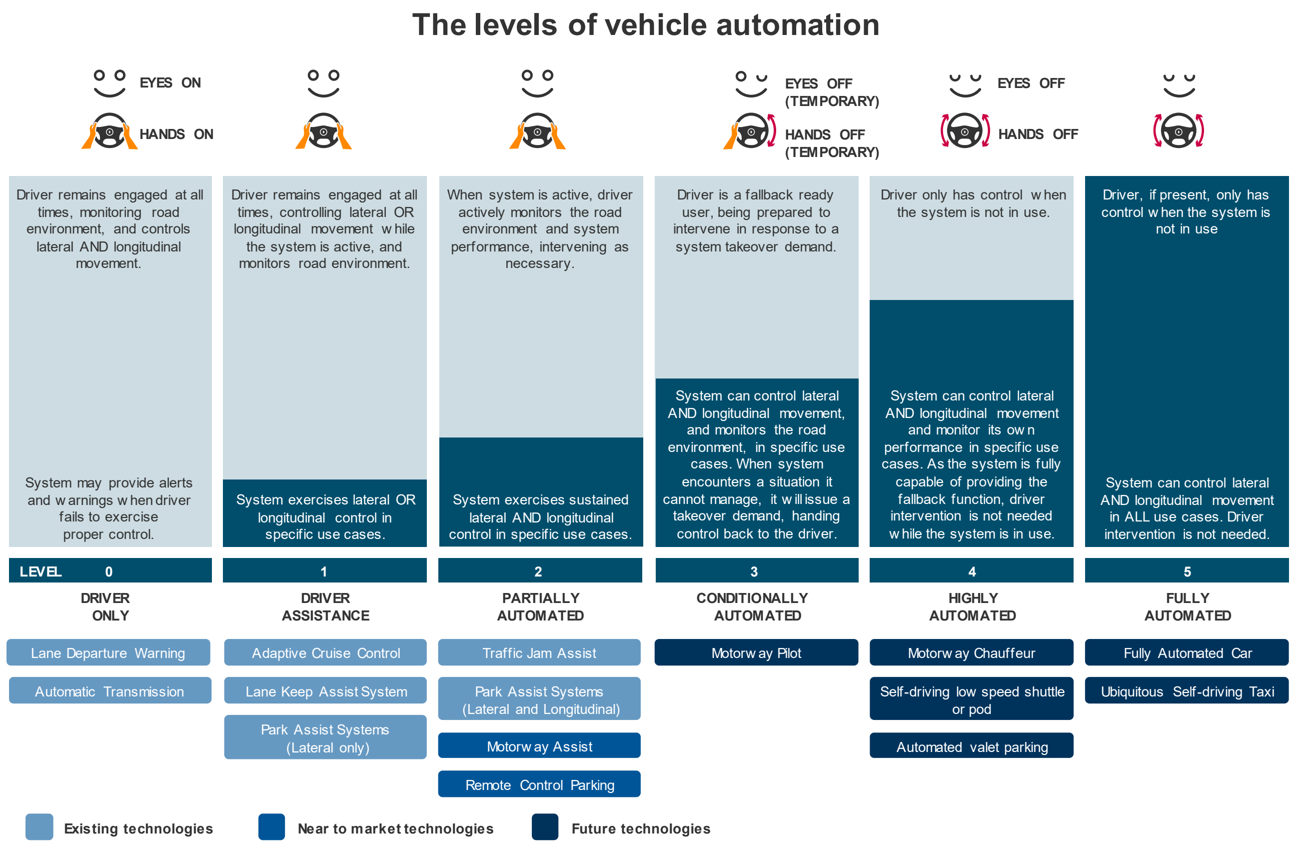


Figure 43: Society of Automotive Engineer (SAE) Levels

5.8 Existing advanced driver assistance technologies are categorised up to level 2. However, for a number of the potential impacts of CAV technology to be realised, a high fleet penetration of level 4 and 5 CAVs may be required.

5.9 We have considered a range of possible impacts of CAVs on road traffic demand shown in Figure 44. These were identified by reviewing emerging research in this area and consulting with both internal and external experts.

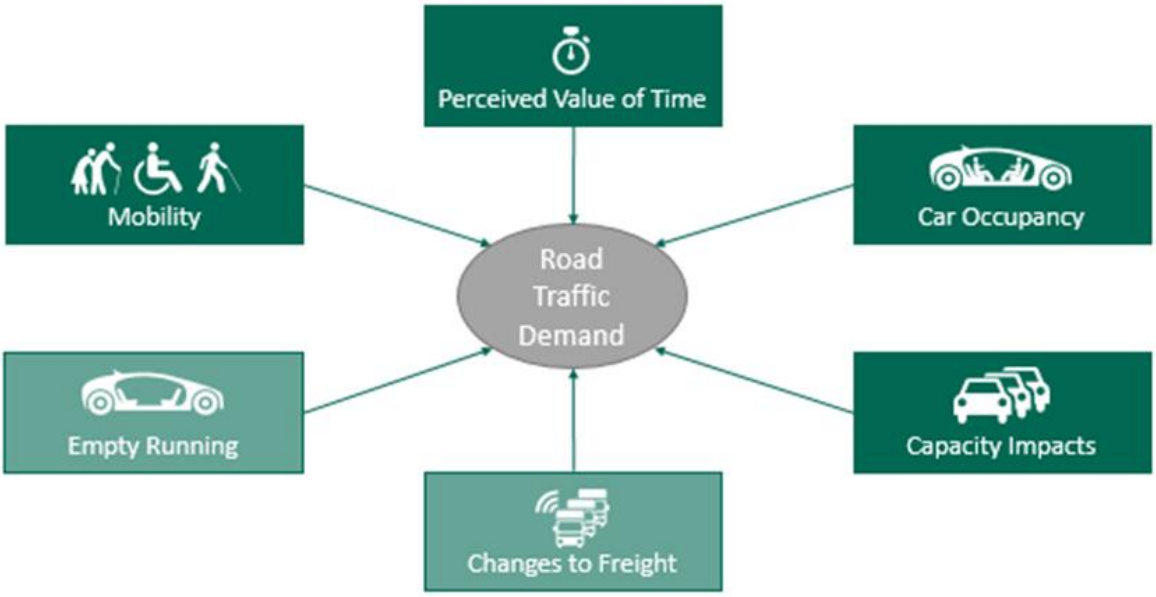


Figure 44: Possible Road Traffic Demand Impacts of CAVs

5.10 Mobility

- Autonomous vehicles with level 4 and 5 capability could facilitate an increase in mobility from people previously unable to travel by car, including those who do not currently hold driving licences and those who are physically unable to drive[46].
- Existing motorists may be encouraged to make more road journeys as new services and technologies make it easier to access a car[47].

