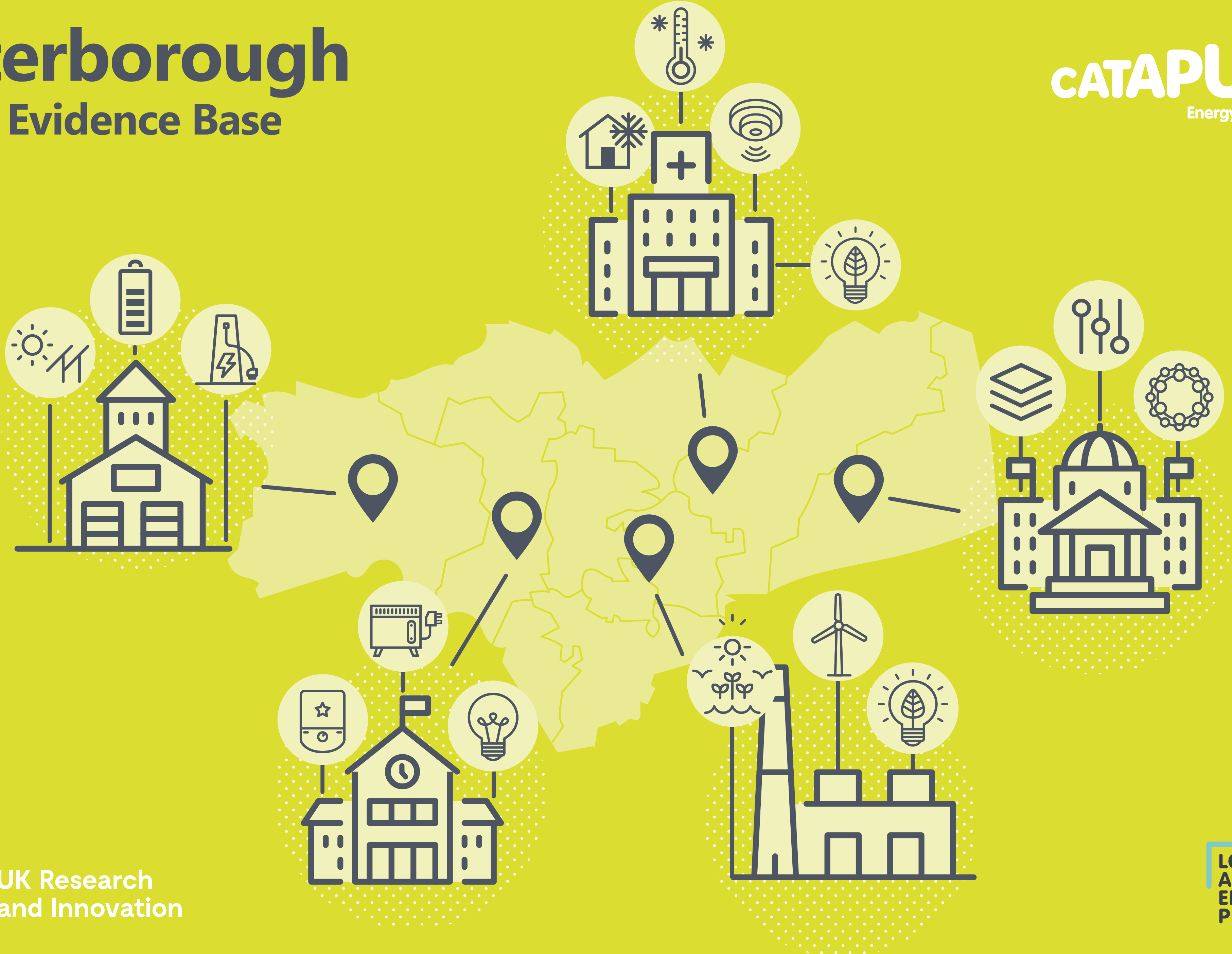
Peterborough

LAEP Evidence Base

CATAPULT
Energy Systems

185



UK Research and Innovation

LOCAL AREA ENERGY PLAN

Introduction

This Evidence Base aims to complement the main document by adding more information about the starting point for Peterborough, how the future-looking modelling was carried out, which data sources were used, and providing some supplementary data/graphs/maps to support the plan.

Contents

Methodology and Data

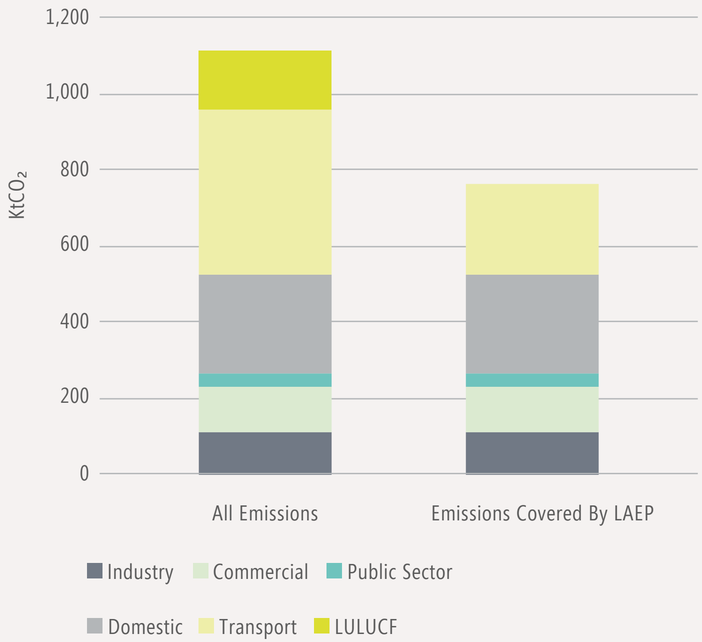
Scope of LAEP and Emissions

The local area energy plan (LAEP) for Peterborough covers roughly 70% of the CO_2 emissions identified in the Local Authority CO_2 data released by the UK Government. Excluded from this LAEP are: land-use, land-use change and forestry (LULUCF), and transport from 'non-private' vehicles. In Peterborough, cars account for 79% of kilometres driven accounting for around 55% of transport emissions.

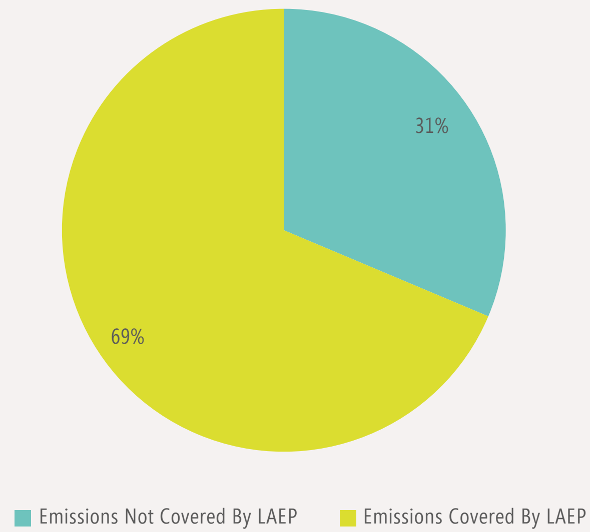
In total, Peterborough's CO_2 emissions in 2019 were approximately 1.1MtCO_2, with transport accounting for 40% of the total emissions.

Carbon offsetting is not included.

Peterborough 2019 CO_2 Emissions Estimates



Proportion of Peterborough 2019 CO_2 Emissions Covered By LAEP

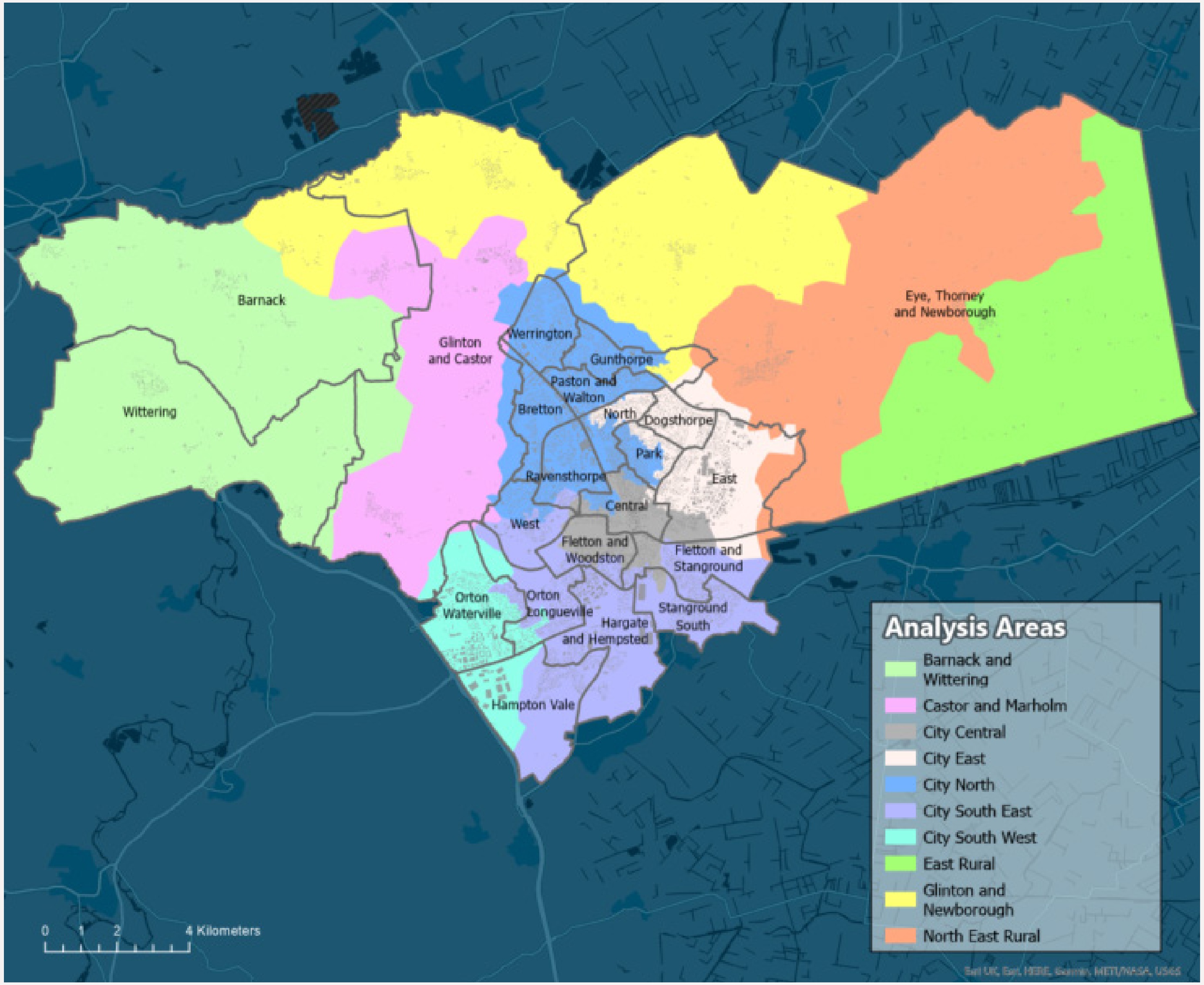


Analysis Zones with Ward Boundaries

To support the conversation with locally elected members, the relationship between analysis zones and electoral wards is shown on this map.

The ten **analysis zones**, defined in the main LAEP report are shown by colour – according to the legend box.

The **electoral wards** are labelled on the map, with ward boundaries overlaid in grey.



Modelling Approach

We have used the ESC-developed EnergyPath Networks™ tool to produce a series of future local energy scenarios for Peterborough. This tool seeks to develop a full range of decarbonisation options for the local area and then use an optimisation approach to identify the combination that best meets the carbon ambitions in a cost-effective way across the whole system.

EnergyPath Networks (EPN) is a whole system optimisation analysis framework that aims to find cost effective future pathways for local energy systems to reach a carbon target whilst meeting other local constraints. EPN is spatially detailed, covers the whole energy system and all energy vectors, and projects change over periods of time. The focus is decarbonisation of energy used at a local level.

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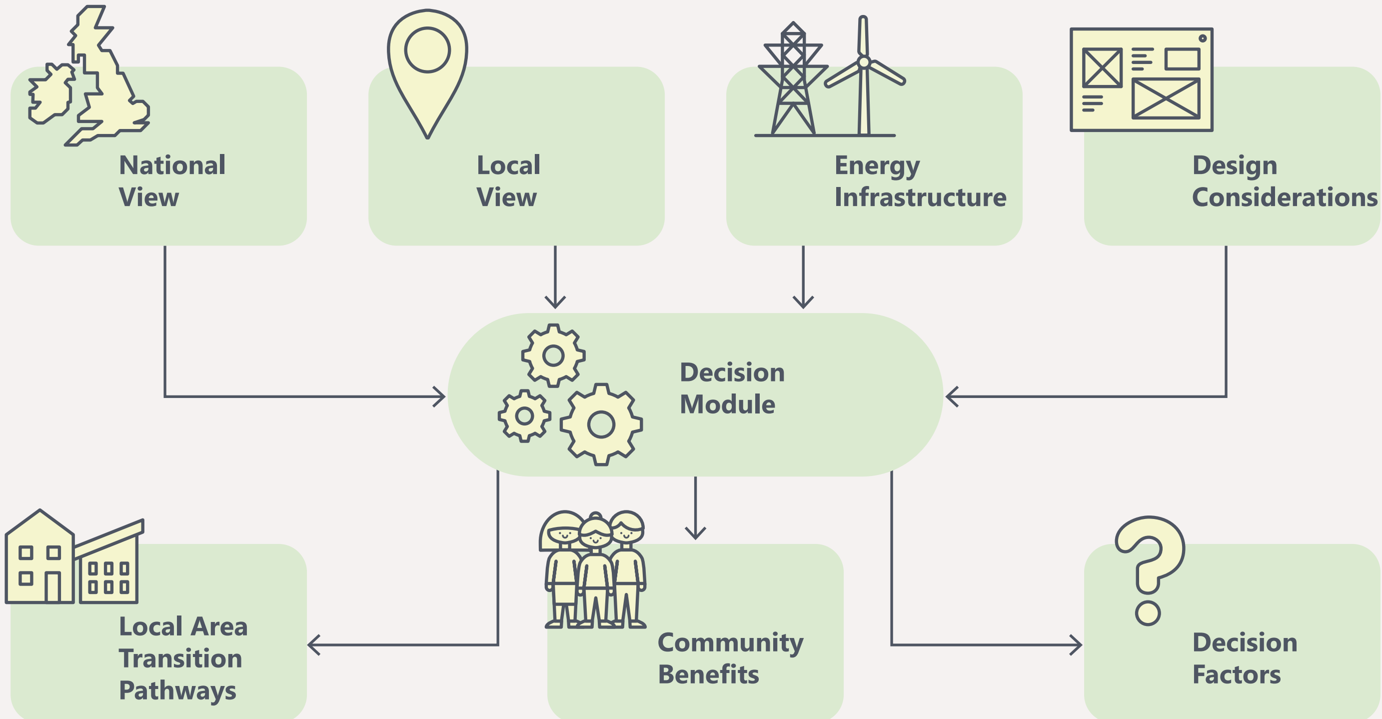
An overview of EPN is shown in the diagram to the right.

At the core of EPN, a Decision Module compares decarbonisation pathways and selects the combination that meets the CO_2 emissions target set for the local area at the lowest possible total cost to society .

A variety of local energy system pathways are possible to meet emissions targets. Running multiple EnergyPath Networks scenarios and doing detailed sensitivity analyses reveals decarbonisation themes that are prevalent across all scenarios.

EPN uses optimisation techniques in the Decision Module to compare many combinations of options (tens of thousands) rather than relying on comparisons between a limited set of user-defined scenarios (although scenarios of different inputs are still typically used and the Decision Module then runs within each of these scenarios).



Modelling Approach

EnergyPath Networks is unique in combining several aspects of energy system planning in a single tool:

- Integration and trade-off between different methods of meeting heat demand – e.g. gas, solid/liquid fuels, electric power, hydrogen, district heating schemes, etc.
- Integration through the energy supply chain from installing, upgrading or decommissioning assets (production, conversion, distribution and storage) to upgrading building fabric and converting building heating systems.
- Inclusion of existing and new build domestic and commercial buildings.
- The spatial relationships between buildings and the networks that serve them, so that costs and benefits are correctly represented for the area being analysed.
- Spatial granularity down to building level when the input data is of appropriate quality.
- A modelled time frame of 2020 to 2050.

Taken together, the analyses enable informed, evidence-based decision-making and can be used to ensure long-term resilience in near-term decisions, mitigating the risks of stranded assets.

The approach to modelling these aspects of the energy system is described in detail over the following pages.

Modelling Approach

Domestic Buildings

The thermal efficiency of domestic buildings is related to the construction methods used, the level of any additional insulation that has been fitted and any modifications that have been undertaken since construction. The oldest buildings in the UK generally have poor thermal performance compared with modern buildings. In addition to building age, the type and size of a building also have a direct influence on thermal performance. For example large, detached buildings have a higher heat loss rate than purpose-built flats, due to their larger external surface area per m^2 of floorspace.

Buildings are categorised into five age bands in EnergyPath Networks, from pre-1914 to the present, shown in the table on the top right. These are broadly consistent with changes in building construction methods (as defined in building regulations) and so represent different levels of 'as built' thermal efficiency. The thermal efficiency of future new homes represents the minimum efficiency level required by current building regulations. There are ten modelled domestic building types, shown in the table on the bottom right. This allows approximately 60 different age and building type combinations which are used to define the thermal characteristics of existing and planned domestic buildings.

Once the current characteristics of a building have been defined, based on its age and type, the basic construction method can then be categorised. For example, the oldest buildings in the region can be expected to be constructed with solid walls. Buildings constructed between 1914 and 1979 are more likely to have been built with unfilled cavity walls. Buildings constructed from 1980 onwards are likely to have filled cavity walls. Where data (for example, Energy Performance Certificates) shows that they are likely to be present, thermal efficiency improvements that have been carried out since construction (such as filling cavity walls) are also included.

Where available, address level data is utilised in the EnergyPath Networks modelling to provide accurate building attributes. Missing building attributes, for example types of wall or windows are filled using rules based on English Housing Survey data.

Property Age Band
Pre – 1914
1914 – 1944
1945 – 1964
1965 – 1979
1980 – Present
New Build

Property Type
Converted Flat: - Mid Floor / End Terrace
Converted flat: - Mid Floor / Mid Terrace
Converted Flat: - Top Floor / End Terrace
Converted Flat: - Top Floor / Mid Terrace
Detached
End Terrace
Mid Terrace
Purpose-Built Flat: - Mid Floor
Purpose-Built Flat: - Top Floor
Semi-detached

Modelling Approach

Domestic Heating Systems

The definition of current (primary) heating systems is handled in a similar way to the definition of the building fabric. Information is used to identify the heating system as follows:

1. Xoserve data is first used to identify which buildings in the local area are not connected to the gas grid.
2. Direct user input is used where the actual heating system in individual buildings is known (e.g. from Energy Performance Certificates).
3. Defining logic rules based on the most likely heating system combinations within each archetype group.

Once the current thermal efficiency of a building has been defined, Ordnance Survey MasterMap and LIDAR data is used to establish its floor area and height. With this knowledge of a building's characteristics there is sufficient information to perform a Standard Assessment Procedure (SAP) calculation. SAP calculations are used to calculate the overall heat loss rate and thermal mass of domestic buildings in the study area.

EnergyPath Networks utilises these SAP results, as well as detailed retrofit and heating system cost data, to group buildings into similar archetypes. EnergyPlus is used to calculate dynamic energy profiles for heat and power demand for each group, for the current and all potential future pathways. These pathways include potential to install varying levels of fabric retrofit and different future heating systems in multiple combinations. Restrictions are applied so that inappropriate combinations are not considered, so for example loft insulation cannot be fitted to a mid-floor flat. EnergyPath Networks also filters out heating systems and storage combinations that cannot be sized to a large enough power within a home to meet a predefined target comfort temperature and hot water requirements based on the EnergyPlus analysis.

Three primary elements are defined in each heating system combination:

1. The main heating system.
2. A secondary heating system which can provide additional heat or hot water.
3. Thermal storage – either not present or a hot water tank.

For each domestic building the modelling assumes that the heating system will be replaced twice between now and 2050. This assumes that heating systems are replaced at their end of life (generally around 15-20 years). On each of these occasions there is an opportunity to change to an alternative heating system and perform some level of building fabric retrofit. Different heating systems reach end of life at different times, but there would need to be some coordination of the change if transitioning to a district heat or community system. Three different levels of retrofit (thermal performance enhancement) are considered, ranging from do-nothing to a full retrofit. In addition, each heating system option can be combined with advanced heating controls and each level of retrofit. Options will be excluded if a new heating system technology is unable to provide sufficient power to meet heat demand in a building with a given level of retrofit. These combinations mean that for each building there can be as many as 126 different future pathways which must be considered.

Modelling Approach

Non-Domestic Buildings

Non-domestic (commercial and industrial) building stock is more diverse than domestic stock. There are a wide variety of construction methods and few robust data sets are available defining the design of any particular building, its heating system or thermal performance. Due to these limitations, an energy benchmarking approach is used to establish the energy demand of the non-domestic stock.

195 Different building types are given an appropriate energy use profile per unit of floor area. The building type represents how the building is used (e.g. industry, retail, offices, school) and is sourced from a variety of datasets including OS Address Base and Energy Performance Certificates.

Benchmarks are defined for electricity (direct electric, ground source heat pump and air source heat pump), gas, hydrogen, oil and heat demand in 30-minute time periods for different characteristic heat days. The characteristic heat days for which energy demand profiles are defined are shown in the table to the right. Benchmarks are defined for current and future use to represent changing energy use over time.

The footprint floor area and height for each building is derived from the OS MasterMap and LIDAR data. The building height is then used to establish the number of storeys, from which the total building floor area is estimated. Using an energy benchmark (derived from CIBSE and CARB2 data) appropriate to the particular use class, the half hour building energy demand for gas, electricity and heat is calculated for each of the characteristic days.

For both domestic and non-domestic pathway options, EnergyPath Networks includes costs of replacing all technologies at their end of life. At these points technologies can be replaced with a lower carbon system or like-for-like. For example, even in a scenario without a local carbon target, costs will be incurred when boilers and windows are replaced with analogous technologies.

