NTEM Planning Data Version 7

Guidance Note

Department for Transport

July 2016

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1. Introduction

1.1. Overview

1.1.1. This introduction provides an overview of the processes, methodology and data sources used to produce the NTEM 7 planning data set. This report is based on an earlier version produced for the preceding version of NTEM[1].

1.1.2. Section 2 describes the methodology used to convert the input assumptions into planning data forecasts. This methodology is implemented in a bespoke software tool, the Scenario Generator, which has been updated for version 7. This section explains the forecasting process, attempting to explain the more complex issues diagrammatically. The mathematical specification of this process is provided in Appendix D.

1.1.3. Section 3 describes the data sources used in the derivation of 2011 base year inputs. These include base year data for population, households, dwellings and employment, segmented into the dimensions required by the Scenario Generator.

1.1.4. Section 4 describes the forecast data requirements needed by the Scenario Generator. This covers use of trend-based population, household and employment figures. The production of a policy-based data set for dwellings is also described in this section.

1.1.5. Section 5 describes the derivation of Expected Growth Factors (EGFs) used within the forecasting process. This includes a brief methodological overview and worked examples of the two methodologies.

1.1.6. Section 6 summarises the results from the forecasting process, including car ownership and trip end projections.

1.2. Outline of NTEM forecasting process

1.2.1. The complete process involved in the production of NTEM forecasts can be seen in Figure 1-1. The process of creating forecast year planning data (the core of this note) involves running through the Scenario Generator process. This creates planning data forecasts for input into the National Car Ownership model and the National Trip End model.

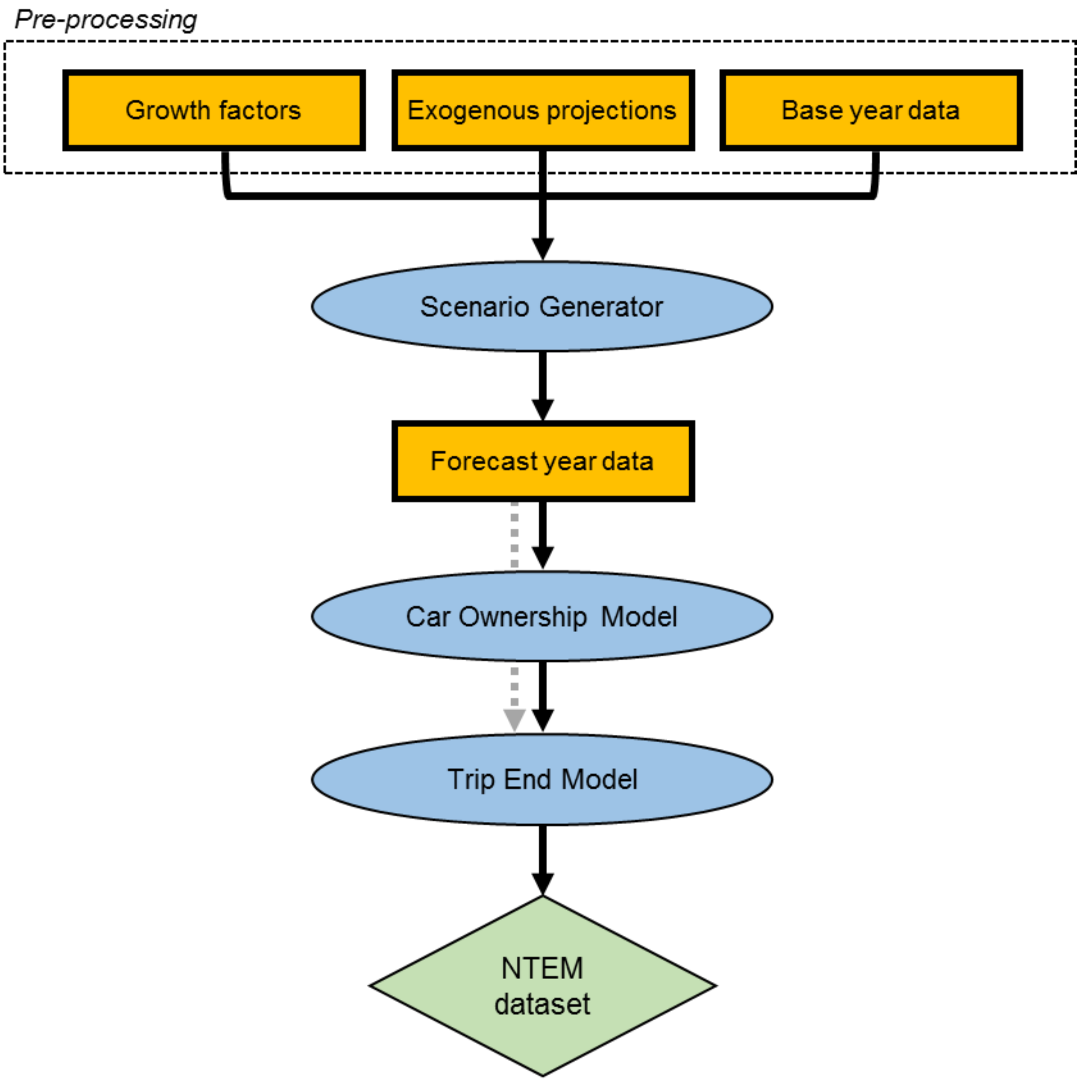
1.2.2. The Scenario Generator software reads in projections for population, households, dwellings and employment at an aggregate spatial level. In the case of policy based dwelling inputs these are extracted from published local authority trajectories. The software also reads in a set of *Expected Growth Factors* (EGFs), representing the levels of growth that would be expected in each zone, as a function of the area type of that zone.

1.2.3. The software uses the base year demographic characteristics of each zone from the 2011 Census of Population. From this, the county/district level projections and the growth factors are used to generate consistent future year planning data at the zonal level. The process runs incrementally through time, with coarse-level changes over the next period being applied to the detailed zone-level results of the previous scenario.

1.2.4. This process has been implemented in five year steps for each study area (roughly equivalent to the former Government Office Regions, Scotland and Wales), to a forecast year of 2051. Intermediate years released in the NTEM dataset via TEMPRO are generated through linear interpolation between the five year Scenario Generator forecasts.

[1] NTEM Planning Data 6.2 – Guidance Note (WSP, 2011)

Figure 1-1: Basic steps in generating the NTEM 7 dataset

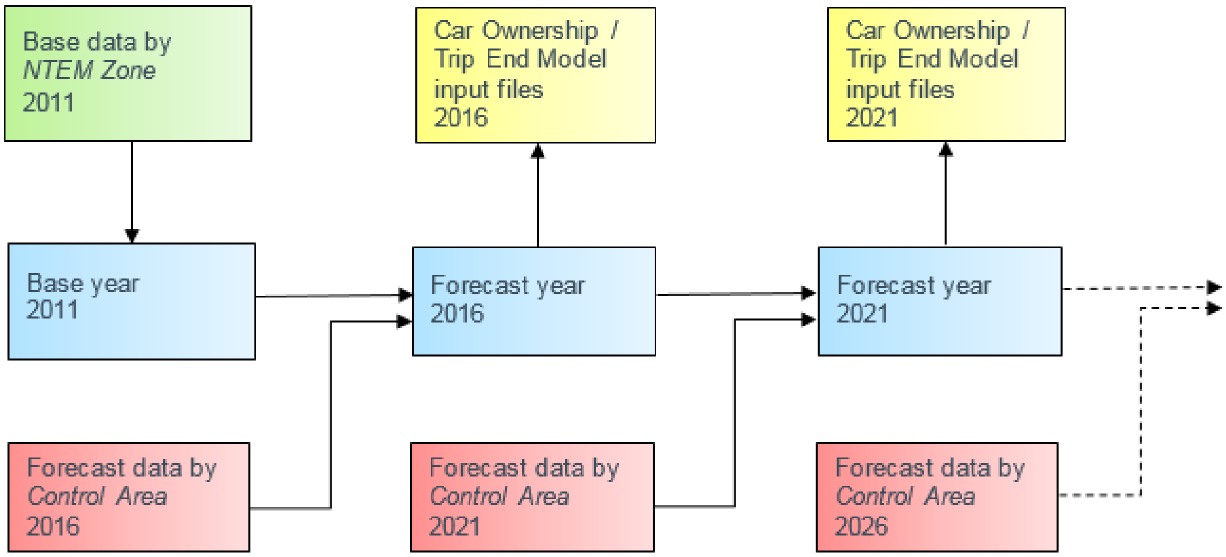


1.2.5. Figure 1-2 shows the general structure of a series of forecast runs for a particular study area. Each scenario builds on the last. At each point results may be exported to the National Trip End Model and the National Car Ownership Model. It is also possible to branch at a certain point and test different planning data inputs beginning from the results of a forecast scenario.

1.2.6. Results from the NTEM forecasting suite are ultimately made available through the Department for Transport's TEMPRO software. For information on this, please see the relevant documentation[2].

[2] https://www.gov.uk/government/collections/tempro [correct as of July 2016]

Figure 1-2: Structure of possible scenario generation



1.3. Summary of changes for NTEM 7

1.3.1. The following elements have been enhanced for NTEM 7:

- A new zoning system has been implemented, consisting of 7700 zones based primarily on middle-layer super output areas;
- Age segmentation has been updated, accounting for general increases in working age and providing a greater level of disaggregation;
- Data sources have been updated to a 2011 base year, including model parameters;
- Forecast data sources have been updated to enable the ultimate time horizon of the model to be extended to 2051;
- Expected growth factors have been re-estimated based on updated planning area types;
- Balancing areas have been re-estimated based on 2011 TTWAs;
- A new trend based employment forecasting methodology has been adopted, based primarily on published sources of information;
- The National Car Ownership model has been re-estimated and updated to a 2011 base year, and to include additional area types and a cohort licence holding model[3];
- A Trip Rate Forecasting Tool has been developed, enabling the production of time-varying trip rates[4]; and,
- Parameters for trip-end modelling have been re-estimated based upon an updated NTS sample; and,
- All software tools, databases and documentation have been updated.

1.3.2. The same basic methodology and processing structure has been retained for the estimation of demographic planning forecasts, car ownership and trip ends. This includes all other aspects of segmentation, including definitions for employment types and land use indicators.

[3] Detailed in the report "Estimation of the National Car Ownership Model for Great Britain, 2011 Base" (RAND Europe, 2016)

[4] Conducted as part of the DfT's "Understanding and Valuing Impacts of Transport Investment" research programme

Geography

1.3.3. The NTEM zone is the main spatial unit in NTEM. NTEM zones for England & Wales are consistent with Middle Super Output Areas (MSOAs), whilst for Scotland, NTEM zones are an aggregation of Data Zones (DZs).

1.3.4. Earlier versions of NTEM (up to and including v6.2) includes Scotland at the same geographical level as England as Wales. However, since the formation of this dataset, significant devolution has occurred in Scotland, with consequences for the implementation of NTEM 7. The 2011 Census, on which the majority of input data is based, was conducted separately for Scotland. As a consequence, different definitions for geography and input data requirements are in place.

1.3.5. Moving to MSOA based geography significantly increases the number of NTEM zones. Where previously there were under 2,500 for the entirety of Great Britain, the number of NTEM 7 zones for England & Wales alone is 7,201. This has not caused any problems with construction of the model or software, and does not present any additional complexity for purposes of quality assurance.

1.3.6. NTEM 7 zones in Scotland have been formed as an aggregation of Data Zones. A total of 499 zones have been established, equivalent to the coverage provided in England and Wales.

1.3.7. In combination, there are now 7,700 NTEM 7 Zones in Great Britain. Table 1-1 shows a comparison between NTEM 6.2 and 7 zoning systems.

Table 1-1: NTEM zone system comparison

Area	Number of NTEM zones (6.2)	Number of NTEM zones (7)
East of England	295	736
East Midlands	260	573
London	57	983
North East	132	340
North West	282	924
Scotland	264	499
South East	410	1,108
South West	244	700
Wales	179	410
West Midlands	168	735
Yorkshire and Humber	205	692
Great Britain	**2,496**	**7,700**

Data segmentation

1.3.8. The NTEM suite contains a variety of age bands for use in demographic projections and trip end modelling. Due to general changes in Census definitions, there has been an expansion of the 'working age' category. This is displayed as 'Planning data' in TEMPRO, as shown in Table 1-2.

Table 1-2: NTEM age definitions

NTEM 6.2	NTEM 7
< 16	< 16
16 to 64	16 to 74
65+	75+

1.3.9. In addition, the age bands used in the Scenario Generator process were also disaggregated. The previous two working age bands (16-29, 30-64), have been amended to four working age bands (16-29, 30-44, 45-64, 65-74). This enables better reflection of changing age structure in the population. This is explained further in Section 3 of this document.

Source data

1.3.10. This version of NTEM has a base year of 2011, requiring extensive use of the 2011 Census of Population and re-formulation of base and forecast parameters.

1.3.11. Reflecting the change of base year, the ultimate time horizon of the model has been extended from 2041 to 2051. The model continues to be run at five year increments, with results interpolated for intervening years in the TEMPRO software.

1.3.12. Forecast data has also been updated, as described in Section 4 of this report.

1.3.13. All parameters, EGFs and balancing areas have been updated to reflect new source datasets.

1.3.14. The forecasting methodology for the Planning Data has not been revised. The National Car Ownership model has been re-estimated with 2011 data, and trip rates by person type have been re-estimated for use in CTripEnd from an updated NTS sample.

2. Planning data methodology

2.1. Summary

2.1.1. The Scenario Generator is a software tool that produces planning data sets by using base and forecast data supplied by the user at various levels of geographical and other detail.

2.1.2. The Scenario Generator used for NTEM 7 has been designed to run with a zoning system based on 2011 Census geography to produce demographic forecasts at five year intervals from 2011 to 2051. The software is flexible enough to allow forecasting for any required period, and at any spatial level given the availability of adequate input data.

2.1.3. This section outlines the steps that the Scenario Generator performs to produce a consistent set of planning data forecasts.

2.2. Objective

2.2.1. The objective of the Scenario Generator is to produce a set of consistent forecasts of population, households and employment for a pre-defined set of zones. The planning data forecasts are obtained by scaling up or down a set of previous zone specific forecasts to match a new set of control totals for more aggregate areas that are input by the user. Pre-processing of forecast data is required to obtain the initial input control totals.

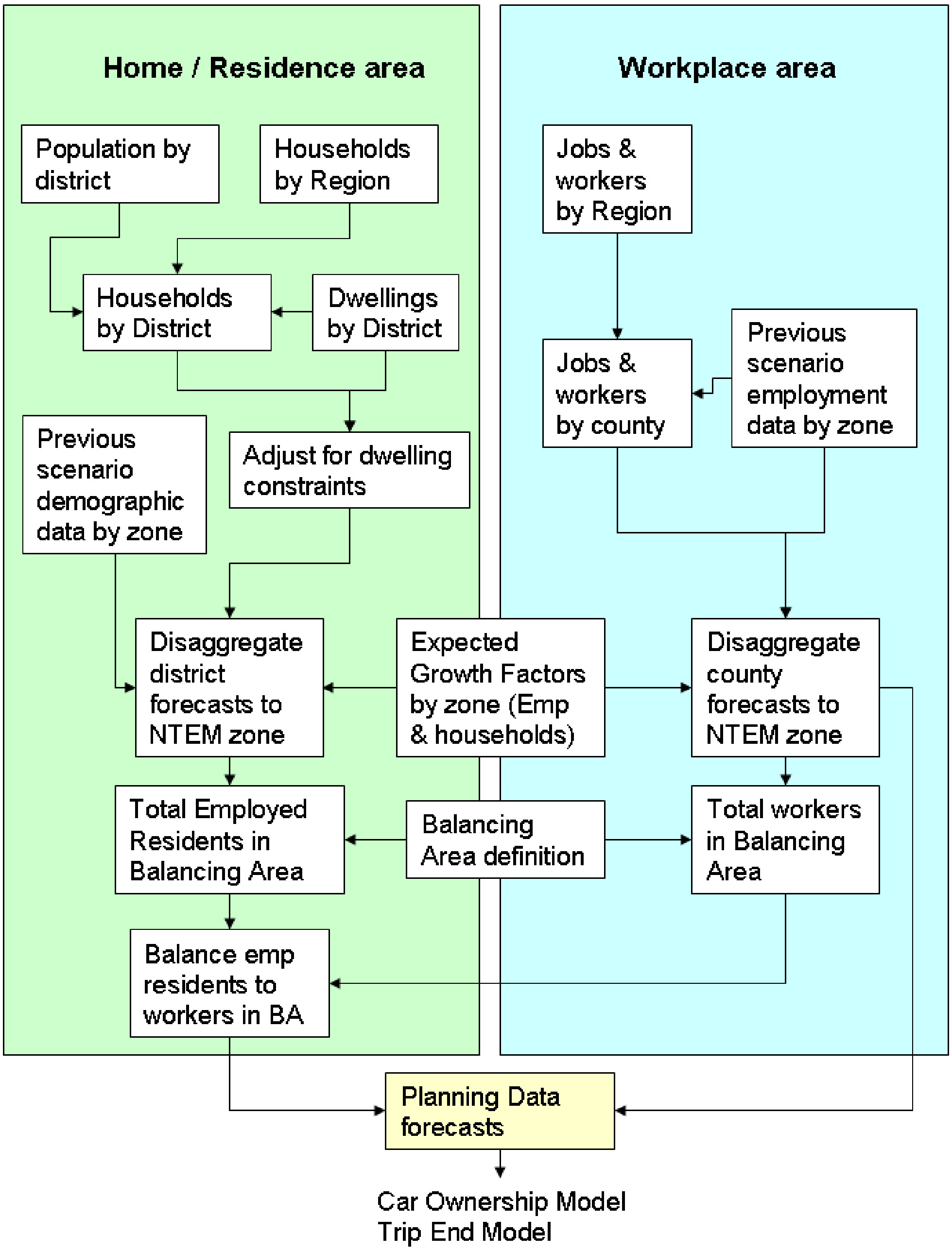
2.2.2. Each of the main variables are segmented into categories as follows:

- Employment: by industry, gender and working status (full-time / part-time);
- Population: by gender, age and working status; and
- Households: by size.

2.2.3. Figure 2-1 shows a basic summary of the steps in producing forecast planning data at the NTEM zone level. The fundamental steps are as follows:

- Derive detailed demographic data for the starting year (either the defined base year or an already generated forecast year);
- Derive forecast year data from input planning projections or policy-based datasets;
- Use expected growth factors to assign change in control area totals to the NTEM zone level;
- Balance workforce (required for jobs) and workers (employed people in households) within a balancing area;
- Update worker profile for changes in employment forecasts; and
- Output planning data for input into the National Car Ownership (NATCOP) model and the Trip End (CTripEnd) model.

Figure 2-1: Summary of Scenario Generator process



2.2.4. The level of aggregation of the resulting planning data forecasts is dependent on the ultimate use, with fewer categories required for the National Car Ownership Model. Demographic forecasts are exported from the Scenario Generator in the precise form required by these models.

2.3. Basic inputs and spatial definitions

Study areas

2.3.1. The methodology assumes that planning data forecasts for each study area will be wholly independent of those for other study areas in Great Britain. Study areas have been defined as the Government Office Regions in England, plus Scotland and Wales. One exception is for the South East, East of England and London Regions. These three are considered as one study area (Wider South East) as London has a large impact on working and commuting patterns on the surrounding areas. The user may generate forecasts for any one of the specified study areas. This allows separate updates to be made for each study area where specific forecast planning data may be obtained in the future.

Control areas

2.3.2. Within each study area, forecast data from various projections or policy-based sources are likely to be provided at a spatial level between NTEM zone and the study area as a whole. These are defined prior to using the Scenario Generator and are referred to as control areas. This allows the software to bridge the gap between NTEM zones and the study area as a whole. In principle, control areas could be any level of spatial aggregation that sits between the NTEM zone definitions and the study area definition:

NTEM ZONES ∈ CONTROL AREAS ∈ STUDY AREA ∈ GREAT BRITAIN

2.3.3. Two control area zoning systems exist for the main data types:

- Population-based (population, households and dwellings); and
- Employment-based (workers and jobs).

2.3.4. However in NTEM 7 the population and employment based control areas are identical. The population-based and the employment-based control areas are both at the local authority district level. This is consistent with the previous version of NTEM (6.2).

Basic input data

2.3.5. There are three main planning data inputs of the forecasting process: households, population and employment (jobs). The input data is typically government provided trend based projections which may be modified during the process of developing a coherent set of planning led forecasts. The input variables are as follows:

- 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.

2.3.6. The policy based inputs which influence the allocation of population and workers in the forecasting process are determined from projections of dwellings and growth factors that represent expected patterns of development.

- Dwellings in each control area;
- Expected growth factors in each zone for employment type; and
- Expected growth factors in each zone for households (all types).

2.3.7. All working data is adjusted to mid-year estimates to avoid issues of under-enumeration that may be evident from basic 2011 Census data. The mid-year estimation process is discussed in Section 3

2.3.8. In addition to the basic input data, several base and forecast control parameters are required in each forecast run. These parameters are generally global in nature, controlling the performance of the model. The control parameters are described in more detail in Appendix C.

Population and household totals

2.3.9. Population projections input data requires an adjustment to account for those persons not living in households who are excluded from the forecasting process. These are people who live / work in communal establishments which include residential care homes, student halls of residence, military barracks and prisons.

2.3.10. According to the 2011 Census, 1.7% of the entire population of Great Britain is not resident in a household. Further analysis of the data demonstrates that the proportion of the population in communal establishments varies by age and to some extent by gender. The largest groups of the population not resident in a household are students between 16-29 and elderly persons aged 75 and over.

2.3.11. There are also variations by gender. This is apparent for the bulk of the adult population (e.g. 30-64) where a higher proportion of males are resident in communal establishments and also the elderly population (75+) where there is a greater proportion of females.

2.3.12. There is limited variation in the proportions of communal residents in the different regions of Great Britain. The set of factors applied are described in Appendix C.

2.3.13. The household totals input are taken directly from government projections as the totals for each study area and summed over household types. This initial estimate is checked against input dwellings figures and may be subsequently adjusted.

Jobs and workers totals

2.3.14. Total number of jobs (employment) at control area level in each forecast year are provided as an input. This information is used to scale the jobs from the previous scenario which are then aggregated to give study area totals.

2.3.15. The number of workers are required in order to relate the employment data measured in units of jobs, to the population data measured in units of persons in employment. A set of factors is derived to convert the numbers of jobs to the numbers of workers. These are described in Appendix C.

Control total checks

2.3.16. Checks are made by the Scenario Generator on the total number of households, people, workers and jobs, to ensure that they are logically coherent before they are disaggregated both spatially and into the categories required for the car ownership and trip end models. The user imposes the acceptable boundary that each variable should fall within.

2.3.17. Table 2-1 outlines the control total ratios used in the Scenario Generator, including the default limits set in the software. These are all checked for consistency at the study area level.

Table 2-1: Control total checks in Scenario Generator processing

Ratio	Lower limit	Upper limit
Average adults per household	1	2.5
Workers to population (employment rate) by gender and age group	50% in general	90% in general
Households to dwellings / household spaces (occupancy and vacancy rates)	-10%	10%
Workers to jobs	No limit, but output to log	

2.3.18. The results of these checks are written to the log file generated for each run. In the case that a certain limit is infringed, the tool will report this and in most circumstances the run will cease. This ensures that the basic input data is robust enough to produce realistic forecasts.

2.4. Households by control area

2.4.1. The allocation of population and households to control areas starts with trend based forecasts and then (if policy based forecasts are used) adjusts these to reflect the availability of dwellings.

Population – trend based estimation

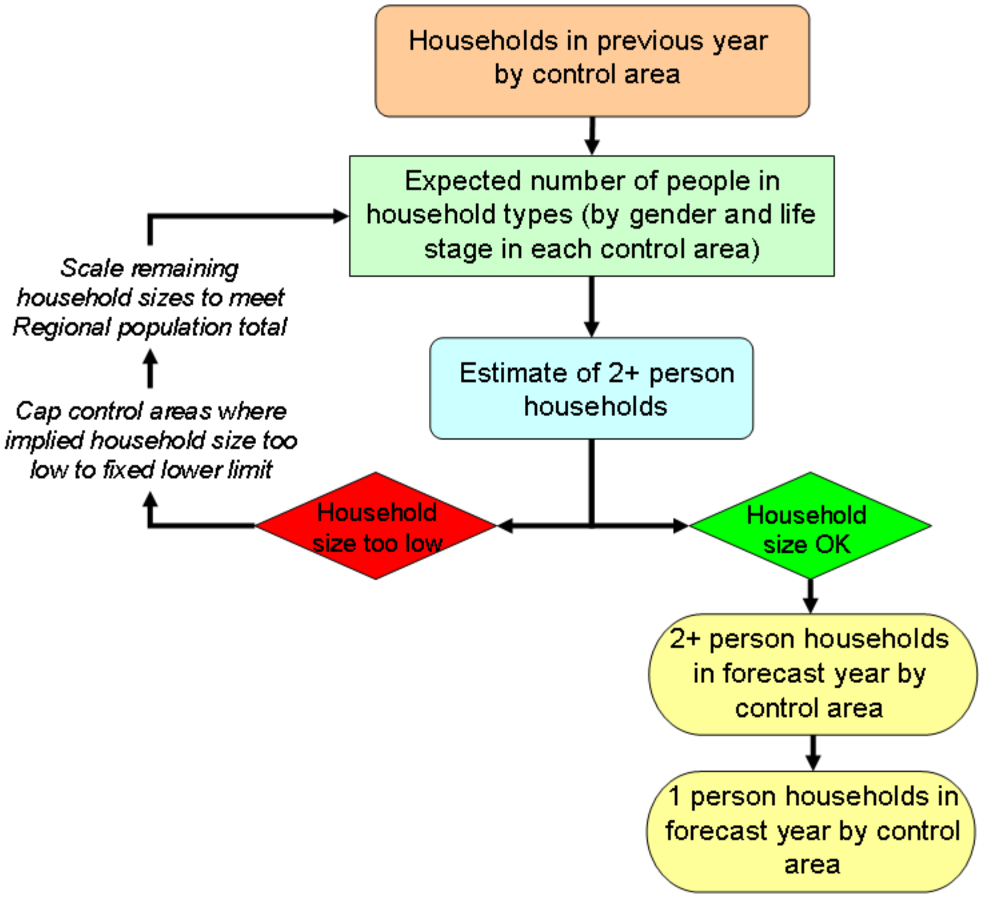
2.4.2. The first step is to disaggregate the study area household projections using input population projections for each control area. This trend based process assumes the change in household size is uniform for all control areas within a study area, however the starting pattern of household size is retained. The result is the first estimate of household demand for each control area.

2.4.3. The number of households in the control area is split into one person and two or more person households. Due to changing household sizes over time it is not possible to take the 'previous' split between 1 and 2+ person households in each control area. The overall change in household size for each study area is known from the input data. Using this information the average size of the 2+ person households in each control area can be scaled back. Since some control areas have relatively low household sizes to start with, it is important to check that the resulting number of people per 2+ person households remains above a specified lower limit.

2.4.4. If the household size of a control area reaches the lower limit, household sizes in other control areas will need to be readjusted to retain the study area control total. This process iterates until stable, providing the trend-based estimate of households by type.

2.4.5. Figure 2-2 outlines the process of obtaining the first estimate of households (by type) in each control area based on change in population.

Figure 2-2: Household estimation based on control area population changes



Dwelling supply – policy based estimation

2.4.6. Forecast year households based on the change in dwellings are also estimated for each control area. This is because in reality the choice of household location in the future is often affected by dwelling supply. It is assumed that household and dwelling growth are moving in the same direction i.e. both are growing or both are declining. If this is not the case, household estimates are based purely on population trends as calculated in the previous step for a given control area.

2.4.7. To implement this step, the change in households specified by the user at the regional level is disaggregated into control areas. This is achieved by using the proportion of forecast year dwelling growth in a control area relative to the regional total.

Combing trend and policy based estimates

2.4.8. In practice the pattern of households is likely to be influenced by a mixture of trends and new developments. Thus a combination of the population-led and dwellings-led approaches are taken. The extent to which household forecasts are policy led is defined by a user specified parameter. A value of 0.75 was adopted to produce the NTEM forecast planning dataset, erring more towards policy based forecasts than past trends. If this parameter were set to zero the forecasts would be wholly dependent on population trends, whilst a value of one indicates that only dwelling supply contributes to the estimate of households. This is consistent with that previously used in NTEM v6.2.

2.4.9. It will often be the case that within a control area housing demand cannot be accommodated by the supply of dwellings. In this case, the Scenario Generator identifies excess households in each control area. Excess households may be suppressed or, if capacity exists elsewhere in the study area, a proportion of them may be redistributed to other control areas in the study area.

2.4.10. The potential supply of housing within a control area is based on the number of available household spaces. This is derived mainly from the number of dwellings allocated to each control area. Other factors that are considered in each control area are as follows:

- Occupancy rate (number of households per occupied dwelling); and
- Vacancy rate (number of presently uninhabited (long term vacant dwellings).

2.4.11. Controls are placed on vacancy and occupancy rates so that these do not change radically over a forecast period. These may also be controlled by the user. Occupancy rates may not change by more than 0.5% in a forecast period. Vacancy rates may not reduce by more than 25% of their previous value. Constraints are also placed on these variables to maintain a realistic housing profile.

2.4.12. Once calculated, the estimated number of households required in each control area is compared to available household spaces. Where this proportion is less than one, there is enough capacity for households to reside within a given control area. Where the proportion is greater than one, there is an excess of households within a given control area and they are subsequently relocated, suppressed or a combination of both.

2.4.13. The suppression of households is expected to alter the mix of household types in the study area due to the different reaction that different households types will have to limited housing capacity. The household type profile of those households being reallocated is assumed to be in line with the control area profile from which the households are moving. The required suppression is a representation of households coalescing or a reduction in household formation. This is more likely to impact on one person households than multi-person households - e.g. young people staying at home longer or grouping together to form multi-person households as they are unable to afford their own place of residence.

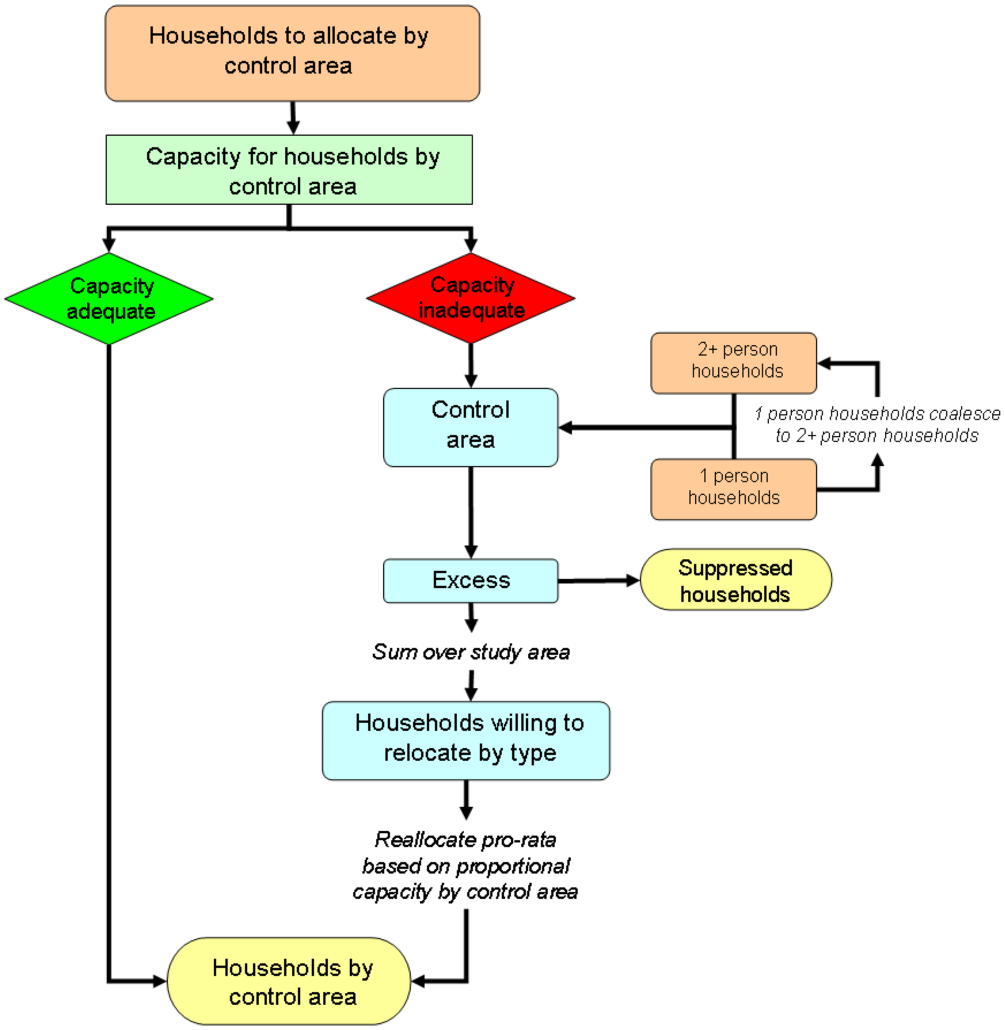
2.4.14. Two key user defined parameters are required here:

- The proportion of excess households that are willing to relocate to other control areas in the study area (default=0.5 for each time period); and
- The number of one-person households suppressed per 2+ person households formed (default=3).

2.4.15. Where households wish to relocate, they are redistributed among the remaining control areas within the study area that have capacity. In the rare case that total capacity in a study area is exceeded, the remaining households are suppressed. Households that were unable to initially be allocated are distributed among other control areas on a pro-rata basis relative to the proportion of capacity within a study area.

2.4.16. Figure 2-3 outlines the process of allocating households to control areas.

Figure 2-3: Allocation of households to control area



2.5. Population by control area

2.5.1. The trend based forecast population is an input for each control area. Household forecasts are adjusted to take account of these population trends, the expected change in dwellings and to alleviate housing pressure. Since there is some reallocation of households amongst control areas within a study area to take account of planning policy, then there should be an associated reallocation of population.