5.11 Perceived Values of Time

- The perceived cost of driving could change in the context of highly autonomous vehicles, as the vehicle could allow occupants to use their in-vehicle time more productively or for leisure[48][49]. When a journey can be used productively or for leisure this has the potential to reduce the value of time an individual places on travel. The value of time could have effects on demand through trip rates, trip lengths and modal substitution.
- The extent to which CAV users will be able to make productive use of their time whilst in the vehicle might be affected by various behavioural factors, the level of connectivity or the effects of motion sickness.
- Automation at lower levels could also reduce the perceived discomfort from driving e.g. driving stress and demands on attention. This could cause a further reduction in the perceived value of time.

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[46] Wadud, Z., MacKenzie, D. and Leiby, P (2016). Help or hindrance? The travel, energy and carbon impacts of highly automated vehicles.

[47] Institution of Mechanical Engineers, Low Carbon Vehicle Partnership and University of Leeds and Institution for Transport Studies (2016), 'Automated Vehicles: Automatically Low Carbon?'.

[48] Wardman, M. and Lyons, G. (2016) The digital revolution and worthwhile use of travel time: Implications for appraisal and forecasting.

[49] Wadud, Z., MacKenzie, D. and Leiby, P (2016). Help or hindrance? The travel, energy and carbon impacts of highly automated vehicles.

5.12 **Car Occupancy**

- The introduction of CAVs into the fleet alongside the adoption of new business models could make ridesharing become increasingly popular, potentially resulting in an increase in car occupancy rates[50]. Transport users may ride share if it is easy and sufficiently cheap. Although early research suggests an existing reluctance to share journeys with strangers and that ride sharing may be more likely to materialise in urban areas for shorter journeys rather than on the Strategic Road Network (SRN).[51]
- Alternatively, CAVs could lead to a reduction in car occupancy. For example, lower vehicle running costs from more efficient driving and/or journey transaction costs could make private travel more viable. Additionally a reduction in escort trips and increase in empty running could lower the average car occupancy rate[52].
- Changes in car occupancy may arise even without the introduction of level 4 and 5 CAVs to the fleet. While some research in this area exists, it is unclear what the take-up of these type of services will be.

5.13 **Capacity Impacts**

- CAVs have the potential to increase the capacity of the roads through more efficient driving[53]. This could occur through the following two mechanisms:
  - Improved traffic management – vehicle-to-vehicle and vehicle-to-infrastructure connectivity could combine to improve traffic flow and reliability. These technologies could allow for safer and more efficient lane closures, and dynamic routing.
  - Increased road space utilisation – road capacity could increase as vehicles could make more efficient use of the road, for example, by travelling with shorter headway using smoother and more optimal driving dynamics.
- On the other hand research indicates the potential for disruption to traffic flow and capacity. Accounting for user preferences, comfort and safety it is plausible CAVs could be more cautious than the current fleet[54]. The impact depends on the capability of vehicles, how they operate, and what consumers will tolerate in terms of driving dynamics.
- The magnitude of both these effects is subject to uncertainty around when this technology will become commercially available.
- As with anything that affects the effective capacity of the network, we would expect this to prompt a second-order impact on demand.

5.14 **Freight Changes**

- CAV technologies could facilitate HGV platooning during off-peak periods, thus changing freight operating models and impacting journey times. Due to modelling constraints we have not been able to model any changes to freight-related automated driving or platooning[55].

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[50] https://www.transportenvironment.org/sites/te/files/publications/Does-sharing-cars-really-reduce-car-use-June%202017.pdf
[51] Kantar Public, Department for Transport, Future Roads: Public Dialogue
[52] https://singularityhub.com/2018/02/14/why-the-rise-of-self-driving-vehicles-will-actually-increase-car-ownership/#sm.000044zl8sacid9oppi2r1q2q1b31
[53] Friedrich , B. (2016). *The Effect of Autonomous Vehicles on Traffic*. P.332
[54] https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/530093/impacts-of-connected-and-autonomous-vehicles-on-traffic-flow-technical-report.pdf
[55] https://ts.catapult.org.uk/2017/02/07/autonomous-vehicles-freight-logistics/

5.15 **Empty Running**

- At Level 4 and Level 5, empty-running becomes a possibility, where cars travel on the road with no passengers and could increase pressure on the road network. There is significant uncertainty about when empty-running might occur, how it might work, and what business model might apply. We are not able to model this specifically in the NTM and NTEM modelling suites.

Demand Sensitivity Tests

5.16 In order to address the uncertainty surrounding the impact of future vehicle technology developments on road traffic demand, DfT have completed a number of sensitivity tests designed to help understand which assumptions related to the consequences of future technology could have the largest impact on demand.

5.17 We have looked to conduct quantified tests within our modelling suite, whilst acknowledging the limited and uncertain nature of the current evidence base. The outputs are sensitive to the input assumptions which although informed by emerging research, the evidence is of low maturity and as such, these tests should be considered as a 'what if' analysis.

5.18 There are limitations to how well we can test these uncertainties in our current modelling framework. We have explored some potential areas of uncertainty by varying existing levers in the models to increase our understanding of the possible impacts. Of the six potential impacts discussed above we have conducted tests on four.

5.19 We are unlikely to have captured the full range of uncertainty associated with future technologies. This could include the impacts of currently unforeseen technological innovations which may significantly impact upon road demand.

5.20 We also acknowledge the fact that the NTM is calibrated to the 'current state of the world', one different to that proposed in the quantified tests. As a result, any modelling in this publication has used 'current state of the world' elasticities (such as those for GDP, fuel cost etc.), which would be subject to change in a world where CAVs make up a significant proportion of the fleet.