Characteristic Heat Day
Autumn Weekday
Autumn Weekend
Peak Winter
Spring Weekday
Spring Weekend
Summer Weekday
Summer Weekend
Winter Weekday
Winter Weekend

Modelling Approach

Electricity Network Infrastructure

In order to assess potential options for future changes to energy systems, knowledge of current electricity, gas and heat network routes and capacities is required. From this the costs of increasing network capacities in different parts of the local area, as well as extending existing networks to serve new areas, can be calculated.

The road network is used in EnergyPath Networks as a proxy to calculate energy network lengths. Substation capacities are established using DNO data and steady-state load flow modelling of networks. For example, EnergyPath Networks will find the load at which a Low Voltage (LV) feeder will require reinforcement and the costs associated with doing so. The cost of operating and maintaining the networks varies with network capacity and is modelled using a cost-per-unit length, broken down by network asset and capacity.

The EnergyPath Networks method does not replicate the detailed network planning and analyses performed by network operators. Rather, the energy networks are simplified to a level of complexity sufficient for numerical optimisation and decision-making. The method is used to model the impact of proposed changes to building heat and energy demand on the energy networks that serve them, for example increased or reduced capacity. The costs of these impacts can then be estimated and the effects of different options on different networks can be compared. Only network reinforcements required inside the study area are explicitly considered as options in EPN.

Western Power Distribution (WPD) and UK Power Networks (UKPN) provided the following data for the current electricity network as both DNOs supply Peterborough:

1. Locations and nameplate capacities of the HV (33kV to 11kV) and LV (11kV to 400V) substations.
2. HV to LV substation connections.

EnergyPath Networks synthesises the routes of the HV to LV substation connections assuming that feeders follow the shortest route allowed by the road network. Customer connections are then derived based on nearest substation and peak load constraints for each feeder. Non-domestic buildings with high demands are assumed to connect directly to the HV network. Network feeder capacities are then calculated based on the current load on each feeder and a headroom allowance. Voltage drop and thermal limits are considered when establishing asset capacity requirements.

EnergyPath Networks performs steady state load flow modelling for electricity and heat networks using the Siemens tool PSS® SINCAL.

Once all the building data has been analysed and the buildings located, it is possible to identify their nearest roads, which shows where the buildings are most likely to be connected to energy networks. In this way the total load and the load profile for each energy network can be calculated at different scales from individual building level, through local networks up to aggregate values for the whole study area. This allows an understanding of different energy load scenarios in different parts of the local area and the energy flows between those locations. In addition, an understanding of network lengths and required capacities can be established.

Modelling Approach

Analysis Areas

Due to the complexity of the number of different options available in EnergyPath Networks (for buildings, networks and generation technologies) the total problem cannot be solved at individual building or network asset level. The study area (Peterborough) is divided into a number of spatial analysis areas, shown in the map below. Decisions are made at this level based on aggregating similar buildings and network assets within each
197 area.

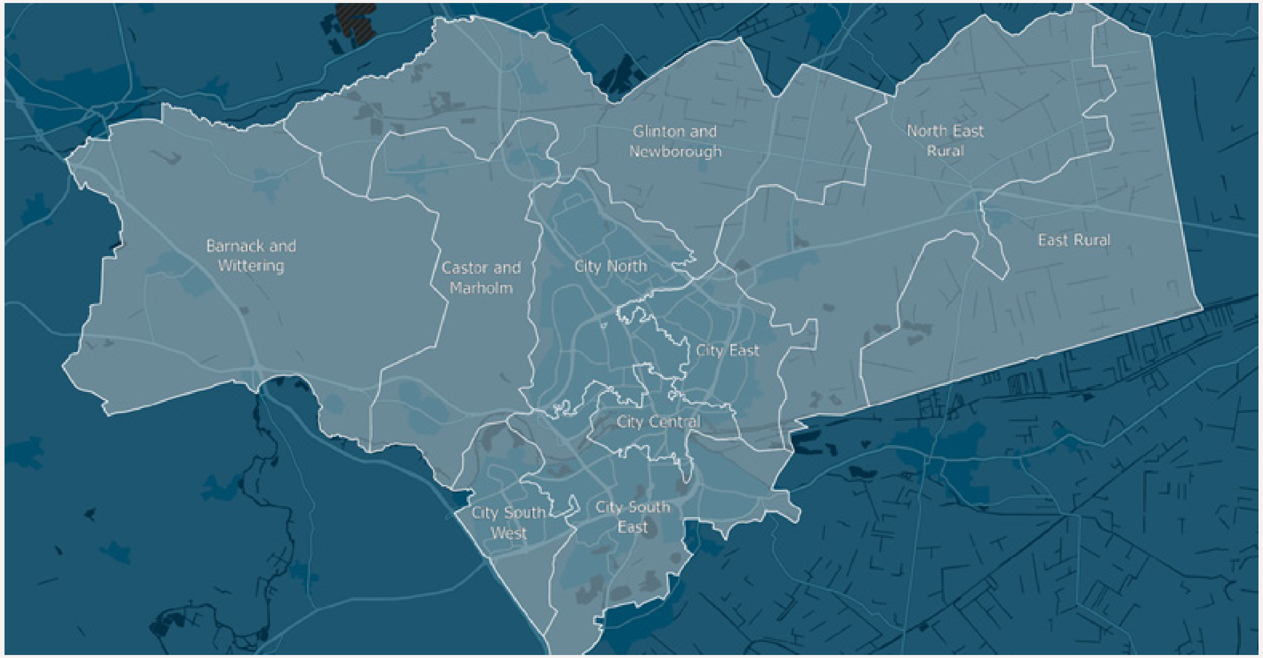
The analysis areas are necessary within the EnergyPath Networks model but do not correspond directly to local districts, wards or neighbourhoods.

Within each analysis area, different components of the system are aggregated. Aggregation of buildings is performed based on energy demand and cost of retrofitting insulation and new heating systems. This way, similar buildings within an individual analysis area will all follow the same pathway. Similarly, decisions on network build and reinforcement are made at an aggregated level. If the electricity loads in one analysis area increase, such that the aggregated capacity of the low voltage feeders is exceeded, then reinforcement of all low voltage feeders within that area will be assumed to be required. The same applies for all other aspects of the energy networks such as low voltage substations, high voltage feeders and substations and heat network capacity.

Since the network options are aggregated, it is important that the boundaries between analysis areas do not cut across the electricity network. It would not be realistic to reinforce the 'downstream' end of an electricity feeder without considering the impact of the loads on those components further upstream in that network.

To ensure consistency in the analysis of electricity network options, the study area was divided by considering each high voltage substation within the local area and all of the electricity network downstream of each substation to give the analysis areas discussed above. Some simplifications to create continuous areas and to remove a low usage private wire substation were applied.

Once the analysis areas had been defined, energy network links between them were defined. This allows transmission of heat, gas and electricity across the analysis area boundaries.



Modelling Approach

Local Energy System Design Considerations

Options which are not considered technically feasible are excluded from EnergyPath Networks – for example, fitting loft insulation into a mid-floor flat or cavity wall insulation to a building which has solid walls.

There are other options which, whilst they may be possible, are not practical in a real-world environment. For example, the use of ground source heat pumps in areas of dense terraced housing: a lack of space means that cheaper ground loop systems cannot be fitted, whilst 198 there is insufficient access for the equipment required to create vertical boreholes. In addition, the heat demand for a row of terraced houses may cause excessive ground cooling in winter leading to inefficient heat pump operation and a need for additional top-up heat from an alternative source.

Consumer preferences also influence suitability of certain options. The installation of domestic hot water tanks for heat storage is a good example. Many low-carbon heat technologies, such as air source heat pumps, work at a lower output power than conventional gas boilers, and this can require the use of heat storage in order to be able to meet peak demand for heat on cold days. However, many households have removed old hot water tanks and fitted combi-boilers to provide hot water on demand. This allowed the space previously occupied by the hot water tank to be repurposed for other uses, which householders find valuable, such as additional household storage.

For example, the English Housing Survey shows that 54% of homes had a combi-boiler in 2016 with this figure rising by around 2% a year since 2001. These consumers often place a high value on the space that has been made available by doing this and are unlikely to embrace heat solutions that require large amounts of domestic space to be sacrificed. A proxy for the value that consumers place on space in their homes is property market values normalised by floor area. With median house price costs in England and Wales in 2017 varying from £32,000 (within County Durham) to £2,900,000 (within Westminster) it is clear that the options for using space for domestic heat storage are likely to be heavily dependent on local factors.

Assumptions and Inputs

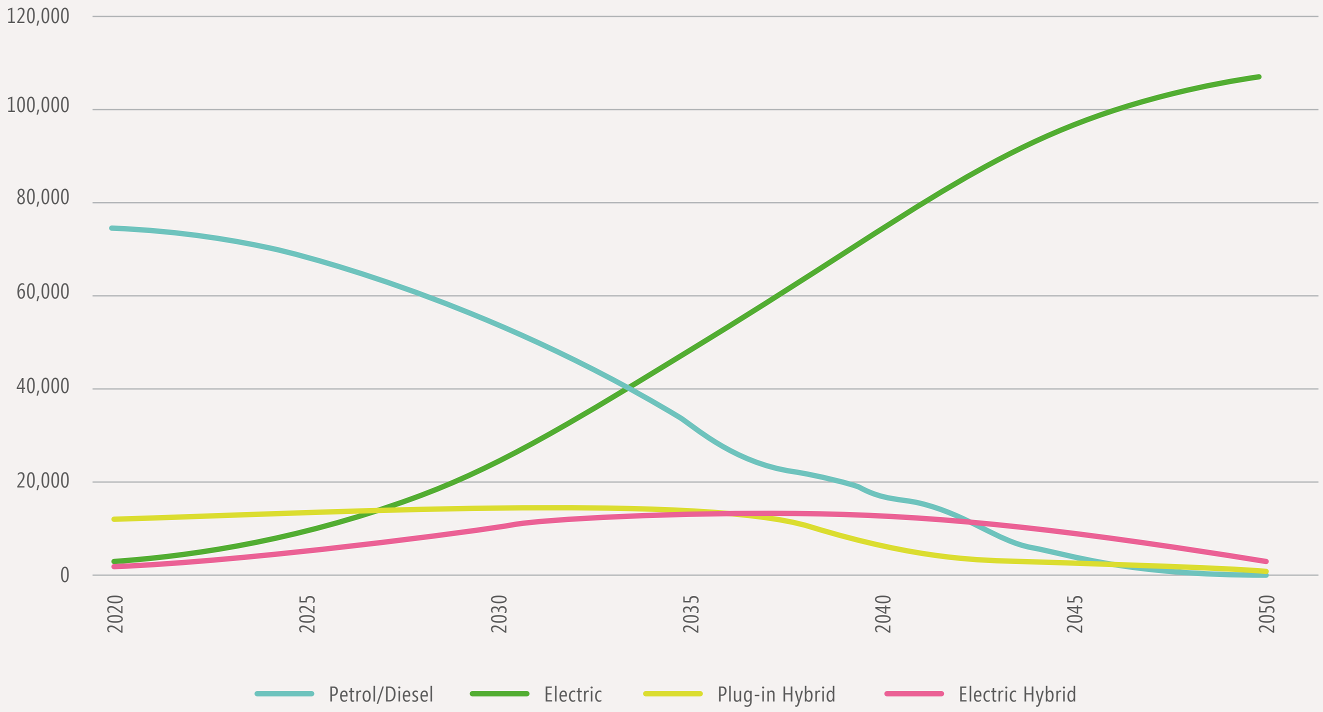
Any technical modelling exercise requires decisions to be made as to the level of complexity and detail that is appropriate. There are several areas where limitations have been applied to limit the complexity of the EnergyPath Networks analysis to keep the scale of the analysis practical, such as grouping buildings into archetypes.

Fixed Input Parameters

Some parameters are considered as fixed inputs
199 within EnergyPath Networks. That is, they are derived externally and presented as inputs to the tool. Any options to vary these parameters are excluded from the decision module. The following energy demands are modelled as inputs:

- Domestic lighting and appliance demands are based on data from DECC's (Department of Energy and Climate Change) household electricity survey which gives these demands for different house types.
- Electric vehicle numbers and charging profiles are based upon assumed take-up rates for electric vehicles and are based on car journeys extracted from the Department for Transport's National Travel Survey. This means that distances travelled (level of charge required) and times of arrival (time of charging) reflect the diversity of real world use. The assumed uptake profile of Electric Vehicles for Peterborough is shown in the graph below.
- The EV charging profiles reflect a vehicle charging immediately after it returns home and so represent a worst case scenario for peak network loads.
- Non-domestic building demands for current systems and future transition options are calculated based on building use and a set of energy benchmarks.

Total number of cars by type



Assumptions and Inputs

Building Modelling

Within the domestic building simulation, a standard target temperature profile is taken from SAP and used for all domestic buildings. This is intended to reflect typical building use patterns. It is recognised that real-world building use will deviate from this profile, as shown by the Energy Follow-Up Survey (EFUS). To reflect this, diversity factors are applied within EnergyPath Networks when individual building energy demands are aggregated to calculate total network demands. These diversity factors modify both the magnitudes of the demands and the times at which they occur.

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Construction standards are assumed for buildings of different ages. For example, all pre-1914 buildings are assumed to have solid walls. Similarly, for some building ages the thermal conductivity of the walls is assumed to be the same for each level of insulation. For example, all walls in buildings constructed between 1945 and 1964 which now have filled cavities are assumed to have the same thermal performance. Note that these performance assumptions are based on 'traditional' brick construction and assume that insulation is correctly installed and performs to its technical potential. Buildings constructed in other ways may not be correctly represented in terms of their thermal performance.

Network Modelling

The network modelling approach assumes that development of future energy systems should be driven by consumer needs. On this basis, the EnergyPath Networks modelling framework works on a traditional network reinforcement model. If load on a network is calculated to exceed capacity, then the network will be reinforced to meet that load.

There is limited capability within the model to consider 'Smart' network control or all aspects of Demand Side Response. For example, if a particular feeder in a street was overloaded, a demand side response could be to raise the price of electricity at peak times to decrease consumer demand on the network. EnergyPath Networks will deploy technologies that minimise electricity use at times of peak costs if it is cost effective to do so, but it is not designed to model the behaviours of the DNO or the consumer in this scenario.

The load-flow modelling is not intended to replace full dynamic network modelling conducted by network operators. EPN uses a steady-state approach which is appropriate for establishing peak loads and the capacity required to meet them, to understand the influence of different options on network costs. It considers both voltage and temperature constraints.

Technology Cost and Performance

EnergyPath Networks models the future energy system which is considered to have the lowest cost to society whilst meeting defined carbon targets. The selected options are influenced by the costs associated with different technologies. The modelled technology cost should represent the cost in a fully competitive UK market, with significant volumes of the technology being sold. This is currently the case for markets for some technologies such as a gas boiler, but not for others such as heat pumps.

Where the market is not fully developed it is not appropriate to use the current price charged to consumers. Instead, an estimate of the current costs of buying and installing is made using a variety of data sources to ensure that estimated costs are within reasonable bounds.

Optimisation Variables

A variety of technology options have been considered within the EnergyPath Networks analysis. These are described over the following pages.

Primary Heating Systems

Different current and future heating system combinations have been considered within the analysis. The heating systems assessed are as follows:

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- **Gas boilers** are the main source of heat for domestic premises in the UK at present.
- **Oil / LPG boilers** are a popular heat source for those buildings which are not connected to the gas network.
- **Biomass boilers** can provide a low-carbon heat source by burning fuel derived from sustainably sourced wood products.
- **Hydrogen boilers** could provide a low-carbon heat source once hydrogen becomes available.
- **Heat pumps** use electrical energy to transfer heat energy from one source to another. They are similar to a domestic refrigerator which transfers heat from a cold space to the surrounding room. This is reversed in a heat pump system so that the internal space is warmed by transferring heat from outside. Heat pumps have an advantage compared to other electrically powered heat sources as they produce more heat energy than the electrical energy required to power them. Different types of heat pump are considered:
    - **Low Temperature Air Source Heat Pumps (ASHPs)** use the outside air as the source of heat and provide hot water to the heating system at temperatures around 45oC. This temperature is lower than that normally used for domestic heating with a gas boiler and so may require changes to heating distribution systems, such as the provision of larger radiators to allow the building to be heated effectively. These changes are accounted for in the costs of the technology used in the model.
    - **Low Temperature Air Source Heat Pump – Gas Boiler Hybrids** use a combination of a low temperature ASHP to provide a large proportion of the heat demand but can top up this heat using a conventional gas boiler at times when it is not efficient to operate the heat pumps, or the heat pump cannot meet the required demand.
    - **Low Temperature Air Source Heat Pumps** can also have supplementary heat provided by direct electric heating when required.
    - **High Temperature Air Source Heat Pumps** are similar to a low temperature Air Source Heat Pump but provide hot water at a higher temperature (typically 55oC) which may remove the need for other modifications to the heating system. They generally operate at a lower efficiency than low temperature air source heat pumps.
    - **Ground Source Heat Pumps** use heat energy stored in the ground to provide hot water to the heating system. Since ground temperatures are higher than air temperatures in winter they can operate more efficiently and provide higher water temperatures than air source heat pumps. Space is required, however, to install pipework to extract heat from the ground and this adds considerably to the cost of installing these systems.
- **Electric Resistive storage heating** is the most commonly used system for buildings which have electric heating. Room heaters are typically charged overnight (where there can be an option to charge the system at a lower, night rate electricity tariff) and then release this heat over the course of the following day.
- **Electric Resistive heating without storage** provides instant heat through panel, fan or bar heaters.
- **District heating** provides heat to buildings through pipes that carry the heat from a central heat source. In current systems, this is typically a large gas boiler or gas fired Combined Heat and Power (CHP) plant which provides heat to the network and generates electricity which is either consumed locally or exported to the electricity network. Once installed these systems can be converted from using gas to lower carbon alternatives such as a large-scale Ground Source Heat Pump or a biomass boiler. Equally, if there is no gas supply in the first place, then systems can be designed from the outset with such alternatives.

Optimisation Variables

Building Retrofit Options

Domestic buildings in the UK have been constructed to a wide variety of building regulations depending on their age. Many older buildings have low levels of insulation and require much more energy to keep them warm in winter than those built to more recent regulations.

There are many options available to reduce heat loss from older buildings some of which could also be applied to more modern buildings. Loft insulation, wall insulation (cavity or solid depending on existing building fabric) and triple glazing retrofit options are modelled within the EnergyPath Networks model.

In addition, some minor improvements are considered as secondary measures. That is, "quick wins", such as draught proofing, that could be installed at the same time as more substantial building fabric upgrades.

Solar

EnergyPath Networks considers the deployment of solar panels within a local area to generate electricity and hot water. Both systems can produce significant amounts of energy in summer months but may produce close to zero energy on winter days when the sun is low in the sky and days are much shorter. This may coincide with times of greatest heat demand, so alternative energy supply options need to be available at these times.

In the case of electricity generation (solar photovoltaics) the power might be used by the home owner or might be exported to the electricity network if the amount being generated exceeds the demand of the generating building.

Solar hot water systems typically heat water in a hot water tank by circulating a fluid between a heating coil within the tank and the roof mounted panel heated by the sun.

Heat Storage

Heat storage can be considered at two scales:

- Individual domestic storage in hot water tanks.
- Large-scale storage in association with heat networks.

In both cases, it is assumed that more heat could be produced at certain times than is required to meet demand. This provides an option to store that heat and then release it back into the heating system at times when the peak demand is high. It can sometimes be a cost-effective solution as it allows a less powerful heat source to be installed that can be topped up using stored heat at times of peak demand.

Depending on the location in the UK, the value of the floor space lost could outweigh the capital savings associated with installing a heating system with a hot water tank over a more powerful heating system without a hot water tank.

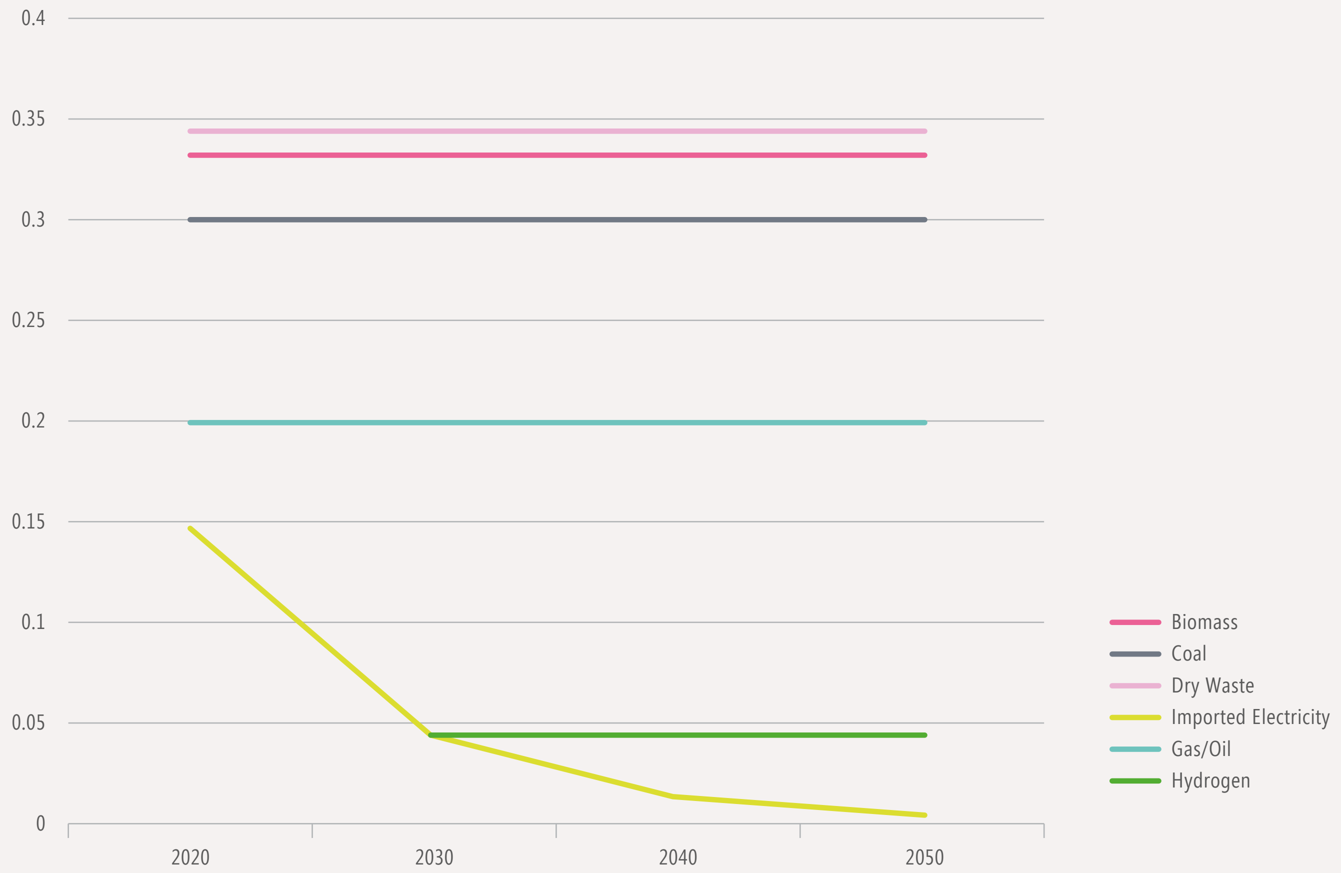
Emission Calculations

EPN optimises to calculate the lowest cost route to meeting a defined carbon target. Domestic, industrial and commercial emissions (i.e. those related to buildings) are in scope for the model. Transport emissions (beyond personal vehicles) and those resulting from land use change are excluded from the analysis.