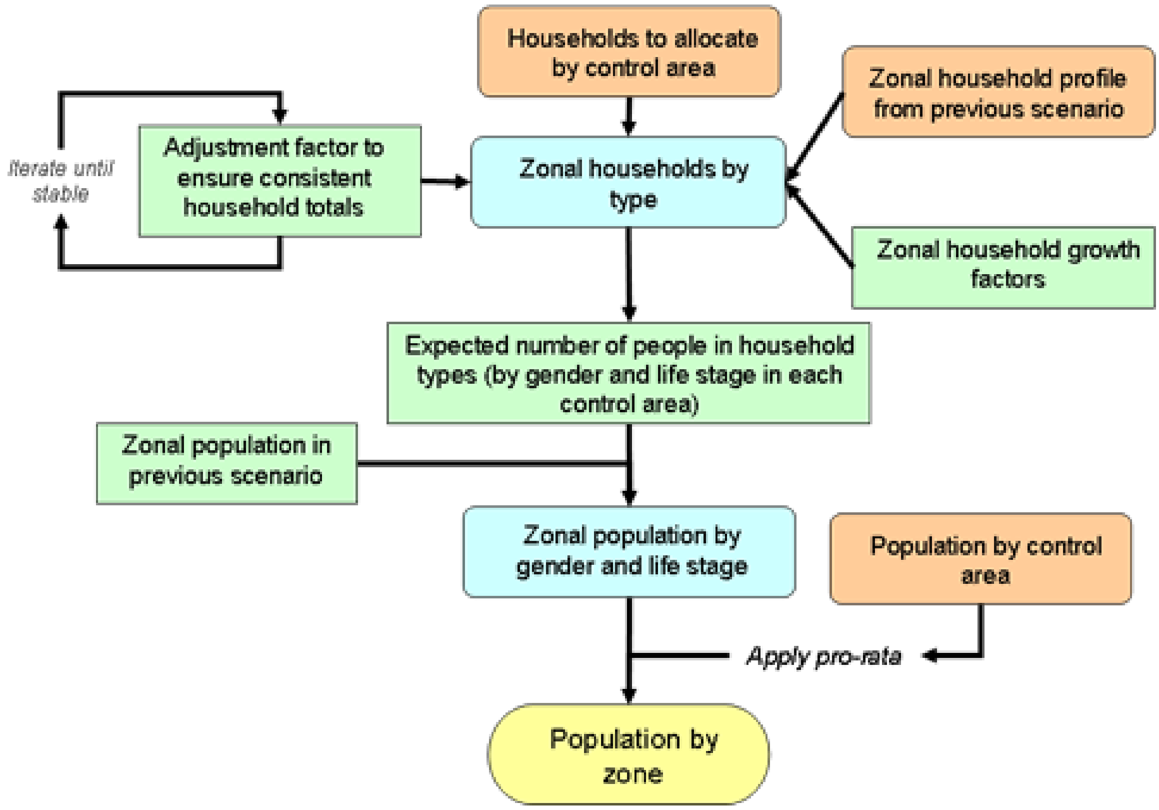
2.5.2. Input population projections are adjusted to reflect policy based household adjustments. An estimate of the number of people (by type) in each control area to be reallocated is calculated from the initial household estimate and the final household figures (by type), taking into account the population profile (persons per household) in each household type.

2.5.3. Where there is a reduction in the number of households between the trend and policy based forecasts, the population is reduced based on the persons per household in that control area. For areas gaining households, the associated population is determined from the average population profile of all the relocating households.

2.6. Population and households by zone

2.6.1. Households remain the main allocation variable based on expected patterns of trends in development. The number of households in each control area are thus distributed to NTEM zones within a control area based on expected growth factors (EGFs), as discussed in Section 5. From the zonal household totals, population totals by NTEM zone may be derived using the numbers of people expected in each household type. Figure 2-4 shows a diagrammatic view of this process.

Figure 2-4: Derivation of households and population by zone



2.6.2. EGFs for households are applied to households by NTEM zone from the previous scenario to form a profile of household growth for each control area. Where growth factors are applied it is possible that in certain areas households by type become negative where areas are in decline. Where this occurs adjustment is required to cap each case so that they cannot fall below zero. Where this does occur, the total that is adjusted back must be applied to all other zones pro-rata based on their relative EGF. This is an iterative process. Once stable, it is applied to ensure that the resulting number of households in each NTEM zone matches the number of households that would be obtained by applying the adjusted growth factors to the previous household total.

2.6.3. Population estimates by NTEM zone may be derived from households by application of the expected number of people in each household type (using those adjusted for the new population profile after the reallocation of households). In addition to disaggregated zonal population totals from the previous scenario, this produces initial estimates of zonal population by age and gender. These are then controlled to the user input population totals for control areas on a pro-rata basis.

2.7. Employment and workers by zone

2.7.1. The allocation of employment from control areas to NTEM zones is carried out using one of three approaches:

- An endogenous approach based on household forecasts (e.g. schools);
- Employment is assumed to follow trends in exogenous industrial sectors; and
- Insufficient data exists and growth is assumed to be based on previous totals.

2.7.2. The allocation of the population led employment is carried out using the projected change in households by NTEM zone. This is then adjusted to match the control totals for the employment sector within the control area.

2.7.3. The allocation of the remaining employment sectors (non-population led) is based on a set of growth factors which are exogenously defined. These are calculated by applying growth factors for each employment sector and then controlling to expected change in employment for each control area. The expected change in employment is the previous year's employment factored up by the input forecast data at the control area level.

2.8. Balance workforce and workers

2.8.1. The Scenario Generator estimates the future year workforce required to fill the input levels of future employment (jobs). The workforce forecast then determines how many people in the population are employed. The workforce (at the workplace) is balanced with the employed residents (at home locations). These Balancing Areas do not mean the area is closed with everyone working within the area also living there. Instead they are areas which are reasonably closed and have a similar number of people commuting out from the area, as commuting in to work.

2.8.2. This process ensures that the proportion of workers that live and work within the same area are in balance. This makes use of the balancing area geography that may be seen in Appendix A. The balancing process is concerned primarily with the 'working age' population (i.e. 16-29, 30-44, 45-64 and 65-74 age groups). The balancing process ensures that:

- There are the correct number of workers of different types living in the balancing area for the jobs available; and
- The number of workers in each zone does not exceed a specified maximum proportion of the resident population.

2.8.3. These two steps are addressed in turn. Firstly by checking and if necessary adjusting the gender / working status profile for the required workers in the balancing area, and secondly reallocating the workers amongst the NTEM zones within the balancing area to ensure no zone breaches the ceiling employment rate.

2.8.4. The number of workers required in each balancing area by age category are obtained by converting employment forecasts (jobs) to the number of workers, and then splitting workers into the working age bands (16-29, 30-44, 45-64 and 65-74). This makes use of two important sets of user-defined parameters that:

- Convert jobs to workers by gender, work type (full time/ part time) and employment sector using the Regional profile; and
- Divide workers into the necessary working age groups using the regional profile provided by the base year Census data.

2.8.5. This internal adjustment process uses the following key concepts:

- Treating the previous population and the new (migrating) population as two separate groups;
- Treating declines before and completely independently to growth – logically they can only be applied to the 'previous' population groups;
- Using 'existing' profiles / employment rates from the previous scenario as an initial estimate of workers;
- Calculating maximum possible numbers of workers by type;
- Adjusting demand profile of workers so no maxima are breached; and
- Determining how far it is necessary to move from the initial values towards the maximum values in order to satisfy demand.

Reduction in population / workers

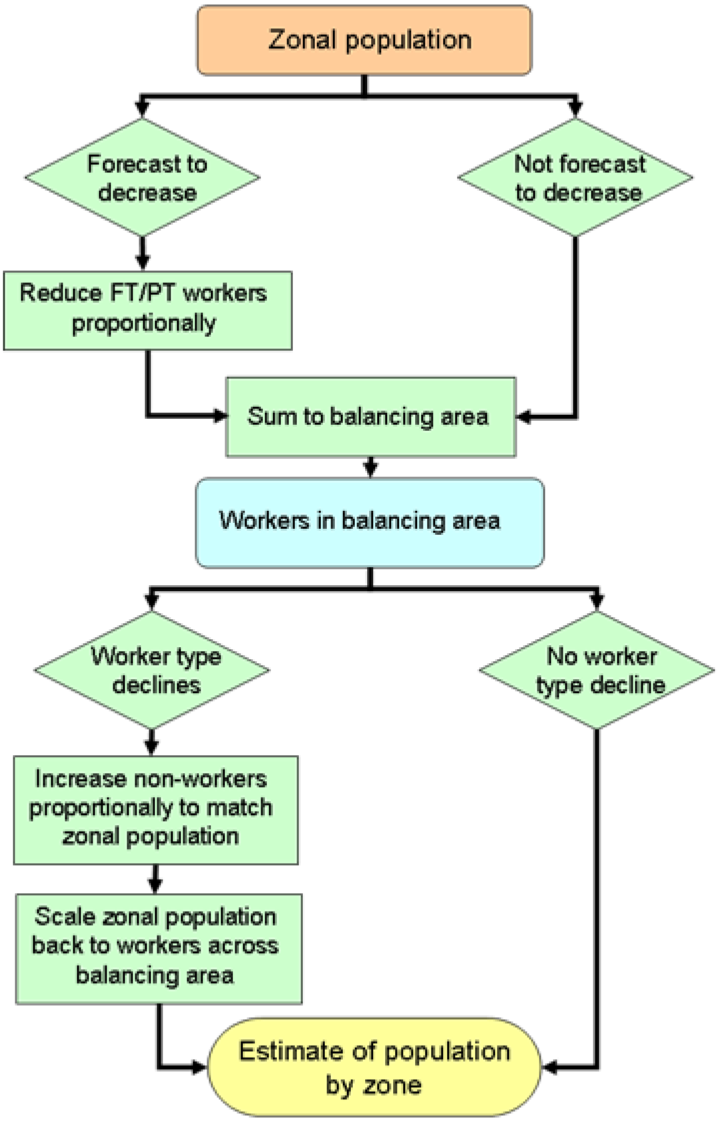
2.8.6. If the population of an NTEM zone within a balancing area is forecast to decline, then this would naturally lead to a reduction in the number of workers in that zone irrespective of whether the required workforce in the balancing area is forecast to decline or grow. In addition, the workforce required in the balancing area might be forecast to fall more or less than the reduction caused by the population change, or alternatively to increase from the previous scenario. This gives two cases which must be considered

2.8.7. The first stage is to account for any reduction in workers due to a reduction in the population. Where this occurs, the population in full-time and part-time work is reduced according to the current proportions of each.

2.8.8. The second stage is required only if the workforce in the balancing area is forecast to decrease in any work type, gender or age category. In this case the number of workers is reduced while retaining the total forecast population numbers by NTEM zone. This is achieved by simply scaling back the number of workers (by working status) in each zone to match the control area total. The number of non-workers are then increased proportionally by the same volume to retain zonal population totals.

2.8.9. Figure 2-5 outlines the process in calculating an estimate of population based on potential reductions in zonal populations or worker types within a balancing area.

Figure 2-5: Estimation of zonal population



Initial estimates of working status profile of zonal population

2.8.10. It is considered that the working status profile of large parts of the resident population will not alter significantly through time, while new developments that lead to significant growth in an area might have very different profiles to the existing population. The population is therefore separated into two groups:

- The existing residents from the previous year / scenario with any declines in population already subtracted – a group for which the working status is known; and
- Any increase in population in the forecast year for which the working status has yet to be forecast.

2.8.11. An initial estimate of the population profile can be obtained by assuming the 'new' population takes on the same profile as the existing population.

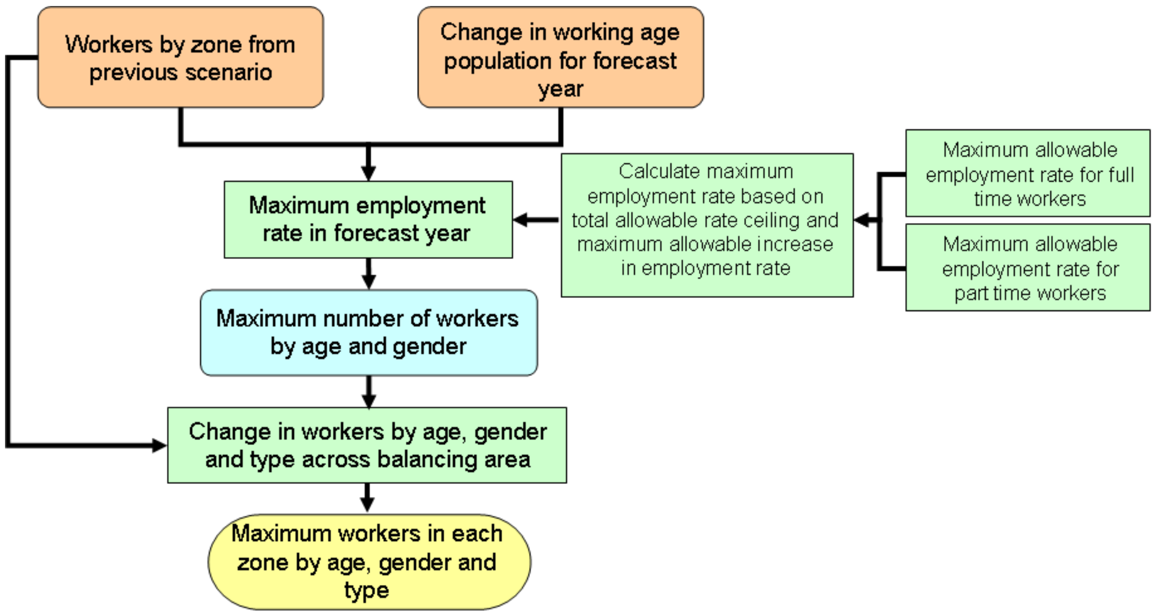
Maximum supply of workers by gender

2.8.12. The maximum supply of workers by gender in a forecast year is calculated. It is derived by applying the maximum acceptable change over the forecast period to the previous scenario. This rate is user defined and defaults to +5% (i.e. employment rate could increase from 65% to 70%). A ceiling rate is also set and when exceeded will cap the maximum worker supply at this level. Maximum employment rate is set for each age and gender combination. A ceiling rate is applied to both full-time and part-time workers, as well as a maximum rate for both types combined. The Scenario Generator ensures that neither limit is breached.

2.8.13. Since the maximum employment rate has been ascertained, the maximum supply of workers per NTEM zone may be calculated. Working age population in the previous year may in the forecast year be capable of working to the higher employment rate. In addition, new working age population introduced through demographic change in the forecast year may introduce new workers, with the maximum capped to the same employment rate. This provides the upper bounds for the number of workers by age and gender.

2.8.14. Figure 2-6 outlines the process in deriving the maximum number of workers in each NTEM zone by age, gender and employment type.

Figure 2-6: Derivation of the maximum number of workers in each NTEM zone by person type



Checking / adjusting the gender profile of worker demand

2.8.15. On comparing the initial estimates of worker demand within a balancing area to the maximum available working population, it is possible that in some cases this will be exceeded for at least one combination of age and gender. If for example the demand for male workers cannot be met by the maximum available male workers in the population within a balancing area, these posts are transferred to female workers if there is availability in the female population.

2.8.16. There are three scenarios considered for each working age band within a balancing area:

- There is no excess in demand for workers of either gender;
- There is excess demand for workers of both genders; or
- There is excess demand for workers of one gender but not the other.

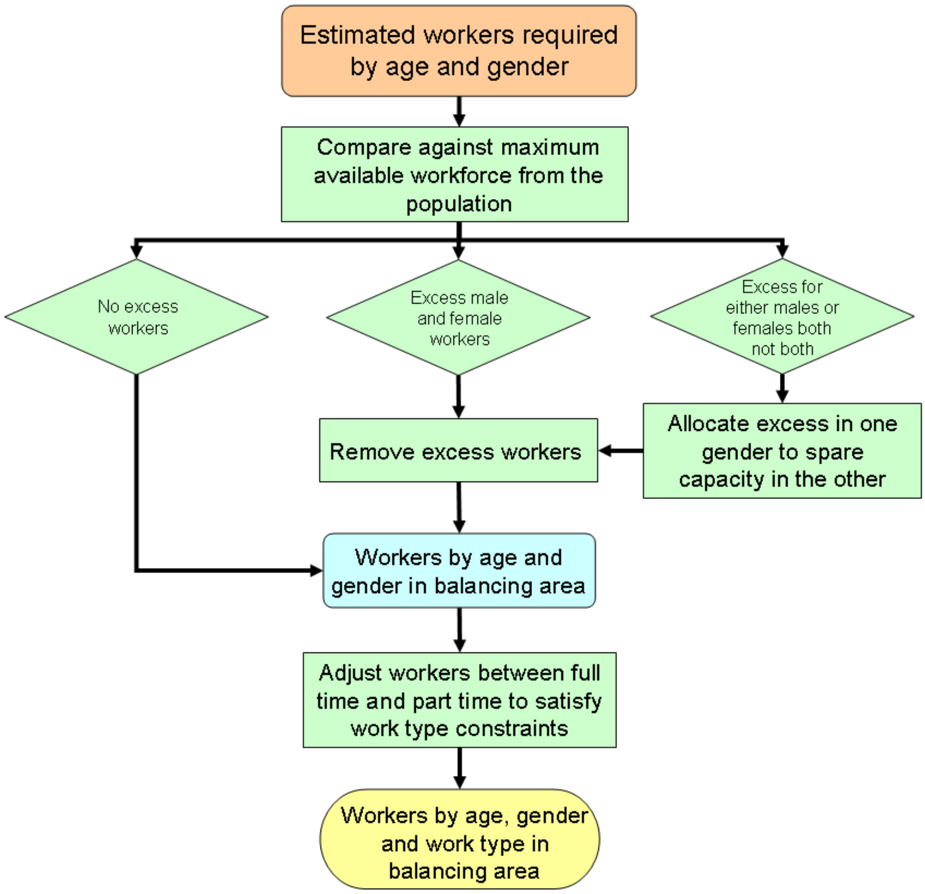
2.8.17. Where there is no excess demand for workers in a balancing area, the maximum available workers in the population may accommodate the labour demand. Therefore no adjustment is necessary.

2.8.18. Where there is excess labour demand for both male and female workers, there is no capacity to reallocate these workers across genders. Therefore this excess is simply written off so that the maximum number of workers does not exceed the maximum possible working population. This effectively assumes that posts will be filled by an increase in double jobbing and the numbers of workers aged 75 and over.

2.8.19. Where demand for workers in one gender exceeds supply, there is scope for the demand to be met by workers of the opposite gender. This of course changes the gender profile of the working population within the balancing area. This is achieved by allocating workers from one gender type to the other. In the event that there is insufficient capacity in the other gender to meet the whole demand, this residual excess is written off.

2.8.20. Figure 2-7 highlights the allocation process in distributing workers within each balancing area by age and gender. It may help understanding by assuming that in this stage, workers by age category are effectively handled separately.

Figure 2-7: Allocation of workers by age and gender in a balancing area



Checking / adjusting the full-time / part-time split of workers

2.8.21. At this stage, workers by age and gender have been resolved, removing any excess workers that cannot be allocated without exceeding the maximum imposed limits. To give a final forecast of the number of workers in each balancing area, the split between full-time and part-time workers needs to be resolved.

2.8.22. For each age and gender combination, the maximum number of available full-time and part-time workers is fixed by the user specified maximum change in employment rate from the previous scenario (5% by default). The Scenario Generator checks whether the number of estimated workers falls within these acceptable limits for each balancing area within the study area.

2.8.23. If full-time and part-time workers may be accommodated, no adjustment is required. It is not possible for both rates to be exceeded since all potential excess has been removed in the previous step (adjustment of the gender profile).

2.8.24. If there is an excess of one working status, those extra workers are switched to the other working status (e.g. where no more full-time workers are permitted, the excess will be accounted for by increasing the number of part-time workers).

2.8.25. This gives a final forecast of workers in each balancing area by age, gender and working status. From these, new employment rates may be derived and are output from the Scenario Generator in the log file. The last step is to allocate workers to zones.

Allocation of workers to zones

2.8.26. The allocation of the adjusted and balanced workers to individual NTEM zones is carried out by looking at the difference between the maximum and initial zonal estimates for the numbers of workers and determining what proportion of this difference is needed to achieve the required demand figures.

2.8.27. There are two possible scenarios:

- Workforce demand is a greater proportion of the population than in the previous scenario (expected to be the norm); or
- Workforce demand is a smaller proportion of the population than in the previous scenario.

2.8.28. If the proportion of the population required to work is less than in the previous scenario, the initial estimates by zone are simply scaled back based on the difference at the balancing area level.

2.8.29. If the proportion of workers has increased then the employment rate lies somewhere between the initial and the maximum employment rate. Where this is the case, each zone requires the working population to be scaled up accordingly. An adjustment factor is derived for the balancing area according to the relative demand for workers between the initial working population estimate and the maximum number of workers possible in the balancing area. This factor is used to scale each zone and controls total workers across all zones to the balancing area total.

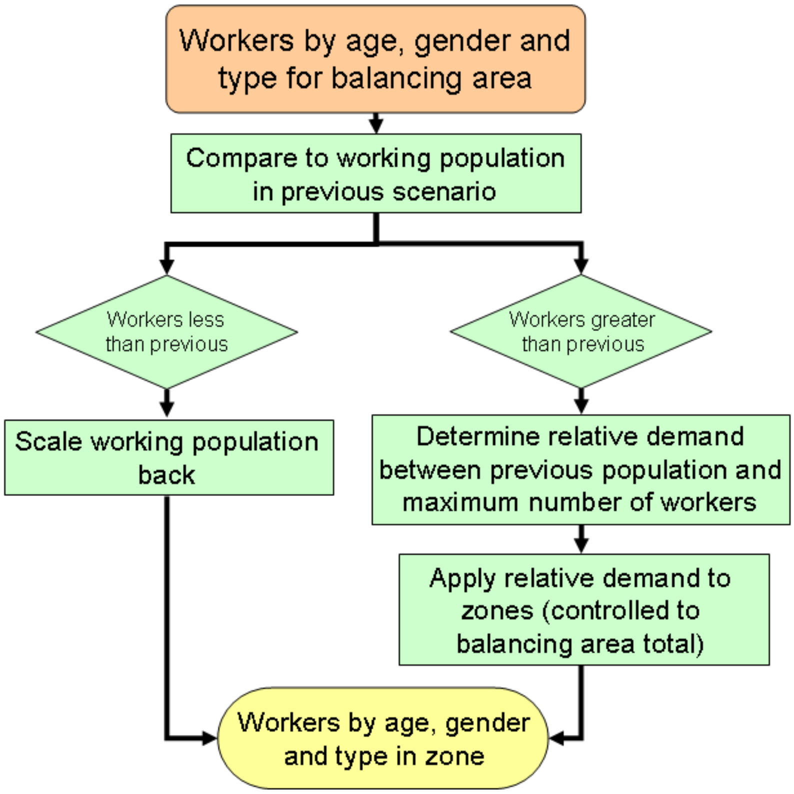
2.8.30. Figure 2-8 outlines the process of allocating workers from Balancing Areas to NTEM zones.

Non-workers by zone

2.8.31. What remains is the allocation of non-workers to NTEM zones. This places the remaining working age population into the student or other categories. These are derived from zonal population and workers and the proportion of non-worker types in the previous scenario. This means that the number of students will vary by scenario.

2.8.32. In rare cases where no non-workers exist in the previous scenario, yet allocation of non-workers is required, the assumption is made that all will be allocated to the 'other' category. The assumption is that the other category is more ubiquitous than the student category and avoids assigning students in areas potentially a long distance from, for example, higher education. In practise these values will be very small.

Figure 2-8: Allocating workers from balancing area to zones



2.9. Update employment forecasts for change in worker profile

2.9.1. The required number of workers by gender, age group and working status is obtained from the number of jobs input data. The demand for workers may not be achievable in population forecasts. The Scenario Generator internally adjusts the gender, working status and age profile of the required workforce in order to balance the demand and supply of workers.

2.9.2. Since employment forecasts are an input in future scenarios, any adjustments made to the profile of the working population is carried through to adjust job profiles. This update can be carried out as a final step in the estimation process, solely to provide an improved base from which future scenarios are forecast.

2.10. Summary of outputs from the Scenario Generator

2.10.1. The Scenario Generator produces three main output files:

- A log file for the scenario(s) generated;
- Population and household forecasts for the National Car Ownership Model;
- Population, household and employment forecasts for the National Trip End Model; and
- Population and economic activity forecasts for trip rate modelling.

2.10.2. The log file summarises the performance and key variables associated with each scenario run. The log informs the user of the successfulness of the run and any errors that may have occurred, including warnings where data consistency issues may need to be resolved. For information purposes, the log file also summarises the key elements of a scenario run:

- Input parameter settings;
- Checks on control totals;
- Allocation and suppression of households;
- Allocation of population; and
- Derived control area vacancy rates.

2.10.3. The planning data forecasts for the National Car Ownership Model are output in the appropriate text file format. These are:

- Total population in NTEM zones; and
- Persons by gender, age and working status.

2.10.4. Planning forecasts for the National Trip End Model are output in the appropriate database format. These are:

- Employment forecasts by zone;
- Number of jobs;
- Number of households;
- Number of jobs by sector;
- Population forecasts by zone; and
- Population in NTEM Zones by gender, age and working status.

2.10.5. An additional table in the database output provides information relating to all person types, which is used as an input to trip rate forecasting.

2.10.6. In addition to these outputs, the results from the forecasting process are stored in data tables within the Scenario Generator database.

3. 2011 base year data

3.1. Summary

3.1.1. The base year for the planning data in NTEM 7 is 2011. This data is primarily obtained from the 2011 Census and then adjusted to 2011 mid-year estimates in order to counter the effects of potential under-enumeration and to ensure consistency with mid-year based projections used for forecasting.

3.1.2. The following datasets constitute the base year inputs:

- Population (age, gender and working status in each NTEM zone);
- Households (size in each NTEM zone);
- Dwellings (quantity in each control area);
- Employment (quantity of jobs by industry, gender and working status in each NTEM zone); and
- 2011 mid-year estimates from projection data (by control area).

3.1.3. Several additional parameters are required as part of the base data input:

- Expected number of people in each household type;
- Maximum acceptable difference between households and dwellings;
- Minimum number of average adults per household;
- Maximum number of average adults per household;
- Occupancy rate for dwellings;
- Proportion of population in communal establishments;
- Dwelling vacancy rate;
- Number of dwellings not used as main residence;
- Ratio of jobs to workers;
- Minimum and maximum acceptable employment rate and change in employment rate over time;
- Maximum allowable change in occupancy rate;
- Proportion of workers in each working age group;
- Proportion of excess households that relocate;
- Weighting of population / dwelling policy-led allocation of households; and,
- Number of suppressed one person households that are reformed as multi-person households.

3.1.4. Base year data is required at the NTEM zone level. England & Wales NTEM zones are identical to Middle Super Output Areas (MSOAs), whilst NTEM zones for Scotland comprise of aggregations of Data Zones (DZ).

3.1.5. This section describes the basic data required in the base year. Where Census tables are not available at MSOA (England & Wales) or DZ (Scotland) level, data at a more coarse geographical level has been utilised, and methods were adopted to convert this data to NTEM zone level. Those assumptions are outlined in this section.

3.2. Population

3.2.1. Base year population is required by gender, age and working status for each NTEM zone. These are broken down into the following categories:

- Gender: male, female;
- Age: children (0-15), working age (16-29, 30-44, 45-64 & 65-74), elderly (75+);
- Working status: full time employed, part time employed, full time students, other.

3.2.2. Children and those over the age of 74 are not differentiated by working status. This effectively gives 36 categories of population for each zone (see Appendix B for detailed segmentation definitions).

3.2.3. Table 3-1 lists the data sources used in the derivation of base population data. All data sources used in deriving the base population are from the 2011 Census. No individual datasets achieve the level of segmentation required, therefore it was necessary to manipulate a combination of datasets in order to produce the base population input for NTEM 7. Categories and definitions do vary between source datasets, thus it was imperative to take this into consideration whilst manipulating the source base population data.

Table 3-1: Base year population data sources

Source	Geography	Description
Census Table DC6107EW	MSOA	All usual residents In England & Wales aged 16+ by economic activity, age and gender.
Census Table DC1117EW	MSOA	All usual residents In England & Wales by age and gender.
Census Table LC1117EW	LAD	All usual residents In England & Wales by age and gender.
Mid-2011 Population Estimates	LAD	2011 Mid-year population estimates for local authorities in England and Wales by age and gender.
Census Table LC1105EW	MSOA	All usual residents by residence type in England & Wales.
Census Table LC6107SC	DZ	All usual residents in Scotland aged 16+ by economic activity, age and gender.
Census Table DC6107SC	Council Area	All usual residents in Scotland aged 16+ by economic activity, age and gender.
Census Table LC1117SC	DZ	All usual residents In Scotland by age and gender.
Census Table DC1117SC	Council Area	All usual residents In Scotland by age and gender.
Mid-2011 Population Estimates	Council Area	2011 Mid-year population estimates for Council Areas in Scotland by age and gender.
Census Table LC1104SC	DZ	All usual residents by residence type in Scotland.

3.2.4. The 2011 Census data has been adjusted to 2011 mid-year estimates. The rationale for mid-year adjustments is to overcome potential under-enumeration of data collected from the 2011 Census and to ensure consistency with the mid-year based population projections. This adjustment is relevant for all of the main base year variables.

3.2.5. The 2011 mid-year population estimates were obtained from ONS for England & Wales and Scotland. The dataset was used to produce a growth factor between the 2011 mid-year population estimates and age categories from the 2011 Census tables DC1117EW and DC1117SC. This provides a set of scaling factors for gender and age group at LAD level in England & Wales and Council Area level in Scotland. These scaling factors are then used to adjust the multi-dimensional 2011 Census population data to 2011 mid-year levels. There is a slight difference in age definitions between the two sources (i.e. mid-year estimates have a 0-14 age category rather than 0-15). The scaling method takes account of this.

3.2.6. As NTEM is a household-based model, communal residents are removed from the base population data in NTEM. The final step in processing the base population data was to apply a factor to remove communal residents from the dataset. Factors were derived by calculating the proportion of communal residents within the population by age group at the NTEM zone level. Census tables LC1105EW & LC1104SC were used to derive these factors.

3.2.7. Table 3-2 shows the total household population of Great Britain in the base year, divided into the segmentations required for the Scenario Generator.

Table 3-2: Population by age, working status and gender (Great Britain, 2011)

Age band	Working status	Female	Male	Total	Proportion of population
0 – 15	All	5,597,102	5,867,952	11,465,054	19%
16 – 29	Full Time	1,983,242	2,627,086	4,610,328	8%
16 – 29	Part Time	1,325,418	845,096	2,170,514	4%
16 – 29	Student	1,114,509	1,204,135	2,318,644	4%
16 – 29	Other	1,135,237	929,507	2,064,744	3%
30 – 44	Full Time	2,675,595	4,780,460	7,456,055	12%
30 – 44	Part Time	2,051,333	526,074	2,577,406	4%
30 – 44	Student	99,769	59,901	159,670	0%
30 – 44	Other	1,466,351	810,547	2,276,899	4%
45 – 64	Full Time	2,841,443	5,126,984	7,968,427	13%
45 – 64	Part Time	2,381,694	734,306	3,116,000	5%
45 – 64	Student	28,534	16,020	44,554	0%
45 – 64	Other	2,692,840	1,839,541	4,532,382	7%
65 – 74	Full Time	62,597	190,267	252,865	0%
65 – 74	Part Time	154,252	158,812	313,064	1%
65 – 74	Student	4,756	4,507	9,263	0%
65 – 74	Other	2,554,154	2,200,702	4,754,856	8%
75+	All	2,645,662	1,865,898	4,511,559	7%
All	**All**	**30,814,488**	**29,787,795**	**60,602,284**	**100%**

3.3. Households

3.3.1. Total households by NTEM zone are separated into one person households and households with two or more people. This dataset is also adjusted to mid-year estimates to be compatible with the rest of the planning data. Table 3-3 lists the data sources used in the derivation of base population data.

Table 3-3: Base year household data sources

Source	Geography	Description
Census Table QS406EW	MSOA	Households by number of resident people.
Census Table QS406SC	DZ	Households by number of resident people.
Household Projections for England from DCLG	LAD	Household projections by number of resident people.
Household Projections for Wales from StatsWales	LAD	Household projections by number of resident people.
Household Projections for Scotland from NRS	Council Area	Household projections by number of resident people.

3.3.2. For England, and Wales, the numbers of 1 person and 2+ person households have been extracted from 2011 Census table QS406EW at MSOA level. These have been summed to LAD level and compared with the mid-year estimates, provided at LAD level, in the 2011-based household projections. Scaling factors have been derived for each LAD and household size, which have then been applied to the Census MSOA data to give mid-year values.

3.3.3. For Scotland, the number of 1 person and 2+ person households have been extracted from 2011 Census table QS406SC at DZ level. Mid-year estimates for all households in 2012 are provided at Council Area level in the 2012-based projections. A comparison between the 2011 Census total households for Council Areas have been compared with the 2012 mid-year estimates to calculate scaling factors to mid-2011 for each Council Area. These factors have been applied to the DZ level data to give mid-year values.

3.3.4. Table 3-4 shows the total number of base year households by study area.

Table 3-4: Study area households totals (Great Britain, 2011)

Study area	1 Person	2+ Person	Total
East Midlands	557,763	1,339,682	1,897,445
North East	365,473	764,167	1,129,639
North West	980,779	2,030,483	3,011,262
Scotland	824,258	1,551,405	2,375,663
South West	699,834	1,570,274	2,270,108
Wales	401,667	902,158	1,303,825
West Midlands	689,660	1,608,290	2,297,951
Wider South East	2,804,555	6,466,820	9,271,375
Yorkshire & the Humber	687,690	1,538,410	2,226,100
Total	**8,011,680**	**17,771,689**	**25,783,369**

3.4. Dwellings

3.4.1. Base year dwellings data has been taken from Census table QS418EW for England & Wales and the equivalent QS418SC table for Scotland (Table 3-4). Dwellings are required by control area.

Table 3-5: Base year dwelling data sources

Data source	Geography	Description
Census Table QS418EW	LAD	Shared or unshared dwellings.
Census Table QS418SC	Council Area	Shared or unshared dwellings.

3.4.2. The dwelling numbers are adjusted to mid-year estimates using dwelling completion data from the Authority Monitoring Reports (formerly Annual Monitoring Reports).

3.4.3. Table 3-6 shows the total number of base year dwellings by study area.

Table 3-6: Study area dwellings totals (Great Britain, 2011)

Study area	Dwellings
East Midlands	1,974,318
North East	1,179,238
North West	3,146,653
Scotland	2,504,397
South West	2,406,025
Wales	1,386,038
West Midlands	2,379,425
Wider South East	9,601,168
Yorkshire & the Humber	2,322,908
Total	26,900,168

3.5. Employment

3.5.1. The data required for the 2011 base year is the number of jobs (both the employed and self-employed) in each NTEM zone divided into forty-eight categories by:

- Employment sector (12 NTEM categories E03 to E14);
- Gender (males and females); and
- Working status (full-time / part-time).

3.5.2. Table 3-7 shows the correspondence that has been defined between the NTEM employment types and SIC 2007 codes.

Table 3-7: NTEM employment types

NTEM employment type	SIC (2007) code	Description
E03	851, 852, 853	Pre-primary, primary and secondary education
E04	854	Higher education
E05	855, 856	Adult and other education
E06	55	Accommodation (hotels and campsites)
E07	451, 453, 471 – 478, 56103	Retail trade
E08	86, 87	Human health and residential care activities
E09	452, 454, 53, 6419, 683, 771, 772, 75, 88	Services (rental, repair, postal activities, real estate and other)
E10	05 – 09, 10 – 33, 35 – 39, 41 – 43, 46, 49 – 52	Industry, construction and transport
E11	56101, 56102, 563	Restaurants and bars
E12	5914, 79901, 90 – 94	Recreation and sport
E13	01, 02, 05	Agriculture, fishing, forestry and logging
E14	All other codes	Other employment

3.5.3. The task of processing base employment data is made more complex due to differing definitions of employment. Household based surveys typically measure the number of workers, whilst employer surveys provide information on the numbers of jobs. In some instances the two datasets differ quite markedly due to double jobbing and job sharing, in addition to differences caused by the survey design and samples surveyed (age categories etc.).

3.5.4. The primary sources of employment data for NTEM are the 2011 Census of Population (workplace population) and the Workforce Jobs data series.

3.5.5. Jobs are controlled to the national 2011 total from Workforce Jobs (WFJ). As NTEM is household based, this is scaled down to remove jobs not included in the NTEM definition (such as workers living in communal accommodation). This provides an NTEM 7 2011 total of jobs for Great Britain of 30.2m. This approach is consistent with that used in NTEM 6.2.