5.21 In the tests it has been assumed that technology develops quickly and a high proportion of the fleet is highly autonomous (level 4 and level 5) by 2050.

Uptake Rates

5.22 In order to model potential impacts of CAV technologies on the network, we need to assume a proportion of vehicles on the road in any given year that are equipped with each level of CAV technology. The makeup of the national vehicle "fleet" in terms of technology is different from the proportion of vehicles sold ("entering the fleet") in any given year.

5.23 We therefore need to make assumptions about when each CAV technology will become commercially available, what proportion of vehicles sold in any given year will be equipped with each technology, how this changes over time (the "uptake rate"), and assumptions about fleet turnover (how long vehicles last before they are scrapped, or the "survival rate"). These can be seen in Table 5.

5.24 The Centre for Connected and Autonomous Vehicles (CCAV)[56] have made such assumptions using market intelligence and a literature review, together with internal sense checking and consistency checking. The technique used to model these assumptions is consistent with an existing internal vehicle fleet penetration model. The uptake rate of CAV technologies (how the vehicle sales percentages change over time) is based on market penetration forecasting theory for new technologies. This assumes an s-curve of sales volumes over time, as early adopters invest in new technologies despite their relatively high price, which creates initial sales volume that allows cost reductions to ensue, which enables mass-market adoption and rapid growth, followed by gradual convergence on market saturation.

5.25 It is important to note the uptake of CAV technologies is highly uncertain and this single uptake rate is not intended to represent the Government view of the most probable scenario or a reflection of Government policy, but rather a possible CAV uptake for the purposes of modelling impacts. It should be noted the scenarios described in sections 3 and 4 contain the implicit assumption there will be zero CAV uptake and so these exploratory tests provide an alternative view, of which there could be many.

5.26 There are a number of limitations to this analysis and these assumptions are subject to change as new information becomes available. The fleet penetration results of this analysis are displayed in Table 5. The tests have been modelled in 2050 when it is assumed that a high proportion of the fleet is highly autonomous.

SAE Level	Year tech enters fleet	10%	25%	50%
Level 3	2021	Late 2020s	-	-
Level 4	2023	Late 2020s	Early 2030s	Early 2040s
Level 5	2035	Early 2040s	Mid 2040s	Late 2040s

Table 5: Possible Fleet Penetration of CAVs over time

[56] https://www.gov.uk/government/organisations/centre-for-connected-and-autonomous-vehicles

Demand Sensitivity Test 1 - Improved Mobility

5.27 This test is split into two parts: increased car accessibility and increased trip rates for over 75s. Some of the increased mobility benefits could be amongst the elderly (over 75 age categories in the National Trip End Model) and are only likely to materialise when a high proportion of the fleet reaches level 4 & 5 automation[57]. As part of this test, we have made a number of assumptions:

- By 2050, 100% of the adult population would be able to use a Level 5 CAV. This has been implemented in the licence cohort model, which is an input to the Car Ownership Model (see Figure 1). We have increased licence holding to 100% of the population for all age categories and genders by 2050. This was done across all area types (including London).
- The licence holding model in NTEM only contains age categories above 17, so no children are assumed to be able to use CAVs. This is a limitation of the tests, since high levels of automation could in theory allow children to travel alone in vehicles. The highlights the limitations of the NTM in modelling this area of uncertainty.
- The trip rates of the over 75 age cohort are assumed to match the trip rates of unemployed adults for certain trip purposes in 2050. All other trip rates for all other traveller types remain constant from 2016 (in line with NTEM7.2). This assumption ignores any behavioural or financial considerations that may prevent the elderly from using these new technologies. We acknowledge here that existing literature makes differing assumptions[58].

5.28 Under these assumptions, we see traffic growth of approximately 42% between 2015 and 2050.

[57] KPMG (2015). Connected and Autonomous Vehicles - The UK Economic Opportunity (https://home.kpmg.com/content/dam/kpmg/pdf/2015/04/connected-and-autonomous-vehicles.pdf)
[58] Wadud, Z., MacKenzie, D. and Leiby, P (2016). Help or hindrance? The travel, energy and carbon impacts of highly automated vehicles.

Demand Sensitivity Test 2 - Perceived Value of Time

5.29 The NTM has an input that allows perceived time valuation to differ by modes. For example, Table 6 below shows waiting times for a bus and rail are weighted at double that of the time of a passenger or a car driver, since individuals dislike waiting.

Mode	Time Valuation
Car Driver	1
Passenger	1
Rail Wait	2
Bus Wait	2

Table 6: Mode Time Valuations

5.30 For this test the time valuation for car and passengers in the NTM is assumed to decrease by 25% to 0.75 by 2050 as a high proportion of the fleet is highly autonomous (Table 5). This is based on a study in the Netherlands[59] that completed a novel stated preference survey of 252 individuals and estimated a discrete choice model. The research found the value of time for an AV with an office interior to be 25% lower than for a conventional car. It should be noted that evidence in this area is thin and speculative with large variance in predicted values.

5.31 A reduction in perceived values of car travel time has two potential impacts in the NTM: it increases trip lengths and leads to mode switching (to cars). In this technology test we have ignored any other technological developments that affect perceived time costs or running costs on other modes, which may overestimate mode switching to car. For example, a driverless bus may be cheaper to run decreasing bus fares.

5.32 Under these assumptions, we see traffic growth of approximately 40% between 2015 and 2050.

Demand Sensitivity Test 3 Car Occupancy

5.33 In the ride-sharing test, ride-sharing is assumed to become well-embedded, with new business models (short and long distance) being extensively used. As a result, average vehicle occupancy rates would dramatically increase and most journeys would be shared. It is plausible ride-sharing could be restricted to shorter urban trips, however this assumption has not been made due to limitations of the NTM suite.

5.34 In the private travel tests, ride-sharing does not become well embedded and vehicles are primarily used by individuals to travel alone. Car-sharing is used for short trip with passengers more likely to travel on their own for the duration of their trip. Less escort trips are required and empty running becomes an increasing factor. Overall car occupancy rates reduce.

[59] De Looff, E., Correia G., Van Cranenburgh S., Snelder, M. and Van Arem, B. (2018). Potential changes in value of travel time as a result of vehicle automation: a case study in the Netherlands

5.35 To conduct a sensitivity test of the possible impact of changes to these rates in the NTM, we have adjusted how passengers perceive costs to bring about the changes in occupancy level as listed in Table 7. This is not considered an ideal methodology, given this is a calibration parameter not intended to be varied over time and highlights some of the limitations with using the NTM in this capacity.