Some types of non-domestic buildings are projected to have reductions in demand and so emissions over the time period to 2050, even if their heat demand continues to be met using gas or electricity. Emission reductions from these buildings can occur due to:

- Conversion of the national grid to low-carbon electricity which decarbonises the emissions associated with local electricity consumption as shown in graph to the right.
- Reduced gas use in buildings where there is historical evidence to support this trajectory – mainly associated with professionally managed buildings whose managers have a commercial incentive to improve energy efficiency.

CO_2 Emissions Inputs to EnergyPath Networks



Note that it is assumed Hydrogen does not become available until the mid-2030s and therefore there are no emissions for Hydrogen prior to 2030.

Cost Optimisation Approach

EnergyPath Networks has been used to provide evidence to support local area energy planning and the development of local energy system designs able to meet local carbon reduction targets. The importance of other factors such as fuel poverty and health benefits should be recognised in the planning of the future energy system but they are not core parameters in EnergyPath Networks.

Once a set of potential options for the buildings and energy networks in the local area have been identified, the Decision Module compares all valid option combinations and selects the set that meets the local CO_2 emissions target at minimum cost.

The costs considered are the total cost to society for the whole energy system including capital costs, fuel costs and operation and maintenance costs to 2050.

The future costs are discounted. Discounting is a financial process which aims to determine the “present value of future cash flows”, or in other words: calculating what monies spent or earned in the future would be worth today. Discounting reflects the “time value of money” – one pound is worth more today than a pound in, say, one year’s time as money is subject to inflation and has the ability to earn interest. A discount rate of 3.5% is used, as suggested in the UK Treasury’s “Green Book” (used in the financial evaluation of UK Government projects).

Taxes and subsidies are excluded as these are transfer payments with zero net cost to society. Their inclusion in the analysis might result in the selection of sub-optimal solutions. The intention is that, once evidence has been used to define a local area energy strategy and possible future local energy system designs then appropriate delivery methods and associated policies can be developed to enable delivery.

Summary of Data Sources

Buildings and Roads

Category	Data Source	Usage	Owner	Reference and Copyright (if applicable)
Domestic, Non-Domestic and Roads	Ordnance Survey AddressBase Premium, MasterMap Topography, Highways, Building Heights, Sites, VectorMap District, Open Roads	• Shows location, footprint and classification of buildings, plus road layout for network modelling. • Provides status and classification of non-domestic building (e.g. office, retail). • Informs building size and height. • Latest data obtained September 2021 for buildings and roads.	Ordnance Survey	© Crown copyright and database rights 2021 OS 100024236
Domestic and Non-Domestic	Lidar Data	• Used to obtain building heights	Department for Environment, Food & Rural Affairs	Lidar data © Crown 2021 copyright Defra licenced under the Open Government Licence (OGL). https://www.nationalarchives.gov.uk/doc/open-government-licence/version/3/
Domestic and Non-Domestic	Energy Performance Certificates (EPC)s	• ESC-built address matching algorithm to match housing attributes from EPCs • Informs building-level attributes – e.g. current heating system, levels of insulation. • Non-domestic Energy Performance Certificates (EPC) and Display Energy Certificates (DEC) to provide further building attributes and demands.	Ministry of Housing, Communities & Local Government	Energy Performance Certificates obtained from https://epc.opendatacommunities.org/ under the Open Government License v3.0 https://www.nationalarchives.gov.uk/doc/open-government-licence/version/3/
Domestic	English Housing Survey	• Informs building-level attributes – e.g. current heating system, levels of insulation.	Ministry of Housing, Communities & Local Government	© Crown copyright material is reproduced with the permission of the Controller of HMSO and the Queen's Printer for ScotlandMinistry of Housing, Communities and Local Government. (2021). English Housing Survey, 2017: Housing Stock Data: Special Licence Access. [19 March 2019]. 2nd Edition. UK Data Service. SN: 8546, http://doi.org/10.5255/UKDA-SN-8546-2
Domestic	Off Gas Postcodes from Xoserve	• Used to determine off-gas buildings	Xoserve	Off Gas Postcodes © Copyright Xoserve Limited 2020
Domestic	Heritage Data: Listed Buildings	• Potential constraint on retrofit for listed buildings	Historic England	© Historic England 2021. Contains Ordnance Survey data © Crown copyright and database right 2021. The Historic England GIS Data contained in this material was obtained on 22/09/2021. The most publicly available up to date Historic England GIS Data can be obtained from http://www.HistoricEngland.org.uk
Domestic	DECC household electricity survey	• Domestic appliance use profiles	UK Government	© Crown copyright, 2013. Data obtained from https://www.gov.uk/government/publications/household-electricity-survey--2 under the Open Government License v3.0 https://www.nationalarchives.gov.uk/doc/open-government-licence/version/3/
Domestic	ETI's Optimising Thermal Efficiency of Existing Housing Project	• Retrofit Costs	ETI	https://www.eti.co.uk/library/optimising-thermal-efficiency-of-existing-housing
Non-Domestic	Land Registry	• Informs classification of non-domestic building.	UK Government	© Crown copyright, 2020. Data obtained from https://use-land-property-data.service.gov.uk/datasets/inspire/download under the Open Government License v3.0 https://www.nationalarchives.gov.uk/doc/open-government-licence/version/3/
Non-Domestic	Energy benchmarks (kWh/m^2) developed in conjunction with Arup	• Non-Domestic building energy profiles	Energy Systems Catapult	
Future Building Stock	Peterborough Land Supply	• Identify location and number of buildings with planned construction dates	Peterborough City Council	

Summary of Data Sources

Networks, Generation, Emissions and Transport

Category	Data Source	Usage	Owner	Reference and Copyright (if applicable)
Networks	Cadent Gas	• Mapping of pipes including material, size and pressure.	Cadent Gas	
Networks and Generation	WPD	• Substation locations, capacities and headroom (for 11kV-400V upwards)•Embedded Capacity Register used to identify registered generation assets within the region	WPD	Supported by WPD Open data. Wester Power Distribution network data downloaded from connecteddata.westernpower.co.uk licensed under the Open Government Licence v3.0 www.westernpower.co.uk/open-data-licence
Networks and Generation	UKPN	• Substation locations, capacities and headroom (for 11kV-400V upwards)•Embedded Capacity Register used to identify registered generation assets within the region	UKPN	UK Power Networks substation network data downloaded from www.ukpowernetworks.opendatasoft.com licensed under CC by 4.0 https://creativecommons.org/licenses/by/4.0/
Networks	ETI Infrastructure Calculator	• Electricity, Gas, Heat and Hydrogen Network Costs	ETI	https://www.eti.co.uk/programmes/energy-storage-distribution/infrastructure-cost-calculator
Networks	ETI Macro Distributed Energy project	• Energy Centre costs and technical parameters	ETI	http://www.eti.co.uk/library/macro-distributed-energy-project/
Networks and Generation	District heating study for Peterborough - HNDU Detailed Project Development stage - Techno-economic feasibility analysis review Draft report (November 2021)	• Capacity and locations of planned generation assets for PIRI heat network•Locations of buildings to be connected to PIRI heat network	Element Energy and Peterborough City Council	
Networks	East Coast Hydrogen Feasibility Report	• Relative proportions of Blue/Green Hydrogen for East Coast Hydrogen•87 % 'blue', 11 % 'green', 0.044 tCO_2e/MWh, £61.20/MWh between 2030-2040 and £54.10 for 2040-2050.	National Grid	https://www.nationalgrid.com/uk/gas-transmission/document/138181/download
Networks	BEIS Hydrogen Production Costs	• Hydrogen Cost and Emissions Calculations	UK Government	© Crown copyright, 2021. Data obtained from https://www.gov.uk/government/publications/hydrogen-production-costs-2021 under the Open Government License v3.0 https://www.nationalarchives.gov.uk/doc/open-government-licence/version/3/
Networks and Emissions	BEIS Green Book	• Electricity Grid Prices and Emissions		© Crown copyright, 2021. Data obtained from https://www.gov.uk/government/publications/valuation-of-energy-use-and-greenhouse-gas-emissions-for-appraisal under the Open Government License v3.0 https://www.nationalarchives.gov.uk/doc/open-government-licence/version/3/
Generation	Renewable Energy Planning Database	• Current planned and operational renewable energy installations (above 150kw)•	UK Government	© Crown copyright, 2020. Data obtained from https://www.gov.uk/government/publications/renewable-energy-planning-database-monthly-extract under the Open Government License v3.0 https://www.nationalarchives.gov.uk/doc/open-government-licence/version/3/
Generation	Feed-in-tariff install reports	• Current levels of domestic PV by postcode	UK Government	© Crown copyright, 2020. Data obtained from https://www.ofgem.gov.uk/environmental-and-social-schemes/feed-tariffs-fit/contacts-guidance-and-resources/public-reports-and-data-fit/installation-reports under the Open Government License v3.0 https://www.nationalarchives.gov.uk/doc/open-government-licence/version/3/
Generation	Peterborough planning database	• Used to identify planned local generation sites.	Peterborough City Council	https://www.peterborough.gov.uk/council/planning-and-development/planning-and-building/search-applications
Emissions	National Atmospheric Emissions Inventory (NAEI)	• Locations of large emission sources	National Atmospheric Emissions Inventory	© Crown 2021 copyright Defra & BEIS via naei.beis.gov.uk, licenced under the Open Government Licence (OGL). https://www.nationalarchives.gov.uk/doc/open-government-licence/version/3/

Summary of Data Sources

Land Classification and Electric Vehicles

Category	Data Source	Usage	Owner	Reference and Copyright (if applicable)
Land	Flood Risk Maps	• Identification of areas unsuitable for ground mounted solar PV	UK Government	© Crown copyright, 2021. Data obtained from https://www.gov.uk/government/publications/flood-risk-maps-2019 under the Open Government License v3.0 https://www.nationalarchives.gov.uk/doc/open-government-licence/version/3/
Land	Natural England: Sites of Special Scientific Interest, Special Areas of Conservation, National Nature Reserves, Areas of Natural Beauty, Ramsar – Wetlands Sites	• Identification of areas unsuitable for ground mounted solar PV	Natural England	© Natural England copyright, 2021. © Crown copyright and database right. Data obtained from https://naturalengland-defra.opendata.arcgis.com/search?collection=Dataset under the Open Government License v3.0 https://www.nationalarchives.gov.uk/doc/open-government-licence/version/3/
Land	Heritage Data: National Parks and Woodland	• Identification of Land use	Historic England	© Historic England 2021. Contains Ordnance Survey data © Crown copyright and database right 2021. The Historic England GIS Data contained in this material was obtained on 22/09/2021. The most publicly available up to date Historic England GIS Data can be obtained from http://www.HistoricEngland.org.uk
Land	Agricultural Land Classification	• Identification of areas unsuitable for ground mounted solar PV	UK Government	© Crown copyright, 2021. Data obtained from https://data.gov.uk/dataset/952421ec-da63-4569-817d-4d6399df40a1/provisional-agricultural-land-classification-alc under the Open Government License v3.0 https://www.nationalarchives.gov.uk/doc/open-government-licence/version/3/
Land	CORINE	• Identification of areas unsuitable for ground mounted solar PV	Environmental Information Data Centre	Cole, B.; De la Barreda, B.; Hamer, A.; Codd, T.; Payne, M.; Chan, L.; Smith, G.; Balzter, H. (2021). Corine land cover 2018 for the UK, Isle of Man, Jersey and Guernsey. NERC EDS Environmental Information Data Centre. https://doi.org/10.5285/084e0bc6-e67f-4dad-9de6-0c698f60e34dData obtained from https://catalogue.ceh.ac.uk/documents/084e0bc6-e67f-4dad-9de6-0c698f60e34d Under the Open Government License v3.0 https://www.nationalarchives.gov.uk/doc/open-government-licence/version/3/
Electric Vehicles	Zap-Map®	• Location and speed of public chargepoints.•National Chargepoint Registry (NCR) has not been used since its data is included within Zap-Map's national database.	Zap-Map®	https://www.zap-map.com/
Electric Vehicles	DVLA Vehicle Licensing Statistics	• Baseline data for ESC analysis on the expected uptake of EVs on the network.	UK Government	© Crown copyright, 2021. Data obtained from https://www.gov.uk/government/collections/vehicles-statistics under the Open Government License v3.0 https://www.nationalarchives.gov.uk/doc/open-government-licence/version/3/
Electric Vehicles	National Travel Survey	• Input for EV charging profiles	UK Government	© Crown copyright, 2021. Data obtained from https://www.gov.uk/government/collections/national-travel-survey-statistics under the Open Government License v3.0 https://www.nationalarchives.gov.uk/doc/open-government-licence/version/3/

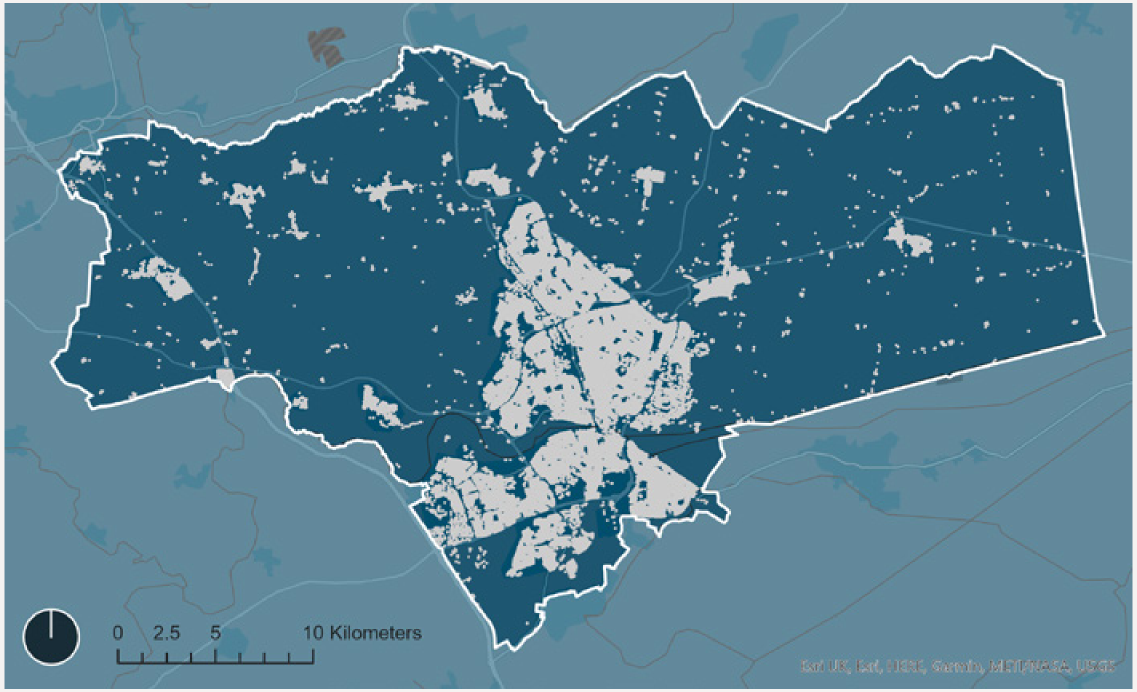
System Baseline

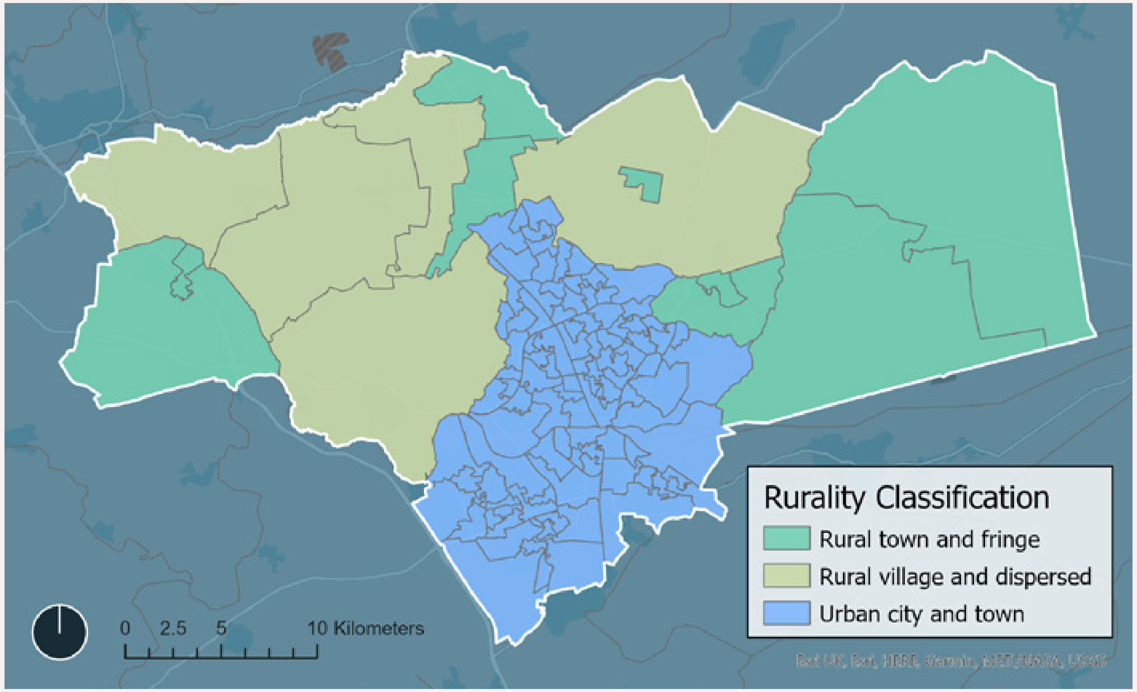
Current View: Local Buildings

Peterborough currently has around 87,000 dwellings which are mainly located in the south and central parts of the local authority area. The top map shows the location of these existing dwellings and non-domestic, commercial, industrial buildings to give an illustration of the overall built environment.

The bottom map shows the rurality classification
209 of each lower-level super output area (LSOA*).
Together these maps show the high density of buildings in and around Peterborough centre.

Between 2022 and 2036, an additional 15,000 dwellings are expected to be built across Peterborough. When built, these dwellings will represent almost 17.5% of the housing stock.





* LSOAs are small geographical areas with an average population of around 1,500 people.

Current View: Dwelling Type & Age

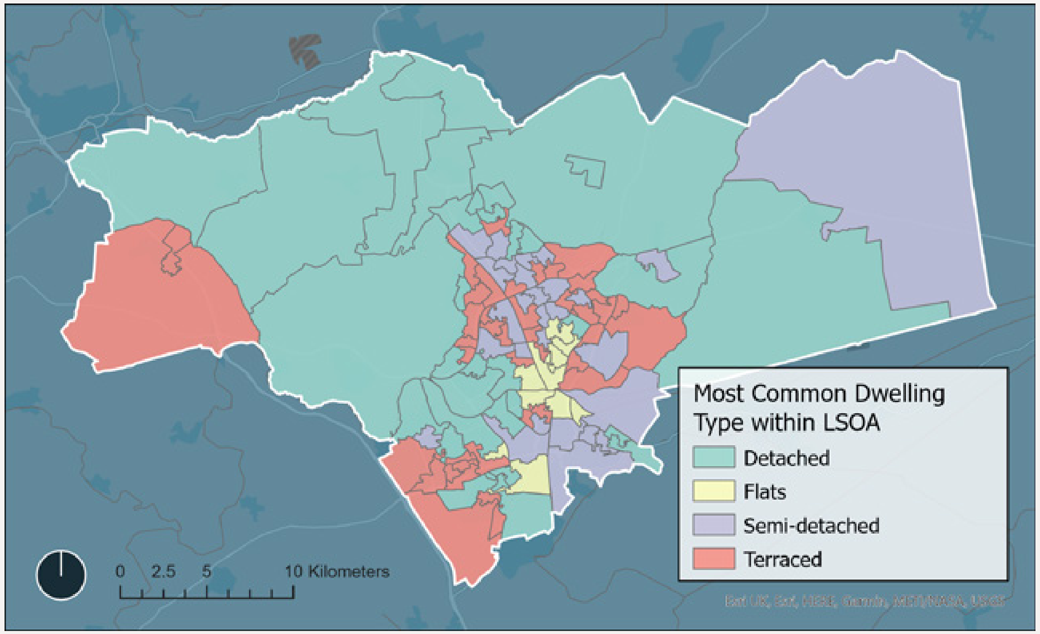
To understand the current housing stock in more detail, it was segmented by: type, age, floor area, heating system, loft insulation level, wall type, and window type. The maps below show the modal (i.e. the most common) dwelling type and age within each LSOA.