3.5.6. In order to achieve the required granularity and segmentation required by NTEM, several other data sources are required, namely the Business Register and Employment Survey (BRES), which provides the breakdown according to industry and working status. Table 3-8 lists the data sources used in the derivation of base employment data.

Table 3-8: Base year employment data sources

Data source	Geography	Description of use
Census tables WP605	MSOA (England and Wales) Council Area (Scotland)	Workplace population (by industry)
BRES	2001 MSOA / 2001 Data Zone	Employment data by detailed geography, industry and working status
Workforce Jobs: Total Jobs 2011	Region	Provides constraint to total number of jobs by SIC category
Workforce Jobs: Employees 2011	Region	Allows gender split by region, broad industry and working status

3.5.7. Using the WFJ derived total as the overriding constraint, 2011 Census tables provide estimates of workplace population. This is consistent with the approach taken in NTEM 6.2. BRES provides MSOA-level data for working status and to determine the split by NTEM employment type. As BRES has retained 2001 Census geography definitions, conversion was required for consistency with the rest of NTEM. This includes merging and splitting of a small number of zones.

3.5.8. Table 3-9 shows total employment (jobs) associated with the household population in Great Britain in the base year, split by NTEM employment type.

Table 3-9: Employment (jobs) by gender and working status (thousands, Great Britain, 2011)

Employment type	Female full-time	Female part-time	Male full-time	Male part-time	Total
E03 Education (school)	609	974	449	230	2,261
E04 Education (higher)	165	128	122	30	445
E05 Education (adult/other)	91	84	67	20	263
E06 Accommodation	117	120	152	71	460
E07 Retail trade	560	1,273	1,100	580	3,512
E08 Health/Medical	1,259	1,097	514	156	3,026
E09 Services	835	657	1,040	202	2,735
E10 Industry/Construction/Transport	886	390	5,211	349	6,836
E11 Restaurants & bars	217	429	287	262	1,196
E12 Recreation & sport	213	298	324	211	1,046
E13 Agriculture & fishing	39	24	193	23	279
E14 Business	2,182	1,582	3,694	698	8,157
Total	**7,174**	**7,056**	**13,153**	**2,834**	**30,216**

4. Forecast data and projections

4.1. Summary

4.1.1. For each study area and forecast year, the following datasets are required for any forecast year / scenario combination:

- Population projections (by age and gender) in each control area;
- Household projections (by size) for the study area;
- Forecast dwellings (in each control area);
- Employment projections (by sector, gender and working status in each control area);
- Zonal growth factors for employment in the period modelled (by sector); and
- Zonal growth factors for households in the period modelled.

4.2. Population

Data required

4.2.1. Forecast year population data is required for each control area subdivided by gender and age group. The following groups are required:

- Children under 16;
- Females / Males 16-29;
- Females / Males 30-44;
- Females / Males 45-64;
- Females / Males 65-74;
- Females / Males 75-79;
- Females / Males 80-84; and
- Females / Males 85+.

Population projections

4.2.2. Population projections exist in two formats: national projections and sub-national projections. Since 2006, the Office for National Statistics (ONS) has been responsible for producing both datasets. These datasets are the principal population projections from the ONS. NTEM 7 uses the latest mid-year based population projections, which were published in 2014 for England and Scotland, and 2013 for Wales. ONS only provide populations projections at control area level (sub-national) up until 2037, therefore national projections have been used to extrapolate beyond 2036 (forecast years 2041, 2046 and 2051).

4.2.3. Table 4-1 indicates the year in which forecast population data has been derived at control area (sub-national) and national level for England, Scotland and Wales.

Table 4-1: Forecast population input data

Area	Geography	Base year	Data range
England	Control area	2012	2012 – 2037
	National	2012	2012 – 2087
Scotland	Control area	2012	2012 – 2037
	National	2012	2012 – 2087
Wales	Control area	2011	2011 – 2036
	National	2012	2012 – 2087

4.2.4. National level projections are used to extend the time horizon of the subnational data. Control area population forecasts were used up to 2036, whilst national level forecasts were used to continue control area trends beyond 2036 up until 2051. A factor based on national level population forecasts was applied to 2036 control areas in order to maintain the regional proportions between control areas up until 2051.

4.2.5. Table 4-2 shows a summary of the total population projections by year and study area input into the NTEM forecasting process.

Table 4-2: Population projections by study area (thousands)

Study area	2016	2021	2026	2031	2036	2041	2046	2051
East Midlands	4,682	4,828	4,971	5,100	5,209	5,325	5,438	5,546
North East	2,632	2,671	2,708	2,738	2,762	2,823	2,883	2,940
North West	7,182	7,316	7,439	7,543	7,629	7,799	7,964	8,122
Scotland	5,386	5,497	5,606	5,698	5,768	5,826	5,877	5,925
South West	5,483	5,670	5,855	6,023	6,167	6,305	6,438	6,566
Wales	3,131	3,199	3,256	3,300	3,334	3,359	3,383	3,405
West Midlands	5,764	5,924	6,074	6,210	6,333	6,474	6,611	6,742
Wider South East	23,853	24,997	26,052	27,009	27,892	28,513	29,118	29,694
Yorkshire & the Humber	5,424	5,555	5,682	5,796	5,894	6,025	6,153	6,274
Total	63,537	65,658	67,643	69,417	70,988	72,449	73,866	75,213

4.3. Households

4.3.1. NTEM 7 household projections for England and Wales are 2011 based, whilst projections for Scotland are 2012 based.

4.3.2. Table 4-3 provides the source from which household projections have been downloaded.

Table 4-3: Forecast year household data sources

Data source	Geography	Description
Household Projections for England from DCLG (2011 based)	LAD	Household projections by number of resident people.
Household Projections for Wales from StatsWales (2011 based)	LAD	Household projections by number of resident people.
Household Projections for Scotland from NRS (2012 based)	Council Area	Household projections by number of resident people.

4.3.3. Mid-year adjustments are not required as all household projection datasets are already mid-year based.

4.3.4. Household projections are required for five-year intervals from 2011 to 2051 by study area, subdivided into 1 person and 2+ person households.

4.3.5. Household projections for England are available for 1 person and 2+ person households separately up to 2021 at LAD level. Projections for all households combined are available up to 2036 at LAD level. Between 2021 and 2036, the trends in 1 person and 2+ person households have been extrapolated, with the total constrained to the combined projections at a regional level. Between 2036 and 2051, the trends in household size have been used to calculate households from the population projections. The same methodology has then been applied as for 2021 to 2036 to determine 1 person and 2+ person households. This is consistent with the approach adopted in NTEM 6.2.

4.3.6. For Wales, projections for 1 person and 2+ person households are available up to 2036. Between 2036 and 2051, the same methodology has been utilised as for England.

4.3.7. For Scotland, projections for 1 person and 2+ person households are available for 2012 to 2037 at 5 year intervals. Interpolation and extrapolation has been used to adjust these to the required years. Between 2037 and 2051, the same methodology has been utilised as for England.

4.3.8. The following tables show household projections (2016-2051) by study area for single person households (Table 4-4) and 2+ person households (Table 4-5).

Table 4-4: Single person household projections by study area (thousands)

Study area	2016	2021	2026	2031	2036	2041	2046	2051
East Midlands	582	609	633	658	679	703	727	750
North East	377	389	400	410	419	435	451	467
North West	1,013	1,045	1,075	1,102	1,126	1,168	1,209	1,249
Scotland	901	965	1,027	1,084	1,138	1,201	1,258	1,314
South West	727	762	792	822	849	876	903	930
Wales	428	456	485	510	534	557	579	602
West Midlands	716	746	774	801	825	855	884	912
Wider South East	2,936	3,088	3,228	3,365	3,492	3,592	3,695	3,799
Yorkshire & the Humber	715	745	773	800	825	856	886	917
Total	8,395	8,805	9,186	9,551	9,888	10,244	10,593	10,940

Table 4-5: 2+ person household projections by study area (thousands)

Study area	2016	2021	2026	2031	2036	2041	2046	2051
East Midlands	1,397	1,453	1,508	1,562	1,610	1,663	1,715	1,766
North East	784	806	824	842	856	887	916	945
North West	2,100	2,171	2,235	2,295	2,348	2,438	2,525	2,612
Scotland	1,559	1,582	1,601	1,618	1,631	1,644	1,655	1,666
South West	1,645	1,717	1,791	1,862	1,926	1,990	2,054	2,117
Wales	921	938	950	958	960	969	974	979
West Midlands	1,672	1,738	1,803	1,865	1,921	1,989	2,056	2,122
Wider South East	6,917	7,376	7,833	8,276	8,694	9,044	9,399	9,753
Yorkshire & the Humber	1,591	1,645	1,698	1,748	1,793	1,852	1,910	1,967
Total	18,585	19,426	20,242	21,025	21,739	22,475	23,202	23,927

4.4. Dwellings

4.4.1. Dwelling stock values are combined with projected annual averages of housing completion from 2011 onwards, in order to calculate the cumulative dwelling stock at Local Authority level between 2011 and 2051.

4.4.2. Dwelling stocks were downloaded for England, Scotland and Wales individually:

- England: the 2011-2014 dwelling stock was extracted from 'Dwelling stock: Number of Dwellings by Tenure and district' published by the ONS;
- Scotland: the 2011-2014 dwelling stock was extracted from 'Estimates of Households and Dwellings in Scotland' published by the NRS; and
- Wales: the 2011 dwelling stock was extracted from the Census table 'QS418EW'. Cumulative dwelling stock information was only available for 2011.

4.4.3. Dwelling trajectories for England, Wales and Scotland were updated to reflect the latest available published information. Sources of dwelling trajectories vary across local authorities due to different planning systems and the lack of statutory requirements in regards to reporting.

4.4.4. Dwelling growth was obtained from the housing trajectories contained within the latest Authority Monitoring Reports (AMR) or Strategic Household Land Availability Assessment published by each local authority. The publication year of these documents varies by authority but is predominantly 2013 or 2014. A description of data sources is included in Appendix F of this report.

4.4.5. The trajectories provided by the authorities predominantly extend to 2026. To extend these to 2051, a trend-based approach was adopted assuming that average growth rates continued to the time horizon of the model.

4.4.6. Table 4-6 summarises total dwelling projections by year and study area input into the NTEM forecasting process.

Table 4-6: Forecast year dwellings by study area (thousands)

Study area	2016	2021	2026	2031	2036	2041	2046	2051
East Midlands	2,061	2,172	2,266	2,366	2,465	2,563	2,662	2,760
North East	1,210	1,255	1,298	1,343	1,387	1,431	1,475	1,519
North West	3,255	3,397	3,508	3,629	3,748	3,866	3,984	4,103
Scotland	2,593	2,694	2,793	2,893	2,992	3,091	3,190	3,289
South West	2,515	2,646	2,754	2,867	2,979	3,091	3,203	3,314
Wales	1,445	1,513	1,578	1,644	1,710	1,776	1,842	1,908
West Midlands	2,456	2,558	2,653	2,748	2,842	2,937	3,031	3,126
Wider South East	10,028	10,556	10,991	11,426	11,865	12,303	12,741	13,179
Yorkshire & the Humber	2,413	2,559	2,695	2,828	2,963	3,098	3,233	3,367
Total	27,977	29,351	30,537	31,743	32,950	34,156	35,361	36,566

4.5. Employment

4.5.1. Forecast year employment data provides the number of jobs segmented by:

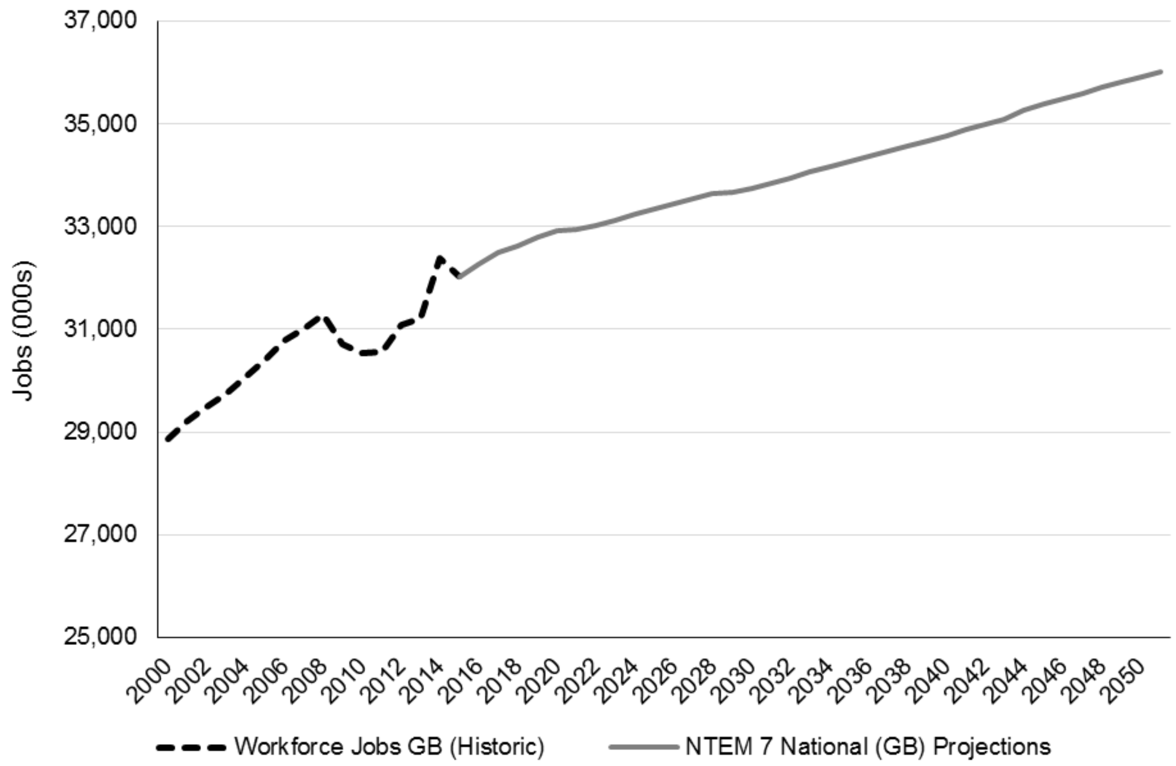
- Gender;
- Employment status (full time or part time); and
- Employment sector (for the twelve NTEM categories).

4.5.2. Those in full time employment are defined as those that work 30 hours or more per week. Part time employment is anything less than this.

Exogenous employment forecasts (long term)

4.5.3. The latest Office for Budget Responsibility (OBR) forecasts of employment are used to provide the long term trend in employment. A factor is derived for each forecast year, which is then applied to the base data.

Figure 4-1: National employment projections (OBR trend)



4.5.4. Working Futures (WF) is a labour market model that provides detailed projections of GB jobs by occupation and industry. The data includes yearly employment projections up to 2022 by industry, gender and pre-defined age category at study area level.

4.5.5. Results for employment projections have the following dimensions:

- Gender;
- Employment status;
- Occupation;
- Industry / sector; and
- Geography.

4.5.6. At a national level, WF provides data[5] for 75 industries, which are broadly consistent with SIC 2-digit codes. Sub-national projections (by LEP zone) are aggregated into 22 industry types. See Appendix E for details of the 22 WF industry types and the relevant SIC 2007 division (2-digit SIC code).

4.5.7. As there is no direct equivalence to NTEM employment categories (the most detailed of which contain SIC 5-digit codes), a correspondence between the two datasets is sought. Crucially, absolute values for employment volumes cannot be used. Instead, a trend can be derived according to the most relevant WF industry types. Table 4-7 shows the source of trend for each NTEM employment type. A list of Working Futures industry types is included in Appendix E of this report.

[5] Working Futures 2012-2022, Technical Report (UK Commission for Employment and Skills, Warwick Institute for Employment Research, Cambridge Econometrics, March 2014)

4.5.8. LEP zones are made up of local authority districts, consistent with control area geography in NTEM. Growth factors derived for LEP zones can therefore be applied to the relevant control area. In a minority of cases, local authority districts may belong to more than one LEP zone. To ensure that employment growth is not overstated, regional growth (also provided by the Working Futures dataset) is calculated and used as an ultimate constraint.

Table 4-7: NTEM 7 employment types and WF industry type for trend calculation

NTEM employment type	Source of trend – WF (22) industry type
E03 Primary & Secondary Schools	19
E04 Higher Education	19
E05 Adult Education	19
E06 Hotels, Campsites etc.	11
E07 Retail Trade	9
E08 Health, Medical	20
E09 Services & Eqpt Rental	9, 10, 16, 17, 20
E10 Industry, Construct, Transport	2, 3, 4, 5, 6, 7, 8, 10
E11 Restaurants & Bars	11
E12 Recreation & Sport	21
E13 Agriculture & Fishing	1
E14 Business	All other codes

4.5.9. Working Futures industry categories are not of sufficient granularity, this is done on a gender and working status basis. Where LEP data is not available, the aggregate regional trend is used. In order to provide regional totals of employment until 2051, regional proportions are applied to the OBR consistent national forecast.

4.5.10. As part of the forecasting process, the employment totals (jobs) are converted to numbers of workers within the Scenario Generator using a parameter that defines the ratio of workers (γ) within each employment sector by gender and working status to jobs for each study area. This is described in more detail in Appendix C. Table 4-8 shows the resulting forecast employment data for use in the NTEM dataset.

Table 4-8: Total employment (jobs) projections by type (thousands)

Type	2016	2021	2026	2031	2036	2041	2046	2051
E03	2,358	2,308	2,343	2,371	2,407	2,444	2,487	2,523
E04	461	442	449	454	461	468	476	483
E05	273	263	267	271	275	279	284	288
E06	508	526	534	540	548	557	566	575
E07	3,720	3,862	3,920	3,968	4,028	4,089	4,161	4,221
E08	3,212	3,388	3,438	3,480	3,533	3,586	3,650	3,703
E09	2,978	3,070	3,115	3,154	3,202	3,250	3,307	3,355
E10	7,262	7,449	7,560	7,653	7,769	7,886	8,025	8,142
E11	1,317	1,383	1,404	1,421	1,442	1,464	1,490	1,512
E12	1,132	1,084	1,100	1,113	1,130	1,147	1,168	1,184
E13	291	300	304	308	313	317	323	328
E14	8,768	8,876	9,008	9,119	9,258	9,396	9,563	9,701
Total	32,280	32,951	33,441	33,852	34,367	34,882	35,500	36,015

5. Expected growth factors

5.1. Summary

5.1.1. Expected Growth Factors (EGFs) influence how much employment and household development from the control area total is distributed to its constituent NTEM zones. In practice this will be governed by a large array of influences, such as pulls of demand and constraints of supply. The EGF methodology is necessary in the absence of a complete set of specific data of individual housing and employment sites over time below the control area level.

5.1.2. In order to forecast trip ends at the NTEM zone level to the horizon of the model, forecasts of demographic information are required at this spatial resolution. However, such forecasts are not available on as detailed a spatial level as the base data. Therefore the purpose of the EGFs is to distribute forecast growth for a control area amongst the constituent NTEM zones.

5.1.3. There are two sets of EGFs required:

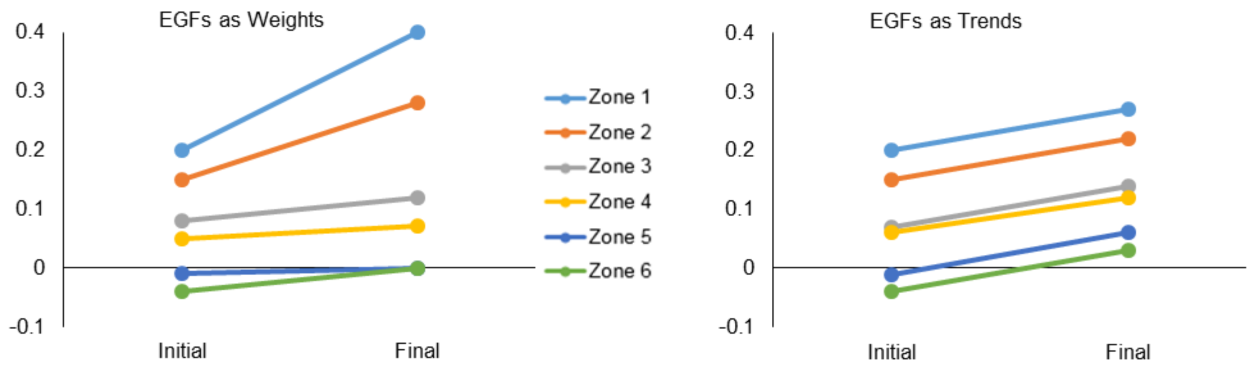
- Household growth for zones within a control area; and
- Employment growth for zones within a control area, which requires growth rates for each employment industry by zone.

5.1.4. There are two different schemes for applying EGFs: growth weights and growth trends. The Scenario Generator tool is capable of using either one of these methods as determined by the user.

- Weights: EGFs are used as a basis of proportional change expected in each zone for the variable in question; and
- Trends: EGFs are used as relative linear factors that will distribute to each zone within a control area based on their relative sizes. This is practically the same as providing absolute expected growth (or decline) over time.

5.1.5. Figure 5-1 shows the impact of the two approaches graphically. The points on the left of the charts are the initial values prior to the application of EGFs, whilst the points on the right of the charts are the zonal values post application of EGFs. In the weights based approach the adjustment is multiplicative, while in the trends based approach it is additive.

Figure 5-1: Expected growth factors applied as weights and trends



5.1.6. As with previous versions, the forecasts delivered for NTEM are generated using the weights-based methodology.

5.2. Household EGFs

5.2.1. Household growth factors are required for each NTEM zone to represent the change in total households. These growth factors are derived by assessing historical changes between 2001 and 2011 for each 2011-based planning area type in order to formulate NTEM zone level household EGFs. The area types have been taken from 'The 2011 Rural-Urban Classification for Small Area Geographies' for England & Wales[6], and 'Urban Rural Classification' for Scotland[7].

5.2.2. The rationale of these planning area types based on clustering together areas that possess similar demographic and morphological characteristics. This resulted in the identification of area types for Great Britain that should share similar patterns of housing development over time. Figure 5-2 shows the planning area types derived for each NTEM zone in 2011.

5.2.3. EGFs for Scotland were calculated separately to those for England & Wales due to differences in Census geography. In addition to Census geography differences, there are also variances in area type definitions (Table 5-1). However as the aim of EGFs is to group together 'similar' areas and since they are defined regionally, it is not an issue that the definitions change slightly between study areas.

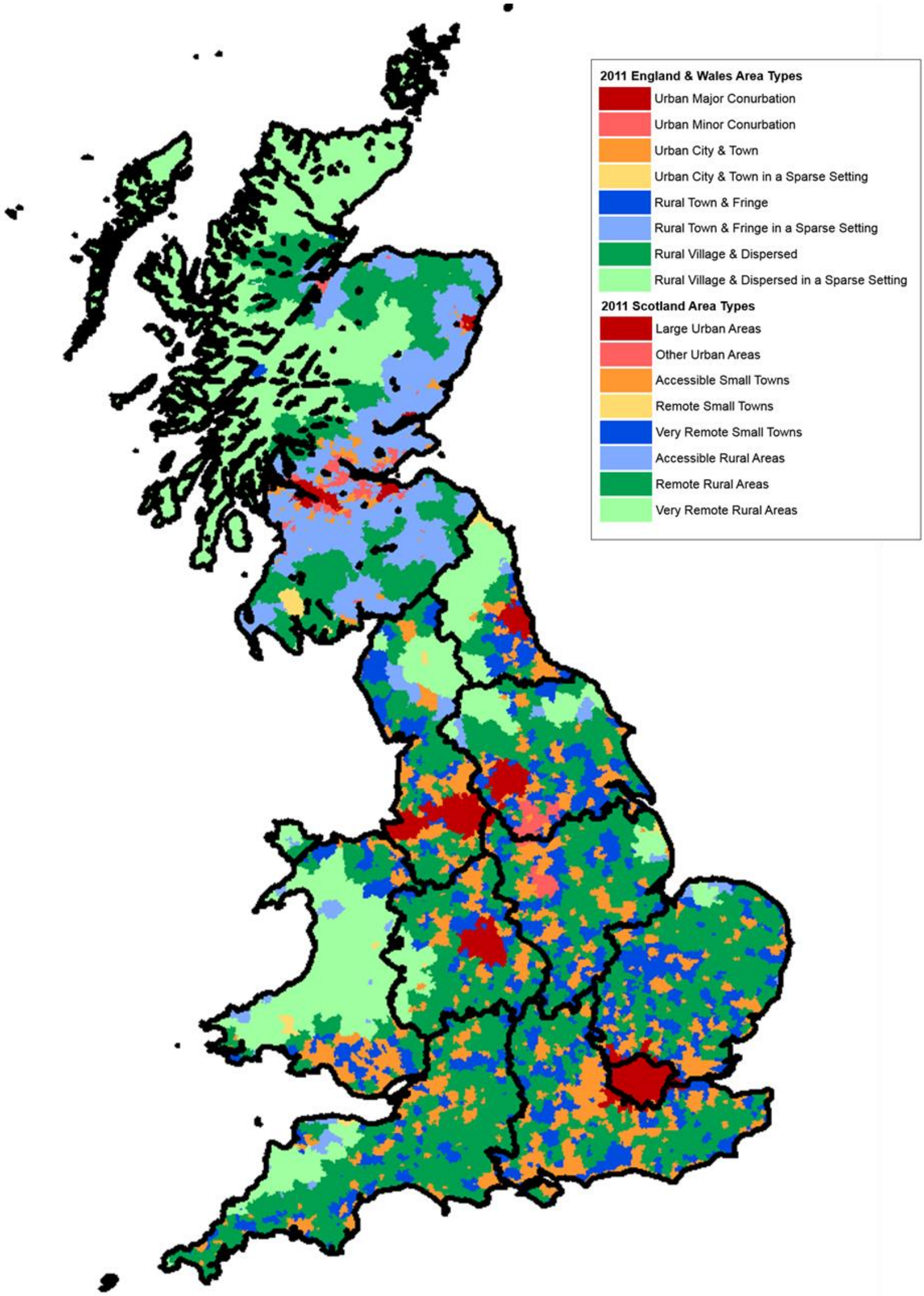
Table 5-1: NTEM 7 EGF area type definitions

NTEM area type ID	NTEM area type	England and Wales area type	Scotland area type
1	Urban major conurbation	Urban major conurbation	Large Urban Areas
2	Urban minor conurbation	Urban minor conurbation	Other Urban Areas
3	Urban city and town	Urban city and town	Accessible Small Towns
4	Urban city and town in a sparse setting	Urban city and town in a sparse setting	Remote Small Towns
5	Rural town and fringe	Rural town and fringe	Very Remote Small Towns
6	Rural town in a sparse setting	Rural town and fringe in a sparse setting	Accessible Rural Areas
7	Rural village and dispersed	Rural village and dispersed	Remote Rural Areas
8	Rural village and dispersed in a sparse setting	Rural village and dispersed in a sparse setting	Very Remote Rural Areas

[6] England & Wales Planning Area Types:
https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/239478/RUC11user_guide_28_Aug.pdf

[7] Scotland Planning Area Types: http://www.gov.scot/Topics/Statistics/About/Methodology/UrbanRuralClassification/Urban-Rural-Classification-2011-12/2011-2012-Urban-Rural-Lookups

Figure 5-2: 2011 planning area types used in household EGF calculation



N.B. All Scottish islands are included, but may appear off the map.

5.2.4. The trend in household change from 2001 to 2011 was taken from Census household data. Due to significant differences in the geography of the two sources, a method was used to allow a comparison between them. Separate methods have been used for England & Wales and Scotland.

5.2.5. As a result of MSOA boundary changes between census years in England & Wales, EGFs have only been calculated for MSOAs that remain unchanged between 2001 and 2011 Censuses. This approach assumes the planning area type of unchanged MSOAs are identical. Of the 7,201 2011 MSOAs, 7,040 have remained unchanged.

5.2.6. Census tables 'UV051' (Number of people living in households) from the 2001 Census and 'QS406EW' (Household size) from the 2011 Census have been utilised to calculate an EGF for all unchanged MSOAs in England & Wales. The total number of households within a study area was calculated by identifying the number of households within all unchanged MSOAs of a given study area. Subsequently an EGF was produced for each planning area type within each study area of England & Wales based on 2001 and 2011 household Census data.

5.2.7. For Scotland, each DZ from the 2001 and 2011 Census has been assigned an NTEM zone, as a lookup between 2001 and 2011 DZs does not exist. It has thus been assumed the planning area type of an NTEM zone has remained the same between Census years (2001 and 2011).

5.2.8. Census tables 'UV51' (Number of people living in households) from the 2001 census and 'QS406SC' (Household size) from the 2011 census have been utilised to calculate an EGF for all Scottish NTEM zones. The total number of households within Scotland was calculated by identifying the number of households within each NTEM zone. Subsequently an EGF was produced for each planning area type within Scotland based on 2001 and 2011 household census data.

5.2.9. To increase the accuracy of the Planning Area Type methodology, EGFs are defined separately according to study area. This contributes towards accounting for any regional variation in planning policy that may exist.

5.2.10. Table 5-2 shows the assumed household EGFs by planning area type in each study area between 2001 and 2011. Note that the values in Table 5-2 are rounded to the nearest whole percentage.

Table 5-2: Household growth factors

Area type	Study area								
	East Midlands	North East	North West	Scotland	Wider South East	South West	Wales	West Midlands	Yorks & Humber
1	6%	5%	6%	7%	8%	-	-	4%	8%
2	6%	-	-	9%	-	-	-	-	6%
3	10%	7%	6%	12%	8%	8%	8%	8%	8%
4	12%	6%	8%	16%	-	5%	6%	14%	2%
5	11%	8%	6%	10%	8%	8%	7%	8%	10%
6	16%	8%	2%	6%	2%	15%	7%	-	9%
7	9%	15%	8%	7%	8%	6%	9%	8%	9%
8	6%	8%	9%	7%	-1%	7%	8%	7%	7%

5.2.11. NTEM zones of the same planning area type within a study area are assumed to have the same level of growth. The final household EGFs for each study area are therefore a weighted average of growth according to the Planning Area Type of the MSOAs or DZs that nest within them.

5.2.12. On allocating households at the zone level, these EGFs are used to growth up the households that already exist in those zones. Total growth is controlled to the total number of households expected in the control area. Therefore, as described in section 5.1, EGFs are adjusted either proportionally (weights-based approach) or linearly (trend-based approach) in order to obtain the required district household total (see example below). In NTEM EGFs are adjusted using the weights-based methodology.

EXAMPLE

Average Expected Growth Rate (EGF)

Zone 1: 9%
Zone 2: 12%

Zone 2 would be expected to receive more household growth than Zone 1 relative to its initial stock. This of course is not necessarily a greater total number of households as this will depend on relative initial size and the total internal adjustment required to the growth factors.

In 2011 Zone 1 has 4,979 households and Zone 2 has 1,779. Using the growth factors, the initial estimate of households is thus:

Zone 1 4,979 * 0.09 = 448 households
Zone 2 1,779 * 0.12 = 213 households

As an example, if only these two zones were in the control area and the household growth total is 800, the growth rates need to be factored up to achieve this level of growth.

Using a weight-based approach this is proportionately (maintaining the same ratio between growth rates by multiplying through to get the correct growth required):

Zone 1 4,979 * (0.09 * 800/661) = 4,979 * 0.109 = 542 households
Zone 2 1,779 * (0.12 * 800/661) = 1,779 * 0.145 = 258 households

Using a trend-based approach this is linearly (maintaining the same absolute difference between growth rates):

An extra 139 households are required in addition to the already established growth

4,979 + 1,779 = 6,758
(800 - 448+213) / 6,758 = 139 / 6,758 = 0.0205

Zone 1 4,979 * (0.09 + 0.0205) = 4,979 * 0.1105 = 550 households
Zone 2 1,779 * (0.12 + 0.0205) = 1,779 * 0.1405 = 250 households

5.3. Employment EGFs

5.3.1. Employment types that are Dwellings-led do not require input growth factors as they will be allocated an EGF using generated household results in the Scenario Generator tool.

5.3.2. EGFs in NTEM are produced using a weights-based approach. These factors are set as constant, therefore causing growth to be distributed pro rata according to existing distribution.

5.3.3. Table 5-3 shows the source of EGFs for each NTEM employment type. These are derived by one of two approaches:

- Dwellings-led (i.e. schools and leisure activities); or
- Constant, all assumed to grow relative to their existing size.

Table 5-3: EGF source by NTEM employment type

Code	NTEM employment type	EGF source
E03	Primary and secondary school employment	Dwellings-led
E04	Higher education employment	Constant, relative to size
E05	Adult education employment	Constant, relative to size
E06	Hotels, campsites, etc.	Constant, relative to size
E07	Retail trade	Constant, relative to size
E08	Health/ medical employment	Constant, relative to size
E09	Services (business & other, eqpt rental, repairs)	Constant, relative to size
E10	Industry, construction and transport	Constant, relative to size
E11	Restaurants and bars	Constant, relative to size
E12	Recreation and sport	Dwellings-led
E13	Agriculture and fishing	Constant, relative to size
E14	Business (other)	Constant, relative to size

6. Planning data results

6.1. Introduction

6.1.1. This chapter outlines the results from NTEM 7 and provides a comparison between NTEM 6.2 and NTEM 7. This will help to explain:

- The main trends in the NTEM 7 dataset as output from ScenGen, National Car Ownership Model and National Trip End Model; and
- The similarities and differences between NTEM 6.2 and NTEM 7 datasets to show how the planning data and ultimately the trip ends may differ between the two versions.

6.1.2. Where data has been analysed at a spatially detailed level, the forecast year of 2031 has been used to review the results midway through the forecasting horizon. As the base year and forecast years, geography and input data of NTEM 6.2 and NTEM 7 differ, a direct comparison is not necessarily appropriate.

6.2. Planning data (Scenario Generator)

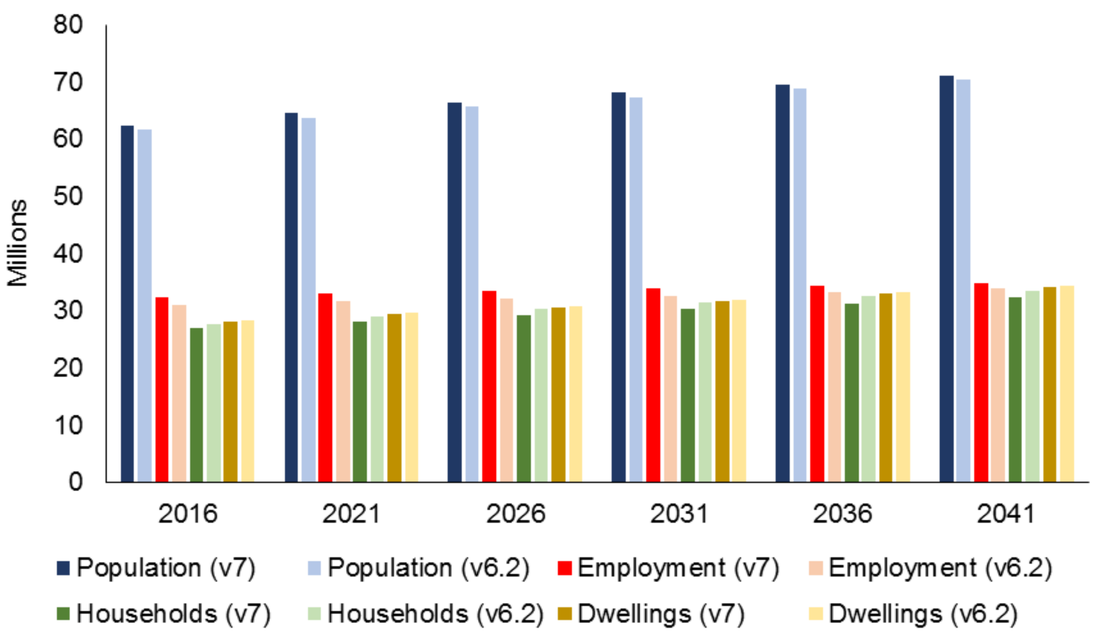
6.2.1. The following demographic forecasts are compared and contrasted between NTEM version 6.2 (referred to as v6.2) and NTEM version 7 (referred to as v7):

- Planning data (population, employment, households and dwellings);
- Average household sizes;
- Vacancy rates; and
- Housing pressure.