5.36 This is not a forecast of how we expect car occupancy to change and is instead a test of the NTM response to changes to car occupancy.

	2015	2050
Scenarios 1 - 7	1.5	1.5
Ride-Sharing	1.5	1.7
Private Travel	1.5	1.3

Table 7: Vehicle Occupancy Rates for High and Low Demand Narratives (average number of drivers and passengers in vehicle)

5.37 Under these assumptions, we see traffic growth of approximately 5% and 55% over the 2015 and 2050 period.

5.38 In the ride-sharing test the model predicts some public transport users become car passengers due to the reduced cost. This is in line with expectations. However, in the private travel test, the model predicts some car passengers become public transport users as being a passenger is effectively more expensive. This does not align with the narrative around private travel which would likely see users moving away from public transport to car 'drivers' and thus is likely to result in an under-estimation of the amount of car traffic in this test. The limitation in this test reflects limitations in our current modelling suite and improvements in this area should be a focus of any further work.

Comparing Demand Tests

5.39 The results of the different demand tests are shown in Table 8. As these tests are pivoted off scenario 1 (the reference scenario) the growth rate to 2050 is included for comparability[60]. The range of traffic growth forecast is between 5% and 55% between 2015 and 2050, clearly showing the great uncertainty around the impact of vehicle technology on road traffic demand.

Tests	Traffic Growth from 2015 to 2050
Reference Scenario	35%
Increased Mobility	42%
Decreased Perceived Value of Time	40%
Private Travel	55%
Ride Sharing	5%

Table 8: Traffic Growth for England & Wales (All Technology Tests)

[60] All 7 scenarios are considered to represent plausible futures and thus all scenarios should be taken into account when using the forecast results.

5.40 These tests show that relatively small changes to car occupancy levels could have a significant impact on the future of road traffic demand. The ride sharing sensitivity test shows the lowest growth at 5%, whilst private travel sensitivity tests shows the most growth of 55%.

5.41 In comparison, the increased mobility test and the decreased perceived value of time test show smaller growth of 42% and 40% respectively. However it should be noted that whilst we have increased the number of trips for the over 75 cohort and increased driving licence holding, there could possibly be further trips from those currently too young to hold a licence.

5.42 The fact there is any growth at all in ride sharing test out to 2050 is in large part due to initial growth in line with the reference scenario until 2025, thereafter is a significant decline in demand resulting from the impact of higher ride sharing. It is worth noting that changes in car occupancy are not necessarily reliant on CAVs and they may arise through new business models using existing technology.

Combined Demand Sensitivity Tests

5.43 The demand sensitivity tests have been split into two narratives, 'private, productive and increased mobility' and 'ride sharing'. A summary of these narratives can be seen in Table 9.

5.44 In the Private, Productive and Increased Mobility Narrative:

- Vehicle and ride sharing does not increase against the baseline. Alternatively, due to less escort trips being required and empty running becoming a factor, car occupancy rates go down.
- Perceived Values of Time decrease as people are able to use their time productively in automated vehicles. Vehicle technology improves such that motion sickness is no longer a major source of discomfort.
- Increased Mobility from over 75 year old cohort and those without driving licences previously not driving resulting in an increase in trips.

5.45 In the Ride Sharing Narrative:

- Ridesharing becomes a common form of travel and thus car occupancy rates increase.
- Perceived Values of Time remain unchanged as people don't typically use their time productively in automated vehicles due to issues with motion sickness.
- No change in trip making behaviour for those over 75 year old and those without driving licences.

Narrative	Mobility	Value of Time	Car Occupancy
Private, Productive & Increased Mobility	Increase	Decrease	Decrease
Ride-Sharing	Scenario 1-7	Scenario 1-7	Increase

Table 9: Combined Sensitivity Tests

5.46 The results of the combined tests are shown in Figure 45. The range of traffic growth forecast is between 5% and 71% between 2015 and 2050, clearly showing the great uncertainty around the impact of vehicle technology on road traffic demand.