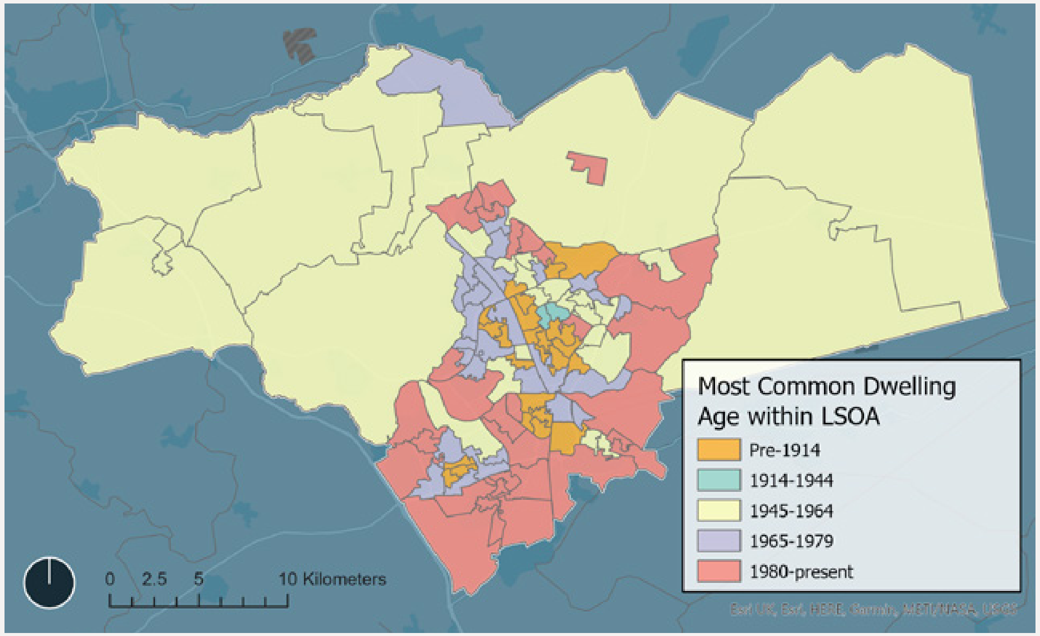
From the maps it can be seen that in the high-density centre of Peterborough there is a predominance of smaller dwelling such as flats and terraces, whereas in the more rural zones larger detached dwellings are more common.

The age of the dwellings also varies spatially. In the majority of the rural zones, the dwellings were most commonly built in the post-war period.

A slight divergence from the pattern is shown in the image to the right where terraced dwellings are common in a rural area in the west of Peterborough.

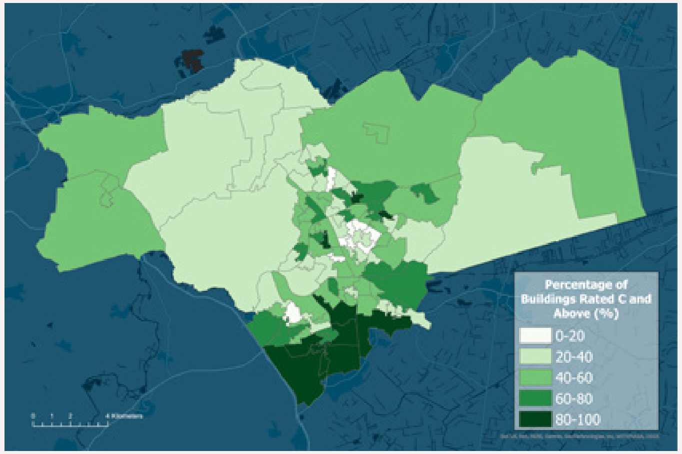
Image from GoogleMaps of Main Street in the west of the region near Wittering.

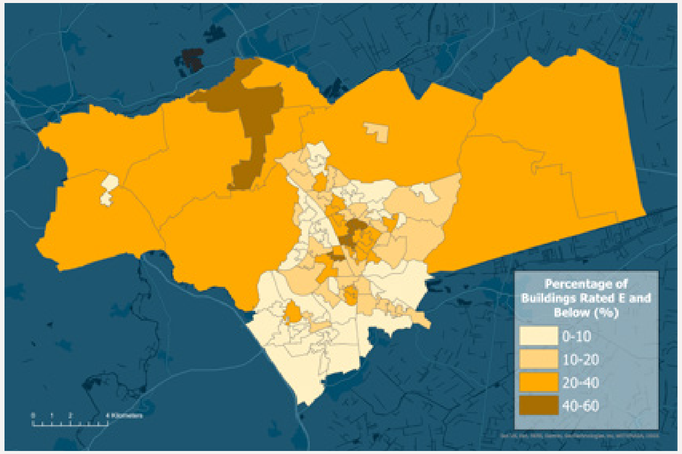


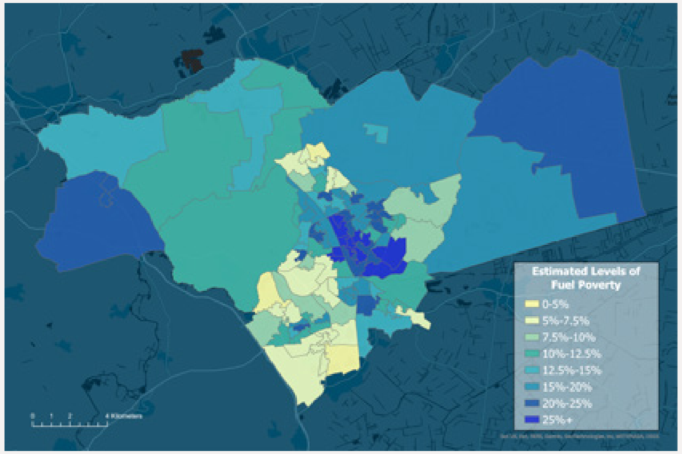


Current View: Domestic Energy Performance

211







The maps above show the current energy efficiency performance of dwellings across Peterborough in different ways: on the left, those with a good level of insulation; and in the centre those with a poor level of insulation. Combined, these two maps show that dwellings in the rural areas typically have worse EPC* ratings than those in urban areas. This is unsurprising as smaller dwellings such as flats and terraces have a lower heat loss due to their lower external exposure.

At a more practical level, the map in the centre can also indicate where to focus government funding (e.g. Home Upgrade Grant) which is only applicable to dwellings with EPC ratings of E or below.

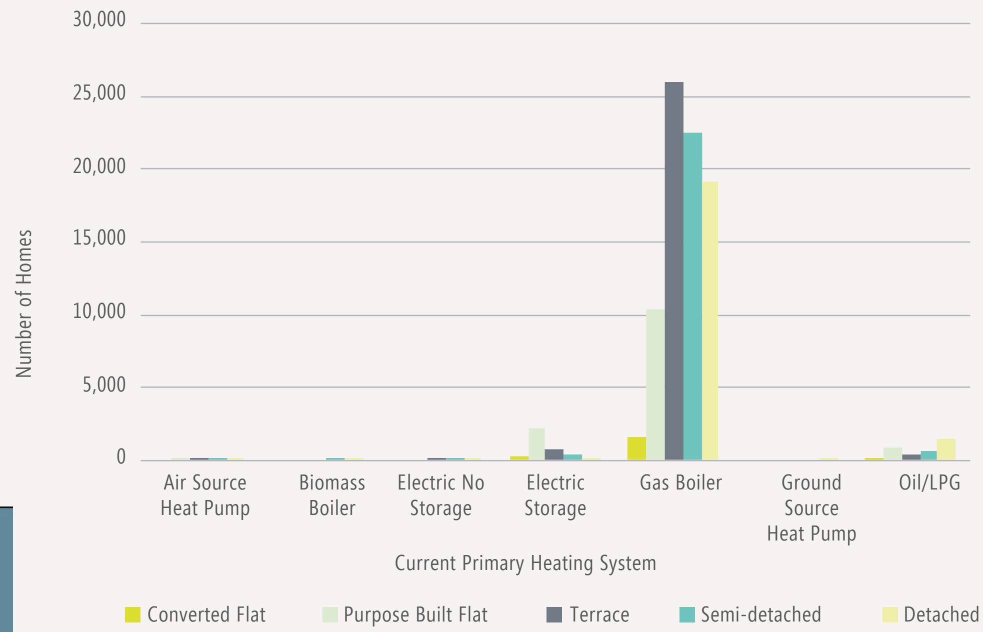
The map on the right shows the estimated level of fuel poverty in each LSOA. Note, the data used is from 2019 and therefore does not reflect any expected increase in fuel poverty due to 2022 fuel prices. However, a broad trend can be identified by comparing the EPC maps and the fuel poverty map. LSOAs where dwellings have a higher average energy performance rating, have a lower incidence of fuel poverty showing the societal link between energy, retrofit and personal finances.

* Energy Performance Certificates

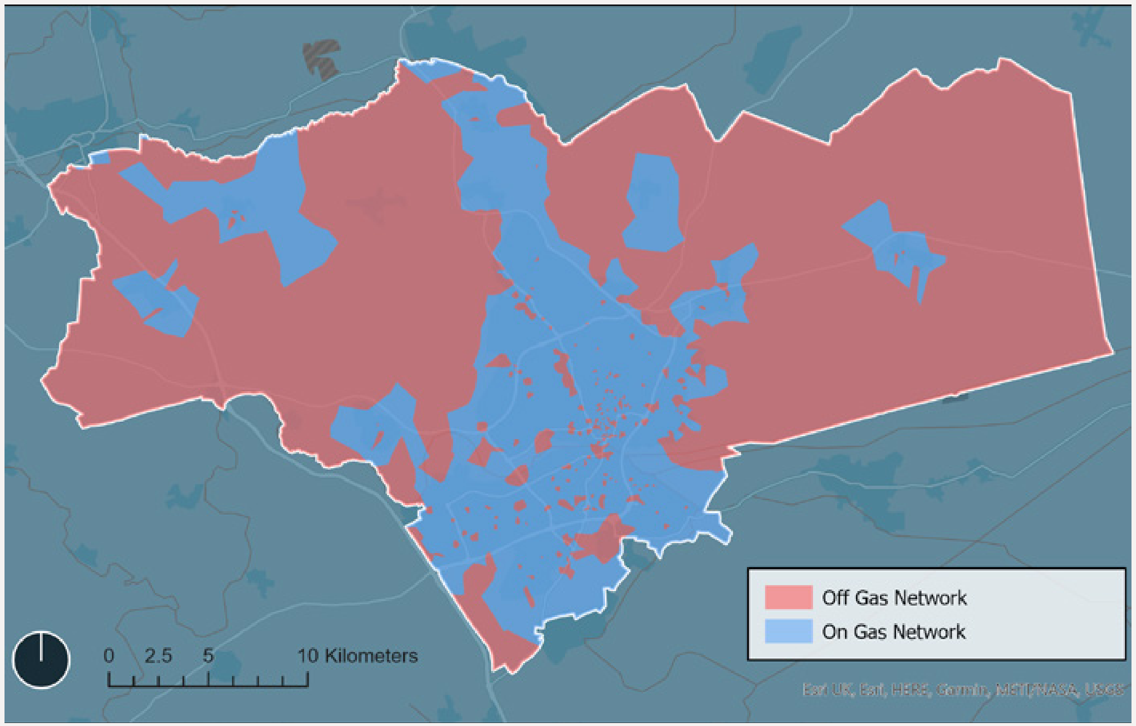
Current View: Domestic Heating Systems

95% of buildings currently use gas, oil or LPG for heating and therefore will need to be decarbonised. The majority of these are gas boilers. Oil and LPG boilers are assumed to be used in more rural off-gas homes.

Using Xoserve data, it has been identified that about 5% of dwellings are not connected to the gas grid. These buildings would therefore be unlikely to have access to hydrogen in the future.



212



Current View: Non-Domestic Buildings

The graphs below show the breakdown of different used for non-domestic buildings by number and floor area. Note that the total floor area of a building represents the aggregate floor area over all storeys.

Energy benchmarks for non-domestic buildings in the model are kWh/m².

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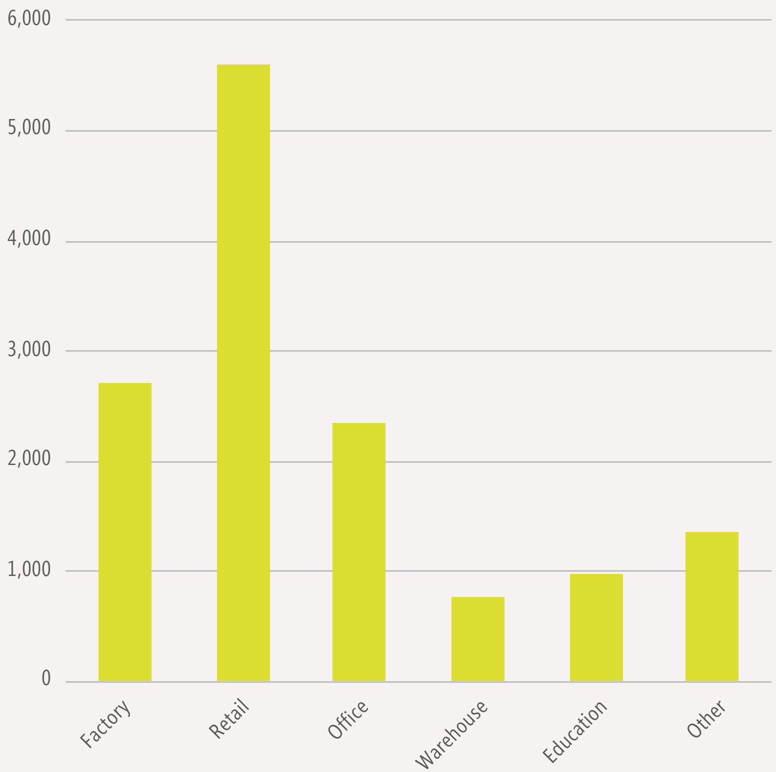
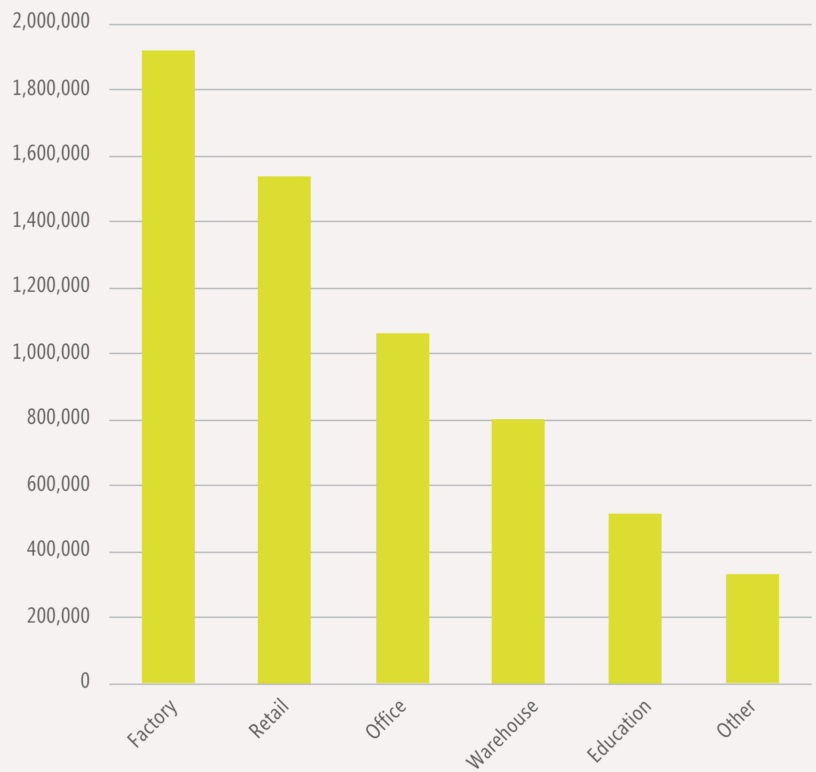
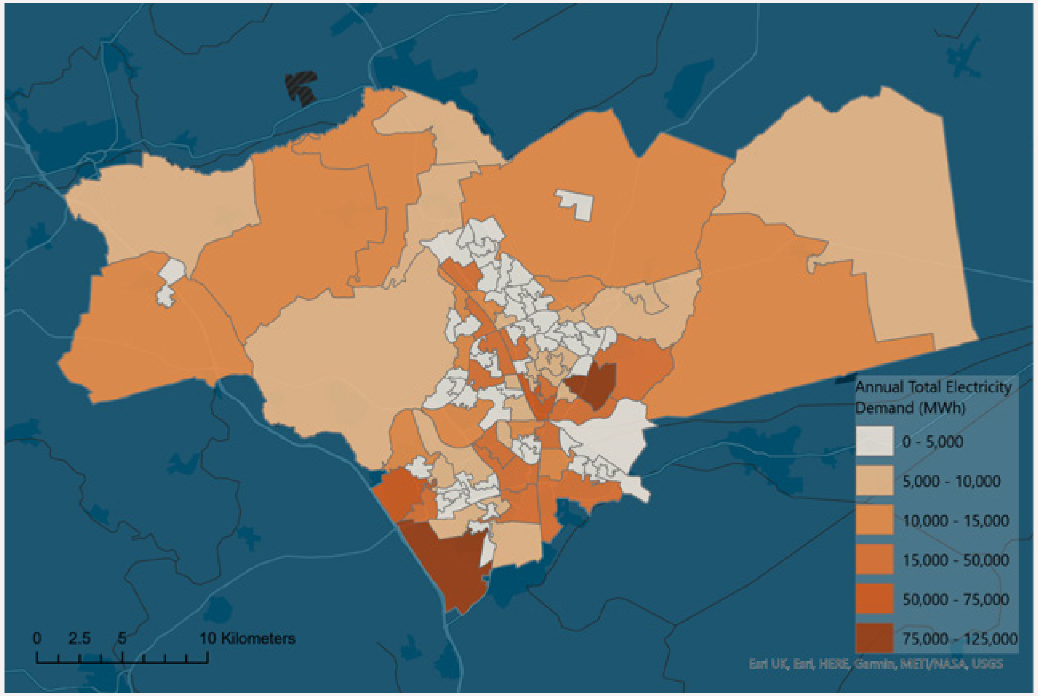
Number of non-domestic buildings

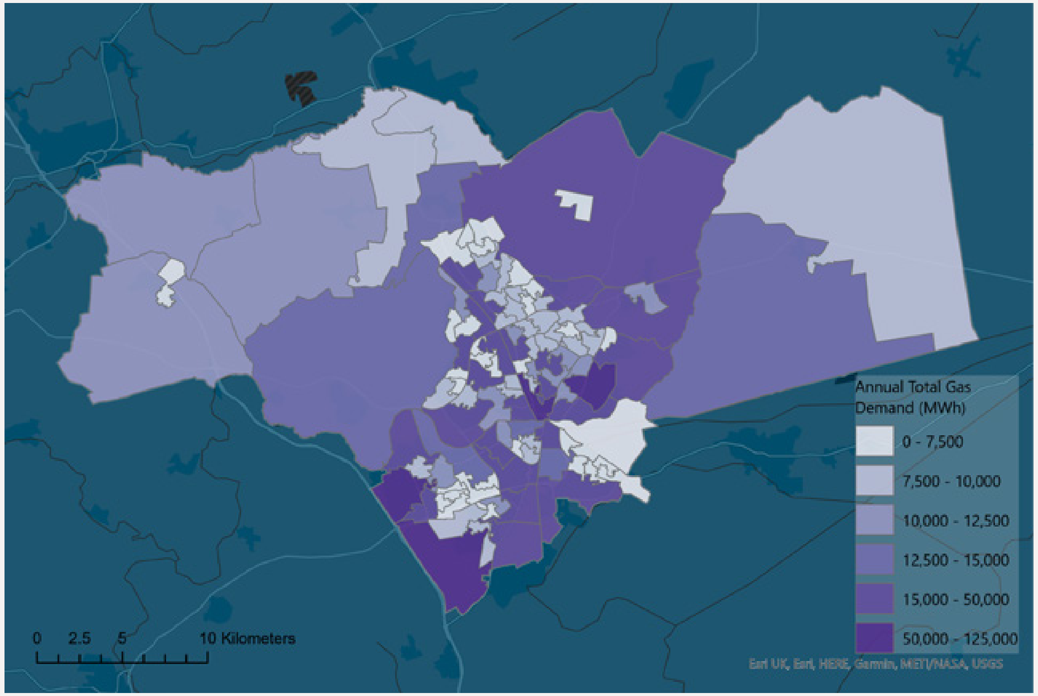


Floor Area (m²)



Current View: Annual Total Demand

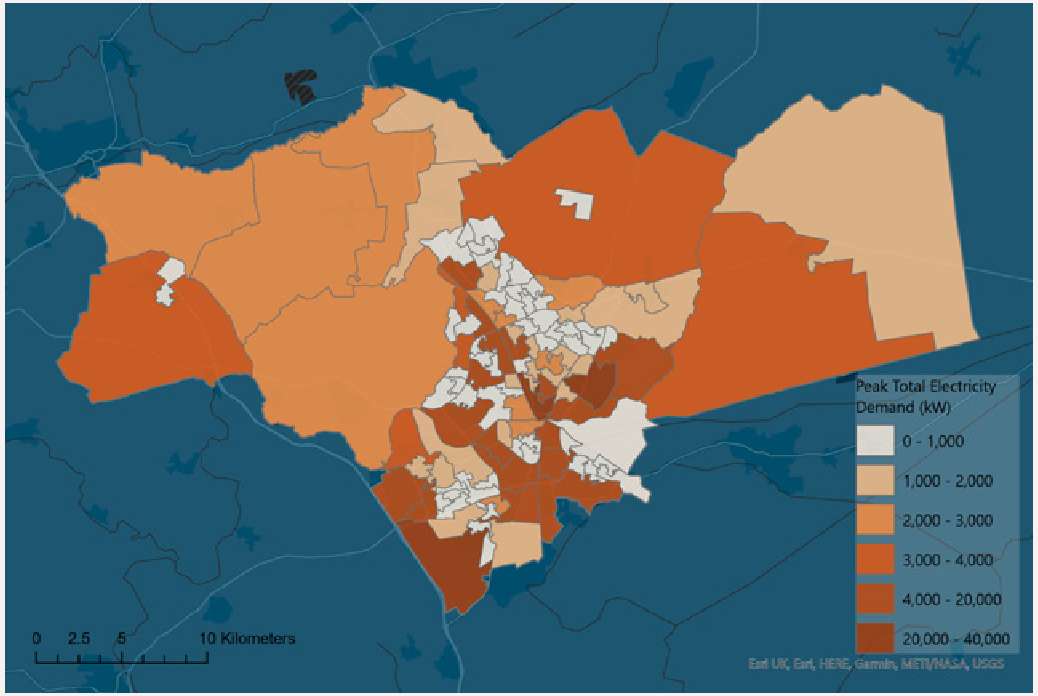


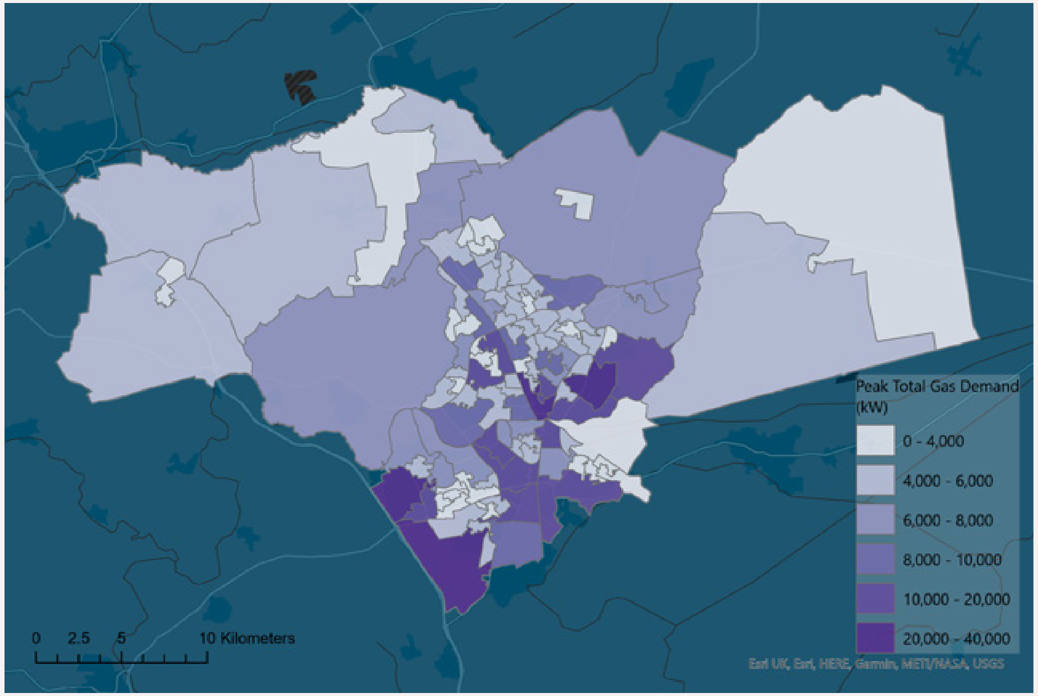


214

The images above show the modelled annual electricity and gas demands (for domestic and non-domestic combined) in each lower-tier super output area (LSOA) across Peterborough.