Comparison of planning data outputs

6.2.2. A high level comparison has been drawn between v6.2 and v7 forecast year planning data (population, employment, household and dwelling) at a global level (Figure 6-1). In general, exogenous forecasts of population, households and dwellings are lower in v7 when compared to v6.2, whilst employment forecasts are slightly higher. Each of these categories will be considered in greater detail.

Figure 6-1: Comparison of planning data totals



Population

6.2.3. Table 6-1 and Figure 6-2 compare population totals in Great Britain between v6.2 and v7. Total population is slightly higher in v7 than v6.2 for all forecast years, with the trends converging over time.

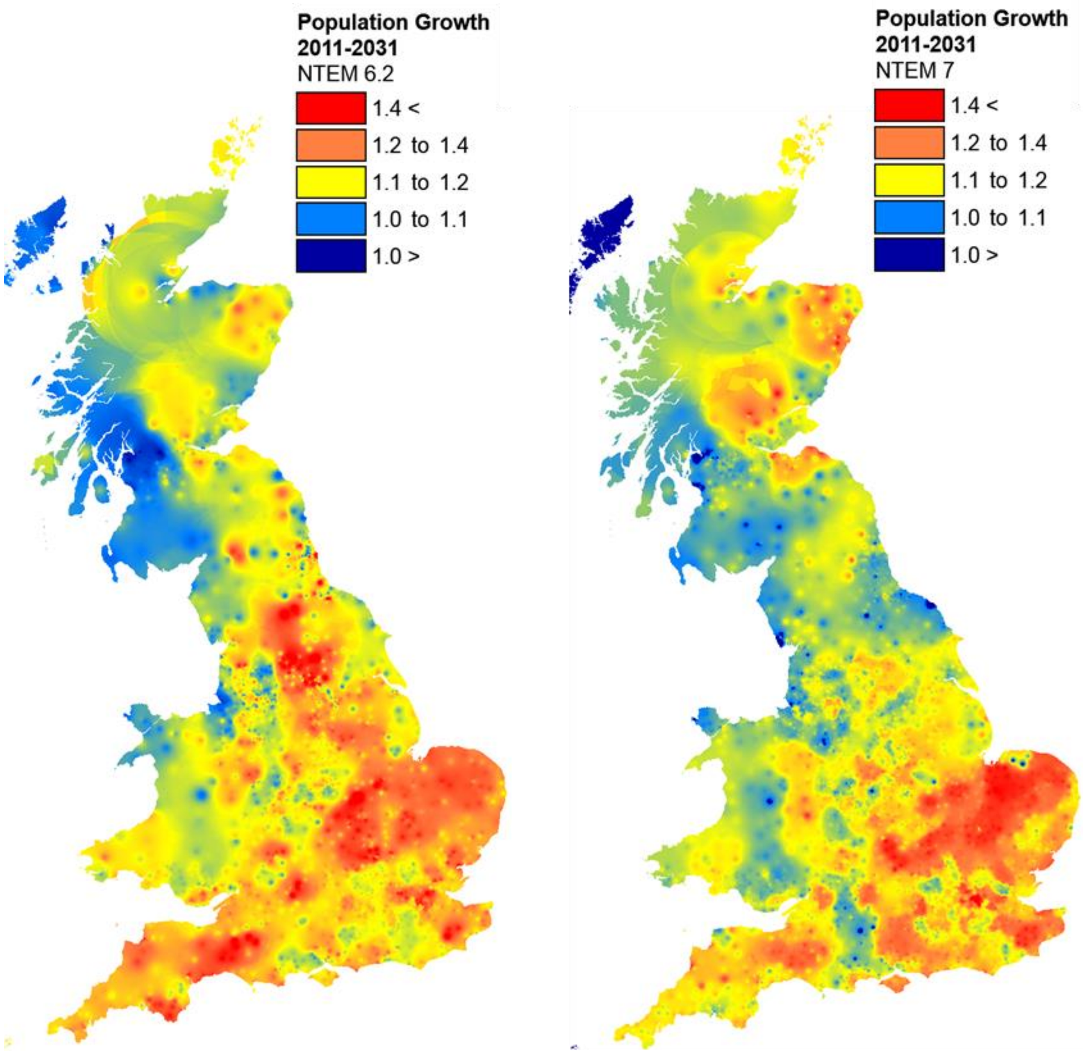
6.2.4. In both cases a “central” forecast of population growth is concerned. Particular variants (high migration, low birth rate etc.) will of course impact this comparison.

Table 6-1: Comparison of GB forecast population data (thousands)

Population	2016	2021	2026	2031	2036	2041
NTEM 7	62,446	64,523	66,431	68,096	69,552	70,984
NTEM 6.2	61,683	63,746	65,684	67,392	68,894	70,337
Difference (v7 - v6.2)	763	777	747	704	658	647
Difference (%)	1.24%	1.22%	1.14%	1.04%	0.96%	0.92%

6.2.5. Spatial variability is similar between the two versions. In general the growth rate in v7 between 2011 and 2031 is lower in the South West and Yorkshire and the Humber, and slightly higher in Scotland and the Wider South East.

Figure 6-2: Population growth (2011-2031) in NTEM 6.2 (left) and NTEM 7 (right)



Employment (jobs and workers)

6.2.6. Table 6-2 compares job totals in Great Britain between v6.2 and v7, whilst Table 6-3 compares worker totals. Workers refers to the total number of people in employment.

6.2.7. There are nearly always a greater number of jobs than there are workers due to people having multiple jobs. Employment totals are higher in v7 than v6.2 for all forecast years, although the difference between the two versions is less apparent in later forecast years.

Table 6-2: Comparison of GB forecast employment (jobs) data (thousands)

Jobs	2016	2021	2026	2031	2036	2041
NTEM 7	32,279	32,951	33,441	33,852	34,367	34,882
NTEM 6.2	31,021	31,576	32,191	32,591	33,232	33,911
Difference (v7 - v6.2)	1,258	1,375	1,250	1,261	1,135	971
Difference (%)	3.90%	4.17%	3.74%	3.73%	3.30%	2.78%

Table 6-3: Comparison of GB forecast employment (workers) data (thousands)

Workers	2016	2021	2026	2031	2036	2041
NTEM 7	29,523	30,174	30,640	31,009	31,448	31,923
NTEM 6.2	28,327	28,787	29,281	29,554	30,063	30,655
Difference (v7 - v6.2)	1,196	1,387	1,359	1,455	1,385	1,268
Difference (%)	4.05%	4.60%	4.43%	4.69%	4.41%	3.97%

6.2.8. Table 6-4 compares the proportion of total jobs across each study area between v6.2 and v7. Similar trends exist between the two versions, with no notable differences.

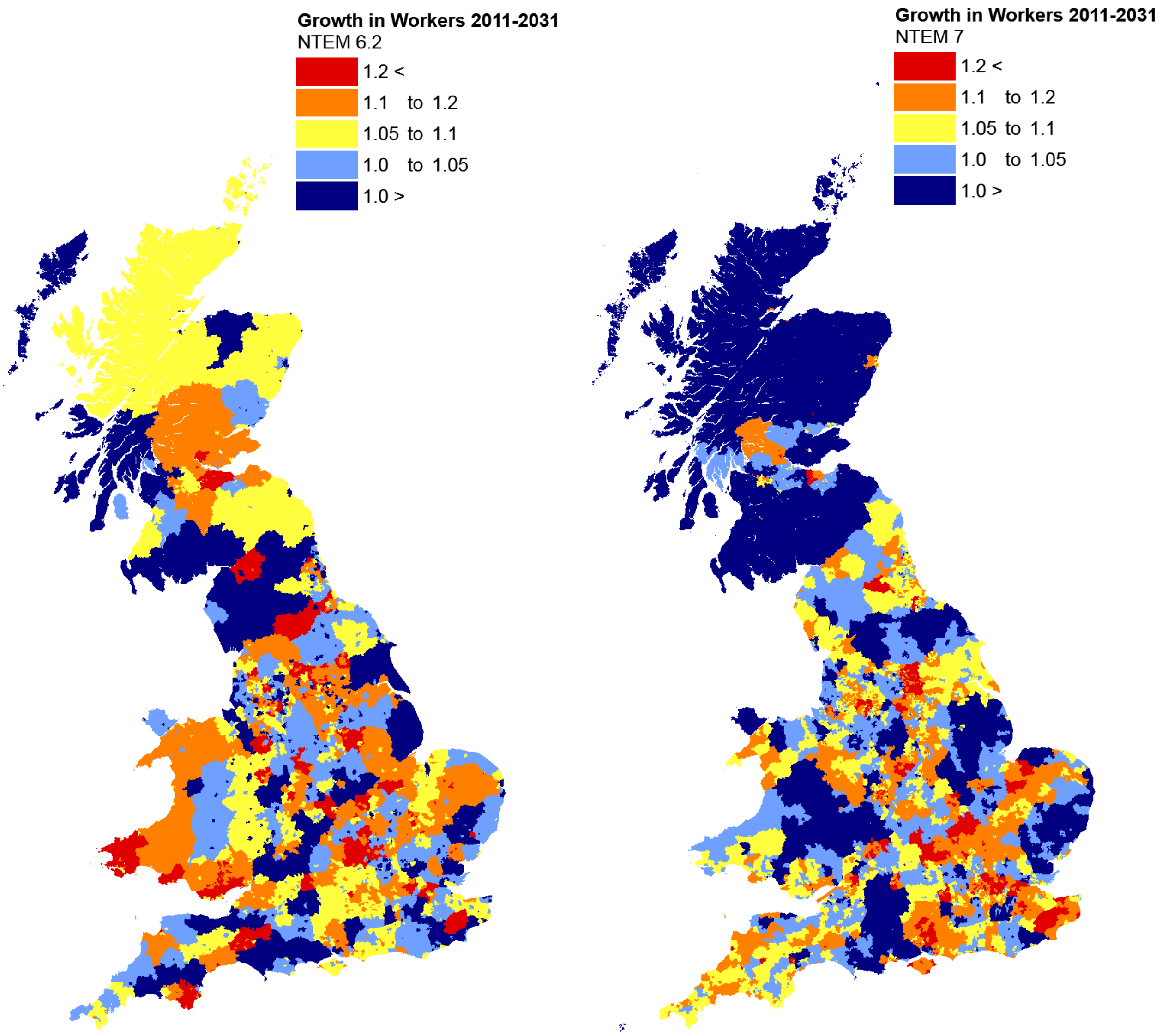
Table 6-4: Proportion of total jobs by study area

Study area	NTEM 6.2			NTEM 7			Difference (%)		
	2021	2031	2041	2021	2031	2041	2021	2031	2041
East Midlands	7.0%	6.9%	6.8%	7.1%	7.1%	7.1%	0.1%	0.2%	0.3%
North East	3.7%	3.6%	3.6%	3.7%	3.7%	3.7%	0.0%	0.1%	0.1%
North West	10.9%	10.7%	10.5%	10.7%	10.7%	10.7%	-0.2%	0.0%	0.2%
Scotland	8.3%	8.4%	8.6%	8.4%	8.4%	8.4%	0.1%	0.0%	-0.2%
South West	8.7%	8.6%	8.5%	8.9%	8.9%	8.9%	0.2%	0.3%	0.4%
Wales	4.2%	4.5%	4.7%	4.4%	4.4%	4.4%	0.1%	-0.1%	-0.4%
West Midlands	8.4%	8.5%	8.6%	8.3%	8.3%	8.3%	-0.1%	-0.2%	-0.3%
Wider South East	40.5%	40.3%	40.2%	40.3%	40.3%	40.3%	-0.2%	0.0%	0.1%
Yorks & Humber	8.3%	8.4%	8.5%	8.2%	8.2%	8.2%	-0.1%	-0.2%	-0.4%
Total	100%	100%	100%	100%	100%	100%	-0.1%	0.1%	-0.2%

6.2.9. In general, v7 demonstrates higher employment growth rates except in a few concentrated areas in Scotland, South Wales and Yorkshire and the Humber (as shown in Figure 6-3).

6.2.10. Considering the pattern of growth in workers, Figure 6-3 shows growth in workers between 2011 and 2031 for NTEM 6.2 and NTEM 7[8]. In addition to different patterns of relative growth, particularly evident is the impact of the increased granularity of the zoning system.

Figure 6-3: Employment growth (workers, 2011-2031) in NTEM 6.2 (L) and NTEM 7 (R)



Households

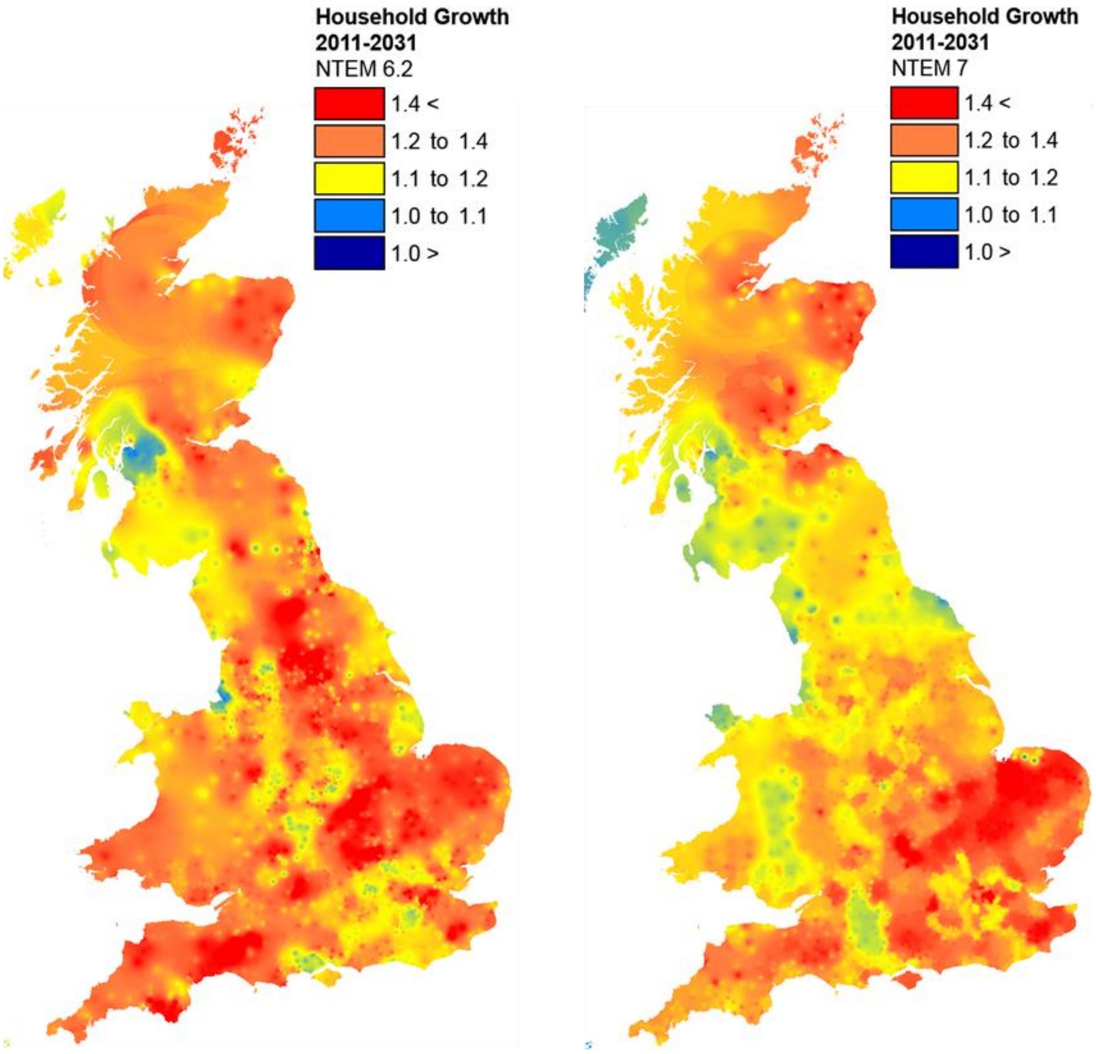
6.2.11. The total number of households is slightly lower in v7 than v 7.2 in all forecast years. This is shown in Table 6-5 and Figure 6-4. The difference between the two versions varies over time, peaking in forecast year 2036.

[8] It should be noted that 2011 is the base year of NTEM 7, but a forecast year of NTEM 6.2

Table 6-5: Comparison of GB forecast year household data (thousands)

Households	2016	2021	2026	2031	2036	2041
NTEM 7	26,948	28,185	29,268	30,302	31,262	32,341
NTEM 6.2	27,529	28,923	30,255	31,491	32,631	33,511
Difference (v7 - v6.2)	-581	-738	-987	-1,189	-1,369	-1,170
Difference (%)	-2.16%	-2.62%	-3.37%	-3.92%	-4.38%	-3.62%

Figure 6-4: Households growth (2011-2031) in NTEM 6.2 (L) and NTEM 7 (R)



Dwellings

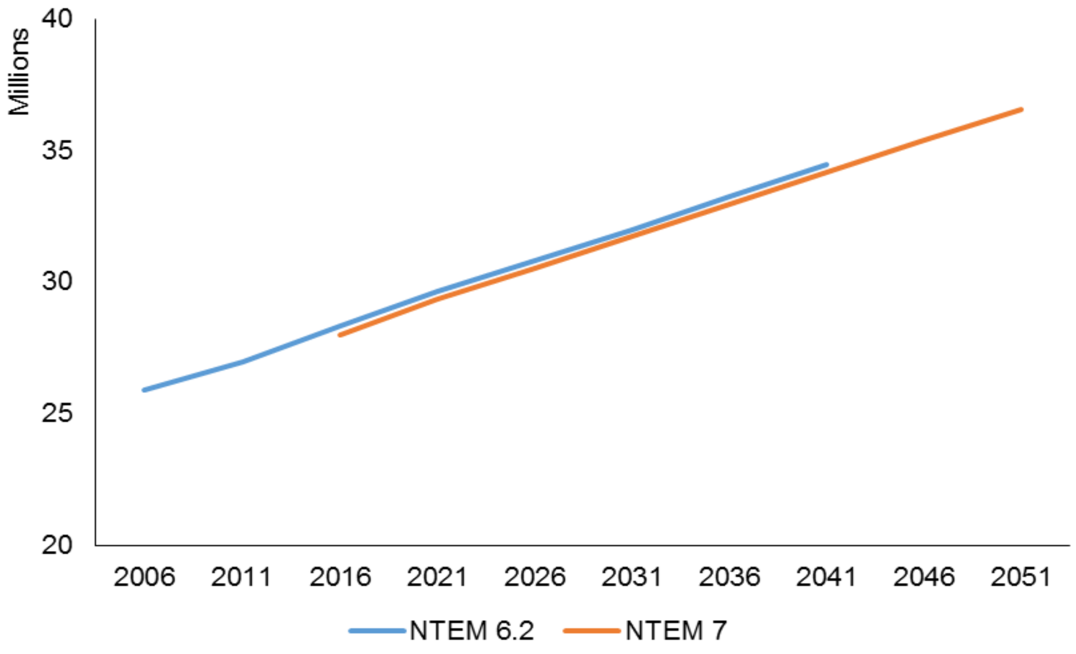
6.2.12. Table 6-6 and Figure 6-5 compare dwelling totals in Great Britain between v6.2 and v7.

6.2.13. The total number of dwellings in v7 and v6.2 are similar for all forecast years. Dwelling totals are slightly lower in v7 than v6.2 across all forecast years.

Table 6-6: Comparison of GB forecast year dwellings data (thousands)

Dwellings	2016	2021	2026	2031	2036	2041
NTEM 7	27,977	29,351	30,537	31,743	32,950	34,156
NTEM 6.2	28,350	29,628	30,789	32,003	33,228	34,456
Difference (v7 - v6.2)	-373	-277	-253	-260	-278	-300
Difference (%)	-1.33%	-0.94%	-0.83%	-0.82%	-0.84%	-0.88%

Figure 6-5: Comparison of GB forecast dwellings data



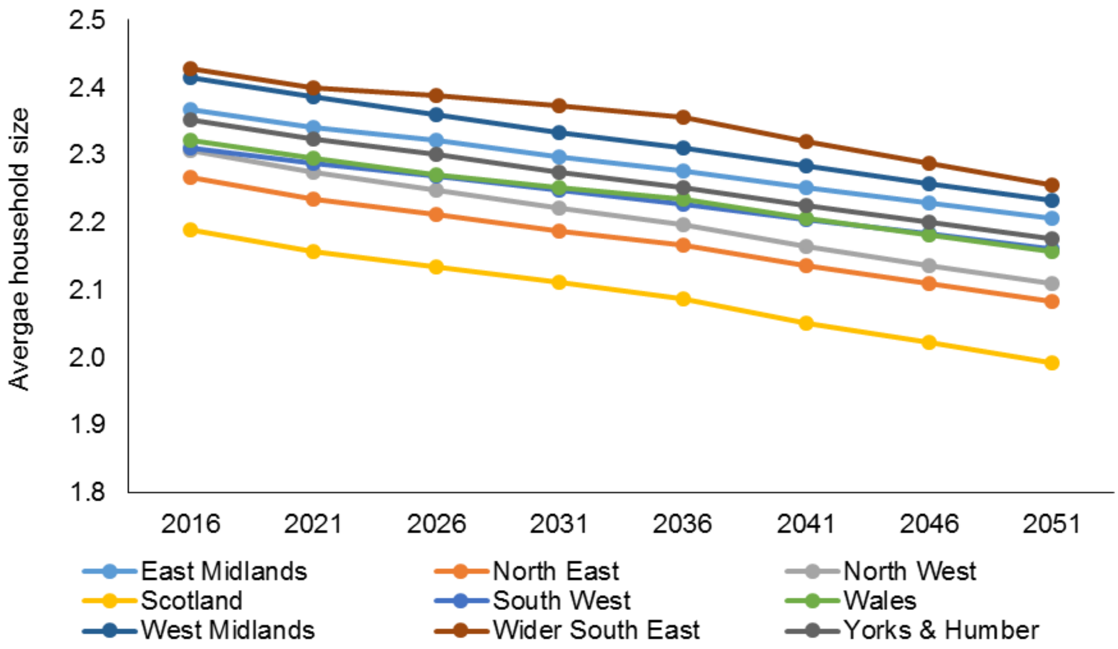
Average household size

6.2.14. There is a reduction in the average household size over time (Figure 6-6), which is comparable to the trends observed in v6.2[9].

6.2.15. The Wider South East study area (London, East of England and South East) has the highest average household size in all forecast years as insufficient dwellings allocations prevent household formation and induce more people to live together in 2+ person households. Scotland has the lowest average household size in all forecast years.

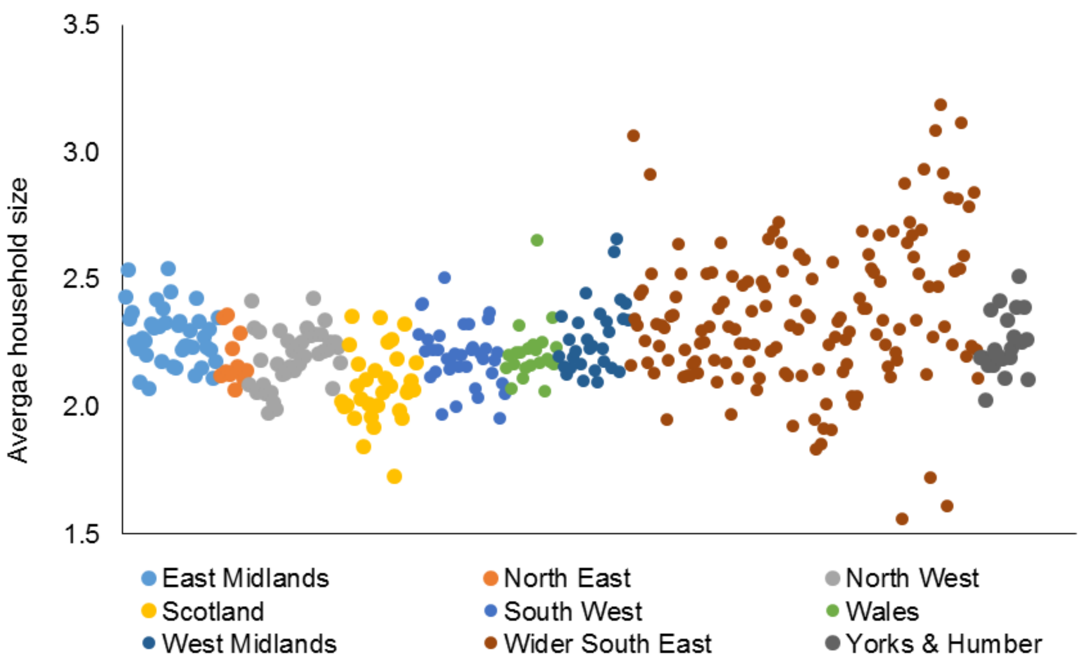
[9] NTEM 6.2 Planning Guidance – Figure 6.1

Figure 6-6: Average household size by study area



6.2.16. Figure 6-7 shows average household sizes at control area level in the 2031 forecast year. The Wider South East study area shows the largest spread of average household sizes in v7; from 3.18 persons per household in Hillingdon to 1.56 in the City of London. This trend is similar to v6.2, where the Wider South East study area also demonstrates the largest dispersion of average household sizes[10].

Figure 6-7: Average household size by control area – forecast year 2031



[10] NTEM 6.2 Planning Guidance – Figure 6.2

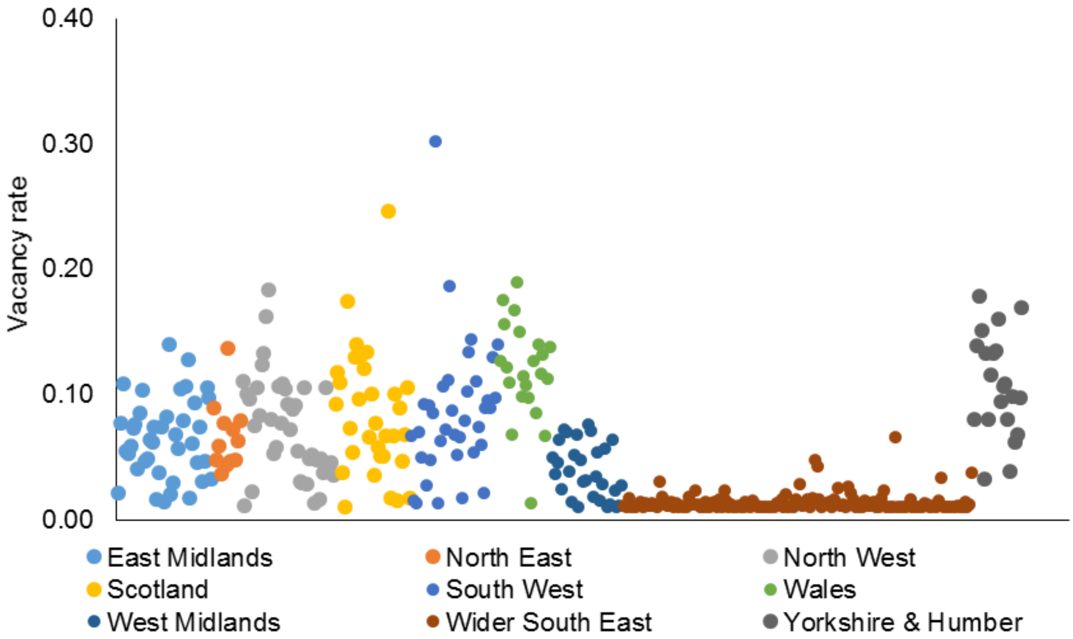
Vacancy rates

6.2.17. Figure 6-8 shows vacancy rates by control area in 2031. The dispersion of control area vacancy rates in v7 is relatively similar between all study area, with the exception of the Wider South East

6.2.18. Control area vacancy rates in the Wider South East are consistently lower than other study area due to continuing pressure on dwelling stock. This is consistent with that seen in NTEM v6.2.

6.2.19. Vacancy rates are generally higher than those shown in NTEM v6.2[11]. This is sensible given the slightly lower projections of households and similar projections of dwellings used in NTEM v7.

Figure 6-8: Vacancy rates by control area – forecast year 2031



Housing pressure

6.2.20. Where household capacity is insufficient within a control area, 50% of the excess households are reallocated evenly to other control areas with vacant dwellings within the study area, whilst the other 50% of excess households are suppressed.

6.2.21. Figure 6-9 shows household capacity before reallocating or suppressing excess households in v7. The overall trend in v7 indicates that housing capacity increases over time, with the exception of the Wider South East study area. This is similar to the trend observed in NTEM v6.2

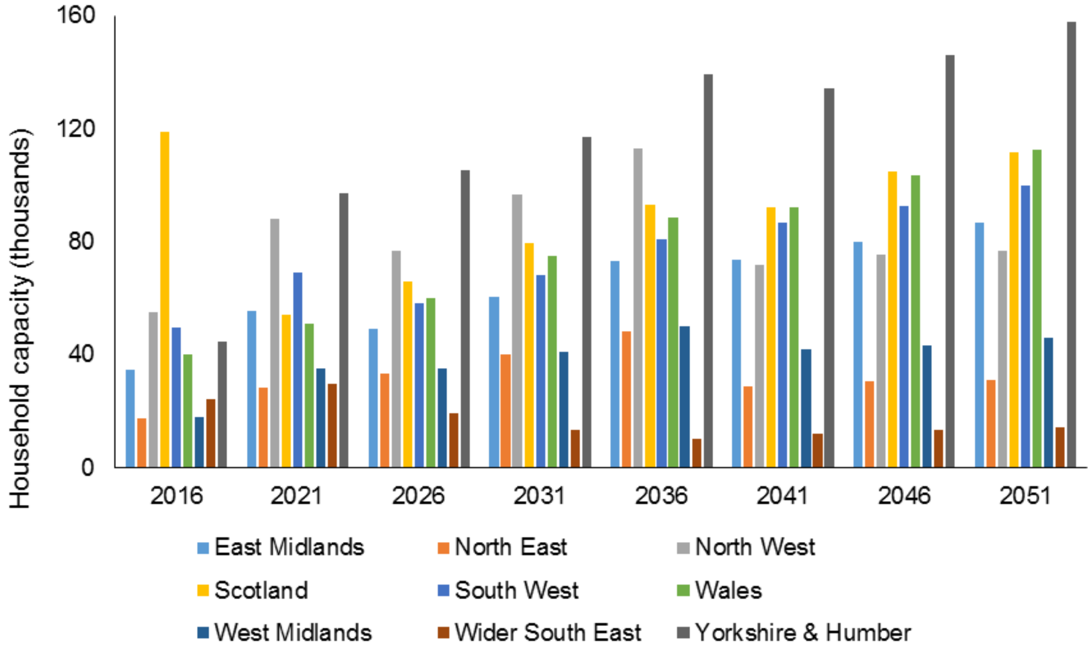
6.2.22. The overall trend in v6.2 also implies that housing capacity generally increases over time[12]. Despite trend similarities between the two versions, average household capacities are greater in v7 than v6.2. However, this capacity is more evenly distributed in NTEM v7, with the highest observed household capacity much greater in v6.2.

6.2.23. North West and Scotland stand out as study areas with a significantly greater level of household capacity in the mid to later forecast years, whereas Yorkshire and the Humber has the highest household capacity in v7. Differences between study area household capacities are not as great in v7 compared to v6.2.

[11] NTEM 6.2 Planning Guidance – Figure 6.3

[12] NTEM 6.2 Planning Guidance – Figure 6.4

Figure 6-9: Household capacity before reallocating or suppressing excess households



6.2.24. It is often the case during the reallocation process that housing demand within a control area cannot be accommodated by the supply of dwellings. As explained in Section 2.4 ('combining trend and policy based estimates'), this may result in excess households within a control area being supressed. Figure 6-10 and Figure 6-11 show the number of households suppressed during the reallocation process in NTEM v7.

Figure 6-10: Households suppressed by study area (excluding Wider South East)

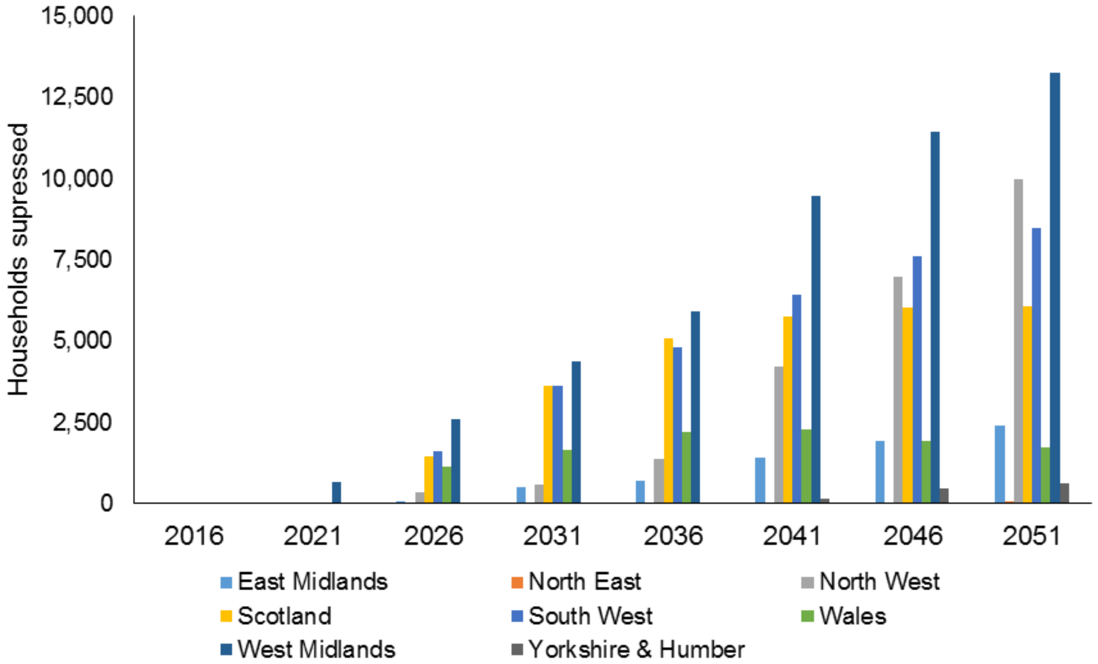
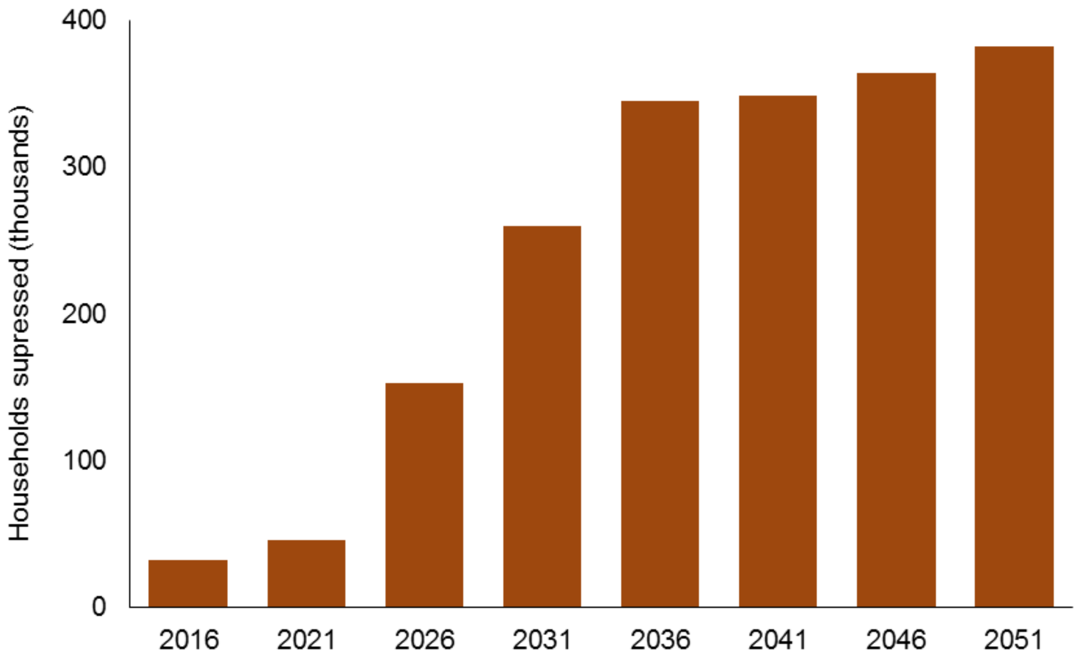


Figure 6-11: Households suppressed by study area (Wider South East)



6.2.25. The suppression of households in ScenGen increases over time, and is observed to much greater in the Wider South East study area.