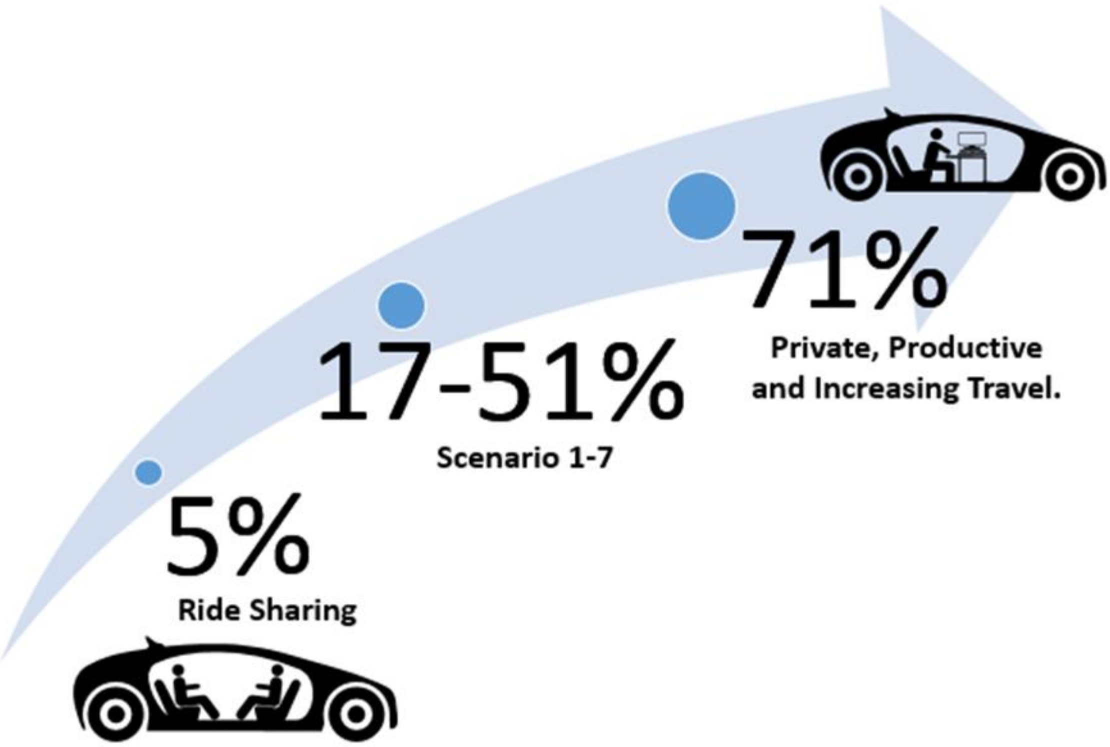

Figure 45: Results of Combined Sensitivity Tests

5.47 It is important to highlight that within these demand tests we are working both without a developed evidence base and without capacity to develop tests on something potentially hugely impactful such as empty running. We wish to develop and update these tests over time and will keep abreast of evidence base changes and reflect upon updating our modelling suite accordingly.

Supply Sensitivity Tests

Test 4 Capacity Benefits

5.48 This test is based on Atkins research that used simple network models to estimate the capacity impact of CAVs[61]. Their microsimulations focused microscopic behaviour of traffic including accelerating/decelerating, longitudinal behaviour, lateral behaviour, gap threshold and decision making.

5.49 Atkins assumed CAVs are manufactured to be able to provide driving behaviour options in order to suit different drivers, who may setup CAVs to fit their own driving behaviour. For example, more assertive drivers may have higher acceleration and keep shorter gaps, while cautious drivers may maintain longer distances from other vehicles. The levels of capability modelled are shown in Figure 46 below.

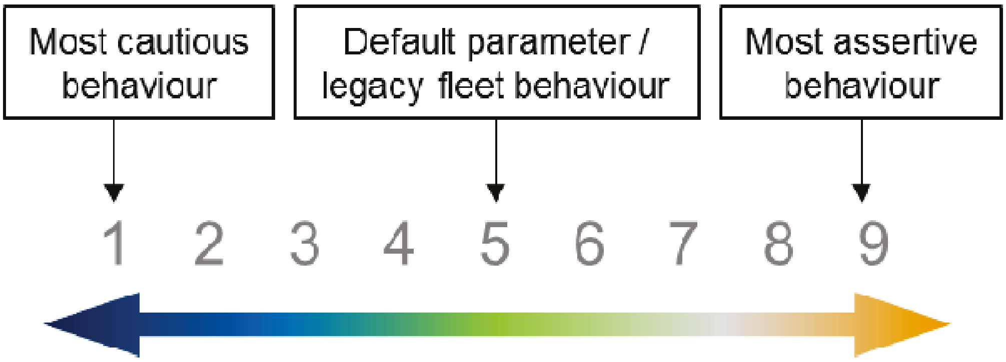

Figure 46: Levels of Driving Behaviour

5.50 Atkins also note the potential for disruptions to traffic flow and capacity, rather than improvements. Table 10 has been based on an average capability of 5-9 in order to explore the positive capacity benefits.

	Fleet Penetration			
	25%	50%	75%	100%
Single Link Lane (60mph)	6%	13%	21%	30%
Multiple Link Lane (60mph)	6%	12%	17%	25%
Signalised junction	5%	9%	15%	21%
Roundabout	6%	12%	19%	26%
Motorway	10%	20%	31%	46%

Table 10: Capacity Benefits of CAVs with Fleet Penetration Level

5.51 To apply these values to the road types in the NTM simplifying assumptions were made as shown in Table 11. Rural minor roads and dual and single urban were

[61] https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/530093/impacts-of-connected-and-autonomous-vehicles-on-traffic-flow-technical-report.pdf

assigned the average capacity benefit of a roundabout and a signalised junction as applying capacity benefits of a road with a 60mph speed limit or a motorway did not seem appropriate.

5.52 Applying the results from a simple network model for a link or a junction to a complex strategic model such as the NTM has limitations. The capacity benefits achieved by CAVs in a strategic model may differ to these simple models. Atkins did not report any capacity benefits for their complex network models due to the potentially misleading nature of this metric. Therefore the congestion improvement in this test should be viewed as exploratory.

NTM	Atkins
Motorway	Motorway
Dual and Single Urban	Average of junction and roundabout
Dual Rural	Multiple Link Lane (60mph)
Single Rural	Single Link Lane (60mph)
Minor	Average of junction and roundabout

Table 11: Mapping of Road Types

5.53 The capacity benefits applied in the NTM are shown below in Table 12. These were calculated using the fleet penetration assumptions as set out in Table 5 and the capacity growth rates in Table 10.

Road Type	Increased Capacity by 2050
Rural Dual	21%
Rural Single	25%
Rural and Urban Motorway	39%
Other	20%

Table 12: Capacity Growth Rates by Road Type

5.54 To give a sense of the potential range of congestion impacts of CAVs, we have considered:

- the Private, Productive and Increasing Mobility narrative with no capacity benefits
- the Ride-Sharing narrative with capacity benefits as per Table 12.

5.55 Increasing capacity in the NTM creates induced demand. As capacity increases, congestion and hence journey times reduce, lowering the cost of road travel. This increases road demand. Under the capacity assumption in Table 12, road demand is increased by 1% by 2050. This has marginally reduced the congestion benefits of the increased capacity.

5.56 Table 13 shows under the private, productive and increased mobility narrative with no capacity benefits 24% of traffic will be in congested conditions by 2050. This contrasts with the ride-sharing narrative with capacity benefits where the percentage of traffic in congested conditions falls to 5%.

Tests	Percentage of traffic in congested conditions
Reference Scenario in 2050	11%
Private, Productive and Mobile - Standard Road Capacity in 2050	24%
Ride Sharing - Increased Road Capacity in 2050	5%

Table 13: Congested Conditions (Combined Tests)

Conclusions and Next Steps for Technology Tests

5.57 The demand technology tests presented here show the level of uncertainty around the impact of vehicle technology on road traffic demand with traffic growth ranging from 5% to 71% between 2015 and 2050. These tests also show that relatively small changes to car occupancy levels could have a significant impact on the future of road traffic demand. The potential for CAVs to create behavioural change leading to ride sharing will be a key focus of research in the near future.