Current View: Peak Total Demand





The images above show the modelled peak electricity and gas demands (for domestic and non-domestic combined) in each lower-tier super output area (LSOA) across Peterborough.

Current View: Domestic Annual Demand

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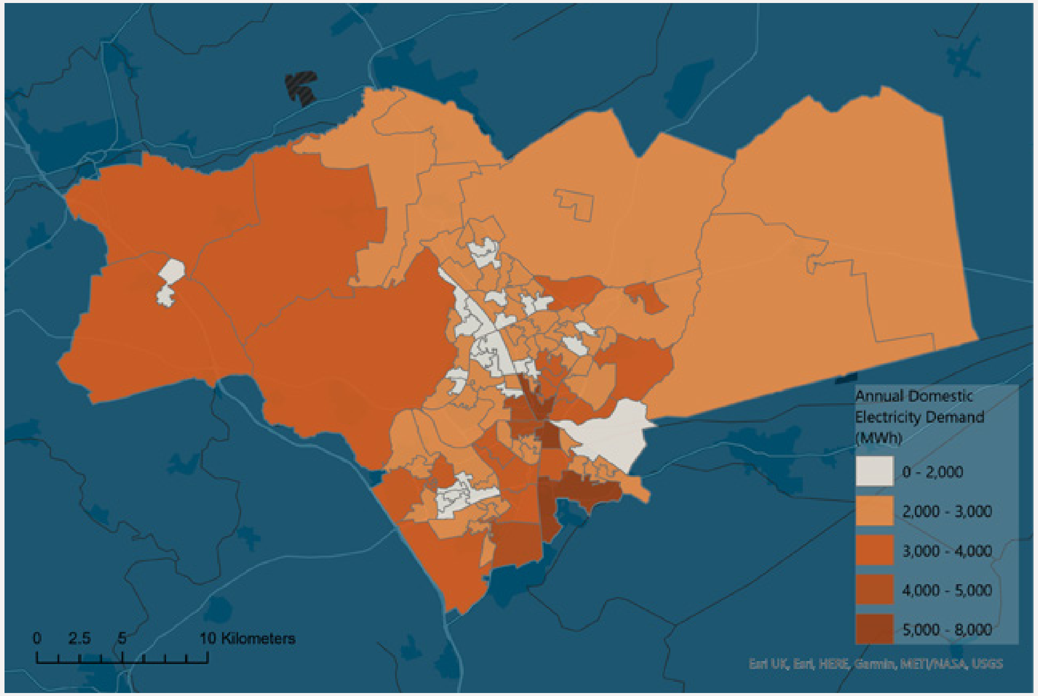
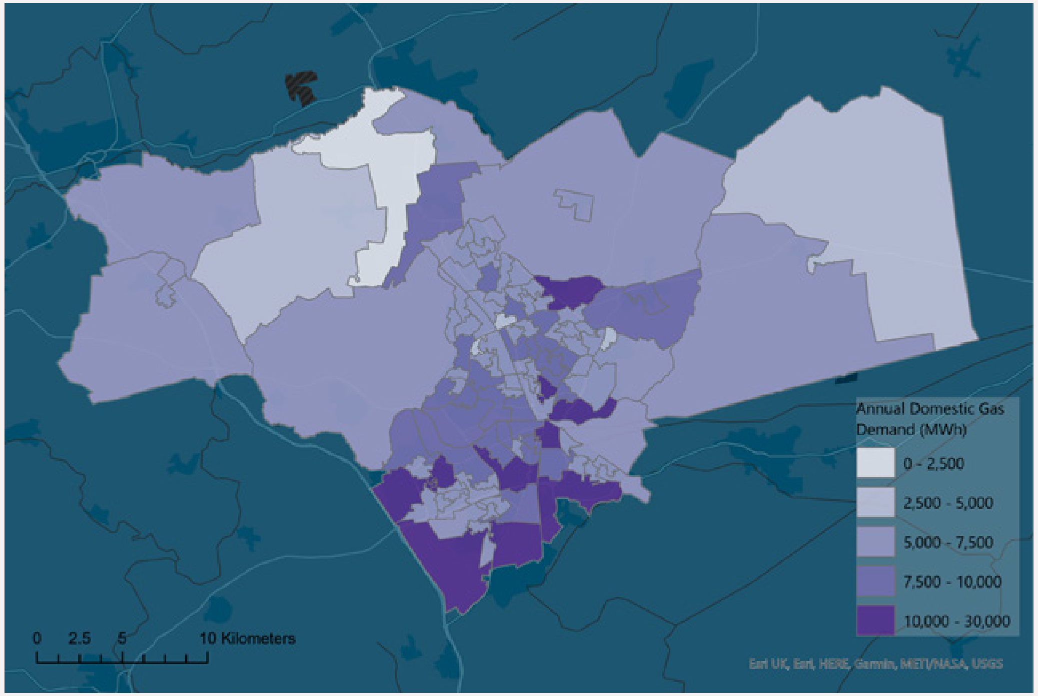
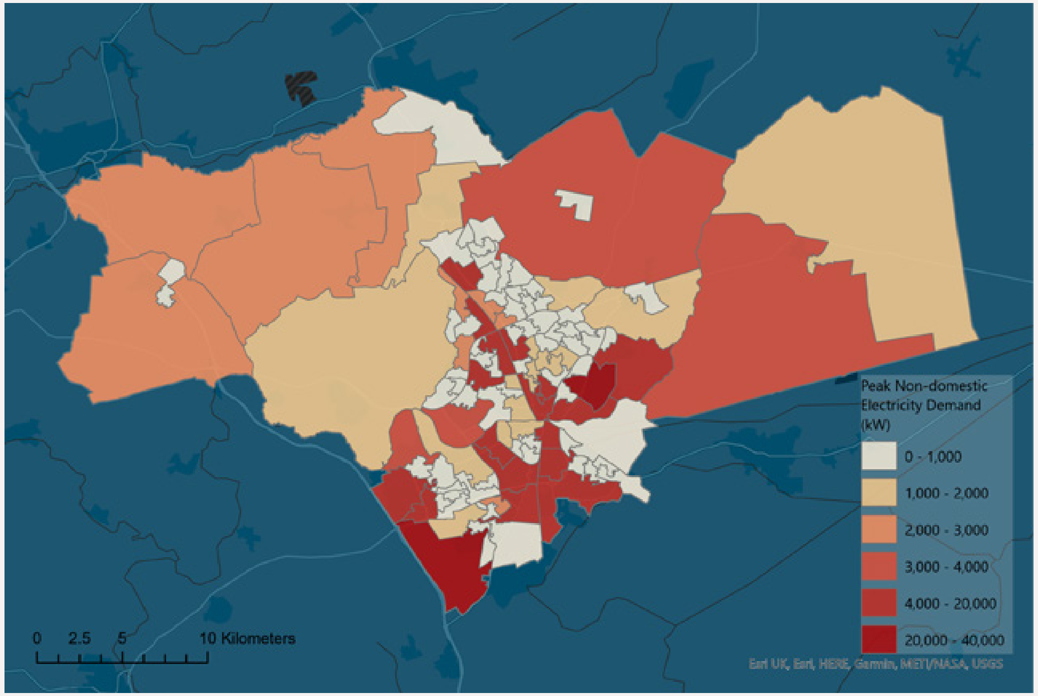
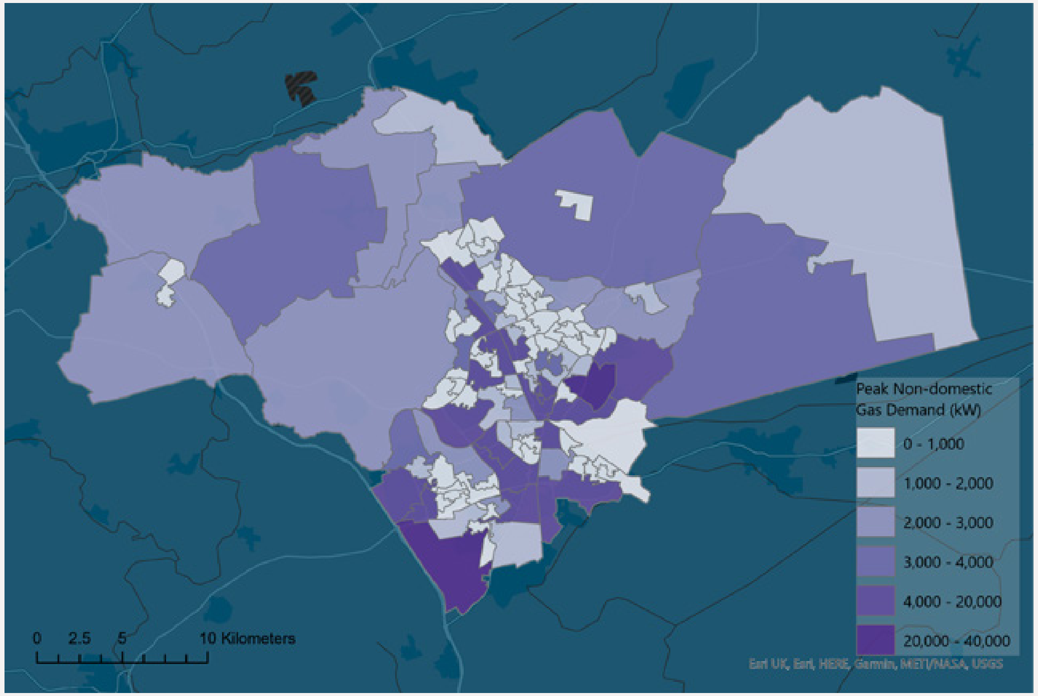




The images above show the modelled annual electricity and gas demands (domestic only) in each lower-tier super output area (LSOA) across Peterborough.

Current View: Non-Domestic Peak Demand





The images above show the modelled peak electricity and gas demands (non-domestic only) in each lower-tier super output area (LSOA) across Peterborough.

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Current View: Off Street Charging Assessment

This is a spatial analysis carried out by attempting to fit a standard UK parking space of 4.8m x 2.4m in the owned area between the house and its nearest road. Doing so helps identify homes that may be able to charge an EV on a driveway, and areas that will require alternative charging solutions for on-street parking.

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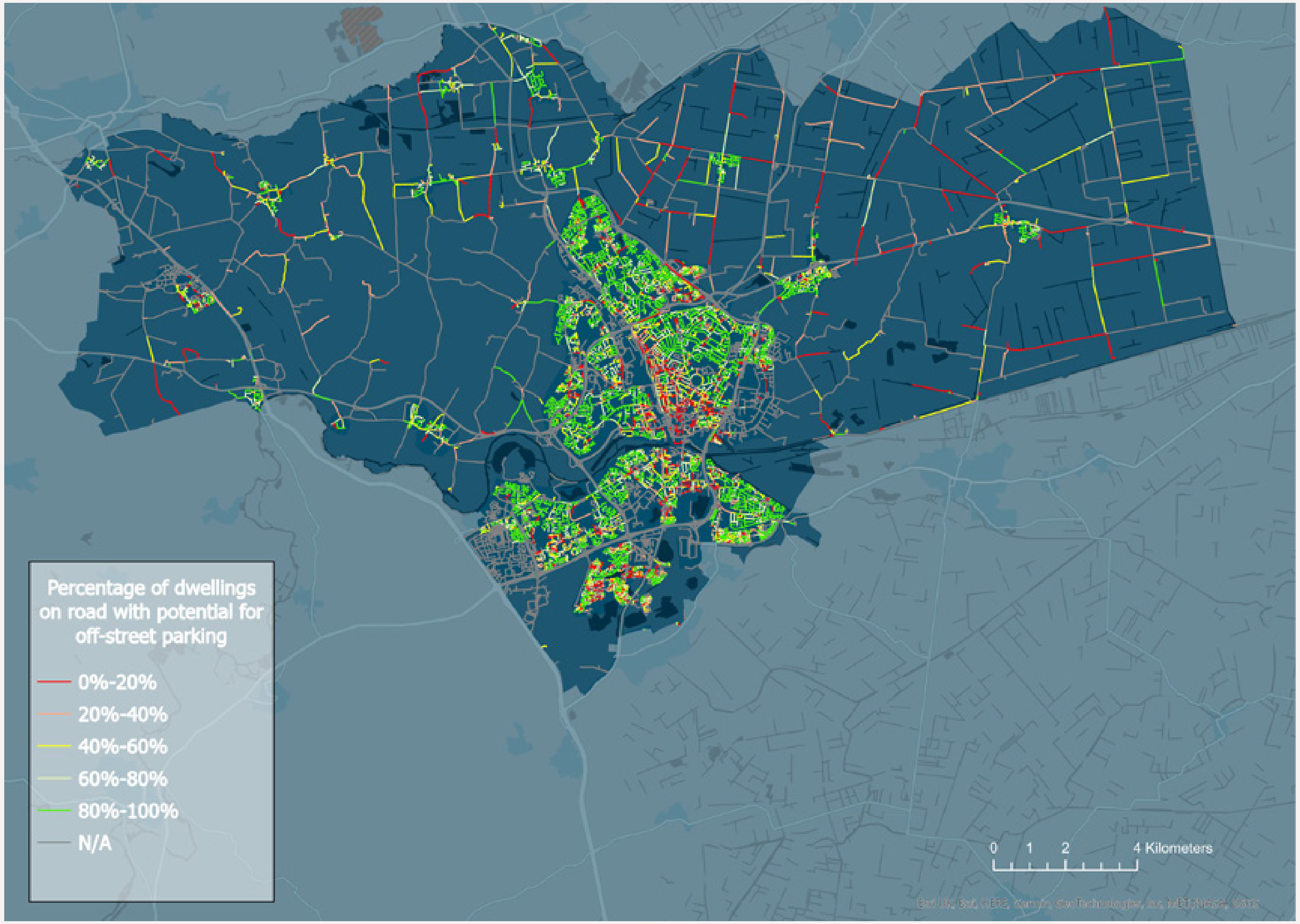
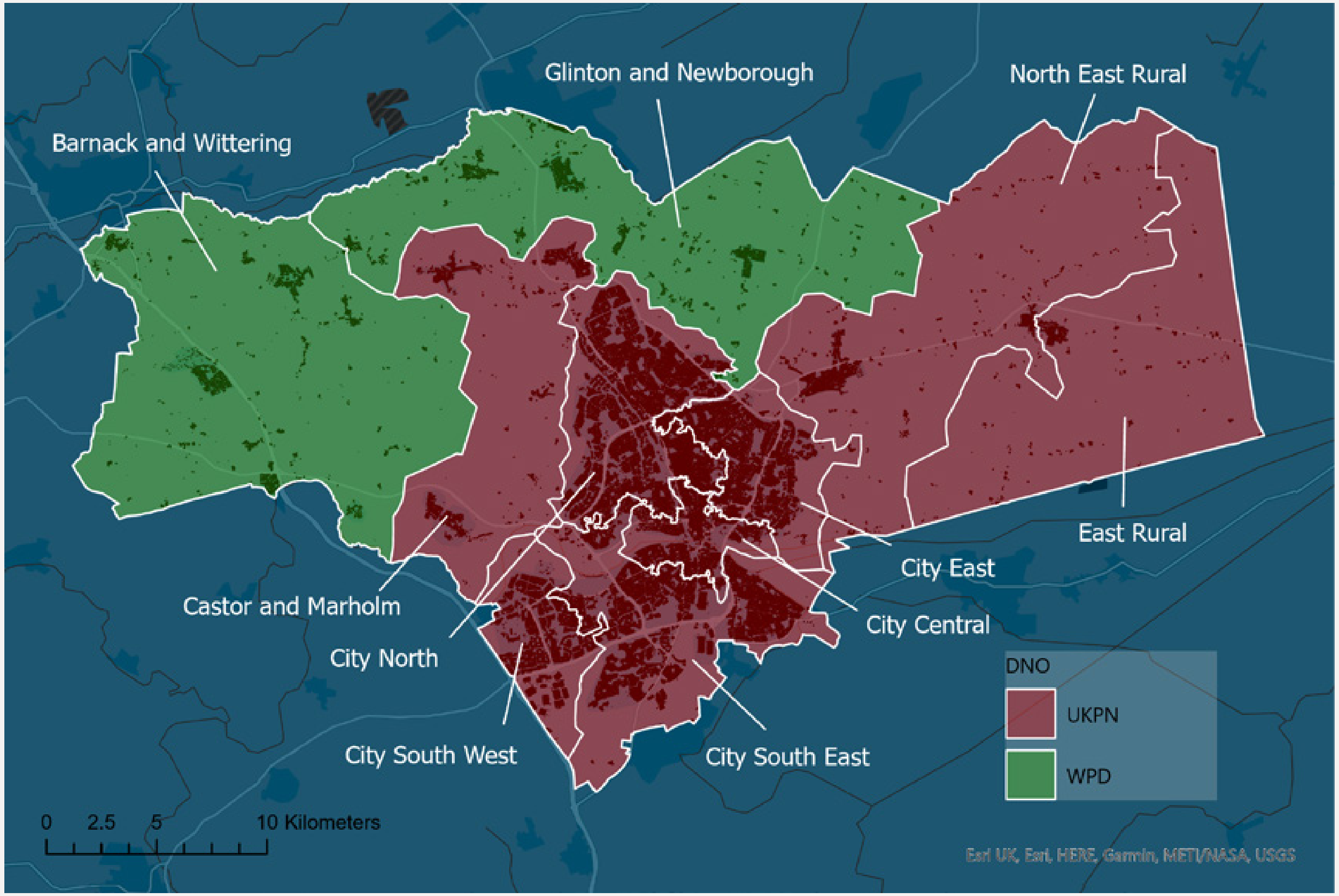
It can be seen that most of the suburban areas have good potential for off-street parking, whereas the most urban areas do not. This is expected given the housing types in these locations. Whether residents are encouraged to remove front gardens for EV charging is a policy decision but should be considered alongside the need for flood management.



Current View: Electricity Network Operators

Electrification of heating and transport places significant additional demand on the electricity network. In some zones this is likely to require upgrades of electrical substations and feeders to meet the increased demand, although there will be opportunities to explore the role that innovative flexibility and storage technologies can play in reducing or deferring the need to invest in upgrades. The rural zones have less network capacity overall as they serve fewer premises, so they see a large increase in required capacity as a proportion of their present capacity to accommodate electrification. In contrast, the city centre zones start with higher present day capacity and see only small proportional increases.

The local authority area of Peterborough is split, with both Western Power Distribution (WPD) and UK Power Networks (UKPN) supplying electricity to different parts. The majority of zones are supplied by UKPN, with the 'Barnack and Wittering' and 'Glinton and Newborough' zones being supplied by WPD.