6.2.26. The overall trend is very similar to that observed in NTEM v6.2[13]. However in general, household suppression is greater in v6.2 than v7. This is consistent with the fact that household projections are greater in v6.2 than v7.

6.3. National Car Ownership model (NATCOP)

6.3.1. Outputs from the Scenario Generator are used in the National Car Ownership Model. This calculates the probability of households owning 0, 1, 2 and 3 or more cars in a given forecast year. In addition to demographic information provided by the Scenario Generator, NATCOP uses household income at the zone level[14] and WebTAG derived trends for vehicle running costs.

6.3.2. The National Car Ownership model has been re-estimated and updated to a 2011 base year, including additional area types (with a better representation of London) and a cohort licence holding model to better reflect changes in driving licence holding over time.

6.3.3. Detailed information on NATCOP is contained within the report, “Estimation of the National Car Ownership Model for Great Britain, 2011 Base”[15].

6.3.4. Car ownership forecasts between NTEM 6.2 (v6.2) and NTEM 7 (v7) are compared in Table 6-7. There is a higher proportion of zero car households in v7, whilst there is a smaller proportion of one car households. In regards to 2+ car households there is minimal difference between the two versions, although slightly higher in v7. There is a greater proportion of 3+ car households in v7, especially in the later forecast years. The total number of cars in 2011 is lower in v7, but by 2041 it is greater in v7. This may be accredited to a rise in multi-car owning households.

[13] NTEM 6.2 Planning Guidance – Figure 6.5

[14] Provided by CACI, © CACI Limited Paycheck 1996-2016

[15] RAND Europe, 2016

6.3.5. The difference between car ownership proportions is relatively consistent across forecast years, with the greatest difference across all car ownership proportions occurring in 2041, the latest year for which both forecasts are available.

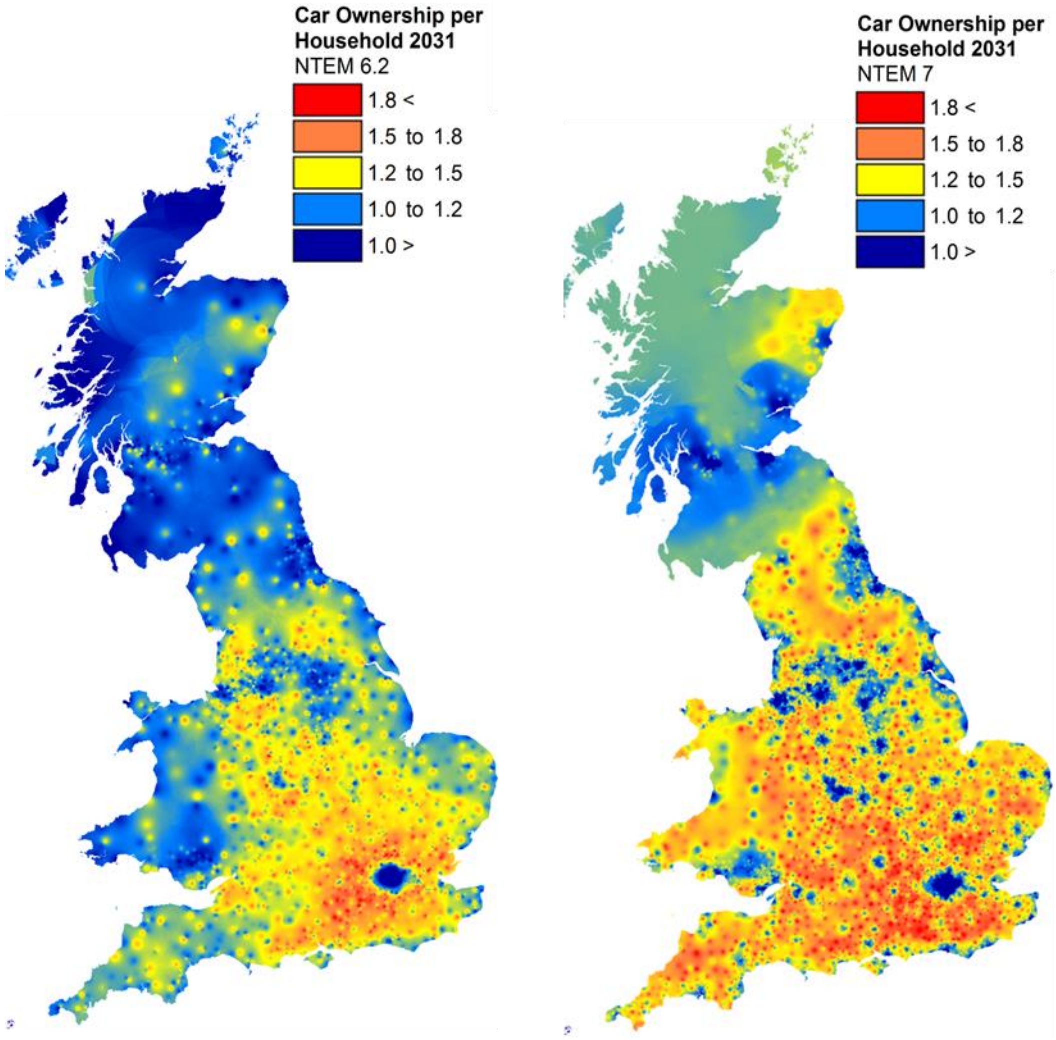
Table 6-7: Forecast car ownership comparison

Year	Household Car Ownership (thousands)				Total Cars	Proportion (%)			
	0 cars	1 car	2 cars	3+ cars		P0	P1	P2	P3P
	Version 6.2								
2011	5,908	12,319	6,298	1,582	29,977	23%	47%	24%	6%
2016	5,713	13,207	6,806	1,727	32,345	21%	48%	25%	6%
2021	5,860	13,917	7,149	1,817	34,029	20%	48%	25%	6%
2026	5,940	14,512	7,486	1,950	35,724	20%	49%	25%	7%
2031	6,016	15,133	7,802	2,064	37,342	19%	49%	25%	7%
2036	6,036	15,705	8,129	2,209	39,032	19%	49%	25%	7%
2041	6,010	16,157	8,453	2,388	40,705	18%	49%	26%	7%
	Version 7								
2011	6,741	10,877	6,295	1,871	29,454	26%	42%	24%	7%
2016	6,736	11,399	6,544	2,270	31,750	25%	42%	24%	8%
2021	6,735	12,005	7,022	2,429	33,821	24%	43%	25%	9%
2026	6,683	12,500	7,500	2,588	35,782	23%	43%	26%	9%
2031	6,630	12,939	7,940	2,794	37,759	22%	43%	26%	9%
2036	6,507	13,320	8,456	2,982	39,774	21%	43%	27%	10%
2041	6,422	13,733	9,038	3,152	41,894	20%	42%	28%	10%
	Difference (v7 - v6.2)								
2011	14%	-12%	0%	18%	-2%	4%	-5%	0%	1%
2016	18%	-14%	-4%	31%	-2%	4%	-6%	-1%	2%
2021	15%	-14%	-2%	34%	-1%	4%	-6%	0%	2%
2026	13%	-14%	0%	33%	0%	3%	-6%	1%	2%
2031	10%	-14%	2%	35%	1%	2%	-6%	1%	3%
2036	8%	-15%	4%	35%	2%	2%	-6%	2%	3%
2041	7%	-15%	7%	32%	3%	2%	-6%	2%	3%

The total car calculation is illustrative and assumes 3+ car households have an average of 3.2 vehicles

6.3.6. Figure 6-12 shows the average number of cars per household in v6.2 and v7 by NTEM zone in 2031. Dense urban areas tend to have fewer cars per household than zones outside of metropolitan areas. The Wider South East, outside of London, has the highest level of car ownership in v7. Trends are comparable between v6.2 and v7, although in general the average number of cars per household is slightly higher in v7.

Figure 6-12: Car ownership per household (2031) in NTEM 6.2 (L) and NTEM 7 (R)



6.3.7. Figure 6-13 and Figure 6-14 show growth[16] in households by car ownership between 2011 and 2031, in v6.2 and v7. This demonstrates the general trend of increased car ownership through time across Great Britain, with greater levels of growth in higher car owning households.

6.3.8. For the majority of Great Britain there is a reduction in zero car households over time, however in densely populated areas there is an increase between 2011 and 2031 in v6.2 and v7. Growth in one and two car households are relatively similar in both versions. The growth in households with three or more vehicles is greater in v7 than v6.2, across Great Britain. This should be considered in the context of Table 6-7 (i.e. there is a lower overall number of 3+ car households, and so growth is from a smaller base).

[16] i.e. 1.5 indicates 50% growth

Figure 6-13: Growth in households by car ownership (2011-2031) in NTEM 6.2

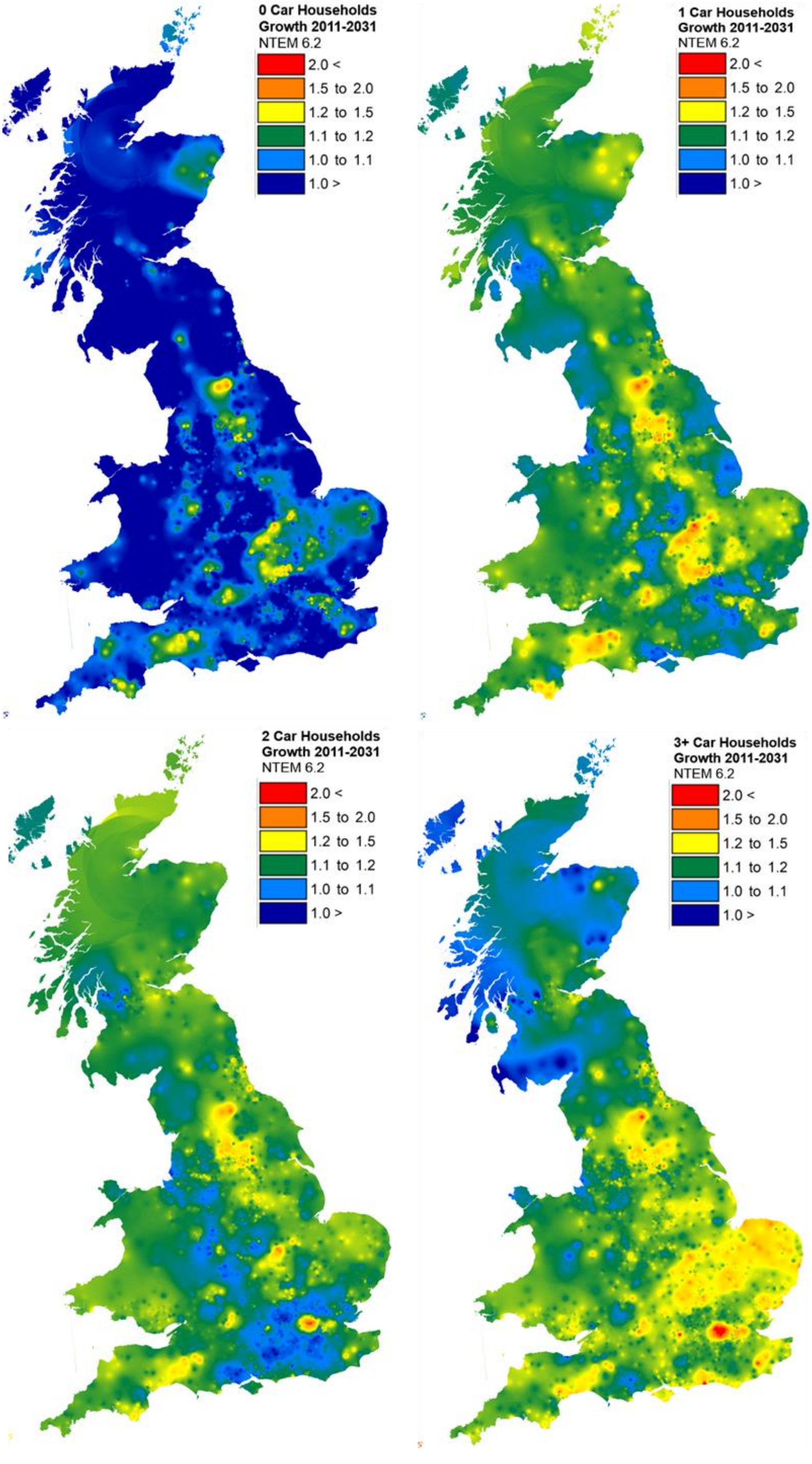
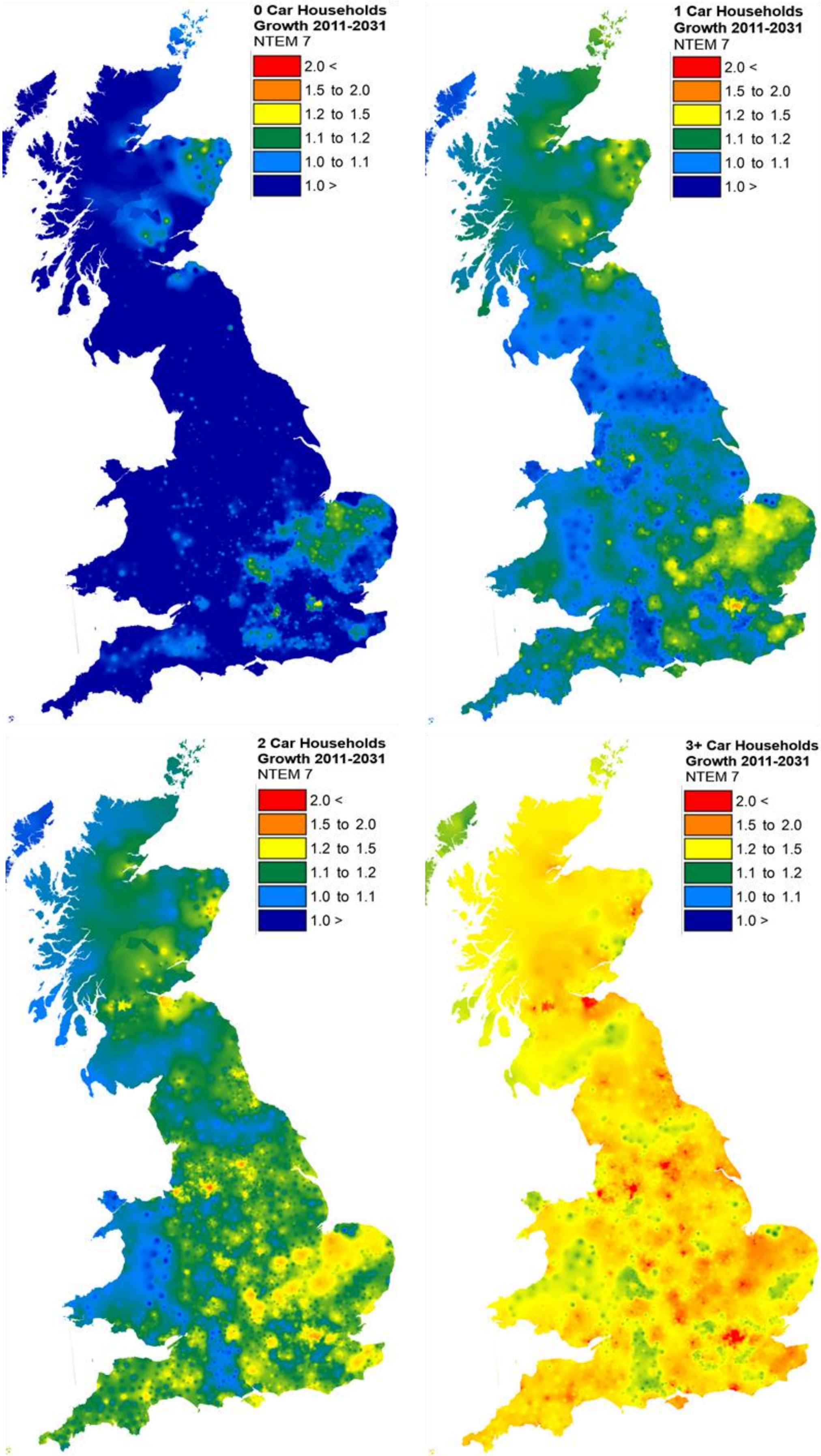


Figure 6-14: Growth in households by car ownership (2011-2031) in NTEM 7



6.4. National Trip End Model (CTripEnd)

6.4.1. The National Trip End Model gives details of trip productions and attractions that are ultimately made available through the TEMPRO system. Whilst the software has been updated (as mentioned in Section 1.3), there has been no change to the underlying methodology.

6.4.2. As part of the Department for Transport's, "Understanding and valuing impacts of transport investment" (UVITI) research programme, home-based trip rates have been re-estimated[17].These trip rates apply to 8 home-based purposes across 88 traveller types (incorporating age, gender, working status and car availability) and 8 different area types.

6.4.3. Recent trends[18] in personal travel have demonstrated a decline in trip making over time, with reductions since the late 1990s. Research carried out on an extended National Travel Survey (NTS) sample has confirmed this for the dimensions required by NTEM. Whilst a full analysis of trip rates is outside the scope of this report, the implementation of the updated evidence base on home-based trip making has reduced total trip productions in 2011 by around 20% when comparing with NTEM 6.2.

6.4.4. Trip rates were estimated from observed data for the base year of 2011. A forecasting model (the Trip Rate Tool, as mentioned in Section 1.3) was used to estimate trip rates in 2016, after which point they are held constant. This results in lower trip rates for 2011 and subsequent forecast years when compared with NTEM 6.2.

Comparison of total trips and growth through time

6.4.5. The volume of trips (shown here as total trip productions) estimated in NTEM v7 is substantially lower than that estimated in NTEM 6.2[19] (Table 6-8 and Figure 6-15). The impact of changing trip rates through time is apparent, with lower trip totals estimated in the forecast year 2016 when compared to the 2011 base.

6.4.6. As the model is conducted at 5-year increments, intervening years are calculated through linear interpolation and made available in TEMPRO.

Table 6-8: Total trip productions in GB comparison (millions per average day)

Version	2011	2016	2021	2026	2031	2036	2041	2046	2051
NTEM 6.2	100.5	104.2	107.5	110.7	113.4	115.9	118.7	-	-
NTEM 7	81.2	79.4	82.1	84.4	86.4	88.2	90.2	92.2	94.1
Difference	-19.3	-24.8	-25.4	-26.3	-27.0	-27.7	-28.5	-	-
Difference (%)	-19%	-24%	-24%	-24%	-24%	-24%	-24%	-	-

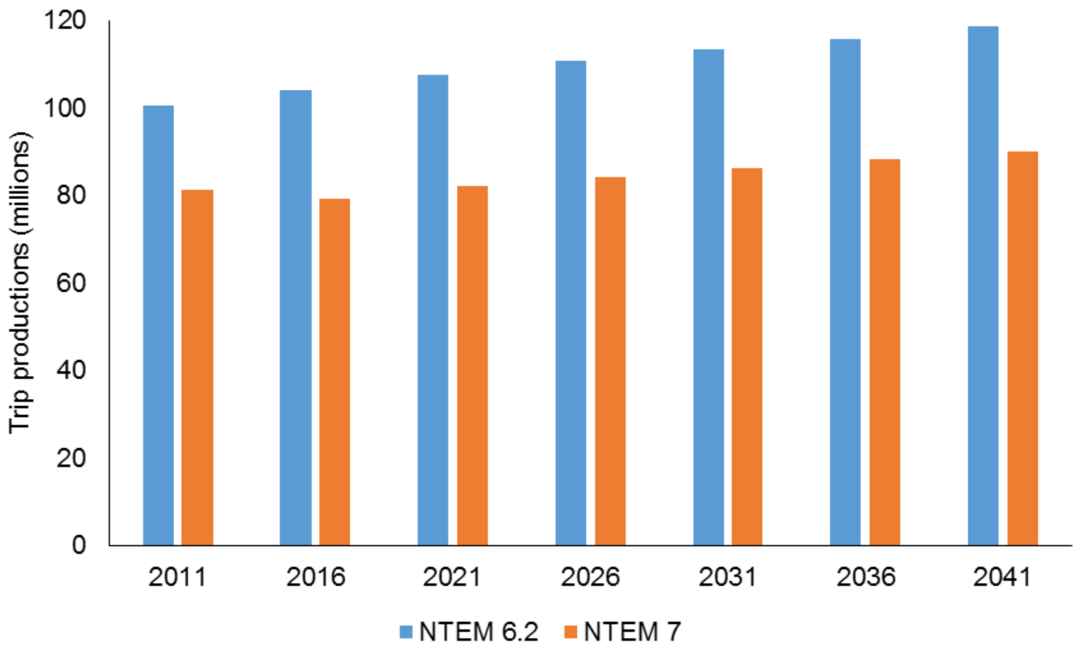
6.4.7. Sensitivity analyses have demonstrated that the major driver behind this are the reduced trip rates estimated from NTS. Application of previously used trip rates to the version 7 dataset produces slightly higher forecasts of trips, reflecting the marginally higher forecasts of population and employment (discussed in Section 6.2).

[17] This work is due to be published in Autumn 2016

[18] For example, from the National Travel Survey (Department for Transport, 2015)

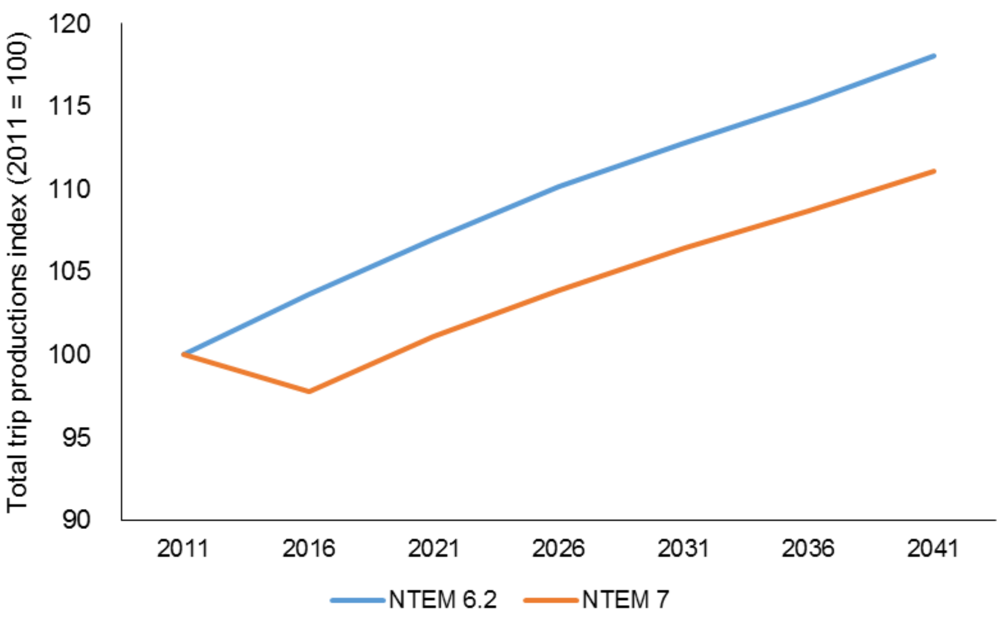
[19] Whilst the base year of NTEM 6.2 was 2001, only results from 2011 onwards will be shown here

Figure 6-15: Change in trip productions over time - NTEM 6.2 and NTEM 7



6.4.8. Updates to trip rates in line with recent NTS data means that direct comparisons between NTEM 6.2 and NTEM 7 are difficult. To aid this, Figure 6-16 shows the difference in growth rate in total trip productions for Great Britain, normalised so 2011 is equal to 100 in both datasets. The effect of the trend in trip rates (discussed in Section 6.4.4) is apparent with a decrease in total trip productions between 2011 and 2016. Growth rates for total trip productions from 2016 onwards are broadly similar between the two datasets, as illustrated in Figure 6-16.

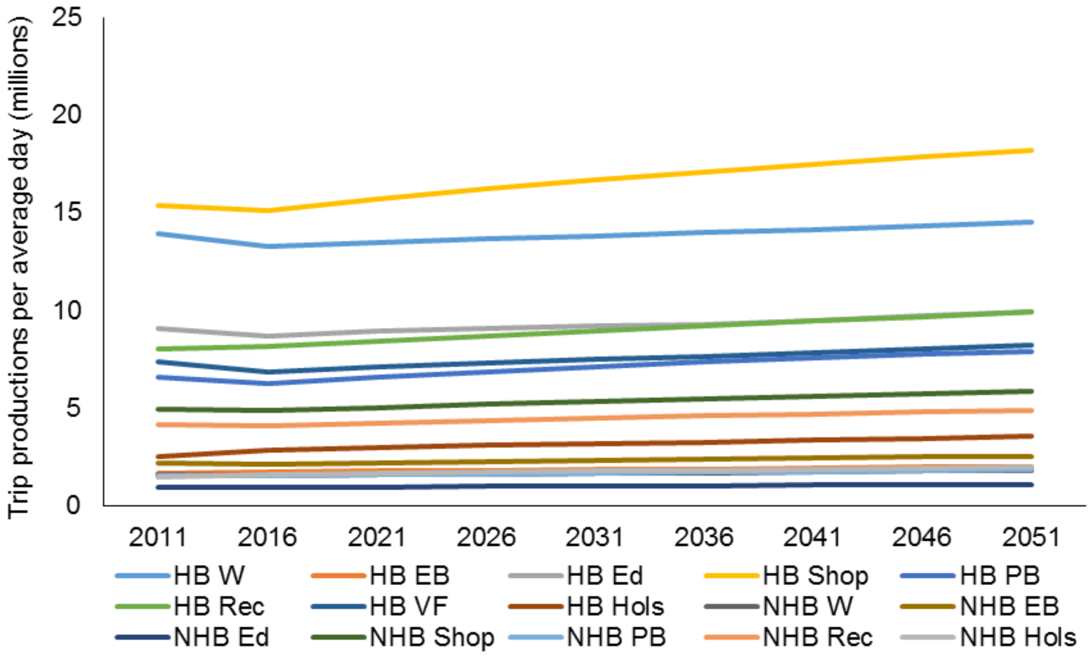
Figure 6-16: Growth in trip productions from 2011 – NTEM 6.2 and NTEM 7



Trips by purpose

6.4.9. NTEM includes 15 trip purposes (8 home based, 7 non-home based). Figure 6-17 shows total trip productions for an average day between 2011 and 2051, split by trip purpose.

Figure 6-17: Total trip productions by purpose in Great Britain – NTEM 7



6.4.10. Figure 6-18 and Figure 6-19 compare the proportion of total trip productions by purpose between v6.2 and v7, in 2011 and 2031 respectively. Split by purpose is relatively similar between versions, and between these two model years.

6.4.11. The largest difference between v6.2 and v7 is associated with home-based recreation trips. In 2011 and 2031, home based recreation trips account for 4% less total trip productions in v7 compared to v6.2.

6.4.12. The largest proportional increase between v6.2 and v7 is associated with home based education trips. In 2011 home based education trips account for an extra 3% of total trip productions in v7 compared to v6.2, and an extra 2% in 2031. This may be attributed to an increase in the total number of people in education.

Figure 6-18: Proportion of total trip productions by purpose (2011) - NTEM 6.2 and NTEM 7

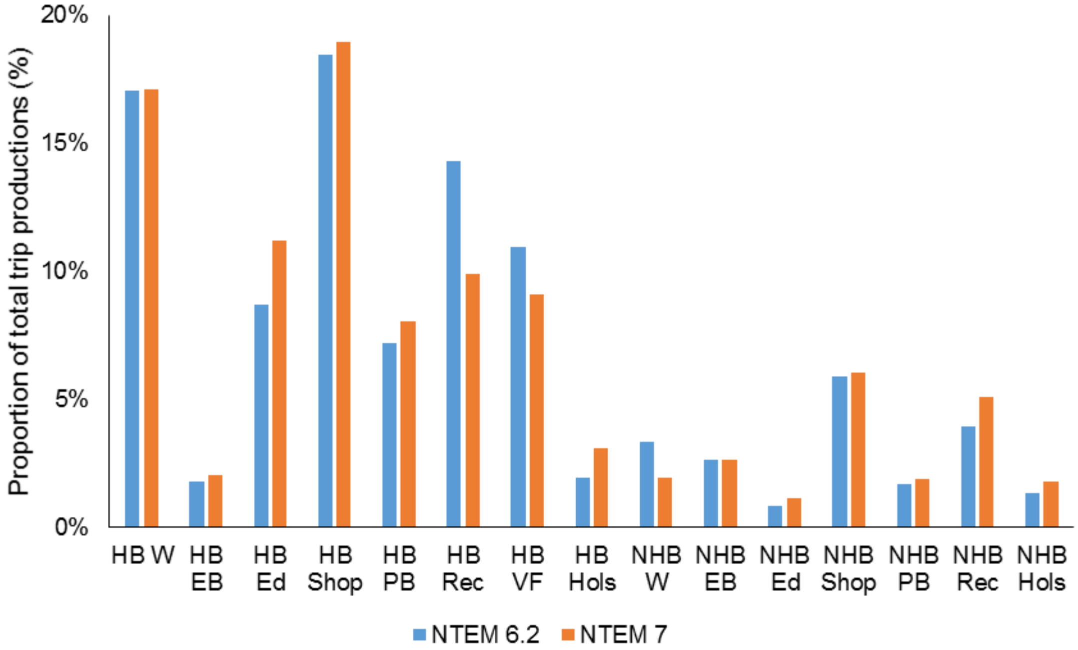
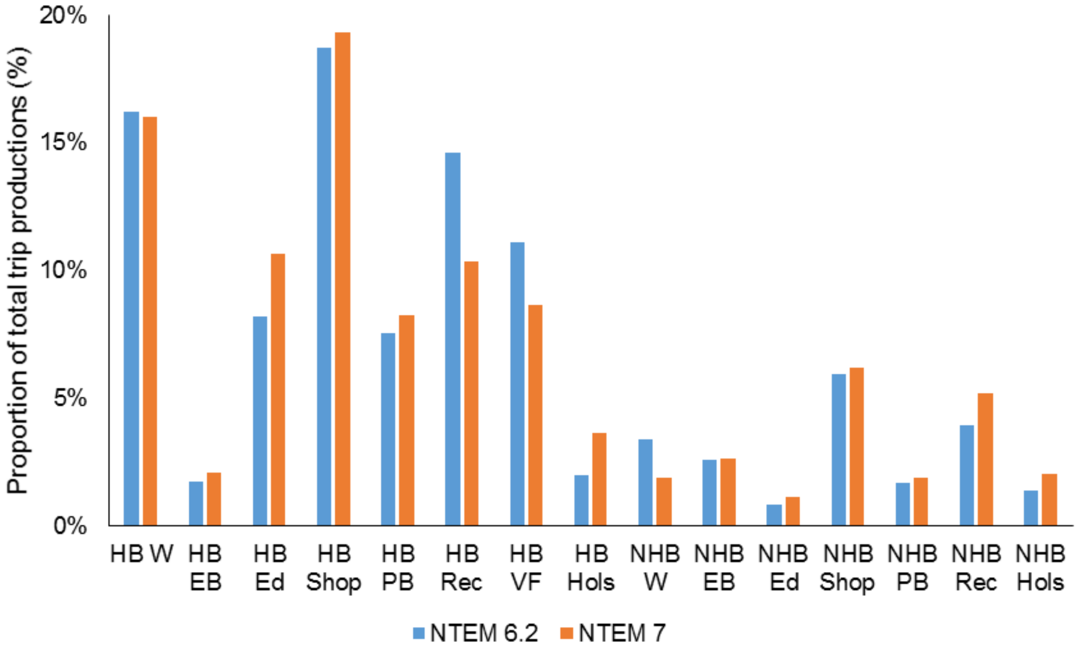


Figure 6-19: Proportion of total trip productions by purpose (2031) - NTEM 6.2 and NTEM 7



Average trips per household

6.4.13. Figure 6-20 and Figure 6-21 show the average number of daily trip productions per household between 2011 and 2041, for v6.2 and v7 respectively. Both versions show a similar trend of decline in trip productions per household over time, which begins to level out in the later forecast years. As trip rates are applied to individuals rather than households, this is consistent with earlier results (Section 6.2) of declining household size over time.