5.58 The supply technology tests demonstrate two key messages. Firstly the potential positive impacts of CAVs reducing congestion through increased capacity. Secondly the negative impacts on congestion if demand is increased without these capacity benefits being realised. As with all tests presented here, the magnitude of the impacts is subject to a great deal of uncertainty.

5.59 For these tests we have worked without either a developed evidence base or capacity to develop tests on something potentially hugely impactful such as empty running. Whilst we believe the technology-focused tests have explored some of the key features of CAVs that may impact road traffic demand, it is clear given the level of uncertainty that we should look to update our modelling capability to be able to more simply quantify the possible range of impacts of such a significant shock to the transport system.


A405, M25, M25

6. Summary & Next Steps

Summary

6.1 In this document we have:

- Evaluated the past performance of the forecasts
- Given details of how our modelling suite has been updated since RTF15
- Discussed the key drivers of road traffic demand and the uncertainty around them
- Shared how we have taken forward a scenarios based approach to forecasting to deal with uncertainty around road traffic demand, focusing on exploring key drivers
- Developed tests exploring the potential impacts of changes to vehicle technology such as Connected and Autonomous Vehicles (CAVs)
- Shared forecasts of possible future road traffic demand

6.2 At the national level, traffic is forecast to increase in all our scenarios, but the size of growth varies depending on the assumptions made about the key drivers of future road demand. From 2015 traffic is forecast to grow between 17% and 51% by 2050 with strongest growth on the Strategic Road Network.

6.3 Congestion is forecast, at an aggregate level, to grow in broadly the same proportions as traffic demand, with higher congestion growth in those scenarios which forecast higher demand growth.

6.4 We have developed a series of tests exploring the uncertainty around CAVs. These clearly show the wide range of impact possibilities at this stage of the evidence base.

Next Steps

6.5 DfT has commissioned development of a new version of the National Transport Model, NTMv5, to analyse personal travel and road traffic with greater geographical detail than the existing model, and also a detailed representation of the road network.

6.6 Understanding future demand for road travel is essential to shape the policies we implement and the investments we make. However, forecasting future demand is complex and there is significant uncertainty about the extent to which existing trends and relationships will carry on into the future. We will continue to develop our understanding of the uncertainty surrounding the key drivers of demand, the relationship between the drivers and the capability of our models to represent this. And therefore we will review and develop the scenarios used in our strategic forecasts as updated evidence emerges.

6.7 Whilst we believe the technology-focused tests have explored some of the key features of CAVs that may impact road traffic demand, it is clear given the level of uncertainty that we should look to update our modelling capability to be able to more simply quantify the possible range of impacts of such a significant shock to the transport system. Within the uncertainty around CAVs, it is clear that any significant behavioural change related to car occupancy levels could impact road traffic demand considerably. This will be a key focus of research in the near future.

6.8 We will continue to work on the evidence base and develop the forecasting approach to improve the transparency and robustness of the model and we will continue our analysis of trip rates. As we do this we will work with stakeholders to increase the understanding of our forecasting approach and to draw on their expertise for how it might be improved.

Annex: Speed Flow Curves

Introduction

1 This section presents details of the speed flow curves used in the National Transport Model. They are consistent with the capacity assumptions and version of the model used in the production of the forecasts above.

2 The curves provide the speeds on different road types occurring in different area types and are based on 'network average' conditions. They therefore represent average levels of hilliness, bendiness and minor (side) road or other accesses. They also assume fair (daytime) visibility and weather conditions.

3 The curves are periodically updated to reflect more recent data relating to speeds, or any other issues that may arise

Speed/Flow Relationships (Vehicles)

4 The below tables and graphs describe the speed flow curves in terms of the number of vehicles per hour per traffic lane. The curves assume average road conditions and percentages of heavy vehicles appropriate to the different road and area types.

Point on Curve	Motorway		T&P Dual		Trunk Single		Principal Single		B Roads		C & Uncl Roads	
	Speed KpH	Flow Veh	Speed KpH	Flow Veh	Speed KpH	Flow Veh	Speed KpH	Flow Veh	Speed KpH	Flow Veh	Speed KpH	Flow Veh
A	117	0	110	0	88	0	79	0	77	0	60	0
B1	-----	-----	-----	-----	60	1016	60	1000	----	----	----	----
B2	112.6	1200	100	1125	10	1650	10	1625	70	400	45	750
C*	55.6	2000	51.6	1800	36	1320	36	1300	40	1100	40	1000
P	20	2500	20	2250	5	2640	5	2600	10	1485	10	1400