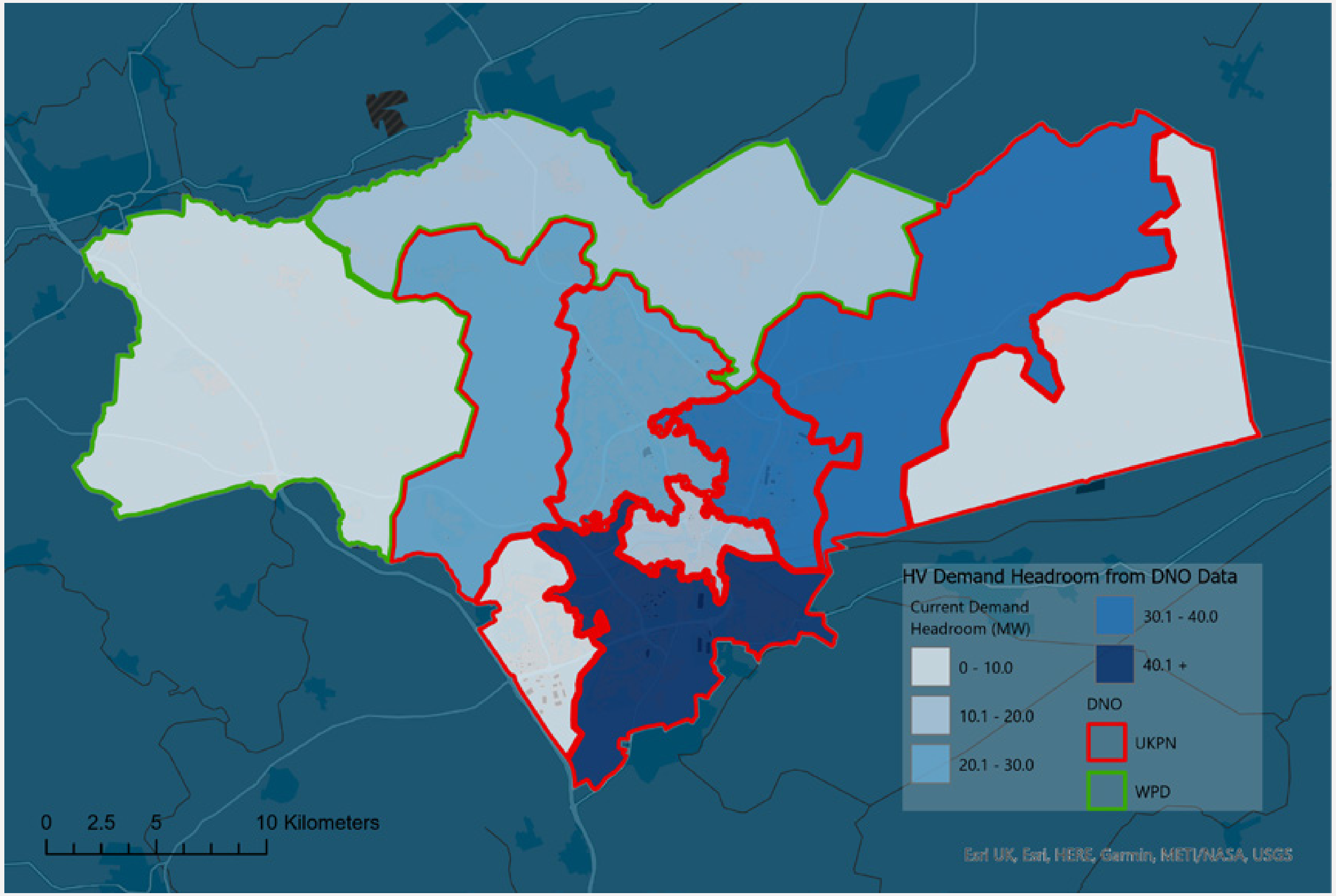


Current View: Electricity Network Capacity

The colours from the previous map have been shown here as outlines, with the blue graded shading representing the current demand headroom on primary substations.

This information was provided by the DNOs and therefore may differ slightly from the modelled data presented elsewhere in this Evidence Base report, or the main LAEP document.

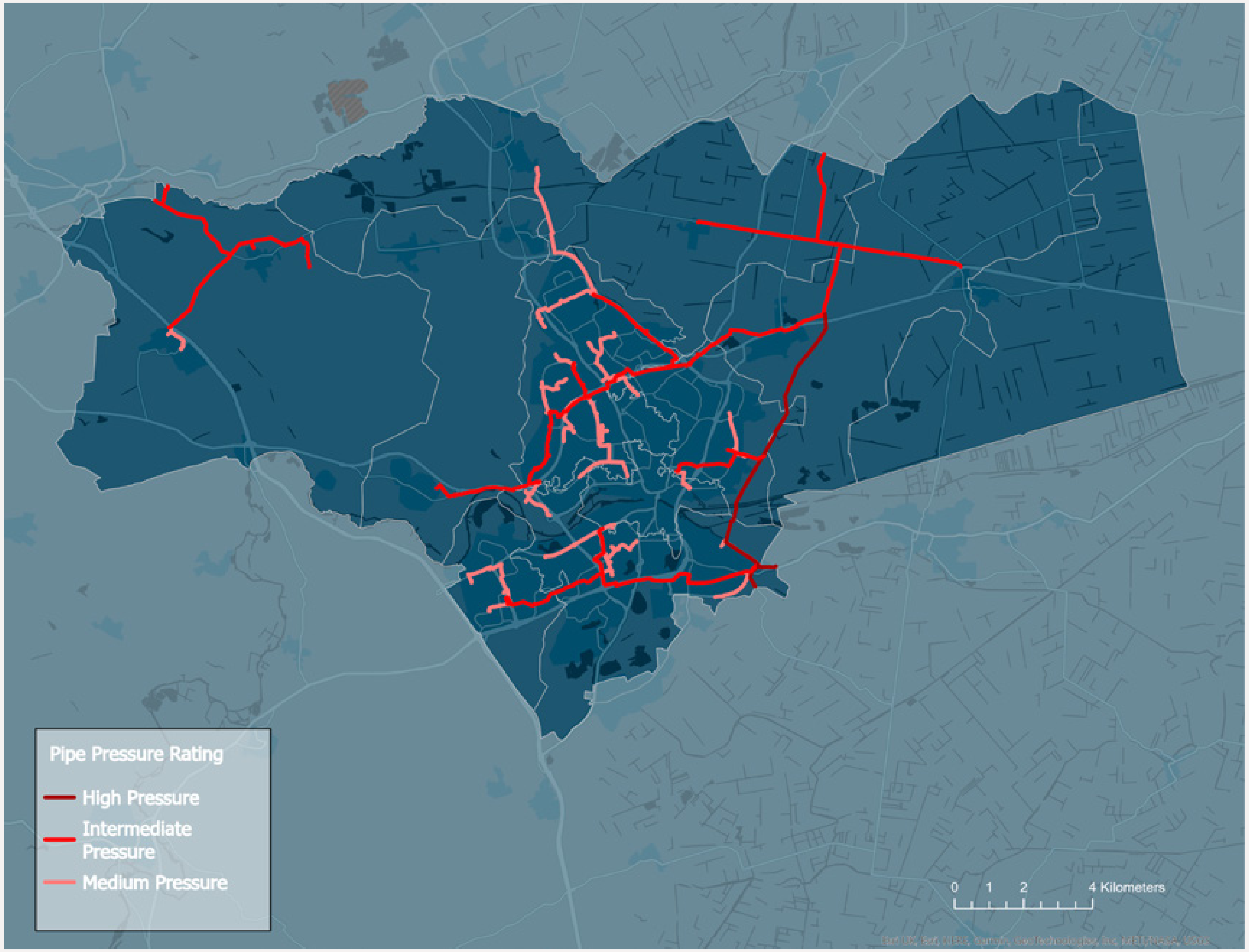
Areas with substantial spare capacity on the network today will be able to make early progress with the installation of heat pumps and EV chargers before encountering a need for network
220 upgrades. For example, City South East has a very large amount of spare capacity which could enable large scale electrification.



Current View: Fossil Gas Network

The map shows the locations of high, intermediate, and medium pressure gas pipes across Peterborough.

In the LAEP modelling, this information from Cadent – the gas network operator – was used alongside other data and costs to identify areas that could be most suitable and cost-effective for transitioning to hydrogen as a heat source when it likely becomes available in the 2030s.



Scenarios

Scenarios

Three key scenarios have been explored to understand the impact of Peterborough's ambition to support the city to reach net zero carbon by 2030 in contrast to later targets and the costs and benefits of doing so.

The scenarios allow various visions of the future to be explored in what they would mean for Peterborough's energy system, building an understanding of where uncertainties are greater and smaller

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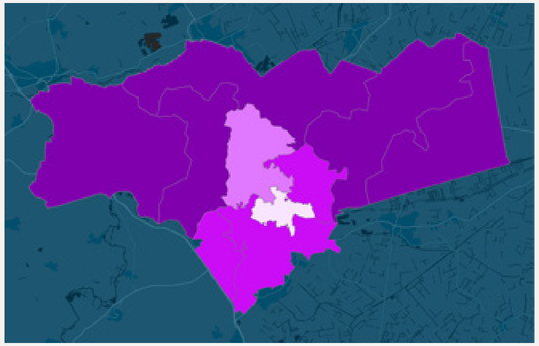
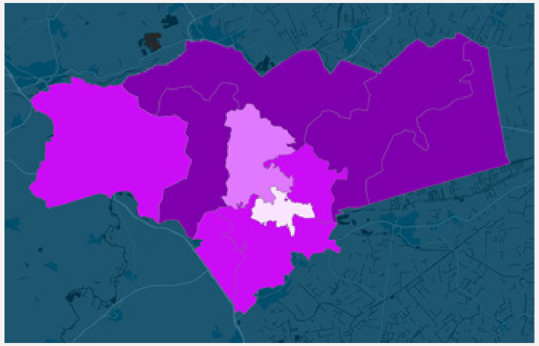
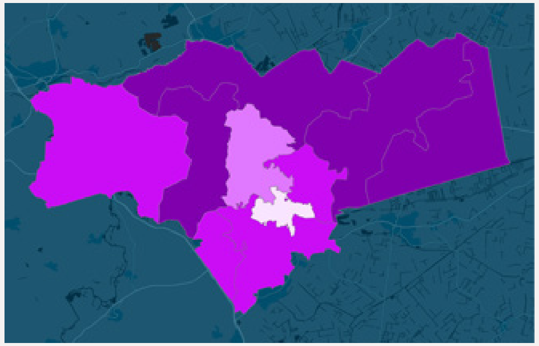
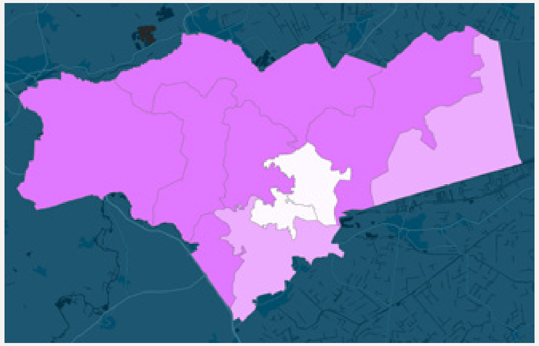
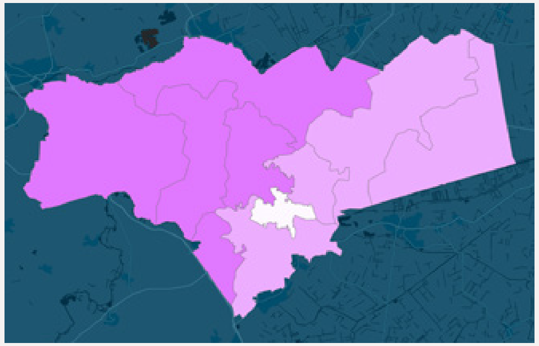
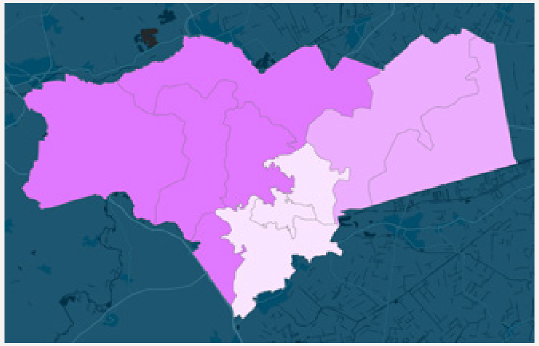
	2030 Net Zero Target	**2040 Net Zero Target**	**2050 National NZ Target**	**Do Nothing**
Description	Getting as close as possible to Peterborough's ambitious target, focussing on actions within local control.	Decarbonising ahead of the UK as a whole.	Decarbonising in line with the rest of the country, according to the legislated target. This provides a counterfactual for the impacts of doing more locally.	Required for compliance with HM Treasury Green Book guidelines, this scenario reflects no further decarbonisation between now and 2050. Only measures deemed to be cost-effective were installed.
Hydrogen	Not available in time to contribute to the 2030 target, but available from the mid 2030s	Available from the mid 2030s to be used where it can cut emissions cost-effectively	Available from the mid 2030s to be used where it can cut emissions cost-effectively	Available from the mid 2030s to be used where it is the most cost-effective option
Building Efficiency Heating Transport Local Generation Networks	These technologies are available for unconstrained deployment in each scenario to find the least-cost energy system arrangement which reaches the carbon target.			

Scenarios

Scenarios	Description
2030 Carbon Target	A cost optimal approach to get as close to existing carbon target as possible, focusing on options within Peterborough's local control.
2040 Carbon Target	Hydrogen is unlikely to be available in time for a 2030 carbon target, so an approach with a softer target to see if H_2 then plays a greater role – and what the cost impacts are.
National Net Zero by 2050	No local target, just following national ambitions. This helps provide context of doing more locally.
2030 Carbon Target (with demand shift)	Not presented as a full scenario. Time shifted demand profiles for EV and heat pumps reflecting greater levels of smart control and flexibility – to what extent does this change network reinforcement requirements and the optimal plan
Business As Usual	Not presented as a full scenario. Shows current spend on energy to give a baseline to compare costs against.

- A variety of energy system scenarios are possible to deliver Peterborough's future energy vision. It is not practical to consider every possible configuration of Peterborough's local energy system in a limited number of scenarios, therefore three main scenarios have been considered with additional analysis on two further scenarios; these represent the prominent cost-effective options that could materialise.
- The scenarios are not predictions or forecasts of the most probable outcomes. They are based on available information and have been used to inform a plan for Peterborough. The decarbonisation of any local energy system will require considerable co-ordination, planning and investment as well as consumer and social engagement.
- The scenarios have been developed through frequent engagement with Peterborough City Council, as well as consulting with a wider group of stakeholders including Cadent, UK Power Networks and Western Power Distribution.
- A brief description of the different scenarios developed and used to inform the plan is given here, with modelling outputs from the scenarios provided in the following pages. These scenarios provide an understanding of pace and scale of activity needed, costs and investment needed for local implementation in support of decarbonisation goals and the commonality and variation of measures across the different future local energy scenarios. The scenarios help to explore choices around how to reach carbon neutrality using different technologies and known solutions where they exist.

Comparison of Scenarios - Domestic

2030 NZ Target	2040 NZ Target	2050 NZ Target
		
		

Percentage of dwellings - basic retrofit
- 0-10
- 10-20
- 20-30
- 30-40
- 40-50
- 50-60

Percentage of dwellings - deep retrofit
- 0-10
- 10-20
- 20-30
- 30-40
- 40-50
- 50-60

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Comparison of Scenarios - Domestic

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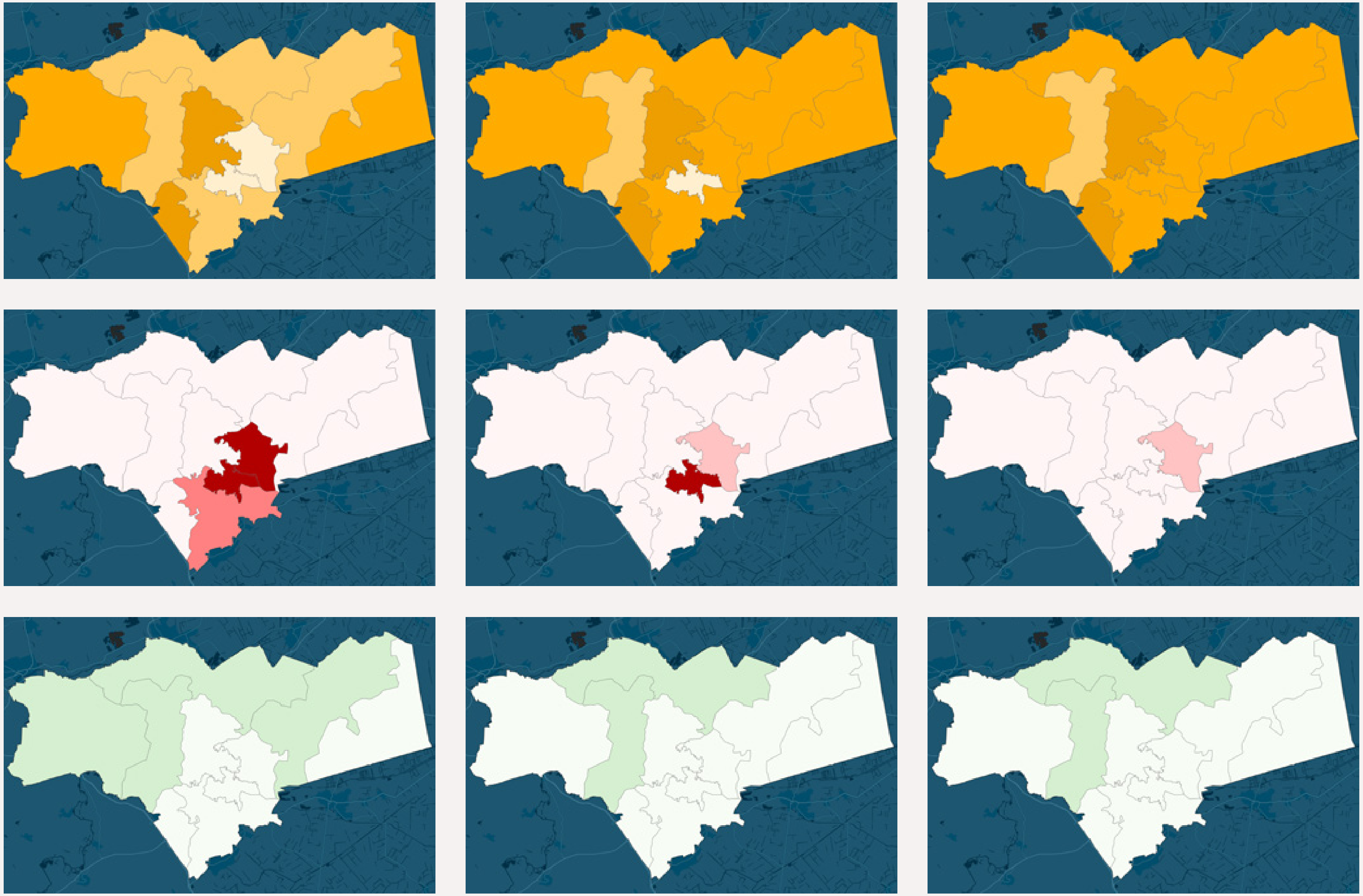
2030 NZ Target | 2040 NZ Target | 2050 NZ Target



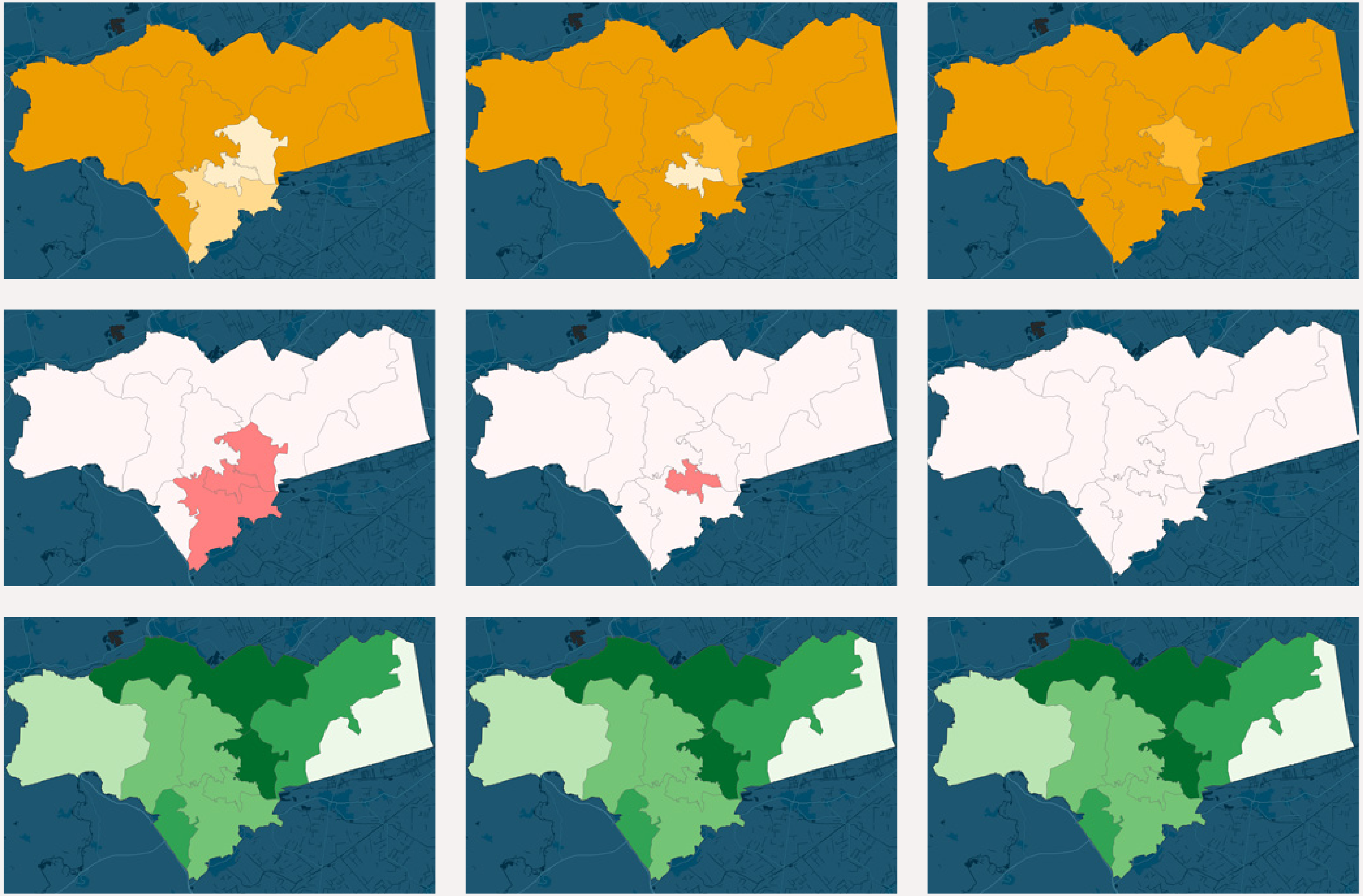
Air Source Heat Pump - Percentage of Buildings
- <20
- 20-40
- 40-60
- 60-80
- 80-100

District Heat - Percentage of Buildings
- <20
- 20-40
- 40-60
- 60-80
- 80-100

Ground Source Heat Pump - Percentage of Buildings
- <20
- 20-40
- 40-60
- 60-80
- 80-100

Comparison of Scenarios - Non-Domestic

2030 NZ Target | 2040 NZ Target | 2050 NZ Target



Electricity – Percentage of Non-Domestic Buildings
- <20
- 20-40
- 40-60
- 60-80
- 80-100

Heat – Percentage of Non-Domestic Buildings
- <20
- 20-40
- 40-60
- 60-80
- 80-100

Hydrogen – Percentage of Non-Domestic Buildings
- <1
- 1-5
- 5-10
- 10-15
- 15-20

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ZeroCarbon.Vote

ZeroCarbon.Vote: Summary

ZeroCarbon.Vote is ESC's prototype online "ZeroCarbon.Vote" platform to engage with residents of a given location. In parallel with the development of the LAEP, ESC used the ZeroCarbon.Vote platform to engage with a small but representative sample of Peterborough's population (approximately matching demographic, household tenure, etc).