Figure 6-20: Average daily trip productions per household by study area - NTEM 6.2

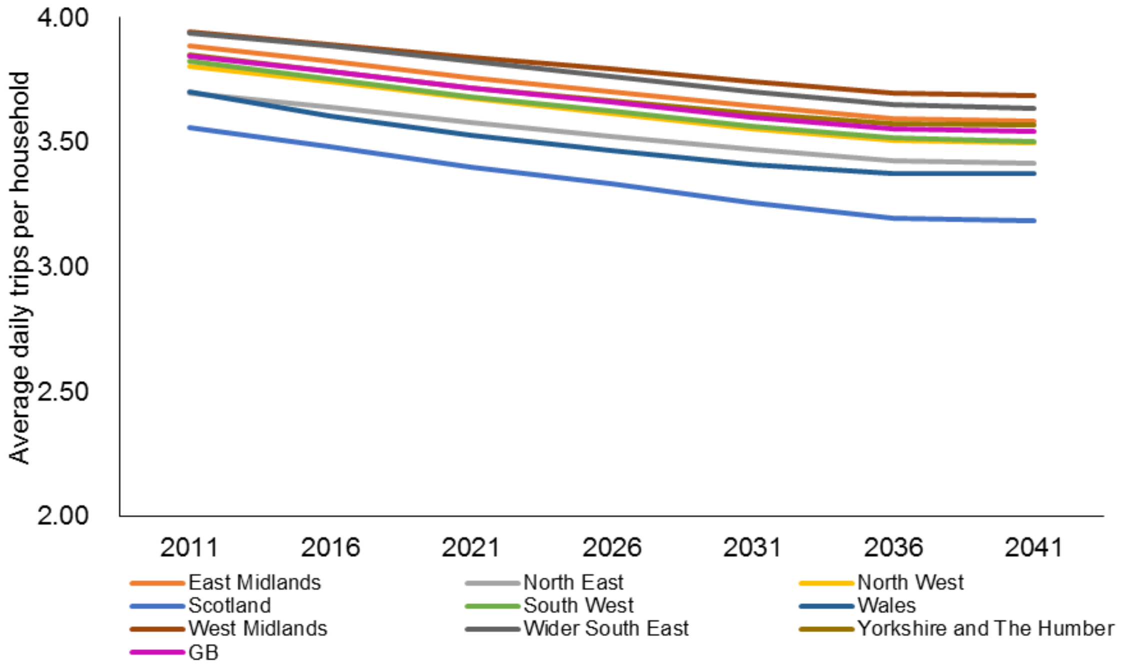
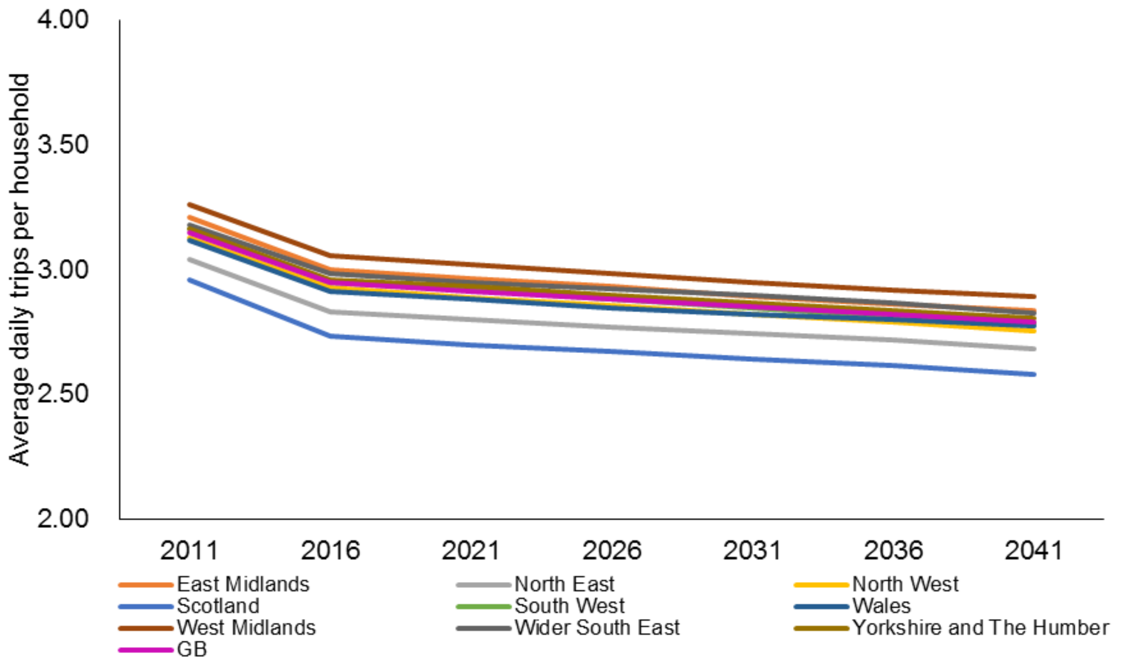


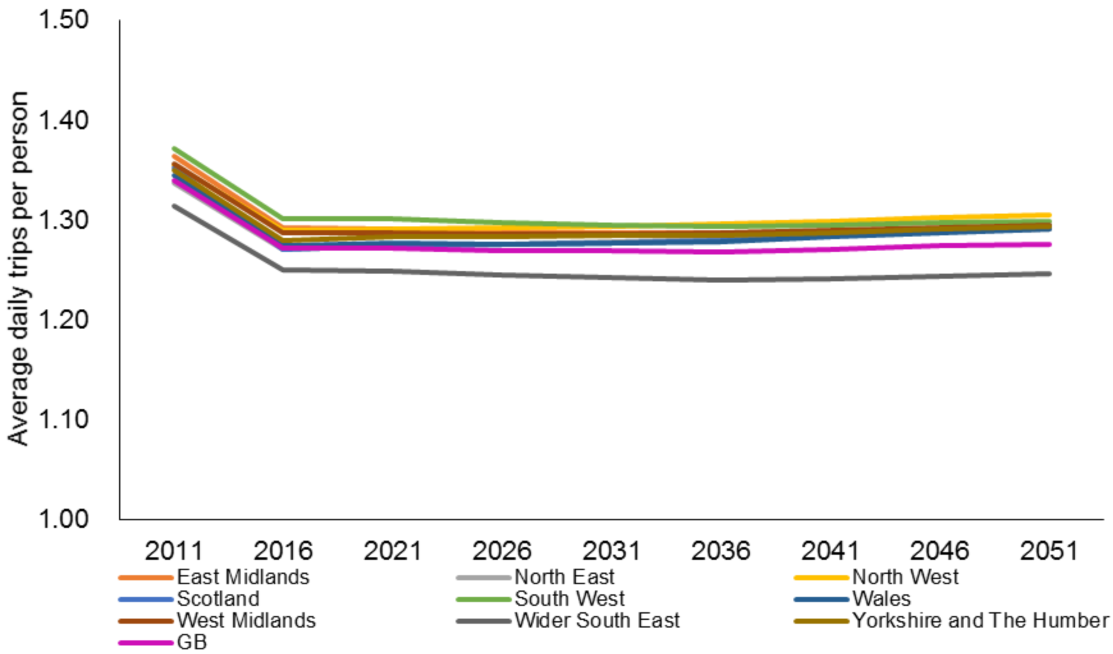
Figure 6-21: Average daily trip productions per household by study area - NTEM 7



Average trips per person

6.4.14. Figure 6-22 shows the average number of daily trip productions per person between 2011 and 2051, in v7. There is a decline in the number of trips between 2011 and 2016, representative of the trip rates used in v7 (as discussed earlier in this section). Change to modelled trip productions post 2016 (which is negligible) is a result of changing population mix and car ownership characteristics.

Figure 6-22: Average daily trip productions per person by study area - NTEM 7

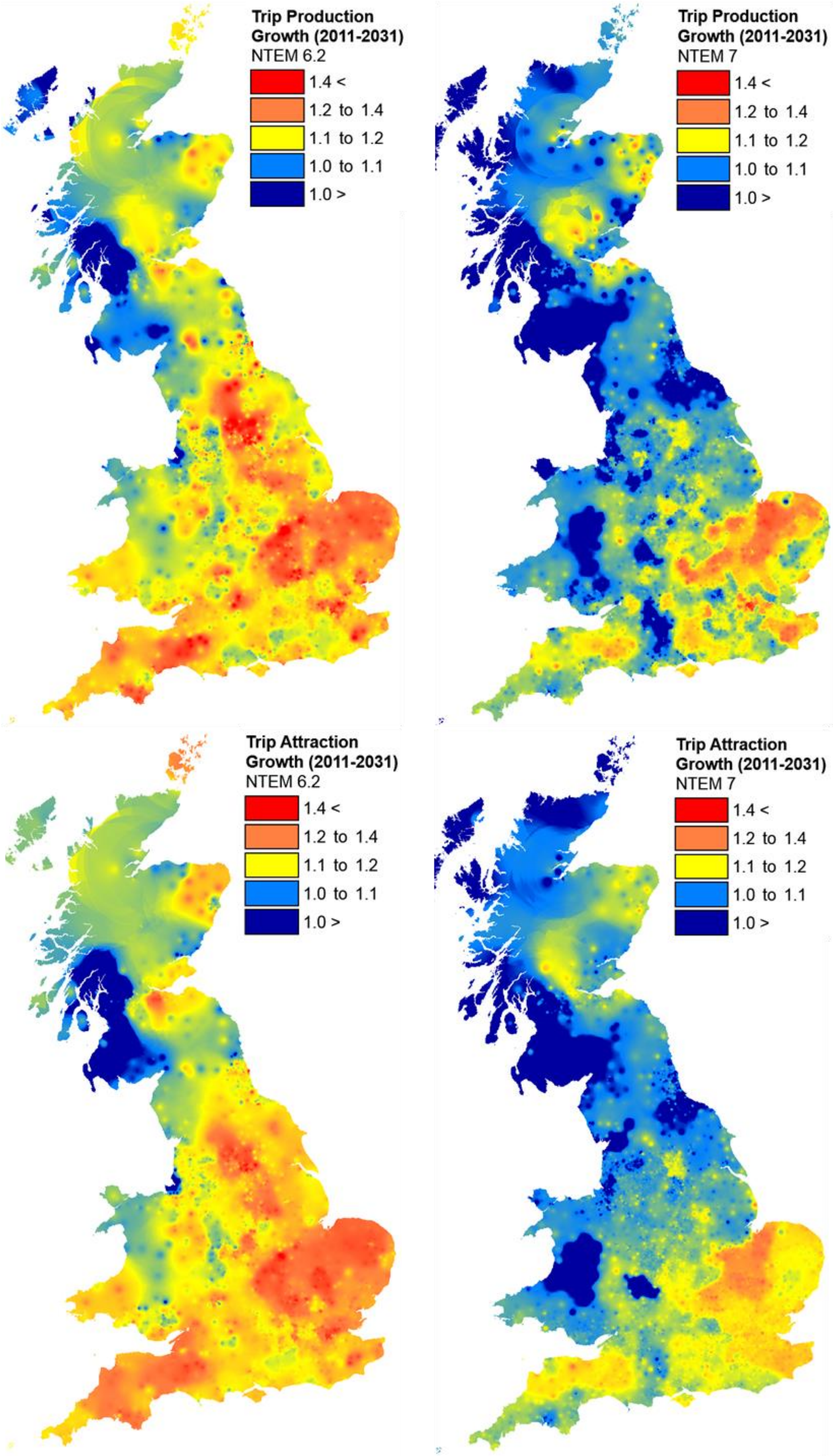


Geographical distribution of trips

6.4.15. Figure 6-23 compares growth in the total number of trip productions and attractions between 2011 and 2031, for v6.2 and v7. As discussed earlier in this section, growth from 2011 is lower in v7 due to an initial reduction in trip rates.

6.4.16. The distribution of growth is similar across the two datasets, concentrated in the East, South East and major metropolitan areas.

Figure 6-23: Growth in trip productions and attractions (2011-2031) in NTEM 6.2 (L) and NTEM 7 (R)



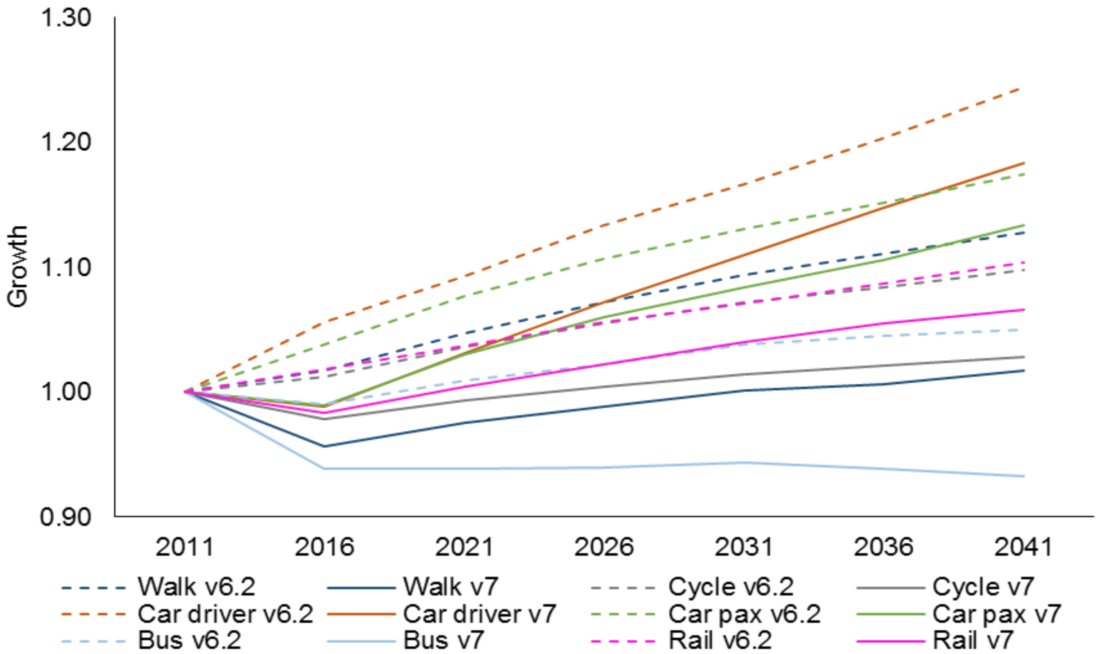
Modal split

6.4.17. The ultimate application of the NTEM dataset, through the TEMPRO software, also includes productions my mode and time of day. As with trip rates, parameters to determine these splits were re-estimated from an updated National Travel Survey (NTS) sample.

6.4.18. In order to provide a comparison, Figure 6-24 shows growth in modal trip productions between 2011 and 2041, for v6.2 and v7 respectively. Differences in growth are due to the different population characteristics, including car ownership. Whilst growth is lower in general (as expected based on results presented earlier in this section), similar trends are apparent. Highest growth rates are present in private, motorised modes, with lower growth in public transport modes (rail, bus).

6.4.19. It should be noted that modal split in NTEM is constant through time and ignores changes in the cost of motoring (fuel and taxation) and public transport fares as well as other components of the generalised cost for travel. Modal growth may therefore form a starting point for appropriate modelling of mode choice where generalised cost needs to be taken into account. They should therefore be treated with caution and the users need to satisfy themselves that they are fit for purpose.

Figure 6-24: Growth rate of modal trip productions from 2011 – NTEM 6.2 and NTEM 7



Appendices

Appendix A. Geography

NTEM zone system

The different levels of geography are, from smallest to largest, NTEM zones, control areas and study areas. All levels are geography are compatible, and so:

NTEM zones ϵ control areas ϵ study areas

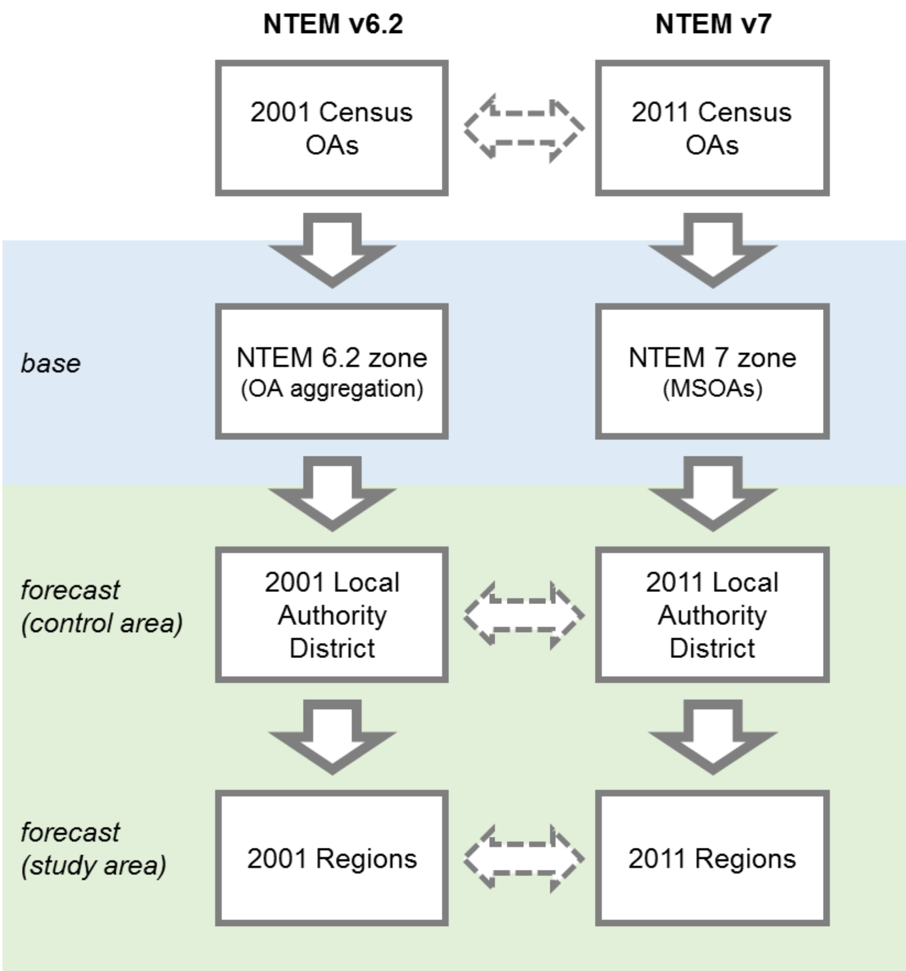
NTEM 6.2 had a zone structure formulated from 2001 Census definitions of Output Areas, aggregated in such a way that they represent different area types (level and scale of urbanisation) and nest within local authority districts. This resulted in 2,496 NTEM zones.

The major source of data for the NTEM dataset is the Census of Population. As NTEM 7 is based on the 2011 Census of Population, it was necessary to reformulate the zone system to be compatible with changing Census geographies.

NTEM 7 makes use of Middle Super Layer Output Areas as the lowest level of geography in England and Wales. This is consistent with the 2011 Census of Population, and the majority of input data, minimising the treatment and manipulation required. Control area and study area definitions remain the same, but reflect changing administrative boundaries.

As such, the zone system is therefore not directly compatible with previous versions of NTEM, as illustrated in Figure A-1.

Figure A-1: NTEM geography comparison



The Scottish Census adopts different geographies, with no direct equivalence (in terms of population and number of households) being available. Therefore a bespoke zoning system was developed, with the following main criteria:

- The zone system must be compatible with other levels of NTEM geography (i.e. control areas);
- The zone system must be granular enough for model processes (e.g. representation of urban/rural split);
- The zone system must be suitable for acquiring the correct data inputs; and
- The zone system must be granular enough for the purposes of model outputs.

The resulting zone system matches these criteria. A comparison of the NTEM 6.2 and NTEM 7 zone system is shown for each TEMPRO study area in Table A-1.

Table A-1: NTEM zone comparison

Study area	Number of NTEM zones (v6.2)	Number of NTEM zones (v7)	Growth (v7/v6.2)
East of England	295	736	2.49
East Midlands	260	573	2.20
London	57	983	17.25
North East	132	340	2.58
North West	282	924	3.28
Scotland	264	499	1.89
South East	410	1,108	2.70
South West	244	700	2.87
Wales	179	410	2.29
West Midlands	168	735	4.38
Yorkshire and Humber	205	692	3.38
Great Britain	2,496	7,700	3.08

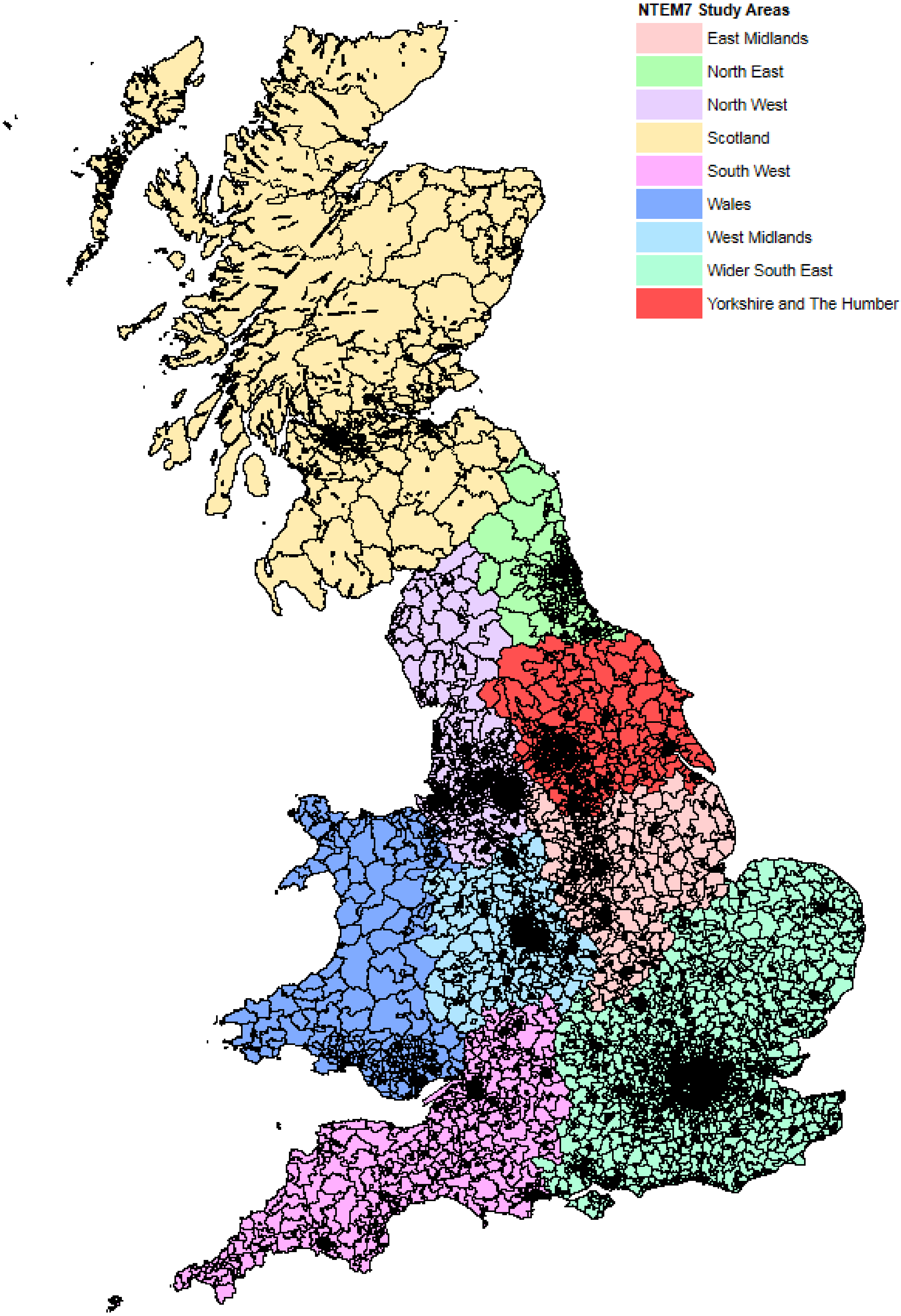
Control area geography is again based on local authority districts in England and Wales and Scottish council areas, reflecting updated administrative boundaries, with a reduction to 380 control areas in total. Study areas have also been retained, representing the English regions, Scotland and Wales. Figure A-2 shows the NTEM 7 zone system.

Balancing areas have also been reformulated based on the 2011 Census[20]. Using the existing definition of balancing areas as a starting point, these were revised to be compatible with the 2011 Travel to Work Areas (TTWA) and new NTEM zoning system. The resulting balancing areas[21] are shown in Figure A-3.

[20] Census table WU02

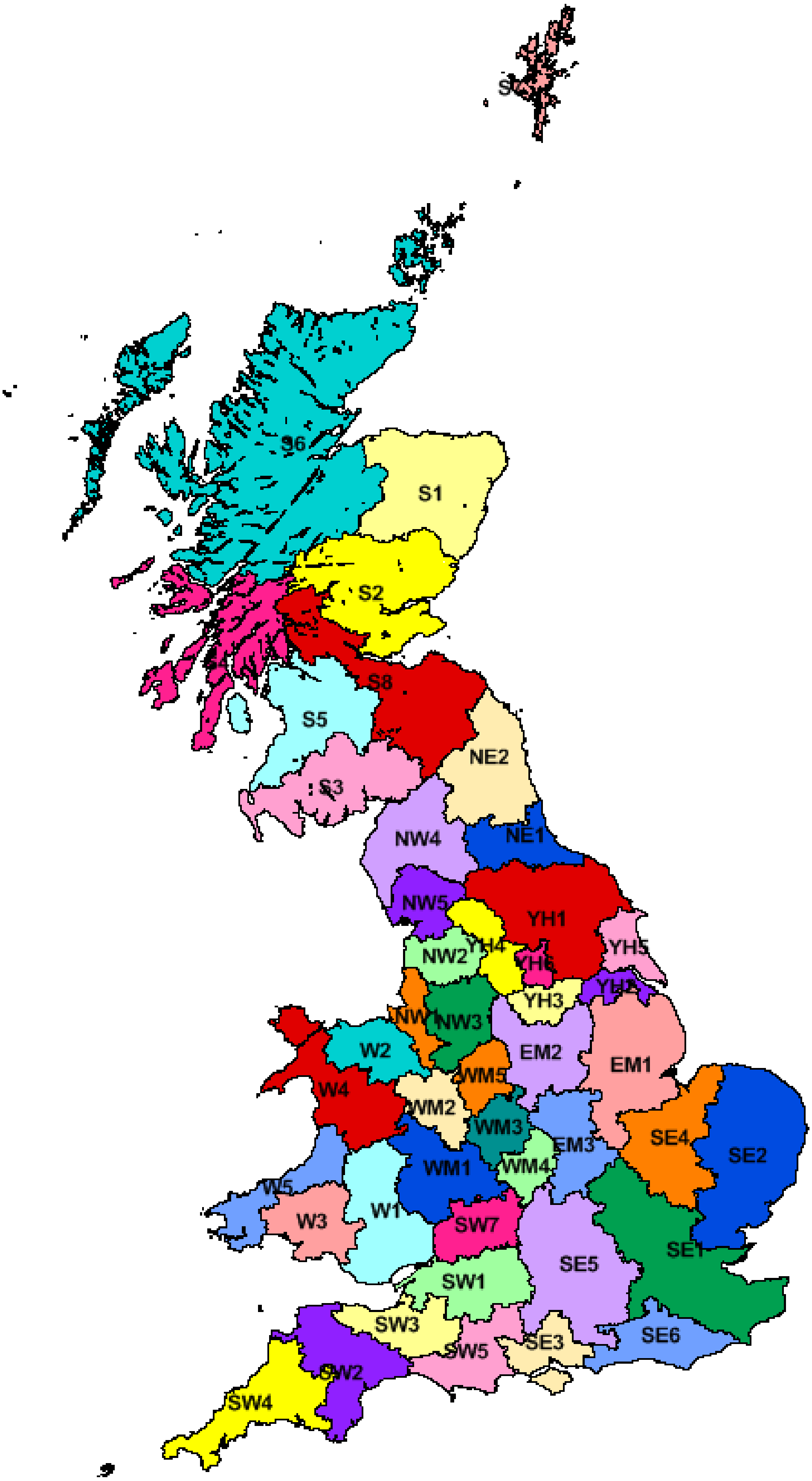
[21] Whilst this is not a requirement, these balancing areas are identical to those implemented in the trip end model, CTripEnd

Figure A-2: NTEM 7 zoning system



N.B. All Scottish islands are also included but may appear off the map.

Figure A-3: NTEM 7 balancing areas



Appendix B. Segmentation definitions

Population segments

Population is segmented by:

- Age / life stage (input);
- Age / life stage (forecasting and output);
- Gender; and
- Working status (for the 16-74 age groups only).

Table B-1: Population segmentation

Age / life stage (input)	Age / life stage (forecasting segment)	Gender	Working status (16-74 age groups only)
0 – 15 16 – 29 30 – 44 45 – 64 65 – 74 75 – 79 80 – 84 85+	0 – 15 16 – 29 30 – 44 45 – 64 65 – 74 75+	Male Female	Full time (≥ 30 hours per week) Part time (< 30 hours per week) Students (not working) Other non-working

Household segments

Households are segmented by number of persons (not just adults). There are two segments:

- 1 person households; and
- 2+ person households.

Employment segments

Employment (jobs) is segmented by:

- Sector (based on SIC 2007 definitions);
- Gender; and
- Working status.

There are 12 employment sectors defined in the planning data forecasts. These relate to the trip attraction variables required by NTEM. The definitions are as shown below. The gender and working status segmentation is as defined above for the population.

Table B-2: Employment segmentation

NTEM employment type	SIC (2007) code	Description
E03	851, 852, 853	Pre-primary, primary and secondary education
E04	854	Higher education
E05	855, 856	Adult and other education
E06	55	Accommodation (hotels and campsites)
E07	451, 453, 471 – 478, 56103	Retail trade
E08	86, 87	Human health and residential care activities
E09	452, 454, 53, 6419, 683, 771, 772, 75, 88	Services (rental, repair, postal activities, real estate and other)
E10	05 – 09, 10 – 33, 35 – 39, 41 – 43, 46, 49 – 52	Industry, construction and transport
E11	56101, 56102, 563	Restaurants and bars
E12	5914, 79901, 90 – 94	Recreation and sport
E13	01, 02, 05	Agriculture, fishing, forestry and logging
E14	All other codes	Other employment

Appendix C. Demographic parameters

Summary

There are several sets of assumptions that are required in the operation of the Scenario Generator in addition to the base and forecast year inputs. These affect the way in which population, households and employment are allocated to zones in forecast years.

The following parameters are required by the Scenario Generator:

- Expected number of people in each household type (by type, gender and life stage in each control area);
- Maximum acceptable difference between households and dwellings;
- Minimum number of average adults per household;
- Maximum number of average adults per household;
- Occupancy rate (number of households that occupy household spaces);
- Proportion of population in communal establishments (by age and gender at the study area level);
- Dwelling vacancy rate;
- Number of dwellings not used as main residence;
- Ratio of jobs to workers (by sector, gender and working status at the study area level);
- Minimum and maximum acceptable employment rate and change in employment rate over time;
- Maximum allowable change in occupancy rate;
- Proportion of workers in each working age group;
- Proportion of excess households that relocate;
- Weighting of population / dwelling policy-led allocation of households (1 = fully dwellings led, 0 = fully population led, 0.5 = evenly weighted); and,
- Number of suppressed one person households that are reformed as multi-person households.

Types of persons in households (π)

This parameter is required for each control area to split the number of persons by age and gender into household types (one person or two or more person households). Table C-1 outlines the data sources used in the derivation of this parameter.

Table C-1: Data sources for calculating parameter π

Data source	Geography	Description
Census Table DC1109EW	LAD	Household composition in England & Wales by age and gender.
Census Table DC1109SC	Council Area	Household composition in Scotland by age and gender.
Census Table DC1104EW	LAD	All usual residents in England & Wales by age and gender.
Census Table DC1104SC	Council Area	All usual residents in Scotland by age and gender.

The household composition Census data (DC1109EW / DC1109SC) gives the total number of people by age and gender in each household type at control area level. However the age categories of the household composition Census data are not in the desired format for NTEM 7, therefore Census population data by age and gender (DC1104EW / DC1104SC) is used to proportionally split the household composition age categories.

Household / dwelling differential (ψ)

This parameter sets a maximum limit on the difference between the number of households and the number of dwellings at a study area level (i.e. how many more dwellings than households there may be). This ensures that the number of dwellings is not significantly greater than expected values. A value of 0.1 (i.e. 10%) has been assigned to this parameter. This value remains unchanged between NTEM 6.2 and NTEM 7.

Minimum number of adults in households (βmin)

This parameter sets a value for the minimum number of adults in a household at study area level. Although there are a very small number of zero-adult households in the Census, the value for this parameter is assumed to be 1. This value remains unchanged between NTEM 6.2 and NTEM 7.

Maximum number of adults in households (βmax)

This parameter sets a value for the maximum number of adults in a household at study area level. Due to the trend towards 1 person households, it is doubtful that the number of adults within a household shall exceed an average of two adults per household in any study area. However, to cover the possibility of this being the case when back-casting, the value of this parameter is set to 3 in order to catch any serious data problems that may occur when generating a scenario. This value remains unchanged between NTEM 6.2 and NTEM 7.

Occupancy rate (θ)

This parameter identifies an occupancy rate based on the number of households that occupy household spaces (i.e. dwellings) at control area level. There are occasional circumstances where more than one household can inhabit a dwelling. Table C-2 outlines the data sources used in the derivation of this parameter.

Table C-2: Data sources for calculating parameter θ

Data source	Geography	Description
Census Table KS401EW	LAD	Total number of dwellings (household spaces) in England & Wales.
Census Table KS401SC	Council Area	Total number of dwellings (household spaces) in Scotland.

The total number of households and dwellings at control area level can be identified from the 2011 Census data (KS401EW / KS401SC). Subsequently, a calculation between the household and dwelling totals provides an occupancy rate for each control area. This parameters works in conjunction with the maximum allowable change in occupancy rate, and therefore varies over time as part of the model operation.

Communal residents (α)

This parameter identifies the proportion of communal residents in the total population by age and gender at study area level. ScenGen removes communal residents from the forecast population data, as it is only household population that is used. Table C-3 outlines the data sources used in the derivation of this parameter. This parameter is derived for the base year (2011), but applies only to forecast years.

Table C-3: Data sources for calculating parameter α

Data source	Geography	Description
Census Table LC1105EW	MSOA	All usual residents by residence type in England & Wales.
Census Table LC1104SC	DZ	All usual residents by residence type in Scotland.

Table C-4 & Table C-5 show the proportion of communal residents by age and gender within each study area. These figures are input into the Scenario Generator.

Table C-4: Proportion of female population that are resident in communal establishments

Study area	0-15	16-29	30-44	45-64	65-74	75-79	80-84	85+
East Midlands	0%	5%	0%	0%	1%	2%	6%	16%
Wider South East	0%	3%	0%	0%	1%	2%	5%	15%
North East	0%	3%	0%	0%	1%	3%	7%	17%
North West	0%	4%	0%	0%	1%	3%	6%	17%
Scotland	0%	4%	0%	0%	1%	3%	7%	17%
South West	1%	4%	0%	1%	1%	2%	5%	16%
Wales	0%	4%	0%	0%	1%	2%	5%	15%
West Midlands	0%	4%	0%	0%	1%	2%	5%	15%
Yorkshire & Humber	0%	4%	0%	0%	1%	2%	6%	16%

Table C-5: Proportion of male population that are resident in communal establishments

Study area	0-15	16-29	30-44	45-64	65-74	75-79	80-84	85+
East Midlands	0%	6%	1%	1%	1%	2%	3%	9%
Wider South East	1%	4%	1%	1%	1%	2%	3%	8%
North East	0%	4%	1%	1%	1%	2%	4%	10%
North West	0%	4%	1%	1%	1%	2%	4%	9%
Scotland	0%	4%	1%	1%	1%	2%	5%	10%
South West	1%	6%	1%	1%	1%	2%	3%	9%
Wales	0%	4%	1%	1%	1%	2%	3%	8%
West Midlands	0%	4%	1%	1%	1%	2%	3%	8%
Yorkshire & Humber	0%	5%	1%	1%	1%	2%	3%	9%

Dwelling vacancy levels (v)

ScenGen requires information on dwellings available for the formation of a new household. The 2011 Census of Population no longer provides complete information on dwelling stock and second homes. Therefore the DCLG dataset[22] on dwelling stocks were used, particularly “dwellings which have been unoccupied and substantially unfurnished for over six months”.

Previous versions of NTEM used Census table CAS048, with estimated of unoccupied dwellings split into holiday accommodation and vacancy dwellings. This allowed estimation of dwellings not used as a main residence (S). This correction still exists in the mathematical formulation of the Scenario Generator, but is not

[22] https://www.gov.uk/government/statistical-data-sets/live-tables-on-dwelling-stock-including-vacants

required, and is therefore set to 0. It should also be noted that calculation of this parameter previously changed from NTEM v5 due to the treatment of student accommodation and communal residents.