Table 14: Values used in Rural Area Speed Flow Curves

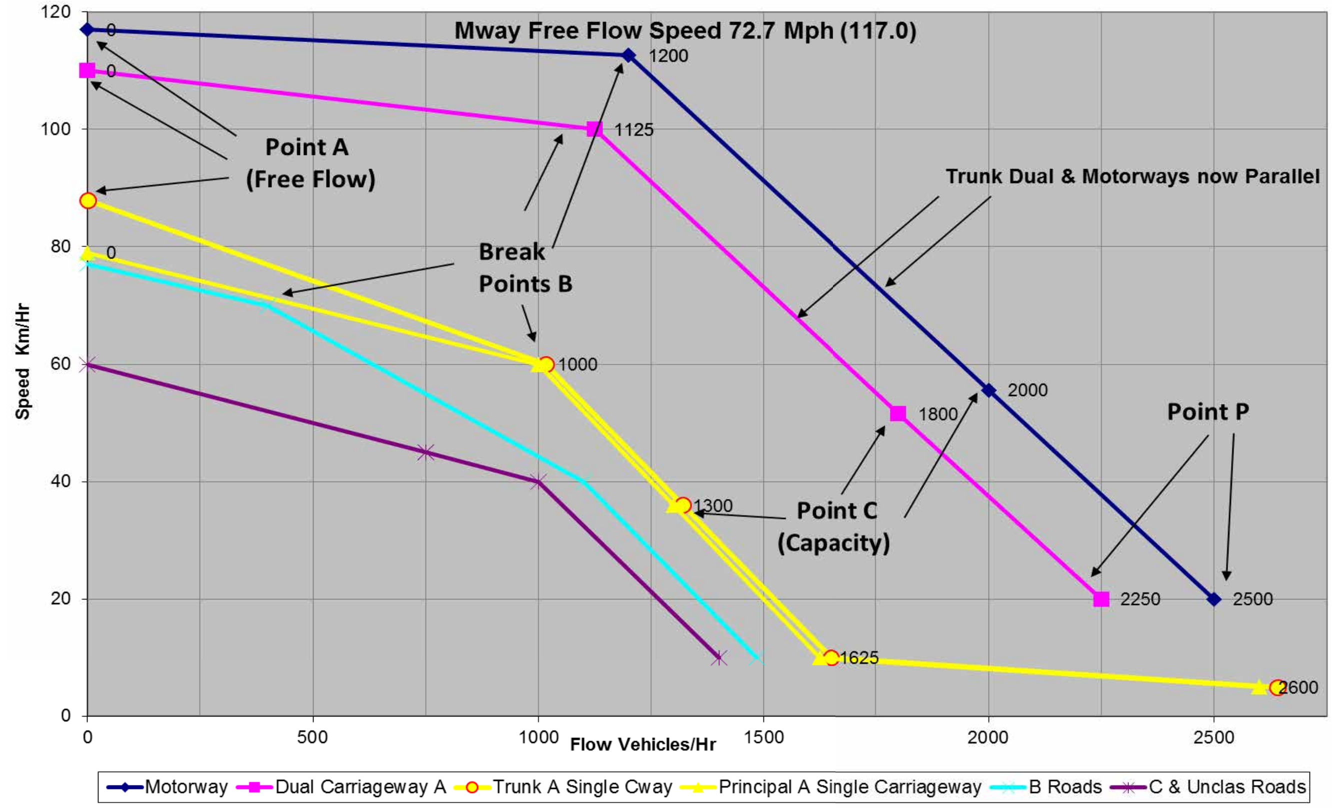

Figure 47: Rural Area Speed Flow Curves

Road Type	Area Types	Area Speed KpH	B1 Speed KpH	B1 Flow Veh	B2 Speed KpH	B2 Flow Veh	C Speed KpH	C Flow Veh	P Speed KpH	P Flow Veh
Mway	1, 2 & 4	77	-------	-------	74	1200	47	1800	20	2400
	3 & 5	117	-------	-------	112.6	1200	55.6	2000	20	2500
	4 - 6	65	60	6205	50	1050	30.2	1500	15	1845
A Rd	1	49	39	300	7.5	630	17.5	525	5	1050
	2	49	43	322	7.5	680	18.8	565	5	1130
	3	58	50	512	10	1185	21.8	985	5	1970
	4	49	43	367	7.5	774	18.8	645	5	1290
	5	58	50	520	10	1200	21.8	1000	5	2000
	6 to 9	64.8	57	620	10	1415	34.5	1000	5	2000
B&C Rd	1	30	14	170	7.5	510	9.1	425	5	850
	2	30	16	368	7.5	552	11.7	460	5	920
	3	35	18.7	592	7.5	888	13.1	740	5	1480
	4	40	24	473	7.5	630	18.5	525	5	1050
	5 & 6	40	24	675	7.5	900	18.5	750	5	1500
	7 to 9	40	24	900	7.5	1200	18.5	1000	5	2000
Unc Rds	1	30	9.3	128	7.5	510	7.9	425	5	850
	2	30	16	138	7.5	552	9.4	460	5	920
	3	30	21.7	222	7.5	888	10.7	740	5	1480
	4	30	19	420	7.5	630	13.3	525	5	1050
	5 & 6	40	24	675	7.5	900	18.5	750	5	1500
	7 to 9	40	24	750	7.5	1050	10.2	1000	5	1700