On the platform, participants are presented with heating technology options relevant to their specific house type, and a little information about each option (such as relative capital and running costs, disruption, etc). They then express preferences and reasons for those preferences. The results give an indication of the extent to which (based on the simple initial information provided to them) residents' preferences align with the potential recommendations for each zone within the plan.

For Peterborough, the survey was live between 31st January and 13th March 2022. A total of 796 residents engaged with the website by inputting their postcode. Of these, 535 voted with 415 completing the full survey. This represents around 0.5% of households in Peterborough.

ZeroCarbon.Vote: Summary

The survey reached a good representation of Peterborough's population in terms of tenure, age and house type when compared to the 2011 Census data.

As expected,

- Homeowners are the largest group *(significantly higher than that expected from the Census data)*
- Social housing seems to be underrepresented

Note: The 'Live in your friend's / relative's or partner's home' category has been grouped together with 'Live in another situation' to match the Census categories.

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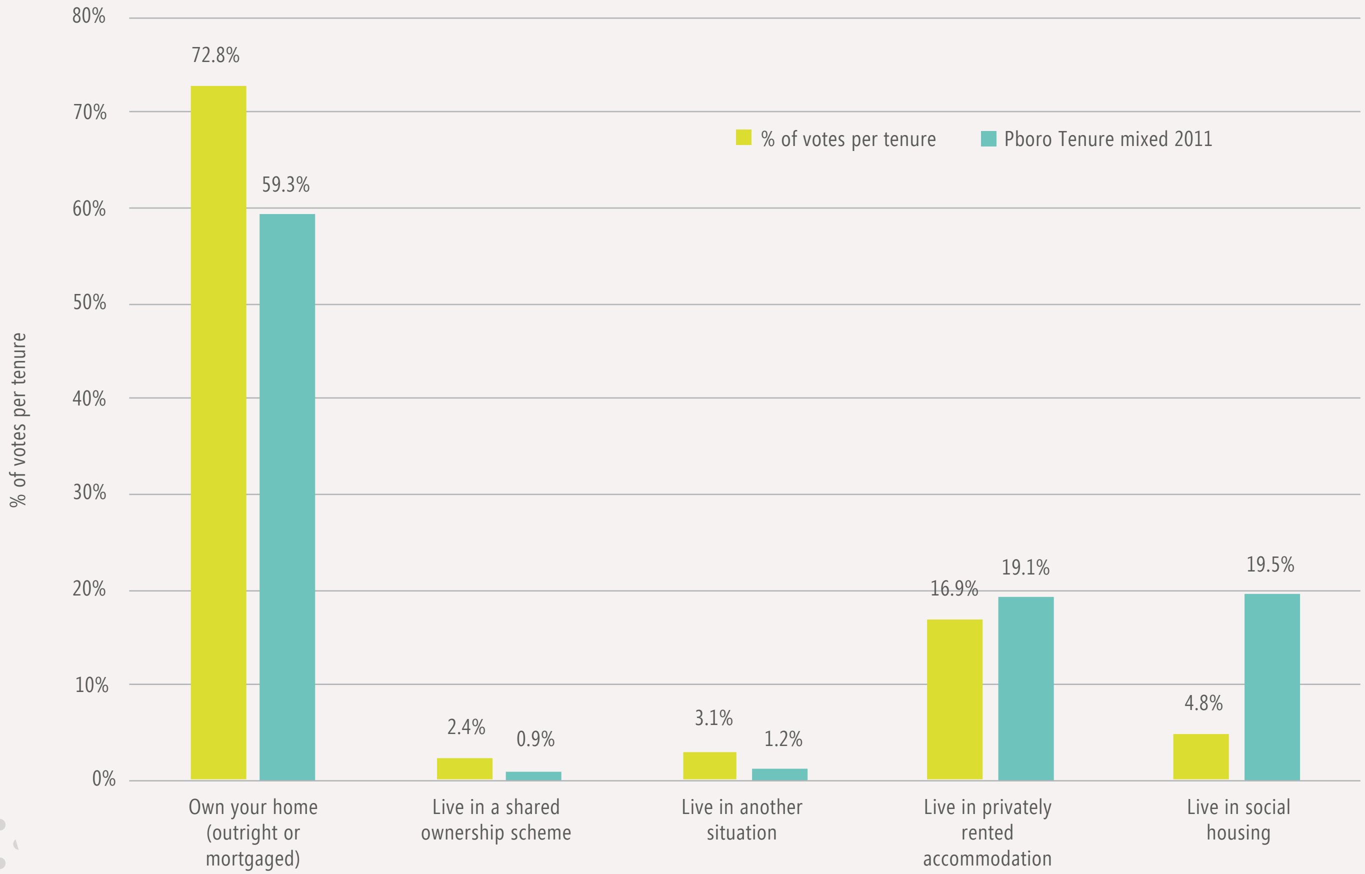

Source Census 2011: UV63 Tenure (Households)

ZeroCarbon.Vote: Summary

Half of the votes come from participants within the 25-44 age band. This percentage is significantly larger than that of Peterborough's population according to the 2011 Census data.

The 18-24 and 75+ age bands are instead underrepresented.

Note: Age bands have been grouped to match those available in the 2011 Census data.

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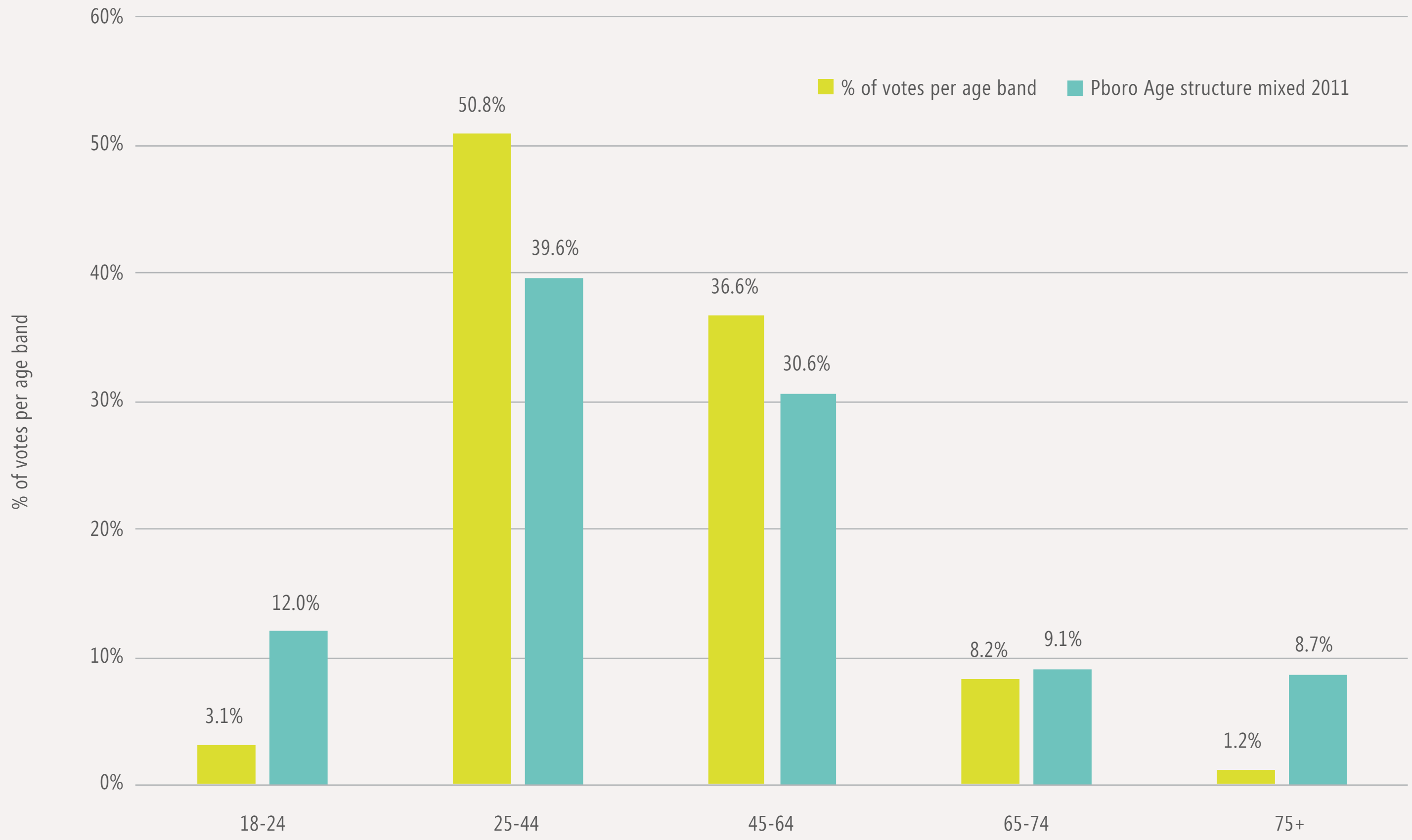
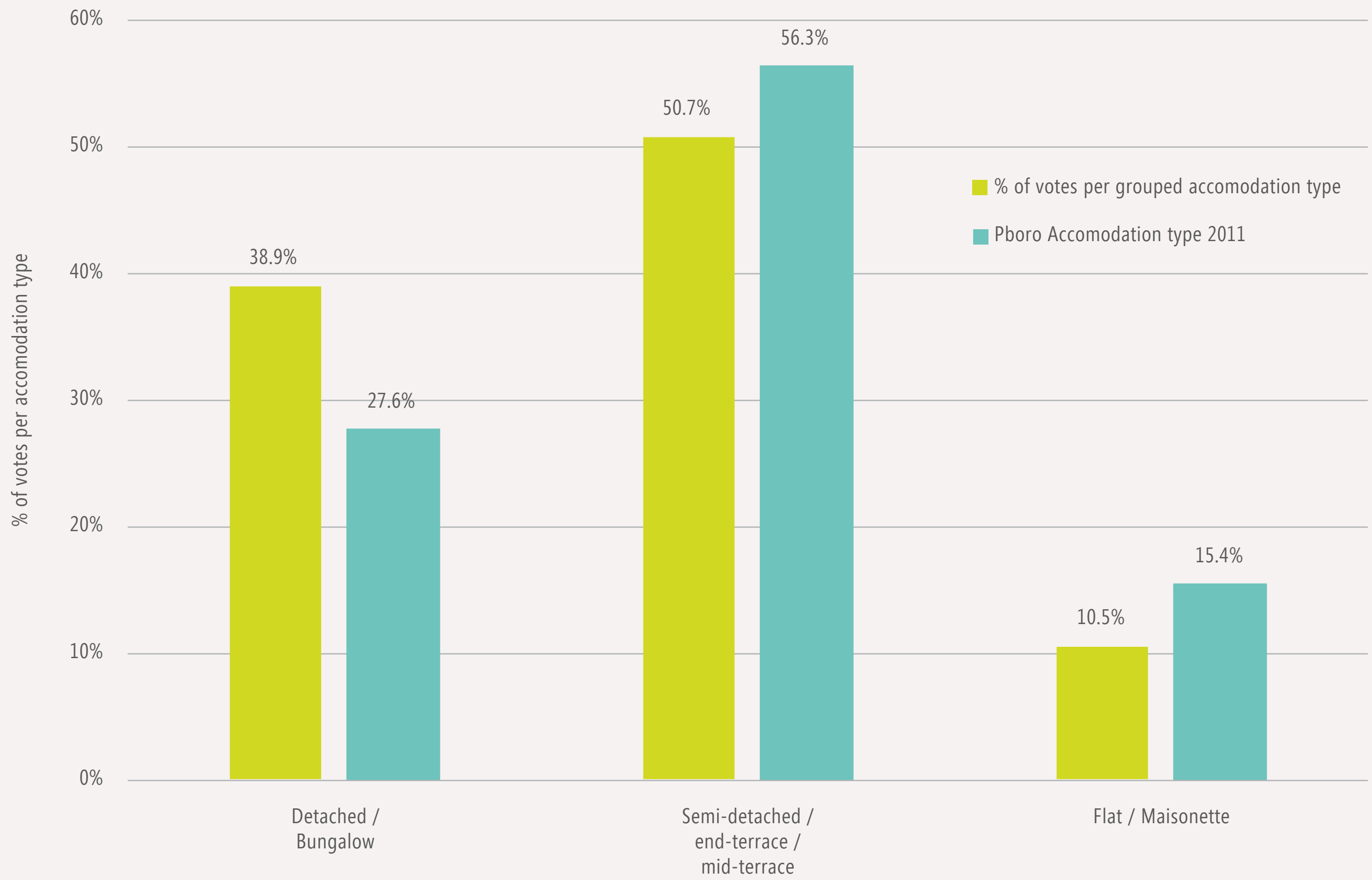


Source Census 2011: KS102EW - Age structure

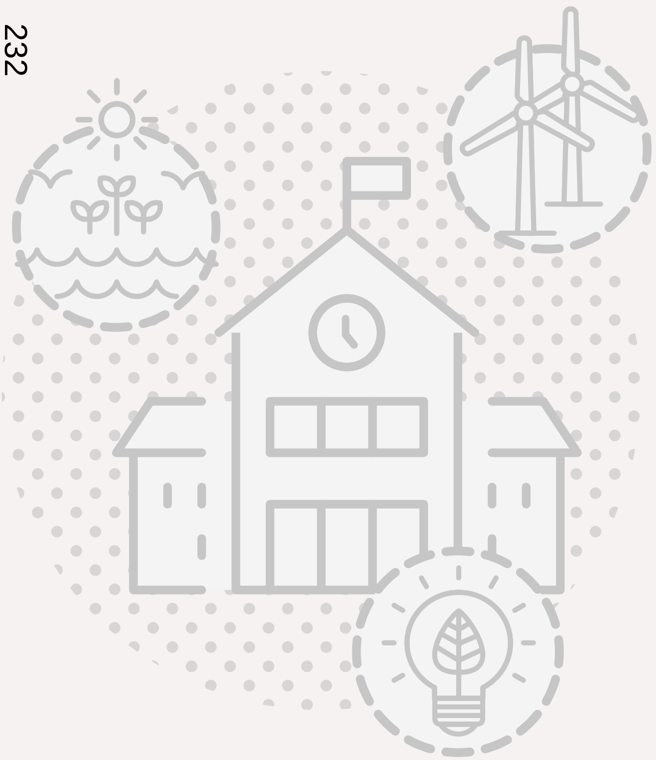
ZeroCarbon.Vote: Summary

The percentage of voters living in detached and/or bungalow houses is larger than that expected from the 2011 Census data however the survey respondents were broadly representative.

Note: House types have been grouped to match the categories available in the Census data.



Source Census 2011: UV56 Accommodation Type (Households)



ZeroCarbon.Vote: Summary

The graph below shows the number of unique votes registered on the ZeroCarbon.Vote platform, however, the population and size of each zone varies significantly. (NB: 'Other' refers to votes from outside of Peterborough)

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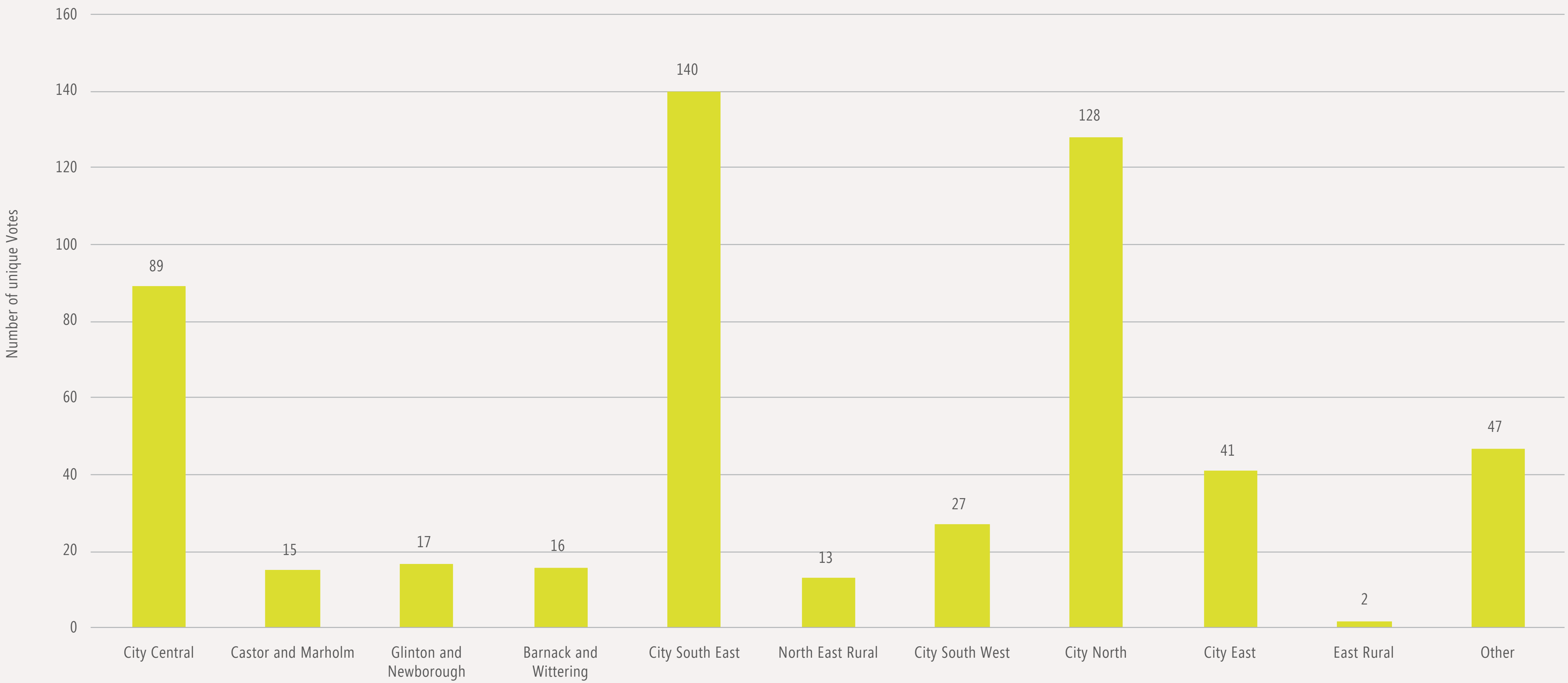
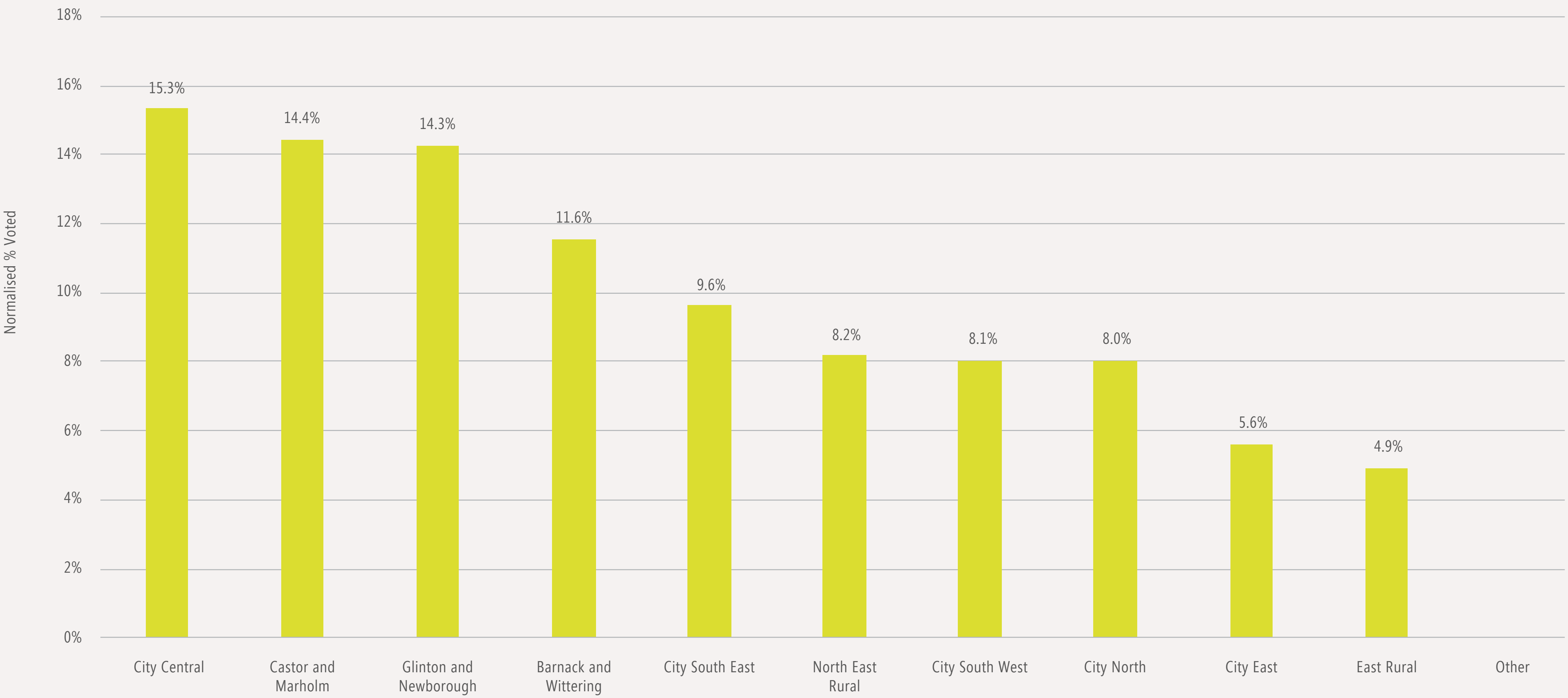


ZeroCarbon.Vote: Summary

When normalised against the population of each zone, it can be seen that the City Central zone is the most “engaged”.