Ratio of workers to jobs (γ)

This parameter is responsible for converting jobs to workers. This is primarily due to the fact that workers are not constrained to having one job and occasionally have second jobs, intuitively more often in the case of part time workers and job sharing results in two workers sharing one job. This parameter is also used in the preparation of the base year data where jobs are required as input rather than workers derived from the Census.

A set of these parameters are required by employment sector, gender and work type (full time/ part time) at study area level. Whilst derived for the base year (if not from the base year data), this parameter is applied only to forecast years. It should also be noted that it does not change at all in forecast years, which is consistent with previous versions of NTEM. Industry and study area specific parameters calculated in the previous version of NTEM were therefore retained for NTEM 7.

Minimum and maximum acceptable employment rate and change in employment rate over time (σmin, σmax, $\hat{\sigma}$)

This parameter sets a minimum and maximum threshold for employment rate and change in employment rate over time by age band and gender for a study area.

Setting a minimum and maximum employment rate ensures that the employment rate lies within a certain threshold. Where the minimum / maximum threshold is breached, the program stops generating the scenario. This prevents the model from exceeding acceptable levels of employment.

The proportion of working age population in employment is calculated from the NTEM 7 base population dataset by working status, age and gender at control area level. An employment rate in excess of the national average is required for those control areas that have higher than average rates. Differentiation by gender and working age group is also required.

At control area level employment rates are as low as 4% for a given age and gender segment. However thresholds used in ScenGen are based on the minimum and maximum employment rates at study area level. Table C-6 shows the minimum and maximum employment rate parameters used in the Scenario Generator. These values are relevant for all forecast years, and therefore must be offer sufficient flexibility for changes in other demographic parameters.

Table C-6: Forecast year minimum and maximum employment rates

Gender	Age group	Minimum	Maximum
Female	16-29	50%	85%
Male	16-29	55%	85%
Female	30-44	55%	99%
Male	30-44	65%	99%
Female	45-64	50%	90%
Male	45-64	60%	90%
Female	65-74	2%	50%
Male	65-74	2%	50%

The maximum change in employment rate over a specified period is also required. A value of 5% has been assigned to this parameter. Where this value is breached the generator will stop, indicating unrealistic data issues. This value remains unchanged between NTEM 6.2 and NTEM 7.

Maximum allowable change in occupancy rate ($\Delta\theta max$)

This parameter sets the maximum rate at which the occupancy rate may change over the forecast period length. The maximum allowable change in occupancy rate is 0.5%, which is deemed to adequately cater for all forecast years as it is not anticipated that this rate will differ significantly over time. This value remains unchanged between NTEM 6.2 and NTEM 7.

Proportion of workers in each working age group (ρ)

This parameter determines the proportion of workers within each working age group (16-29, 30-44, 45-64 and 65-74) by gender and working status (full-time / part-time) at study area level. Table C-7 outlines the data sources used in the derivation of this parameter.

Table C-7: Data sources for calculating parameter ρ

Data source	Geography	Description
Census table DC6107EW	MSOA	Working status by age and gender in England & Wales.
Census table DC6107SC	MSOA	Working status by age and gender in Scotland.
Census table DC6103	Study area	Communal resident economic activity by age and gender

Working status at study area level can be identified from the 2011 Census data by age and gender (DC6107EW / DC6107SC). As the base population data excludes communal residents, these are also removed from the dataset (DC6107EW / DC6107SC) to calculate the proportion of workers within each working age group. However this was only possible for England and Wales (DC6103EWla) as communal resident economic activity data does not exist for Scotland, therefore the economic activity of all residents has been used (DC6107SC).

NTEM 6.2 contained working age segments only to 65. The total proportion of workers in the 16-64 age band was decreased over time to reflect expectations around a higher proportion of workers falling outside of this. For NTEM 7, a larger number of age bands have been included, in addition to an extension to 74. In the base year, a very small proportion of workers are present in the upper working age band (65-74). This has been gradually increased over time, at the expense of the preceding (45-64) age band. This is a general re-balancing of these two segments, and reflects general expectations of the increased proportions of older workers. As with NTEM 6.2, in the absence of robust data, only a gradual change has been applied.

Proportion of excess households that relocate (λ)

This parameter identifies the proportion of excess households that relocate at control area level.

Where household allocation within a control area exceeds housing supply, a proportion will be dispersed to other control areas with surplus dwelling supply within the same study area. A value of 0.5 has been assigned to this parameter, resulting in half of all excess households to relocate to other control areas where housing demand is unfulfilled. The remainder will be suppressed or in the case of one person households may coalesce to become multi-person households (see parameter μ). This value remains unchanged between NTEM 6.2 and NTEM 7.

Population / dwelling policy-led development (ζ)

This parameter determines whether the process of allocating households across control areas will follow dwelling availability or projected population trends. A value of 0.75 is assigned to this parameter, erring more towards policy based forecasts than past trends. If the parameter is set to 1, this indicates total dependency on dwellings in relocating future households, whilst a value of 0 represents a total dependency on population projections. This value remains unchanged between NTEM 6.2 and NTEM 7.

Suppressed single person households that convert to multiple person households (μ)

This parameter that determines the number of suppressed one person households that are reformed as multi-person households at a global level. This occurs where households that wish to locate in a control area are unable to do so due to restricted dwelling supply. This models the real-world case where people elect to live with others where they cannot find a suitable dwelling on their own (e.g. parental home). A value of 3 is assigned to this parameter, indicating that every third single person household will convert to multi-person households. This value remains unchanged between NTEM 6.2 and NTEM 7.

Appendix D. Mathematic specification of methodology

Notation and terminology

The main variables and their definitions are shown in Table D-1.

Table D-1: Quantity variables

Variable	Description
E	Employment (jobs including the self-employed).
H	Households.
P	Population (people) living in households - excludes those living in communal establishments. $P = W + N$.
$\hat{P}$	Total population (input) – includes those in communal establishments.
W	Workers (working population) – full-time / part-time.
N	Non workers (i.e. students and others).
D	Dwellings.
S	Household spaces.

Subscripts attached to a variable denote the time and space applicable to the variable (Table D-2), whilst superscripts denote categories or variable type (Table D-3). Forecasts are described as for the current year and scenario (*t*) for the period (*p*), starting from a previous year and scenario (*t-1*).

Table D-2: Subscripts - time and place

Subscript	Description
i	NTEM zone.
c	Control area for forecasting tools - an aggregation of i for study area R at which the forecasts are controlled to exogenous projections. c=county level. c^H =district level for home / residential variables – all variables except E. c^E =county level for employment / workplace variables E.
B	Balancing Area, $i \in$ B.
R	Study area to be processed = Region in most cases equivalent to the term “Definition” in the existing tool.
t	Forecast scenario - if forecast scenario is t, previous forecast scenario is (t-1).
p	Forecast period from scenario (t-1) to scenario t.

Table D-3: Superscripts – categories / dimensions

Superscript	Variable	Category / dimension
a	*E*	Employment sector (for trip attractions) as defined in Appendix B and Section 3.5
g	*P, W*	Gender (Male, Female, Both –children).
h	*H*	Modelled household types – 1 and 2+ person households.
l	*P, W*	Modelled age bands (<16, 16-29, 30-44, 45-64, 65-74, 75+) (l for life stage).
m	*P*	Age (input bands / years) of input data (m ∈ l).
w	*P, W, E*	Working status - *only relevant for 16-29, 30-44, 45-64 and 65-74 age groups.* For variable P, w = F – full time, P – part time, S – students, O – other For variable W and E, w = F – full time or P – part time For variable N, w = S – students, O – other

Other notation / assumptions applied are:

n used to denote iteration n in an iterative procedure.

^ used to identify user specified input data / parameters which may be internally adjusted during the forecasting process.

~ used to denote intermediate values for variables / parameters.

(1), (2) used in balancing process to denote many intermediate estimates of a variable

Final forecasts / estimates have no hieroglyphics.

For each of the main variables there are a more detailed set of categories as follows:

- Employment by sector, gender and working status (full-time / part-time), E_{ti}^{agw}
- Population by gender, age and working status, P_{ti}^{glw}
- Households by size, H_{ti}^{h}

Parameter definitions

The parameters and their definitions are shown in Table D-4.

Table D-4: Subscripts - time and place

Parameter	Definition
α_R^{gm}	The proportion of the population within a given gender and age group residing in communal establishments in a study area (region) *R*.
β_{min}, β_{max}	Acceptable range for the number of adults per household in a study area.
$\hat{\beta}$	Minimum number of persons allowed per 2+ person household.
ψ	Acceptable difference in the ratio of households to dwellings in a study area (e.g. 0.25 means within ±25%).
θ_c	The occupancy rate (household spaces per dwelling) in control area *c* in the base year (2011).
$\Delta\theta_{max}$	The maximum allowable increase in occupancy rate (households per dwelling) from the base year values.
υ_c	The vacancy rate in control area *c* in 2011 base year.
υ_{min}	The minimum allowable vacancy rate.
χ	The proportion of the vacancy rate from the previous scenario that the vacancy rate in the present scenario may fall to.
S_c^Y	The number of household spaces in the control area c otherwise occupied (i.e. not vacant and not occupied by households – e.g. holiday homes) in the base year [currently set to 0].
ς	The proportion of household locations that are dwelling / policy led rather than based on population trends.
μ	Determines the number of one person (type 1) suppressed households that are reformed as multi person households (type 2).
π_c^{hgl}	The expected number of persons of type *gl* in household type *h* in control area *c*, from the 2011 Census.
γ_R^{agw}	Ratio within employment sector *a* of workers of gender *g* and working status *w* (F or P), to jobs. S and O are irrelevant as they are non-workers.

Population and household totals for study area (region)

An initial estimate of total population is taken as:

$$\tilde{P}_{tR}^{gl} = \sum_{c \in R} \tilde{P}_{tc}^{gl} \text{ and } \tilde{P}_{tc}^{gl} = \sum_{m \in l} \hat{P}_{tc}^{gm}\left(1 - \alpha_R^{gm}\right) \text{ and } c \in R \qquad \text{(Eq 1)}$$

where $\hat{P}_{tc}^{gm}$ Is population by gender *g* and age *m* for a control area *c* of study area *R* in scenario *t*.

α_R^{gm} Is the assumed proportion of the population in age group *m* of gender *g* residing in communal establishments in Study Area *R*.

An initial estimate of total households is taken as:

$$\tilde{H}_{tR} = \sum_h \hat{H}^h_{tR} \qquad \text{(Eq 2)}$$

Job and worker totals for study area (region)

Total number of jobs (employment) at the control area level in each forecast year is provided as an input. This information can be used to scale job totals from the previous scenario which are then aggregated to give study area totals.

$$\tilde{E}^{agw}_{tc} = E_{(t-1)c}\left(\frac{\hat{E}_{tc}}{\hat{E}_{(t-1)c}}\right)\frac{E^{agw}_{(t-1)c}\left(\dfrac{\hat{E}^{agw}_{tc}}{\max(\hat{E}^{agw}_{(t-1)c}, 0.001)}\right)}{\sum_{agw} E^{agw}_{(t-1)c}\left(\dfrac{\hat{E}^{agw}_{tc}}{\max(\hat{E}^{agw}_{(t-1)c}, 0.001)}\right)}$$

where $\hat{E}_{tc} = \sum_{agw} \hat{E}^{agw}_{tc}$ and $\tilde{E}^{agw}_{tR} = \sum_{c \in R} \tilde{E}^{agw}_{tc}$ (Eq 3)

A set of factors are derived to relate employment measured in units of jobs to population measured in units of persons in employment. This allows the derivation of the number of workers as follows:

$$W^{glw}_{tR} = \rho^{glw}_{tR} \sum_a \gamma^{agw}_R \tilde{E}^{agw}_{tR} \qquad \text{(Eq 4)}$$

where $\tilde{E}^{agw}_{tR}$ The initial estimate of employment by sector *a*, gender *g* and working status *w*, for study area *R* in year *t* from 'Eq 3'.

γ^{agw}_R The assumed ratio of workers of gender *g* and working status *w* to jobs in employment sector *a* (stored parameter table that could be modified occasionally), for study area *R*.

ρ^{glw}_{tR} The proportion of workers by gender *g* and working status *w* who are in the working age groups *l*, for study area *R* in year *t*.

Control total checks

The relationship between the adult population and households is checked to ensure that the average number of adults (in this case aged 16+) per household is acceptable.

$$\beta_{min} \le \frac{\sum_{g,l \ne child} \tilde{P}^{gl}_{tR}}{\tilde{H}_{tR}} \le \beta_{max} \quad \text{where } \beta_{min} \ge 1 \text{ and } \beta_{max} > \beta_{min} \qquad \text{(Eq 4a)}$$

With declining household sizes through time, a second check is prudent. This check calculates the average number of persons per 2+ person households for the study area as a whole.

$$\frac{\sum_{g,l} \tilde{P}_{tR}^{gl} - \hat{H}_{tR}^{h=1}}{\hat{H}_{tR}^{h=2}} \leq \hat{\beta} \quad \text{where} \quad \hat{\beta} \geq 2 \text{ (specified by user)} \tag{Eq 5b}$$

The workforce required to satisfy the employment forecasts should also be compared with the potential workers available from the population forecasts.

$$\sigma_{t,min}^{gl} \leq \frac{\sum_{w} W_{tR}^{glw}}{\tilde{P}_{tR}^{gl}} \leq \sigma_{t,max}^{gl} \quad \text{where} \quad 0 < \sigma_{t,min}^{gl} < \sigma_{t,max}^{gl} < 1 \tag{Eq 6}$$

Ratio of workers to jobs: $\frac{\sum_{glw} W_{tR}^{glw}}{\sum_{agw} \tilde{E}_{tR}^{agw}}$ (Eq 5)

The forecast number of households is checked to ensure that it will fit within the forecast development of dwellings.

$$S_{tR}^{\max} = \sum_{c \in R} D_{tc} \left(\theta_c + \Delta\theta_{\max}\right)\left[1 - \max\left(\upsilon_{\min}, \upsilon_{(t-1)c}\chi\right)\right] - \sum_{c \in R} S_c^Y \tag{Eq 6}$$

where $\upsilon_{(t-1)c}$ is the vacancy rate obtained from the previous scenario and $\upsilon_{(t=0)c} = \upsilon_c$.

The ratio of household demand to the supply of space is checked against the bounds specified and the result output to the log file for the user to check.

$$\left| 1 - \frac{\tilde{H}_{tR}}{S_{tR}^{max}} \right| > \psi \tag{Eq 9}$$

Households by control area

The allocation of population and households to the control areas starts with trend based forecasts and then adjusts these to reflect the dwelling allocations provided by the regional planning bodies.

The first step is to disaggregate study area household projections using input population forecasts for control areas. This assumes the change in household size is uniform for all control areas within the study area, but that the starting pattern of household sizes is retained.

The previous total household estimates are scaled by the input change in population and controlled to the input Regional total

$$H(1)_{tc} = \tilde{H}_{tR} \frac{H_{(t-1)c} \sum_{gl} \tilde{P}_{tc}^{gl} \Big/ \sum_{gl} P_{(t-1)c}^{gl}}{\sum_{c \in R} H_{(t-1)c} \sum_{gl} \tilde{P}_{tc}^{gl} \Big/ \sum_{gl} P_{(t-1)c}^{gl}} \tag{Eq 10a}$$

These households must then be split into those with one person (h=1) and those with two or more persons (h=2).

The household size parameters for 2+ person households (h=2) are first adjusted in each control area to reflect household forecasts by size. Parameters for 1 person households remain unchanged. Those for 2+ person households are scaled based on the change in input data. The lower bound of $\hat{\beta} \geq 2$ is also applied to the 2+ person household size parameters.

$$\pi_{tc}^{(h=1)gl} = \pi_{c}^{(h=1)gl}$$

$$\pi_{tc}^{(h=2)gl} = A_{tc}\pi_{c}^{(h=2)gl} \quad \text{and} \quad \sum_{gl}\pi_{tc}^{(h=2)gl} \geq \hat{\beta}$$

The value of adjustment factor A_{tc} is calculated iteratively with estimates of the number of 2+ person households (h=2) as follows:

$$A_{tc}^{n+1} = max\left(A_{tc}^{n}\frac{\sum_{c\in R} H(1)_{tc}^{(h=2)n}}{\hat{H}_{tR}^{h=2}}, \frac{\hat{\beta}}{\sum_{gl}\pi_{c}^{(h=2)gl}} \right) \quad \text{and} \quad H(1)_{tc}^{(h=2)n} = \frac{\sum_{gl}\tilde{P}_{tc}^{gl} - H(1)_{tc}}{A_{tc}^{n}\left(\sum_{gl}\pi_{c}^{(h=2)gl} - 1\right)} \qquad \text{(Eq 10b)}$$

The initial value for the scaling factor should be based on the change from the previous number of persons in an average 2+ person household to the new average number of persons in a 2+ person household. Again the lower bound should be applied. Thus:

Starting with $$A_{tc}^{1} = max\left(\frac{\left(\sum_{gl}\tilde{P}_{tR}^{gl} - \hat{H}_{tR}^{h=1}\right) \Big/ \hat{H}_{tR}^{h=2}}{\left(\sum_{i\in R}\sum_{glw}P_{(t-1)i}^{glw} - \sum_{i\in R}H_{(t-1)i}^{h=1}\right) \Big/ \sum_{i\in R}H_{(t-1)i}^{h=2}}, \frac{\hat{\beta}}{\sum_{gl}\pi_{c}^{(h=2)gl}} \right)$$

where π_{c}^{hgl} Is the expected number of persons of type *gl* in household type *h* in control area *c*

and $\hat{H}_{tR}^{h}$ Is the number of households by type.

$H(1)_{tc}$ Is the estimated total number of households in the control area as calculated by Eq 10a

This iterative process continues until $\left| \frac{A_{i}^{n+1}}{A_{i}^{n}} - 1 \right| \leq 1 \times 10^{-5}$.

Once $H(1)_{tc}^{(h=2)}$ has been obtained from this iterative process, the number of 1 person households is obtained by subtraction:

$$H(1)_{tc}^{(h=1)} = H(1)_{tc} - H(1)_{tc}^{(h=2)} \qquad \text{(Eq 10c)}$$

In reality the change in dwellings supply will affect the distribution of households. An allocation of households purely based on the change in dwellings would be:

If $\frac{\hat{H}_{tR}^{h} - H_{(t-1)R}^{h}}{\Delta D_{pR}} > 0$ (i.e. dwellings and households are forecast to move in the same direction) then:

$$H(2)_{tc}^{h} = H_{(t-1)c}^{h} + \left(\hat{H}_{tR}^{h} - H_{(t-1)R}^{h}\right)\frac{\Delta D_{pc}}{\Delta D_{pR}}$$

where $\Delta D_{pc} = D_{tc} - D_{(t-1)c}$ and $\Delta D_{pR} = \sum_{c \in R} \Delta D_{pc}$ (Eq 7)

otherwise $H(2)_{tc}^{h} = H_{(t-1)c}^{h} + \left(\hat{H}_{tR}^{h} - H_{(t-1)R}^{h}\right)\frac{H_{(t-1)c}^{h}}{H_{(t-1)R}^{h}}$

In practice the pattern of households is likely to be influenced by a mixture of trends and new developments, so a combination of the above two approaches seems appropriate:

$$\tilde{H}_{tc}^{h} = (1-\zeta)H(1)_{tc}^{h} + \zeta H(2)_{tc}^{h} \quad \text{(Eq 8)}$$

In the absence of any data to determine the mix, the starting assumption is that $\zeta = 0.75$

Finally it is necessary to evaluate whether there is an implied excess household demand over the supply of space, and then if appropriate, to reallocate the household demand across the control areas within the study area or to suppress excess demand.

The number of household spaces using the initial vacancy rates and occupancy rates is:

$$S_{tc} = D_{tc}\theta_c\left(1-\upsilon_{c(t-1)}\right) - S_c^Y \quad \text{(Eq 9)}$$

The maximum number of household spaces available in each control area can be calculated (as seen for the study area in Eq 8) as:

$$S_{tc}^{\max} = D_{tc}\left(\theta_c + \Delta\theta_{\max}\right)\left[1 - \max\left(\upsilon_{\min}, \upsilon_{c(t-1)}\chi\right)\right] - S_c^Y \quad \text{(Eq 10)}$$

where:

- The base year occupancy rate (household spaces / dwellings) θ_c in control area *c* can change by a maximum amount $\Delta\theta_{\max}$.
- The vacancy rate obtained in the previous scenario $\upsilon_{c(t-1)}$ in control area *c* can decrease by a maximum proportion χ down to a lower bound $\upsilon_{\min}$ (1%) and $\upsilon_{c0} = \upsilon_c$.
- S_c^Y is the number of household spaces otherwise occupied (derived from the Census and taken as fixed).

The adjusted vacancy rate for the scenario (required for future dependent scenarios) is calculated as:

$$\upsilon_{ct} = \max\left(\upsilon_{\min}, \upsilon_{c(t-1)}\chi, \upsilon_{c(t-1)} - \left(\frac{H_{tc} - S_{tc}}{D_{tc}\theta_c}\right)\right) \quad \text{(Eq 11)}$$

Where H_{tc} is output by Eq 20.

The housing pressure is then calculated as:

$$HPressure_{tc} = \frac{\widetilde{H}_{tc}}{S_{tc}^{\max}} \quad \text{(Eq 12)}$$

If any control area in a given study area has excess households, i.e. $\frac{\widetilde{H}_{tc}}{S_{tc}^{max}} > 1$ for any c, then identify spare capacity and reallocate a proportion of the excess households between the control areas within the study area based on the capacity available

Excess households: $\widetilde{X}_{tc} = max\left[\widetilde{H}_{tc} - S_{tc}^{max}, 0\right]$ and $\widetilde{X}_{tR} = \sum_{c \in R} \widetilde{X}_{tc}$ (Eq 13)

Capacity available: $C_{tc} = max\left[S_{tc}^{max} - \widetilde{H}_{tc}, 0\right]$ and $C_{tR} = \sum_{c \in R} C_{tc}$ (Eq 14)

The user may specify whether all excess households are prepared to relocate within the study area or whether only a proportion of them will move – in which case the remainder will be suppressed. If there is insufficient capacity even those identified as willing to relocate will be suppressed. On this basis the revised estimates of households in each control area would be:

Households by control area: $H_{tc} = \widetilde{H}_{tc} - \widetilde{X}_{tc} + \left(min\left(\lambda_t \widetilde{X}_{tR}, C_{tR}\right)\right)\left(\frac{C_{tc}}{C_{tR}}\right)$ (Eq 15)

Where: λ_t is the proportion of households willing to move to other parts of the study area. When $\lambda_t < 1$, this will lead to a reduction in the number of households from the input data. Without an empirical basis for this proportion, initially assume that $\lambda_t = 0.5$ (i.e. 50%).

In practice we need to obtain revised household totals by type in each control area. Thus the types of household being suppressed and relocating need to be estimated.

It is likely that the inadequate space will impact differently on the different household types and as a result the suppression of households might be expected to alter the mix of household types in the study area. On this basis the updated household forecasts by household type for each control area are estimated as:

For household type 1:

$$H_{tc}^{h=1} = \widetilde{H}_{tc}^{h=1} - \widetilde{X}_{tc}\frac{\widetilde{H}_{tc}^{h=1}}{\widetilde{H}_{tc}}\left(\lambda_t + (1-\lambda_t)\left(\frac{\mu}{\mu-1}\right)\right) + \left(\min\left(\frac{C_{tR}}{\lambda_t \widetilde{X}_{tR}}, 1\right)\sum_c \left(\lambda_t \widetilde{X}_{tc}\frac{\widetilde{H}_{tc}^{h=1}}{\widetilde{H}_{tc}}\right)\right)\left(\frac{C_{tc}}{C_{tR}}\right)$$

And for household type 2:

$$H_{tc}^{h=2} = \tilde{H}_{tc}^{h=2} - \tilde{X}_{tc}\frac{\tilde{H}_{tc}^{h=2}}{\tilde{H}_{tc}} + (1-\lambda_t)\tilde{X}_{tc}\left(\frac{1}{\mu-1}\right)\frac{\tilde{H}_{tc}^{h=1}}{\tilde{H}_{tc}} + \left(\min\left(\frac{C_{tR}}{\lambda_t \tilde{X}_{tR}},1\right)\sum_{c}\lambda_t \tilde{X}_{tc}\frac{\tilde{H}_{tc}^{h=2}}{\tilde{H}_{tc}}\right)\left(\frac{C_{tc}}{C_{tR}}\right)$$

(Eq 16)

where $\tilde{H}_{tc}^{h}$ is the number of households from equation 12, and

μ determines the number suppressed households that are reformed as household type 2. If μ =4, then for every 4 single person households suppressed, 1 multi-person household is formed. Assume μ =4 initially as this is consistent with existing policy led forecasts.

This will work so long as $\frac{\tilde{X}_{tc}}{\tilde{H}_{tc}} \le \frac{\mu-1}{\mu-\lambda}$, otherwise more 1 person households will be suppressed than exist. In this exceptional case the program will terminate with an error.

The second term in the equations above is the proportion of the excess that is to be reallocated to other control areas with spare capacity. The third term is the remaining proportion of the excess that are suppressed by altering household formation rates. The fourth term is the additional households being reallocated to the control area.

The following summary of adjustments made is recorded to the log file:

- Excess households identified: $\sum_{c\in R} X_{tc}^{h=1} = \sum_{c\in R}\left(\lambda_t \tilde{X}_{tc}\frac{\tilde{H}_{tc}^{h=1}}{\tilde{H}_{tc}}\right) + (1-\lambda_t)\left(\frac{\mu}{\mu-1}\right)\sum_{c\in R}\tilde{X}_{tc}\left(\frac{\tilde{H}_{tc}^{h=1}}{\tilde{H}_{tc}}\right)$ and $\sum_{c\in R} X_{tc}^{h=2} = \sum_{c\in R}\left(\tilde{X}_{tc}\frac{\tilde{H}_{tc}^{h=2}}{\tilde{H}_{tc}}\right) - (1-\lambda_t)\left(\frac{1}{\mu-1}\right)\sum_{c\in R}\tilde{X}_{tc}\left(\frac{\tilde{H}_{tc}^{h=1}}{\tilde{H}_{tc}}\right)$
- Of which $\sum_{c\in R}\left(\tilde{H}_{tc}^{h=1} - H_{tc}^{h=1}\right)$ and $\sum_{c\in R}\left(\tilde{H}_{tc}^{h=2} - H_{tc}^{h=2}\right)$ were suppressed; and
- $\sum_{c\in R} X_{tc}^{h=1} - \sum_{c\in R}\left(\tilde{H}_{tc}^{h=1} - H_{tc}^{h=1}\right)$ and $\sum_{c\in R} X_{tc}^{h=2} - \sum_{c\in R}\left(\tilde{H}_{tc}^{h=2} - H_{tc}^{h=2}\right)$ were reallocated.

Population by control area

The trend based forecast population is an input for each control area defined. Household forecasts are adjusted to take account of these population trends, (optionally) the expected change in dwellings and to alleviate housing pressure. Since there is some reallocation of households amongst control areas within a study area, then there should be an associated reallocation of population.

The input trend based population control totals are adjusted to reflect the household adjustment. An estimate of the number of people by type in each control area to be reallocated is calculated from the initial trend based household estimate $H(1)_{tc}^{h}$ and the final household figures H_{tc}^{h} by type – taking into account how the household reallocation is converted into persons.

The input household size parameters for the 2+ person households (h=2) were previously adjusted in each control area to reflect household forecasts (Eq 10b). Those for 1 person households remain unchanged.

We know the number of households which are moved when converting from a trend to a policy based forecast and we know those who move out of crowded control areas. So by applying the updated persons per household, the population moving out is:

$$H_{tc}^{h^-} = \left[max\left(H(1)_{tc}^{h} - \tilde{H}_{tc}^{h}, 0\right) + \left(\lambda_t \tilde{X}_{tc} \frac{\tilde{H}_{tc}^{h}}{\tilde{H}_{tc}} \right) \cdot min\left(\frac{C_{tR}}{\lambda_t \tilde{X}_{tR}}, 1 \right) \right] \text{ and } H_{tR}^{h^-} = \sum_c H_{tc}^{h^-}$$

$$P_{tc}^{hgl^-} = \pi_{tc}^{hgl} H_{tc}^{h-} \text{ and } P_{tR}^{hgl^-} = \sum_c P_{tc}^{hgl^-}$$

The significant variations in persons per household between alternative control areas within the study area (Region) should be taken into account when revising the population forecasts. The average household size for those moving within the study area (Region) is:

$$\Pi_{tR}^{hgl} = P_{tR}^{hgl^-} \Big/ H_{tR}^{h^-}$$

The population moving into control areas is thus:

$$P_{tc}^{hgl^+} = \Pi_{tR}^{hgl} \left(max\left(\tilde{H}_{tc}^{h} - H(1)_{tc}^{h}, 0\right) + min\left(\frac{C_{tR}}{\lambda_t \tilde{X}_{tR}}, 1 \right) \sum_c \lambda_t \tilde{X}_{tc} \frac{\tilde{H}_{tc}^{h}}{\tilde{H}_{tc}} \right) \left(\frac{C_{tc}}{C_{tR}} \right)$$

Having accounted for the changing household size to determine the number of people moving into and out of each control area, the trend based population forecasts can be adjusted as:

$$P_{tc}^{gl} = \tilde{P}_{tc}^{gl} - \sum_h P_{tc}^{hgl^-} + \sum_h P_{tc}^{hgl^+} \qquad \text{(Eq 17)}$$

Processing growth factors

The revised approach provides the user with two options:

- Weights based factoring – where all input EGFs must be of the same sign. The adjustment is then applied multiplicatively to ensure the control totals are met. Thus the relative difference between the input EGFs is retained.
- Trend based adjustments- where the input EGFs can be of mixed signs to reflect growth and decline. In this case the absolute difference between the EGFs is retained.

Adjustment to input EGFs for weights based approach:

This works in a similar way to previous versions of TEMPRO. An initial adjustment is made to the growth factors to achieve the required control area changes (note that for employment the totals are for each sector *a* – summed over gender and working status groups *gw*). The adjusted growth factors would be calculated as:

$$g_{pi}^{a} = \frac{max\left(\hat{g}_{pi}^{a} \Delta\tilde{E}_{pc}^{a}, 0\right)}{\sum_{i \in c} min\left(\hat{g}_{pi}^{a} E_{(t-1)i}^{a}, 0\right)} \quad \text{if} \quad \Delta\tilde{E}_{pc}^{a} \le 0$$

and $$g_{pi}^{a} = \frac{max\left(\hat{g}_{pi}^{a} \Delta\tilde{E}_{pc}^{a}, 0\right)}{\sum_{i \in c} max\left(\hat{g}_{pi}^{a} E_{(t-1)i}^{a}, 0\right)} \quad \text{if} \quad \Delta\tilde{E}_{pc}^{a} > 0$$

where $\Delta\tilde{E}^{a}_{pc} = \sum_{gw}\tilde{E}^{agw}_{tc} - \sum_{i\in c}E^{a}_{(t-1)i}$

(in fact the ~ is redundant since $E^{a}_{tc} = \tilde{E}^{a}_{tc}$ as it is only the *gw* split that is adjusted).

A further adjustment is then required at the time of application if any of the adjusted growth factors within the Control Area is less than -1.

For households the equivalent equations are:

$$g^{H}_{pi} = \frac{max\left(\hat{g}^{H}_{pi}\Delta H_{pc},0\right)}{\sum_{i\in c} min\left(\hat{g}^{H}_{pi}H_{(t-1)i},0\right)} \quad \text{if} \quad \Delta H_{pc} \le 0$$

and $$g^{H}_{pi} = \frac{max\left(\hat{g}^{H}_{pi}\Delta H_{pc},0\right)}{\sum_{i\in c} max\left(\hat{g}^{H}_{pi}H_{(t-1)i},0\right)} \quad \text{if} \quad \Delta H_{pc} > 0$$

where $\Delta H_{pc} = \sum_{h}H^{h}_{tc} - \sum_{h,i\in c}H^{h}_{(t-1)i}$

Adjustment to input EGFs for trend based approach:

This approach maintains the absolute difference between EGFs and adds a constant to each EGF to ensure the required control area change is required. There is no differential treatment for mixed sign EGFs or where the sign of the input EGFs is different to the control area change required. The only adjustment made is to prevent negative volumes of activity in any zone in scenario *t*.

In this case the adjusted growth factors are calculated as:

$$g^{a}_{pi} = \hat{g}^{a}_{pi} + \frac{\Delta E^{a}_{pc} - \sum_{i\in c}\hat{g}^{a}_{pi}E^{a}_{(t-1)i}}{\sum_{i\in c}E^{a}_{(t-1)i}}$$

For households the equivalent adjustment is:

$$g^{H}_{pi} = \hat{g}^{H}_{pi} + \frac{\Delta H_{pc} - \sum \hat{g}^{H}_{pi}H_{(t-1)i}}{\sum_{i\in c}H_{(t-1)i}}$$

Population and households by zone

The households in each control area are distributed to the zones within the control areas based on expected growth factors which are exogenously specified.

So $H_{ti} = H_{(t-1)i}\left(max\left(1 + g^{H}_{pi},0\right)\right)$

However we require households by type in each zone which can be forecast as:

$$H_{ti}^{h} = H_{tc}^{h} \frac{H_{(t-1)i}^{h}\left(max\left(1+g_{pi}^{H},0\right)\right)A_i}{\sum_{i\in c} H_{(t-1)i}^{h}\left(max\left(1+g_{pi}^{H},0\right)\right)A_i} \qquad \text{(Eq 18)}$$

Where the adjustment term A_i is required to ensure that the resulting number of households in each zone matches the number of households that would be obtained by applying the adjusted growth factors to the previous household total. This can be achieved *iteratively* (maximum of 100 iterations) as:

$$A_i^{n+1} = H_{(t-1)i} \Bigg/ \sum_h \left(\frac{H_{tc}^{h} H_{(t-1)i}^{h}}{\sum_{i\in c} H_{(t-1)i}^{h}\left(max\left(1+g_{pi}^{H},0\right)\right)A_i^{n}} \right)$$

until $\left|\frac{A_i^{n+1}}{A_i^{n}} - 1\right| \leq 0.01$ and where $A_i^{0} = 1$

A first zonal estimate of the population by gender and age is obtained by estimating the change in population by type from the change in households by type and then adding the expected change to the previous population. Note that the π_{tc}^{hgl} values used here are those obtained once the household forecasts have been determined.

$$\tilde{P}_{ti}^{gl} = \max\left(P_{(t-1)i}^{gl} + \sum_h \pi_{tc}^{hgl}\left(H_{ti}^{h} - H_{(t-1)i}^{h}\right), 0 \right) \qquad \text{(Eq 19)}$$

The first estimate must then be adjusted to ensure the input control totals on population are met. Thus the population by zone is obtained as:

$$P_{ti}^{gl} = P_{tc}^{gl} \frac{\tilde{P}_{ti}^{gl}}{\sum_{i\in c} \tilde{P}_{ti}^{gl}} \quad \text{to ensure} \quad \sum_{i\in c} P_{ti}^{gl} = P_{tc}^{gl} \qquad \text{(Eq 20)}$$

The change in the zonal population from the previous scenario is:

$$\Delta P_{pi}^{gl} = P_{ti}^{gl} - P_{(t-1)i}^{gl} \qquad \text{(Eq 21)}$$

The working status for the population within the zone is established as part of the balancing process for the demand for workers.