Table 15: Values used in Urban Area Speed Flow Curves

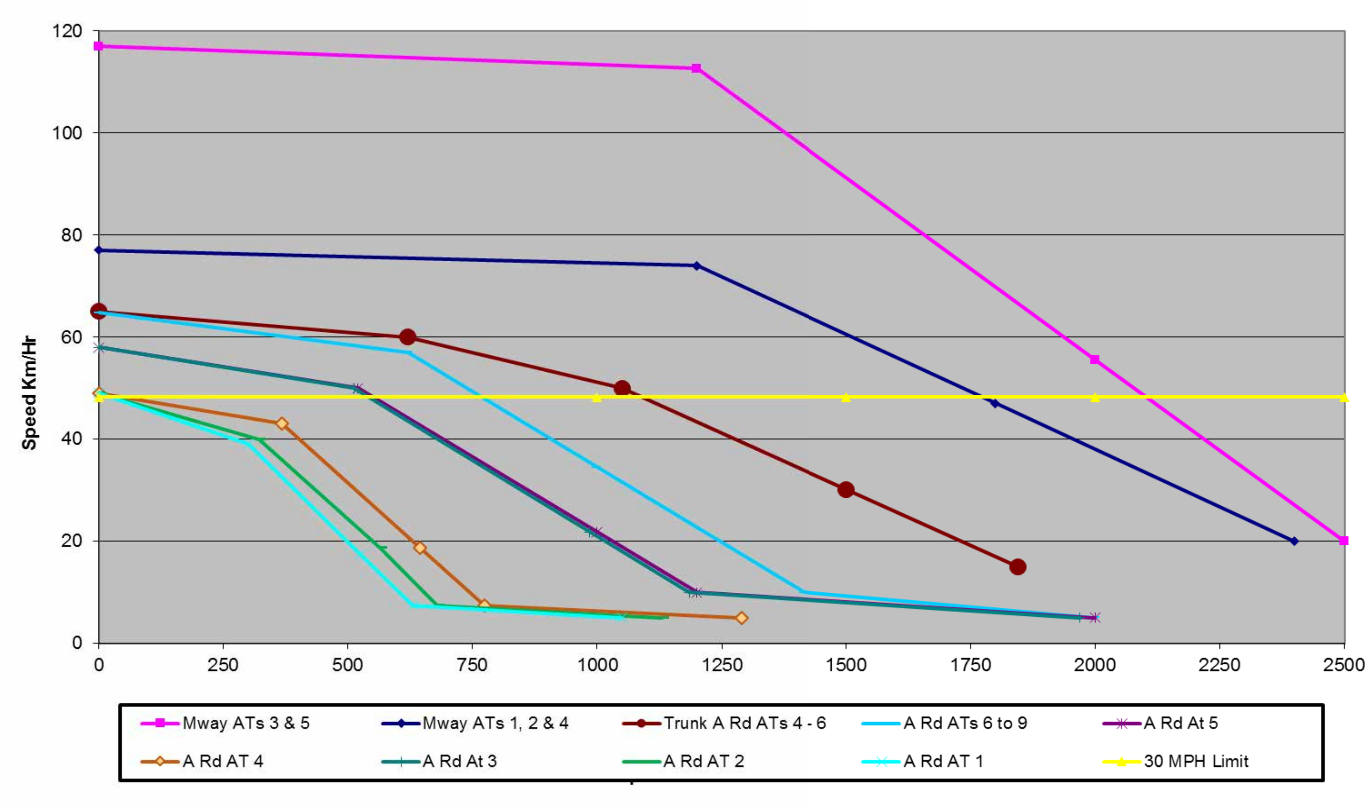

Figure 48: Urban Major Road Speed Flow Curves

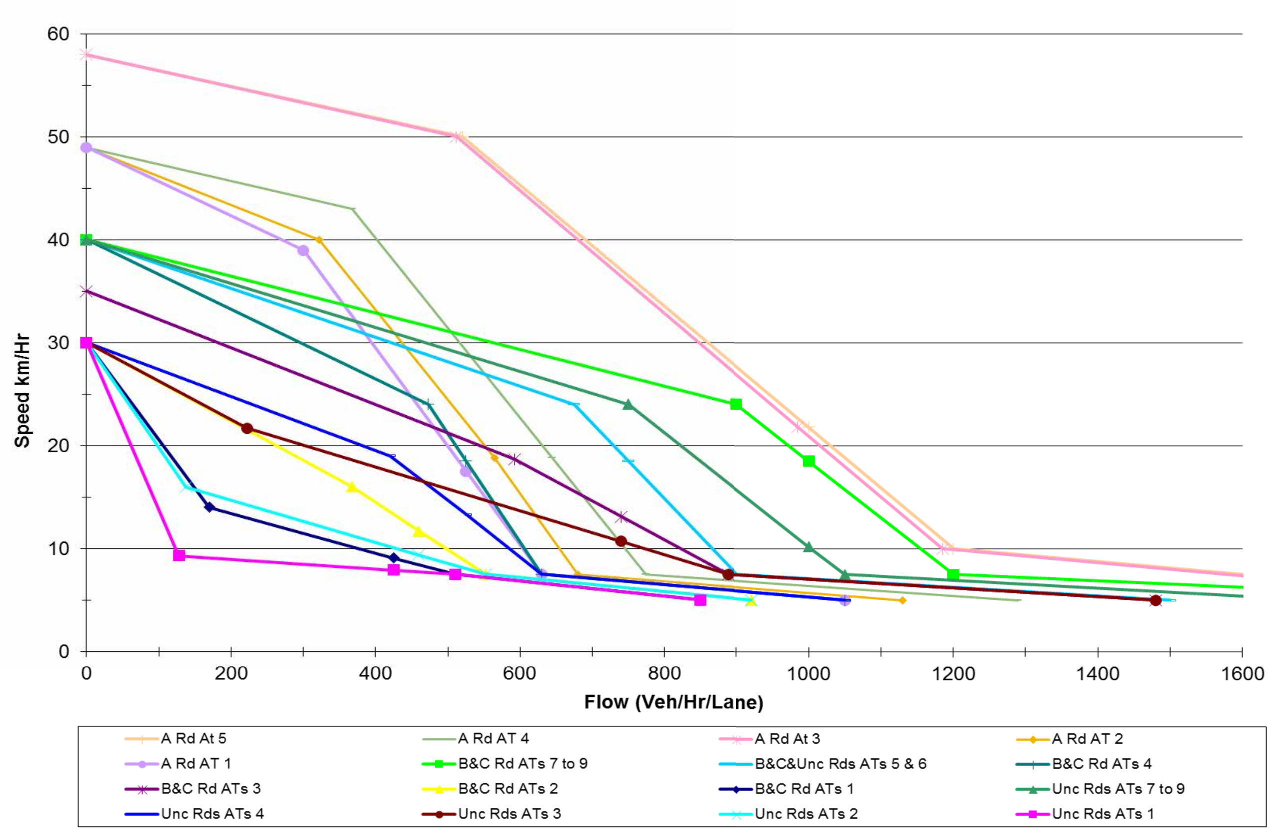

Figure 49: Urban Minor Road Speed Flow Curve

Annex: Glossary of Terms and Acronyms

Acronym	Long Title
AV	Autonomous Vehicle
BEIS	Department for Business, Energy & Industrial Strategy
CAV	Connected Autonomous Vehicle
CO2	Carbon Dioxide
DfT	Department for Transport
EEP	Energy and Emissions Projections
EV	Electric Vehicle
FFPA	Fossil Fuel Price Assumptions
FORGE	Fitting On Regional Growth Effects
GBFM	Great Britain Freight Model
GDP	Gross Domestic Product
HE	Highways England
HGV	Heavy Goods Vehicle
ITC	Independent Transport Commission
LGV	Light Goods Vehicle
LOS	Level of Service
MaaS	Mobility as a Service
NATCOP	National Car Ownership Model
NIC	National Infrastructure Commission
NOx	Generic term for the mono-nitrogen oxides
NTEM	National Trip End Model
NTM	National Transport Model
NTS	National Travel Survey
OBR	Office for Budget Responsibility
ONS	Office for National Statistics
PM10	Particulate Matter 10 micrometres or less in diameter
PT	Public Transport
RIS1	1st Road investment Strategy
RIS2	2nd Road Investment Strategy
RTF15	Road Traffic Forecasts 2015
RTF18	Road Traffic Forecasts 2018
RTMs	Regional Traffic Models
SAE	Society of Automotive Engineers
SRN	Strategic Road Network
ULEV	Ultra Low Emission Vehicle
V/C	Volume over Capacity ratio
VOC	Vehicle Operating Costs
VoT	Value of Time
WebTAG	Web-based Transport Analysis Guidance
ZEV	Zero Emission Vehicle


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