Employment and workers by zone

The allocation of employment from control areas to zones is carried out using two mechanisms:

- Dwelling-led distribution of population; and
- Independent of changes in dwellings and population, following exogenous employment growth by sector.

The allocation of the population led employment is carried out using the same zonal growth factors as the household information and is then adjusted to match the control totals for the employment sector. Thus zonal employment is initially calculated as:

$$E(1)_{ti}^{agw} = E_{(t-1)i}^{agw} \frac{H_{ti}}{H_{(t-1)i}} \qquad \text{(Eq 22)}$$

A single scalar adjustment is then applied to ensure the control totals are met

$$\tilde{E}_{ti}^{agw} = \tilde{E}_{tc}^{agw} \frac{E(1)_{ti}^{agw}}{\sum_{i \in c} E(1)_{ti}^{agw}} \quad \text{so that} \quad \sum_{i \in c} \tilde{E}_{ti}^{agw} = \tilde{E}_{tc}^{agw} \qquad \text{(Eq 23)}$$

where $\tilde{E}_{tc}^{agw}$ is the initial employment data for the control area from Eq 3.

The input growth factors are adjusted to estimate the zonal employment as:

$$\tilde{E}_{ti}^{agw} = \tilde{E}_{tc}^{agw} \frac{E_{(t-1)i}^{agw}\left(max\left(1+g_{pi}^{a},0\right)\right)}{\sum_{i \in c} E_{(t-1)i}^{agw}\left(max\left(1+g_{pi}^{a},0\right)\right)} \qquad \text{(Eq 24)}$$

Balance workforce and workers

The balancing process is concerned primarily with the ‘working age’ population (i.e. 16-29, 30-44, 45-64 and 65-74 age groups). It is assumed that the proportion of population aged 75+ will not be of sufficient significance. The balancing process ensures that:

- There are the correct number of workers of different types for the jobs available living within a given balancing area; and
- The number of workers in each zone does not exceed a specified maximum proportion of the resident population.

The implied numbers of workers required in a balancing area in the scenario given are:

$$\tilde{W}_{tB}^{glw} = \sum_{i \in B} \rho_{tR}^{l|gw} \left(\sum_{a} \gamma_{R}^{agw} \tilde{E}_{ti}^{agw} \right) \quad \text{for } w = F, P \qquad \text{(Eq 25)}$$

The change in demand for workers from the previous scenario is:

$$\Delta\tilde{W}_{pB}^{glw} = \tilde{W}_{tB}^{glw} - W_{(t-1)B}^{glw} \quad \text{for } w = F, P \qquad \text{(Eq 26)}$$

The changing employment profile through time should lead to a change in gender profile of the workforce in each employment sector. The Scenario Generator includes an internal adjustment of the assumed gender and working status split by employment sector.

This internal adjustment process uses the following key concepts:

- Treating the previous population and the new population as two separate groups;
- Treating declines before and completely independently to growth – logically they can only be applied to the “previous” population groups;
- Using ‘existing’ profiles / employment rates from the previous scenario as an initial estimate of workers;
- Calculating maximum possible numbers of workers by type;
- Adjusting profile of workers demanded so no maxima are breached; and
- Determining how far it is necessary to move from the initial values towards the maximum values in order to satisfy demand.

Reduction in population and / or workers

The first stage is to account for any decreases in workers due to decreases in population. This gives an intermediate population estimate:

If $\Delta P_{pi}^{gl} < 0$ then $P(1)_{ti}^{glw} = P_{(t-1)i}^{glw} + \Delta P_{pi}^{gl}\left(\frac{P_{(t-1)i}^{glw}}{P_{(t-1)i}^{gl}}\right)$ otherwise $P(1)_{ti}^{glw} = P_{(t-1)i}^{glw}$ (Eq 27)

and $P(1)_{tB}^{glw} = \sum_{i \in B} P(1)_{ti}^{glw}$ (Eq 28)

The second stage is required only if either (FT, PT or both) of the required workforce categories *w* for the gender and age group *gl* in the scenario *t* is less than in the previous scenario *(t-1)*. In this case the number of workers of type *w* must be reduced while retaining the total forecast population numbers by zone (from Eq 31). This is achieved by simply scaling back the number of workers (by status) in each zone to match the control area total. The non-workers are then increased by the same volume to retain the zonal population totals.

Thus if $\Delta W_{pB}^{w} < 0$ then:

$$P(2)_{ti}^{gl(w=F,P)} = P(1)_{ti}^{gl(w=F,P)} \frac{W_{tB}^{gl(w=F,P)}}{\sum_{i \in B} P(1)_{ti}^{gl(w=F,P)}} \quad \text{for w = F,P} \qquad \text{(Eq 29)}$$

At this stage the total population by gender and age remains as above so that:

$$P(2)_{ti}^{gl} = P(1)_{ti}^{gl} = \sum_{w} P(1)_{ti}^{glw} \qquad \text{(Eq 30a)}$$

With the non-working population (not required at this stage) being the difference:

$$P(2)_{ti}^{gl(w=S,O)} = P(2)_{ti}^{gl} - \sum_{w=F,P} P(2)_{ti}^{gl(w=F,P)} \qquad \text{(Eq 34b)}$$

This gives an intermediate forecast of population by working status $P(2)_{ti}^{glw}$ accounting for decreases in population and / or workers.

If $\Delta P_{pi}^{gl} \geq 0$ and $\Delta W_{pB}^{w} \geq 0$ then there are no decreases in population or workers. In this case the starting population data are the previous scenario results. To simplify notation for remaining balancing process, set

$$P(2)_{ti}^{glw} = P_{(t-1)i}^{glw}.$$

Initial estimates of working status profile of population in each zone

- For this part it is proposed to treat the population in two groups:
- The existing residents – from the previous scenario (year) with any declines already subtracted – a group for which the working status *w* is known: $P(2)_{ti}^{glw}$
- The change in population in period *p* (from (*t-1*) to *t*): $\Delta P_{pi}^{gl} = P_{ti}^{gl} - P_{(t-1)i}^{gl}$ for which the working status *w* has yet to be forecast.

An initial estimate of the population profile can be obtained by assuming the "new" population takes on the same profile as the existing population:

Thus $\tilde{P}(3)_{ti}^{glw} = P(2)_{ti}^{glw} + \Delta P_{pi}^{gl} \left(\frac{P(2)_{ti}^{glw}}{P(2)_{ti}^{gl}} \right)$ for w= F, P (Eq 31)

If there is no existing population, the new population is split equally besewn FT and PT workers.

The adjusted initial estimate of workers for zone and the balancing area is then calculated:

$$P(3)_{ti}^{glw} = \min\left(\tilde{P}(3)_{ti}^{glw}, P(4)_{ti,\max}^{glw}\right) \text{ for w= F, P}$$

$$P(3)_{tB}^{glw} = \sum_{i \in B} P(3)_{ti}^{glw} \text{ for w= F, P} \quad \text{(Eq 32)}$$

Maximum supply of workers by gender

For the new population the maximum rate is the specified ceiling rate. Thus:
Maximum employment rate for existing population in zone:

$$\sigma_{ti,\max}^{gl} = \min\left(\sum_{w} \left(\Delta\sigma_{\max}^{glw} + \sigma_{(t-1)i}^{glw} \right), \sigma_{\max}^{gl} \right) \quad \text{(Eq 33)}$$

Or $\sigma_{ti,\max}^{gl} = \left(\sigma_{\max}^{gl} \right)$ when there is no existing data

Giving a maximum supply of employees:

$$P(2)_{ti,max}^{gl} = \sigma_{ti,max}^{gl} P(2)_{ti}^{gl} \quad \text{(Eq 34)}$$

and a possible maximum for each working status type of:

$$\tilde{P}(2)_{ti,max}^{glw} = \left(\sigma_{(t-1)i,}^{glw} + \Delta\sigma_{max}^{glw} \right) P(2)_{ti}^{gl}$$

Although it may not be possible for both maxima by working status to be attained within the overall ceiling rate.

i.e. it is possible that $P(2)_{ti,max}^{gl} = \sum_{w} \tilde{P}(2)_{ti,max}^{glw}$ or $P(2)_{ti,max}^{gl} \neq \sum_{w} \tilde{P}(2)_{ti,max}^{glw}$.

The two estimates $P(2)_{ti,max}^{gl}$ and $\tilde{P}(2)_{ti,max}^{glw}$ are used in separate stages of the remaining forecasting steps.

For the 'new' population the maximum number of employees by gender is:

New population: $\Delta P(3)_{pi,max}^{gl} = \Delta P_{pi}^{gl} \sigma_{t,max}^{gl}$ (Eq 35)

Thus the maximum workers in zone: $P(3)_{ti,max}^{gl} = P(2)_{ti,max}^{gl} + \Delta P(3)_{pi,max}^{gl}$ (Eq 36)

Aggregating the results for all zones in the balancing area, gives a maximum number of male and female workers by age group:

Maximum workers by gender in balancing area:

$$P(3)_{tB,max}^{gl} = \sum_{i \in B} P(3)_{ti,max}^{gl} \quad \text{(Eq 37)}$$

The working status profile of the change in demand for workers (i.e. the new demand) is used to split the potential workers in the “new population” into the two working status groups:

$$\Delta P(3)^{glw}_{pi,max} = \Delta P(3)^{gl}_{pi,max} \frac{max\left(\Delta W^{glw}_{pB},1\right)}{\sum_w max\left(\Delta W^{glw}_{pB},1\right)} \quad \text{(Eq 38)}$$

The maximum number of workers by gender and working status available in the population is then calculated as:

$$P(4)^{glw}_{ti,max} = \left(\tilde{P}(2)^{glw}_{ti,max} + \Delta P(3)^{glw}_{pi,max}\right) \text{ and } P(4)^{glw}_{tB,max} = \sum_{i \in B} P(4)^{glw}_{ti,max} \quad \text{(Eq 39)}$$

Since the estimates of the maximum full and part time workers may sum to more than the physical maximum a final adjustment is required.

To make this final adjustment the difference between the initial zonal estimates $P(3)^{glw}_{ti}$ and $P(4)^{glw}_{ti,max}$ are considered for the two cases w=F and w=P. For the working status with the smallest difference between the initial estimate and the initial maximum the maximum value is taken. For the other working status the maximum value is recalculated to ensure the overall employment rate is not breached. Thus:

If $\sum_w P(4)^{glw}_{ti,max} \le P(3)^{gl}_{ti,max}$ then $P(5)^{glw}_{ti,max} = P(4)^{glw}_{ti,max}$

Else $P(5)^{gl(w=F)}_{ti,max} = P(4)^{gl(w=F)}_{ti,max}$ if $\left(P(4)^{gl(w=F)}_{ti,max} - P(3)^{gl(w=F)}_{ti}\right) < \left(P(4)^{gl(w=P)}_{ti,max} - P(3)^{gl(w=P)}_{ti}\right)$

Else $P(5)^{gl(w=F)}_{ti,max} = P(3)^{gl}_{ti,max} - P(4)^{gl(w=P)}_{ti,max}$

and vice versa:

$P(5)^{gl(w=P)}_{ti,max} = P(4)^{gl(w=P)}_{ti,max}$ if
$\left(P(4)^{gl(w=P)}_{ti,max} - P(3)^{gl(w=P)}_{ti}\right) < \left(P(4)^{gl(w=F)}_{ti,max} - P(3)^{gl(w=F)}_{ti}\right)$

Else $P(5)^{gl(w=P)}_{ti,max} = P(3)^{gl}_{ti,max} - P(4)^{gl(w=F)}_{ti,max}$

Checking / Adjusting the Gender Profile of the Workers Demanded

Excess workers are: $Z^{gl}_{tB} = \max\left(\tilde{W}^{gl}_{tB} - P(3)^{gl(w=F,P)}_{tB,\max},0\right)$ and $Z^{l}_{tB} = \sum_g Z^{gl}_{tB}$ (Eq 40)

Capacity for workers is: $Y^{gl}_{tB} = max\left(P(3)^{gl(w=F,P)}_{tB,max} - \tilde{W}^{gl}_{tB},0\right)$ (Eq 41)

If $Z^{l}_{tB} > Y^{gl}_{tB}$, then modifying the gender profile will not completely resolve any mismatch and in this case $Z^{l}_{tB} - Y^{gl}_{tB}$ workers are lost from the working age population – assumed to be filled by the over 75s and by increased double jobbing.

The final estimates of workforce by gender are:

$$W^{gl}_{tB} = \tilde{W}^{gl}_{tB} - Z^{gl}_{tB} + min\left(Y^{gl}_{tB},Z^{l}_{tB}\right) \quad \text{(Eq 42)}$$

Checking / adjusting the full-time / part-time split of workers

The next step is to finalise the working status of the population in a balancing area. To start, it is assumed that the working status profile of the modified demand is the same as for the initial demand. So demand for workers by working status is:

$$W(1)_{tB}^{glw} = W_{tB}^{gl} \frac{\widetilde{W}_{tB}^{glw}}{\widetilde{W}_{tB}^{gl}} \qquad \text{(Eq 43)}$$

By this stage it is ensured that demand for male and female workers can be accommodated within the population supply. As before there is either an excess or capacity calculated as:

Excess workers are: $Z_{tB}^{glw} = max\left(W(1)_{tB}^{glw} - P(5)_{tB,max}^{glw}, 0\right)$

and $Z_{tB}^{gl} = \sum_{w} Z_{tB}^{glw}$ (Eq 44)

Theoretical capacity for workers is: $Y_{tB}^{glw} = max\left(P(5)_{tB,max}^{glw} - W(1)_{tB}^{gl}, 0\right)$ (Eq 45)

In practice there may be less capacity than indicated by Eq 49 since the sum of the maxima for the two working status groups could in theory be greater than the available population. However since adjustments have already been made to the workforce demanded by gender and age group, balanced estimates of workforce by gender, age and working status can be calculated as:

$$W_{tB}^{glw} = W(1)_{tB}^{glw} - Z_{tB}^{glw} + min\left(Y_{tB}^{glw}, Z_{tB}^{gl}\right) \qquad \text{(Eq 46)}$$

And a revised set of employment rates:

$$\sigma_{tB}^{glw} = \frac{W_{tB}^{glw}}{P_{tB}^{gl}} \qquad \text{(Eq 47)}$$

Allocations of workers to zones

Required data:

Workers to be accommodated in the balancing area are: W_{tB}^{glw} from Eq 50.

Initial estimates of workers in the balancing area are $P(3)_{tB}^{glw}$ from Eq 36.

Adjustment required to initial estimates to match demand: $W_{tB}^{glw} - P(3)_{tB}^{glw}$

The maximum number of workers in the balancing area is $P(3)_{tB,max}^{gl}$ from Eq 41, with separate estimates of the maximum number of workers by status $P(5)_{tB,max}^{glw}$ being available from Eq 43.

Maximum adjustment to initial estimates that is possible is then $P(4)_{tB,max}^{glw} - P(3)_{tB}^{glw}$

There are two possible cases:

- The workforce demanded is a greater proportion of the population than in the previous scenario (expected to be the norm) i.e. $W_{tB}^{glw} \geq P(3)_{tB}^{glw}$; or

- The workforce demanded is a smaller proportion of the population than in the previous scenario i.e. $W_{tB}^{glw} < P(3)_{tB}^{glw}$

If the proportion of the population required to work is less than in the previous population (i.e. $W_{tB}^{glw} < P(3)_{tB}^{glw}$) the initial estimates can be scaled back and:

$$W_{ti}^{glw} = \frac{W_{tB}^{glw}}{P(3)_{tB}^{glw}} P(3)_{ti}^{glw}$$

If the proportion of population working has increased then the employment rate lies somewhere between the initial and the maximum employment rate:

$$P(3)_{tB}^{glw} \le W_{tB}^{glw} \le P(5)_{tB,max}^{glw}$$

and the proportion of the possible adjustment that is required is: $\tau_{tB}^{glw} = \dfrac{W_{tB}^{glw} - P(3)_{tB}^{glw}}{P(5)_{tB,max}^{glw} - P(3)_{tB}^{glw}}$

The zonal forecasts of workers by zone are calculated as:

$$W_{ti}^{glw} = P_{ti}^{glw} = P(3)_{ti}^{glw} + \tau_{tB}^{glw}\left(P(5)_{ti,max}^{glw} - P(3)_{ti}^{glw}\right)$$

These two cases can be combined into the single equation:

$$W_{ti}^{glw} = min\left(1, \frac{W_{tb}^{glw}}{P(3)_{tB}^{glw}}\right) P(3)_{ti}^{glw} + max\left(\tau_{tB}^{glw}, 0\right)\left(P(5)_{ti,max}^{glw} - P(3)_{ti}^{glw}\right) \quad \text{(Eq 48)}$$

With the total number of workers being $W_{ti}^{gl} = \sum_{w} W_{ti}^{glw}$

Non-workers by zone

The non-working population is the difference between the workers and total population, whilst the split between students and others is assumed to remain the same as the previous scenario.

$$N_{ti}^{glw} = \left(P_{ti}^{gl} - W_{ti}^{gl}\right)\frac{N_{(t-1)i}^{glw}}{N_{(t-1)i}^{gl}} \quad \text{for w=S,O} \quad \text{(Eq 49)}$$

Update employment forecasts for change in worker profile

The input employment data by sector is obtained by aggregation across the gender and working status groups:

$$E_{ti}^{a} = \sum_{gw} \tilde{E}_{ti}^{agw}$$

The revised split is then estimated as:

$$E_{ti}^{agw} = E_{ti}^{a} \frac{\tilde{E}_{ti}^{agw} \sum_{l} W_{tB}^{glw} \Big/ \sum_{l} \tilde{W}_{tB}^{glw}}{\sum_{gw}\left(\tilde{E}_{ti}^{agw} \sum_{l} W_{tB}^{glw} \Big/ \sum_{l} \tilde{W}_{tB}^{glw}\right)} \quad \text{(Eq 50)}$$

Appendix E. Working Futures Industry Types

Industry ID	Industry	SIC 2007 Section	SIC 2007 Division
1	Agriculture	A	01-03
2	Mining & quarrying	B	05-09
3	Food, drink & tobacco	C	10-12
4	Engineering	C	26-28
5	Rest of manufacturing	C	13-25,29-33
6	Electricity & gas	D	35
7	Water & sewerage	E	36-39
8	Construction	F	41-43
9	Wholesale & retail trade	G	45-47
10	Transport & storage	H	49-53
11	Accommodation & food	I	55-56
12	Media	J	58-60, 63
13	IT	J	61,62
14	Finance & insurance	K	64-66
15	Real estate	L	68
16	Professional services	M	69-75
17	Support services	N	77-82
18	Public administration & defence	O	84
19	Education	P	85
20	Health & social work	Q	86-88
21	Arts & entertainment	R	90-93
22	Other services	S	94-96

Appendix F. Source of dwelling trajectories

Dwelling trajectories are required at the control area (local authority district level), as discussed in Section 4.4. There is no single source of data, and therefore projections are not consistent in terms of base, horizon or general definition. The robustness of this data source should be considered alongside the ultimate purpose of dwelling projections, as described in Section 2 and Appendix D.

The table below shows the source of dwelling trajectory for each control area. The main source is the relevant AMR (Annual Monitoring Report / Authority Monitory Report). Due to changes in statutory reporting requirements, these are not available for all areas. Other sources listed are LDP (Local Development Plan), SHLAA (Strategic Housing Land Availability Assessment), LHS (Local Housing Strategy), UDP (Unitary Development Plan), CS (Core Strategy) and HLS (Housing Land Supply). In some cases, multiple sources, supplementary documents, updates or appendices have been used to inform the trajectory; in this case, the ultimate parent has been cited.

Control area	Source	Report year	Projection horizon	Control area	Source	Report year	Projection horizon
Aberdeen City	LDP	2012	2030	Mansfield	AMR	2011	2026
Aberdeenshire	LDP	2015	2026	Medway	AMR	2014	2029
Adur	AMR	2014	2031	Melton	AMR	2013	2036
Allerdale	AMR	2014	2028	Mendip	AMR	2012	2028
Amber Valley	AMR	2011	2025	Merthyr Tydfil	AMR	2014	2020
Angus	LDP	2015	2025	Merton	AMR	2014	2026
Argyll & Bute	LDP	2015	2024	Mid Devon	AMR	2013	2026
Arun	HIS	2015	2030	Mid Suffolk	AMR	2014	2031
Ashfield	AMR	2014	2024	Mid Sussex	SHLAA	2015	2031
Ashford	SHLAA	2009	2021	Middlesbrough	AMR	2012	2021
Aylesbury Vale	SHLAA	2009	2026	Midlothian	LHS	2013	2023
Babergh	AMR	2014	2031	Milton Keynes	AMR	2012	2026
Barking & Dagenham	AMR	2013	2029	Mole Valley	AMR	2014	2019
Barnet	AMR	2013	2029	Monmouthshire	LDP	2014	2021
Barnsley	AMR	2010	2026	Moray	LHS	2013	2022
Barrow-in-Furness	SHLAA	2014	2027	Neath Port Talbot	LDP	2015	2026
Basildon	AMR	2010	2027	New Forest	AMR	2015	2026
Basingstoke & Deane	AMR	2014	2027	Newark & Sherwood	CS	2011	2026
Bassetlaw	AMR	2014	2027	Newcastle upon Tyne	AMR	2014	2030
Bath & NE Somerset	SHLAA	2014	2030	Newcastle-under-Lyme	AMR	2011	2026
Bedford	SHLAA	2010	2021	Newham	AMR	2011	2027
Bexley	AMR	2012	2029	Newport	LDP	2012	2025
Birmingham	SHLAA	2030	2014	North Ayrshire	LDP	2014	2024
Blaby	AMR	2012	2026	North Devon	AMR	2012	2026
Blackburn with Darwen	AMR	2013	2025	North Dorset	SHLAA	2011	2026
Blackpool	SHLAA	2014	2027	North East Derbyshire	AMR	2014	2031
Blaenau Gwent	LDP	2012	2021	North East Lincolnshire	AMR	2014	2029
Bolsover	AMR	2014	2031	North Hertfordshire	SHLAA	2014	2031
Bolton	AMR	2014	2026	North Kesteven	LDP	2014	2026

Control area	Source	Report year	Projection horizon	Control area	Source	Report year	Projection horizon
Boston	AMR	2011	2026	North Lanarkshire	LDP	2012	2017
Bournemouth	AMR	2014	2026	North Lincolnshire	AMR	2013	2026
Bracknell Forest	AMR	2012	2026	North Norfolk	AMR	2013	2026
Bradford	AMR	2013	2030	North Somerset	AMR	2013	2026
Braintree	AMR	2014	2026	North Tyneside	AMR	2014	2032
Breckland	AMR	2014	2026	North Warwickshire	AMR	2012	2028
Brent	AMR	2014	2026	North West Leicestershire	AMR	2013	2031
Brentwood	AMR	2012	2017	Northampton	AMR	2009	2026
Bridgend	LDP	2012	2025	Northumberland	SHLAA	2014	2029
Brighton & Hove	AMR	2014	2030	Norwich	AMR	2014	2026
Bristol	SHLAA	2009	2026	Nottingham	AMR	2013	2028
Broadland	AMR	2014	2026	Nuneaton & Bedworth	AMR	2014	2028
Bromley	SHLAA	2013	2025	Oadby & Wigston	AMR	2014	2026
Bromsgrove	AMR	2014	2030	Oldham	AMR	2014	2031
Broxbourne	AMR	2014	2019	Orkney Islands	HLS	2014	2016
Broxtowe	SHLAA	2014	2029	Oxford	AMR	2014	2026
Burnley	AMR	2012	2021	Pembrokeshire	LDP	2012	2021
Bury	AMR	2013	2029	Pendle	AMR	2013	2030
Caerphilly	LDP	2010	2021	Perth & Kinross	LHS	2011	2024
Calderdale	AMR	2011	2026	Peterborough	AMR	2014	2026
Cambridge	AMR	2013	2031	Plymouth	AMR	2013	2029
Camden	AMR	2013	2029	Poole	AMR	2013	2026
Cannock Chase	AMR	2013	2028	Portsmouth	SHLAA	2014	2027
Canterbury	AMR	2014	2031	Powys	LDP	2013	2026
Cardiff	LDP	2013	2019	Preston	AMR	2010	2025
Carlisle	AMR	2014	2030	Purbeck	AMR	2007	2017
Carmarthenshire	LDP	2013	2020	Reading	AMR	2013	2026
Castle Point	AMR	2014	2031	Redbridge	AMR	2014	2030
Central Bedfordshire	AMR	2014	2033	Redcar & Cleveland	AMR	2014	2029
Ceredigion	AMR	2014	2021	Redditch	AMR	2014	2030
Charnwood	AMR	2014	2028	Reigate & Banstead	AMR	2012	2027
Chelmsford	AMR	2014	2021	Renfrewshire	LHS	2011	2016
Cheltenham	SHLAA	2013	2031	Rhondda, Cynon, Taff	LDP	2011	2021
Cherwell	AMR	2015	2031	Ribble Valley	AMR	2014	2028
Cheshire East	AMR	2013	2029	Richmond upon Thames	AMR	2015	2026
Cheshire West & Chester	AMR	2013	2018	Richmondshire	AMR	2014	2028
Chesterfield	SHLAA	2012	2017	Rochdale	AMR	2014	2028
Chichester	AMR	2014	2029	Rochford	AMR	2014	2027
Chiltern	AMR	2014	2029	Rossendale	AMR	2014	2026
Chorley	AMR	2013	2026	Rother	SHLAA	2013	2028
Christchurch	AMR	2013	2027	Rotherham	AMR	2014	2028
City of London	AMR	2014	2028	Rugby	AMR	2014	2026
City of Westminster	AMR	2014	2028	Runnymede	AMR	2013	2026

Control area	Source	Report year	Projection horizon	Control area	Source	Report year	Projection horizon
Clackmannanshire	HLS	2011	2019	Rushcliffe	AMR	2013	2028
Colchester	AMR	2014	2029	Rushmoor	SHLAA	2015	2029
Conwy	LDP	2007	2022	Rutland	AMR	2014	2026
Copeland	AMR	2012	2021	Ryedale	SHLAA	2015	2027
Corby	AMR	2014	2021	Salford	SHLAA	2013	2032
Cornwall	SHLAA	2015	2025	Sandwell	AMR	2015	2026
Cotswold	SHLAA	2014	2034	Scarborough	AMR	2014	2024
County Durham	AMR	2011	2021	Scottish Borders	LHS	2012	2017
Coventry	SHLAA	2014	2026	Sedgemoor	AMR	2014	2029
Craven	AMR	2015	2021	Sefton	SHLAA	2013	2027
Crawley	AMR	2013	2026	Selby	AMR	2015	2028
Croydon	SHLAA	2013	2025	Sevenoaks	AMR	2014	2026
Dacorum	AMR	2015	2031	Sheffield	AMR	2011	2026
Darlington	AMR	2011	2026	Shepway	AMR	2014	2026
Dartford	AMR	2014	2026	Shetland Islands	*No data*		
Daventry	AMR	2014	2029	Shropshire	SHLAA	2014	2026
Denbighshire	HLS	2015	2020	Slough	AMR	2014	2026
Derby	AMR	2012	2028	Solihull	AMR	2013	2028
Derbyshire Dales	SHLAA	2013	2028	South Ayrshire	LHS	2011	2016
Doncaster	AMR	2014	2028	South Buckinghamshire	AMR	2014	2026
Dover	AMR	2014	2028	South Cambridgeshire	AMR	2014	2031
Dudley	AMR	2015	2026	South Derbyshire	AMR	2014	2026
Dumfries & Galloway	LDP	2009	2024	South Gloucestershire	AMR	2014	2027
Dundee City	LDP	2014	2024	South Hams	AMR	2011	2026
Ealing	AMR	2013	2028	South Holland	AMR	2010	2026
East Ayrshire	LHS	2013	2018	South Kesteven	AMR	2014	2026
East Cambridgeshire	AMR	2013	2031	South Lakeland	AMR	2014	2025
East Devon	AMR	2011	2026	South Lanarkshire	LHS	2012	2025
East Dorset	AMR	2012	2026	South Norfolk	AMR	2014	2026
East Dunbartonshire	LHS	2013	2018	South Northamptonshire	AMR	2014	2029
East Hampshire	AMR	2013	2028	South Oxfordshire	AMR	2012	2027
East Hertfordshire	AMR	2012	2031	South Ribble	AMR	2014	2026
East Lindsey	AMR	2014	2024	South Somerset	AMR	2013	2028
East Lothian	LDP	2014	2029	South Staffordshire	AMR	2014	2028
East Northamptonshire	AMR	2013	2021	South Tyneside	AMR	2010	2025
East Renfrewshire	LHS	2012	2024	Southampton	SHLAA	2013	2026
East Riding of Yorkshire	AMR	2013	2029	Southend-on-Sea	AMR	2013	2028
East Staffordshire	SHLAA	2014	2029	Southwark	HLS	2014	2029
Eastbourne	AMR	2014	2019	Spelthorne	AMR	2014	2026
Eastleigh	AMR	2012	2017	St Albans	AMR	2014	2029
Eden	AMR	2013	2025	St Edmundsbury	AMR	2013	2031
Edinburgh, City of	LDP	2014	2023	St. Helens	AMR	2011	2027
Eilean Siar	LDP	2012	2019	Stafford	LDP	2014	2031

Control area	Source	Report year	Projection horizon	Control area	Source	Report year	Projection horizon
Elmbridge	AMR	2014	2026	Staffordshire Moorlands	AMR	2014	2026
Enfield	AMR	2013	2021	Stevenage	AMR	2014	2031
Epping Forest	AMR	2013	2021	Stirling	LDP	2014	2023
Epsom & Ewell	AMR	2015	2026	Stockport	AMR	2010	2026
Erewash	AMR	2011	2026	Stockton-on-Tees	AMR	2014	2030
Exeter	SHLAA	2015	2030	Stoke-on-Trent	AMR	2014	2026
Falkirk	LHS	2012	2033	Stratford-on-Avon	AMR	2014	2031
Fareham	AMR	2015	2026	Stroud	AMR	2010	2025
Fenland	AMR	2008	2013	Suffolk Coastal	AMR	2013	2028
Fife	LHS	2015	2028	Sunderland	AMR	2010	2025
Flintshire	UDP	2006	2026	Surrey Heath	AMR	2014	2028
Forest Heath	AMR	2012	2031	Sutton	AMR	2014	2024
Forest of Dean	SHLAA	2013	2026	Swale	AMR	2014	2031
Fylde	AMR	2014	2029	Swansea	LDP	2011	2025
Gateshead	AMR	2014	2030	Swindon	AMR	2013	2026
Gedling	AMR	2014	2028	Tameside	AMR	2012	2029
Glasgow City	LHS	2011	2025	Tamworth	AMR	2011	2026
Gloucester	AMR	2011	2030	Tandridge	AMR	2014	2026
Gosport	AMR	2014	2029	Taunton Deane	AMR	2014	2027
Gravesham	AMR	2015	2028	Teignbridge	AMR	2014	2029
Great Yarmouth	AMR	2014	2029	Telford & Wrekin	CS	2007	2026
Greenwich	AMR	2013	2028	Tendring	AMR	2014	2031
Guildford	SHLAA	2014	2031	Test Valley	AMR	2014	2029
Gwynedd	LDP	2015	2026	Tewkesbury	AMR	2014	2019
Hackney	AMR	2012	2026	Thanet	AMR	2014	2026
Halton	AMR	2012	2028	The Vale of Glamorgan	LDP	2011	2026
Hambleton	AMR	2014	2026	Three Rivers	AMR	2014	2026
Hammersmith & Fulham	AMR	2014	2029	Thurrock	AMR	2014	2026
Harborough	AMR	2015	2031	Tonbridge & Malling	AMR	2014	2021
Haringey	AMR	2014	2026	Torbay	AMR	2013	2031
Harlow	AMR	2013	2026	Torfaen	LDP	2010	2021
Harrogate	SHLAA	2013	2028	Torridge	AMR	2011	2026
Harrow	AMR	2012	2013	Tower Hamlets	AMR	2013	2028
Hart	SHLAA	2015	2032	Trafford	AMR	2013	2026
Hartlepool	SHLAA	2015	2030	Tunbridge Wells	AMR	2013	2026
Hastings	AMR	2014	2028	Uttlesford	AMR	2013	2029
Havant	AMR	2014	2026	Vale of White Horse	AMR	2011	2029
Havering	AMR	2014	2024	Wakefield	AMR	2014	2030
Herefordshire	AMR	2014	2031	Walsall	AMR	2013	2026
Hertsmere	AMR	2010	2027	Waltham Forest	AMR	2014	2031
High Peak	AMR	2014	2031	Wandsworth	SHLAA	2009	2014
Highland	LDP	2010	2029	Warrington	AMR	2014	2027
Hillingdon	AMR	2013	2026	Warwick	AMR	2014	2029

Control area	Source	Report year	Projection horizon	Control area	Source	Report year	Projection horizon
Hinckley & Bosworth	AMR	2013	2026	Watford	AMR	2013	2031
Horsham	AMR	2014	2026	Waveney	AMR	2014	2025
Hounslow	AMR	2014	2030	Waverley	AMR	2012	2028
Huntingdonshire	AMR	2015	2036	Wealden	AMR	2014	2027
Hyndburn	SHLAA	2009	2021	Wellingborough	AMR	2013	2021
Inverclyde	LHS	2011	2025	Welwyn Hatfield	AMR	2014	2029
Ipswich	AMR	2014	2030	West Berkshire	AMR	2014	2026
Isle of Anglesey	HLS	2015	2019	West Devon	AMR	2012	2026
Isle of Wight	AMR	2014	2027	West Dorset	AMR	2014	2028
Isles of Scilly	AMR	2012	2020	West Dunbartonshire	LHS	2011	2019
Islington	AMR	2013	2029	West Lancashire	AMR	2015	2027
Kensington & Chelsea	AMR	2015	2026	West Lindsey	AMR	2010	2026
Kettering	AMR	2013	2021	West Lothian	LHS	2012	2028
King’s Lynn & West Norfolk	AMR	2013	2028	West Oxfordshire	AMR	2013	2027
Kingston upon Hull	AMR	2014	2030	West Somerset	LDP	2012	2032
Kingston upon Thames	AMR	2015	2029	Weymouth & Portland	SHLAA	2014	2028
Kirklees	SHLAA	2013	2029	Wigan	SHLAA	2015	2030
Knowsley	AMR	2012	2027	Wiltshire	AMR	2011	2026
Lambeth	HIS	2015	2026	Winchester	AMR	2014	2031
Lancaster	SHLAA	2009	2024	Windsor & Maidenhead	AMR	2010	2026
Leeds	AMR	2013	2028	Wirral	AMR	2014	2037
Leicester	SHLAA	2014	2029	Woking	SHLAA	2014	2029
Lewes	SHLAA	2014	2029	Wokingham	SHLAA	2015	2026
Lewisham	AMR	2014	2030	Wolverhampton	AMR	2014	2026
Lichfield	AMR	2014	2019	Worcester	AMR	2013	2030
Lincoln	LDP	2014	2026	Worthing	AMR	2014	2026
Liverpool	AMR	2012	2028	Wrexham	LDP	2013	2028
Luton	SHLAA	2014	2031	Wychavon	AMR	2013	2030
Maidstone	SHLAA	2009	2026	Wycombe	AMR	2014	2024
Maldon	AMR	2012	2023	Wyre	AMR	2013	2021
Malvern Hills	AMR	2013	2030	Wyre Forest	AMR	2014	2026
Manchester	SHLAA	2009	2021	York	AMR	2011	2031