ZeroCarbon.Vote: Results

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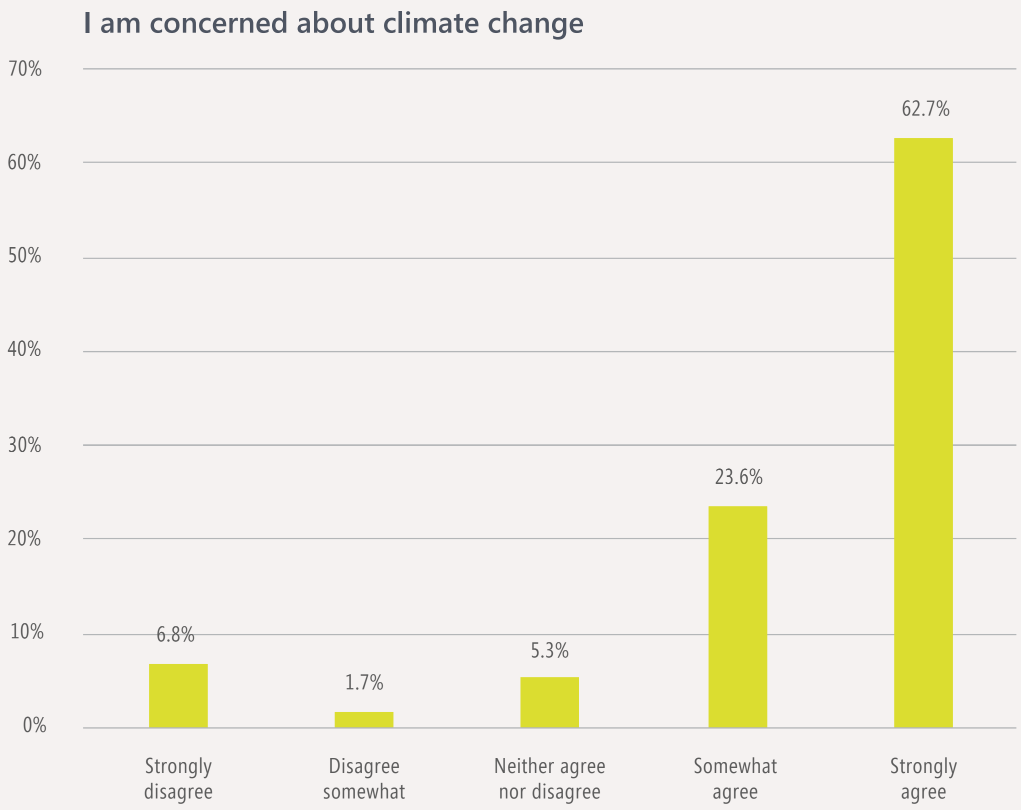
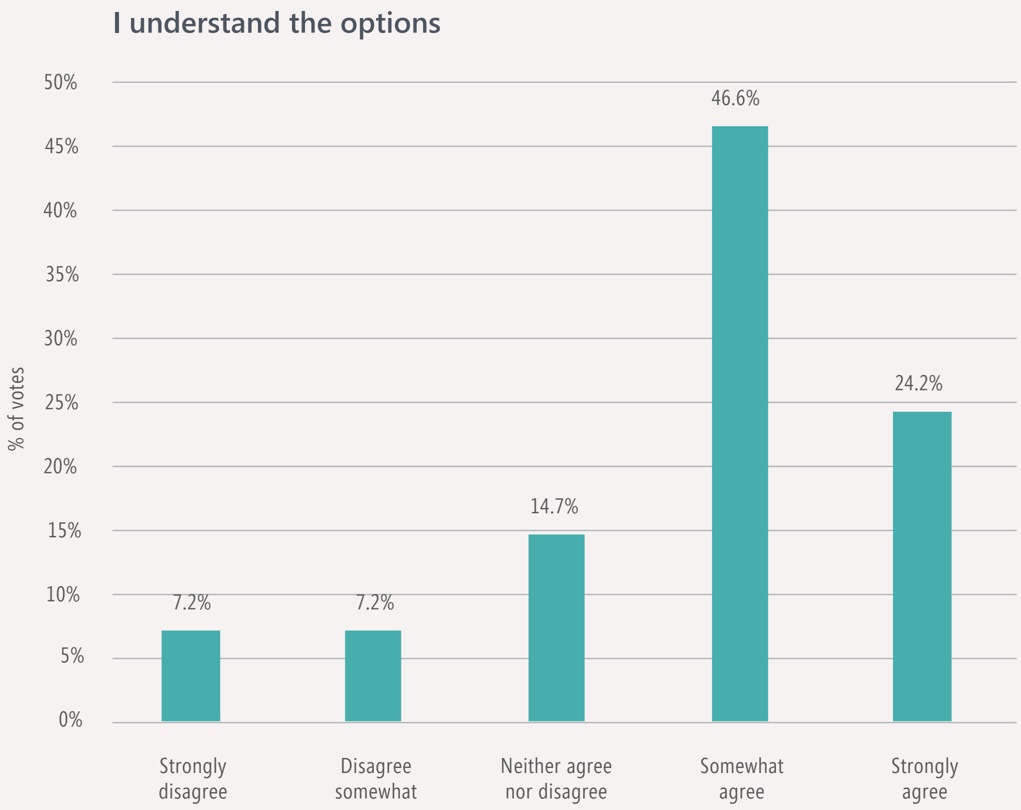
Question: How much do you agree with the statement "I am concerned about climate change"

- More than **86%** of the respondents are agree with the statement



Question: How much do you agree with the following statement "I understood the options to help me vote"?

- Around **70%** of the respondents claim to have understood the options shown.



ZeroCarbon.Vote: Results

Which heating system was selected the most when available?

- Hydrogen boiler was the most "preferred" option across all voters, selected almost half of the times it was offered. (Note: Not all options were shown to every respondent meaning their preference may not have been available to them.)
- Hydrogen was also the most voted individual technology (154 out of the 535 votes).
- When combined, 'heat pumps' were the most voted for with 292 votes.

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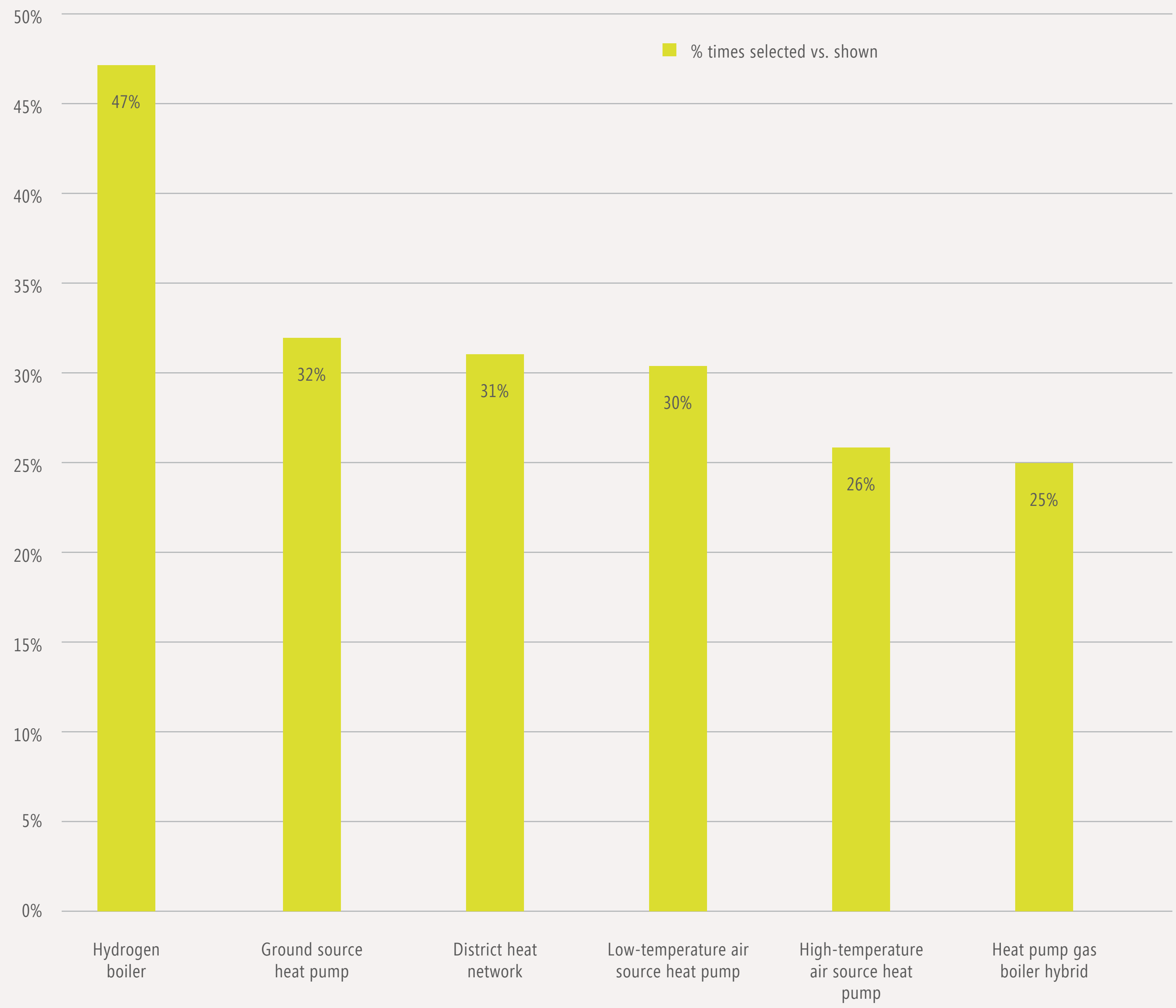
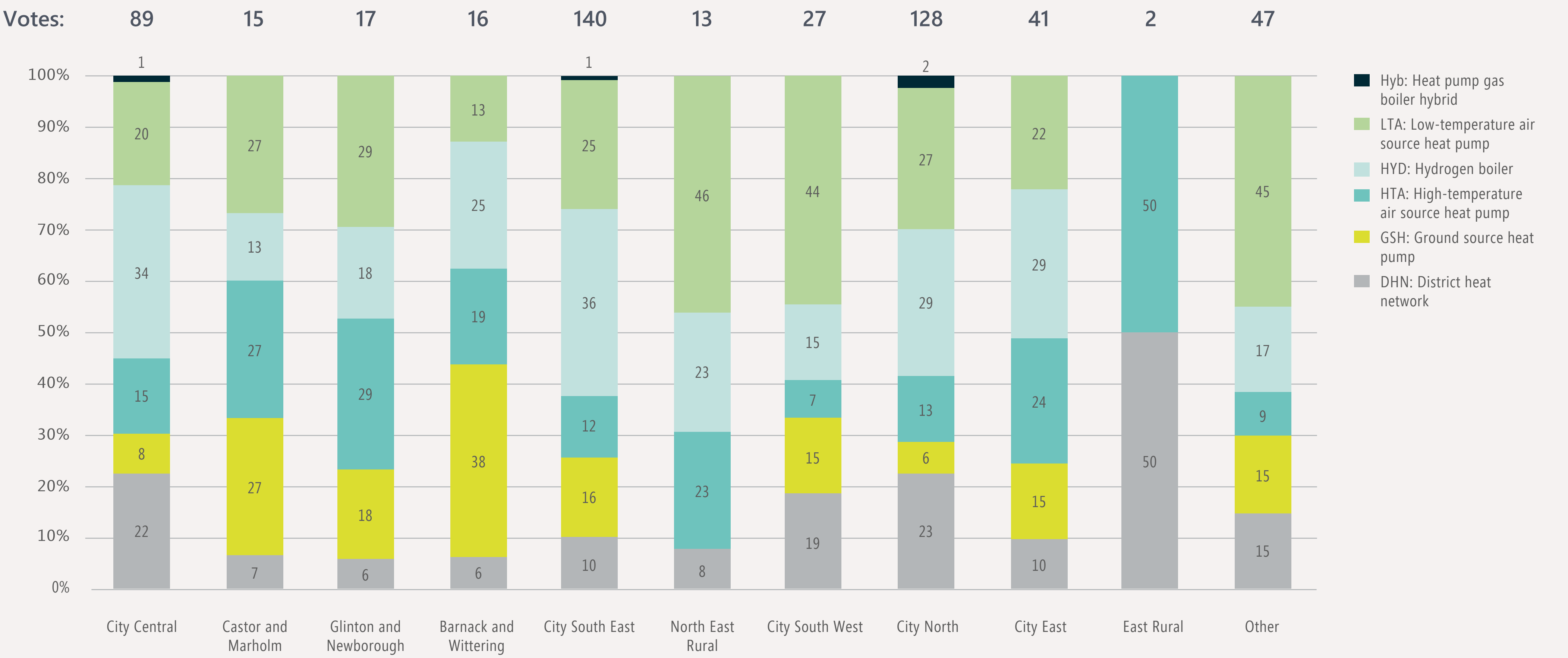


ZeroCarbon.Vote: Results

The graph shows the number of votes that each technology type received in each zone.

(Note: Not all options were shown to every respondent meaning their preference may not have been available to them.)

237

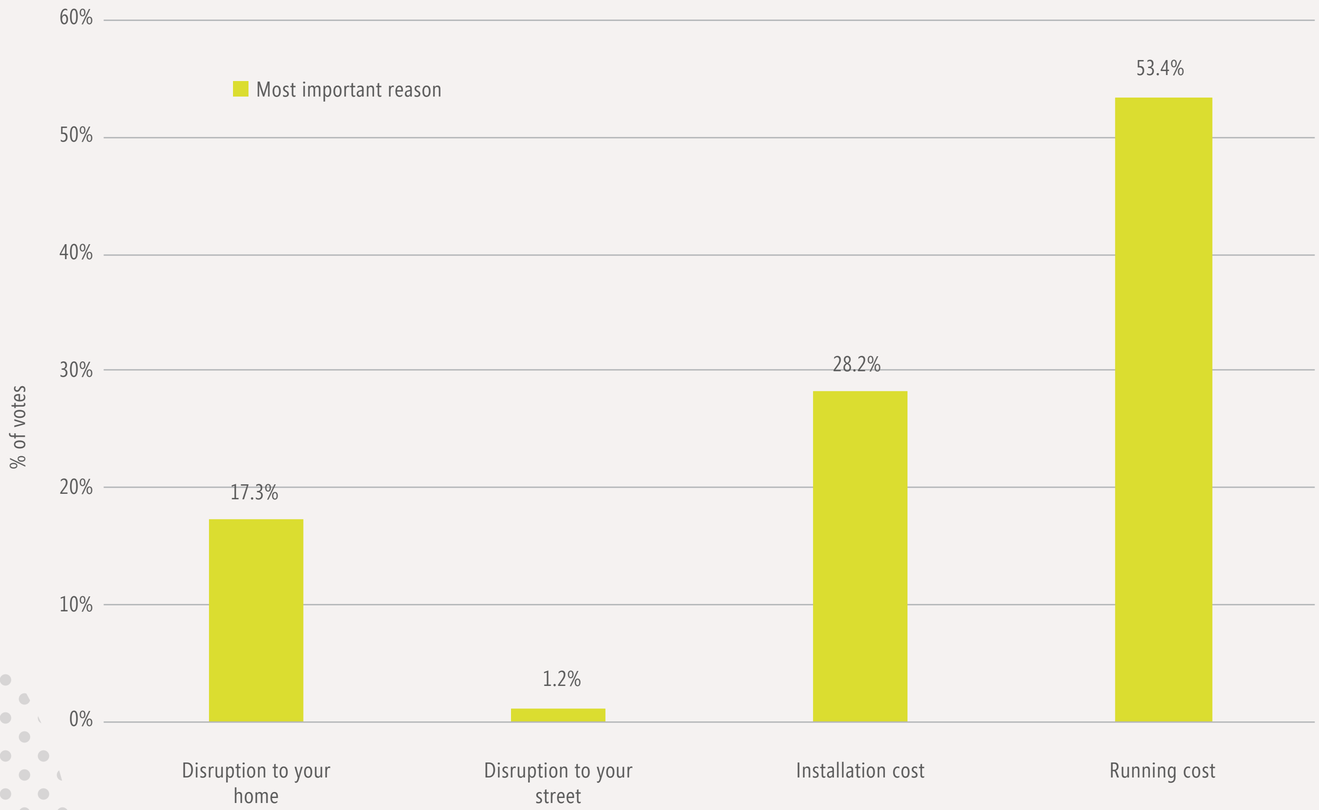


ZeroCarbon.Vote: Results

Question: What was most important when deciding to vote for that heating technology?

The most selected reason by respondents for making the heating technology selection was 'running costs'. Least selected was 'disruption to your street', being selected by only five respondents out of 535.

Note: This survey was done in the run up to the first major energy price rise in 2022 which may have altered the considerations of respondents.



ZeroCarbon.Vote: Results

From the survey responses, it was found that more than 74% of the respondent's current heating systems are over four years old, with over 25% reporting their heating system was over ten years old.

The respondents in 'Castor and Marholm' had the highest average age of heating system at over nine years old.

Note: Heating system ages were given in the following categories: Less than a year, 1-3 years, 4-7 years, 8-10 years, 10+ years. Midpoints were taken to calculate the average with 10+ being assumed to be 12.

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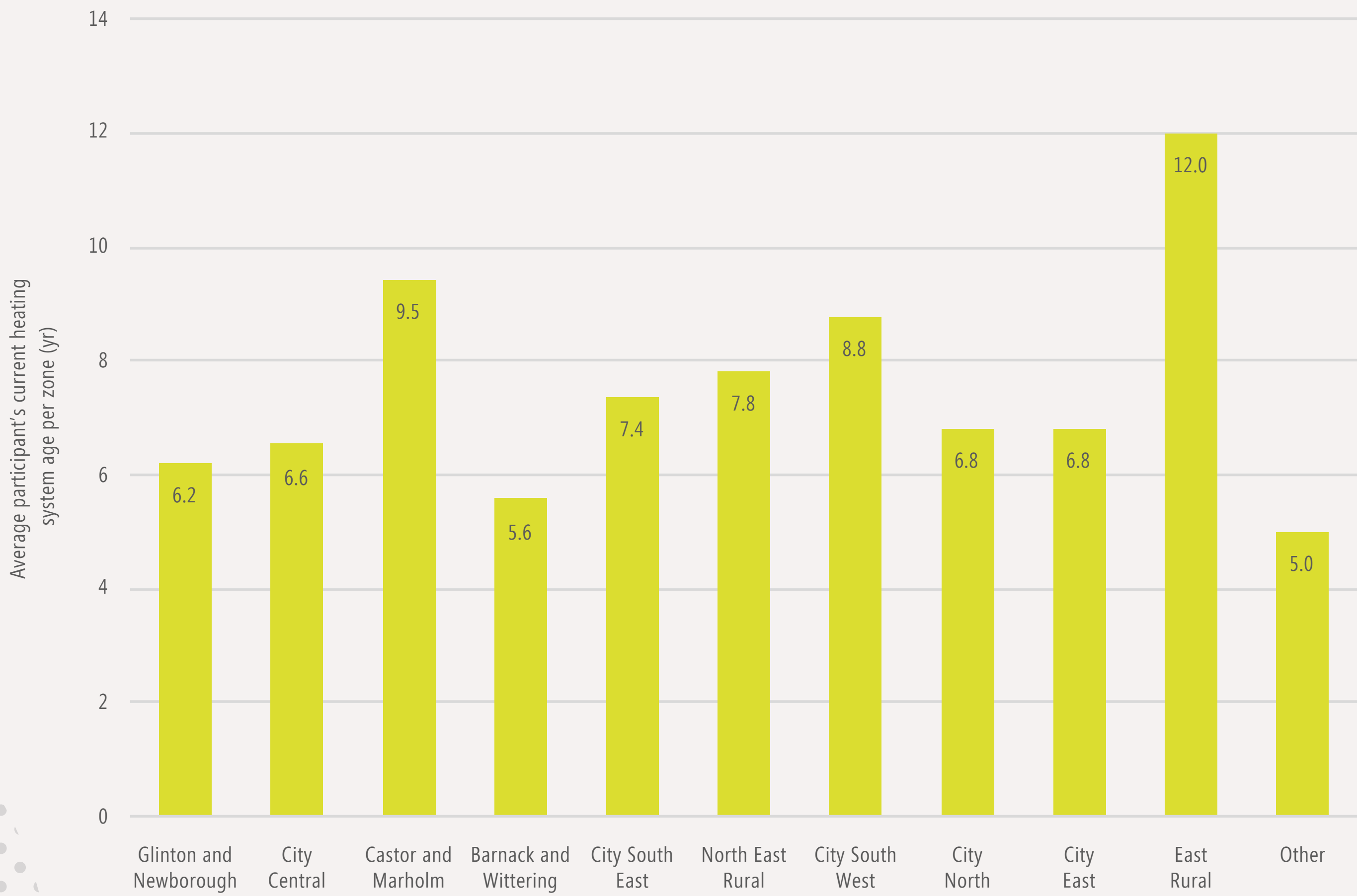
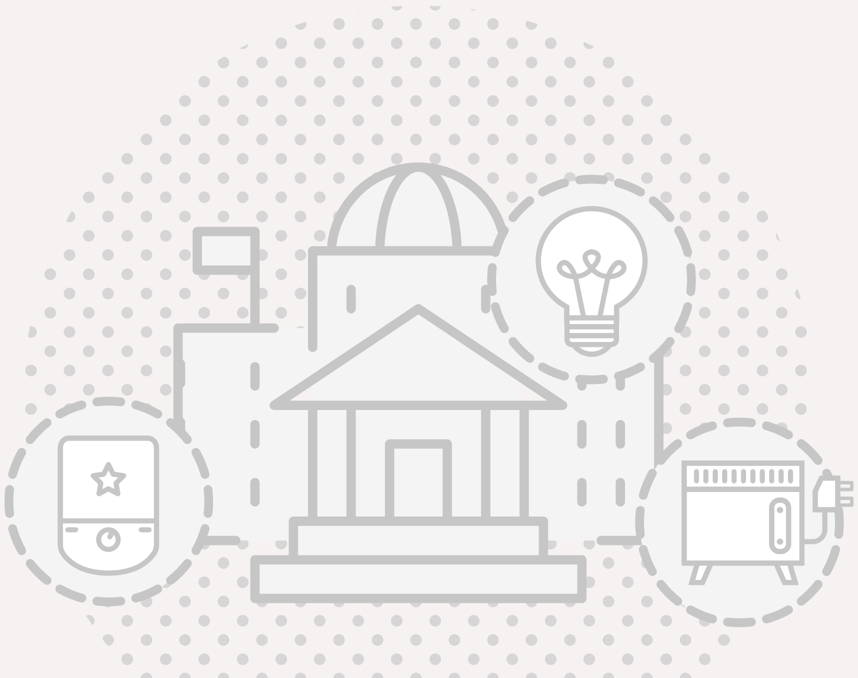
Note: Low number of votes in some zones.

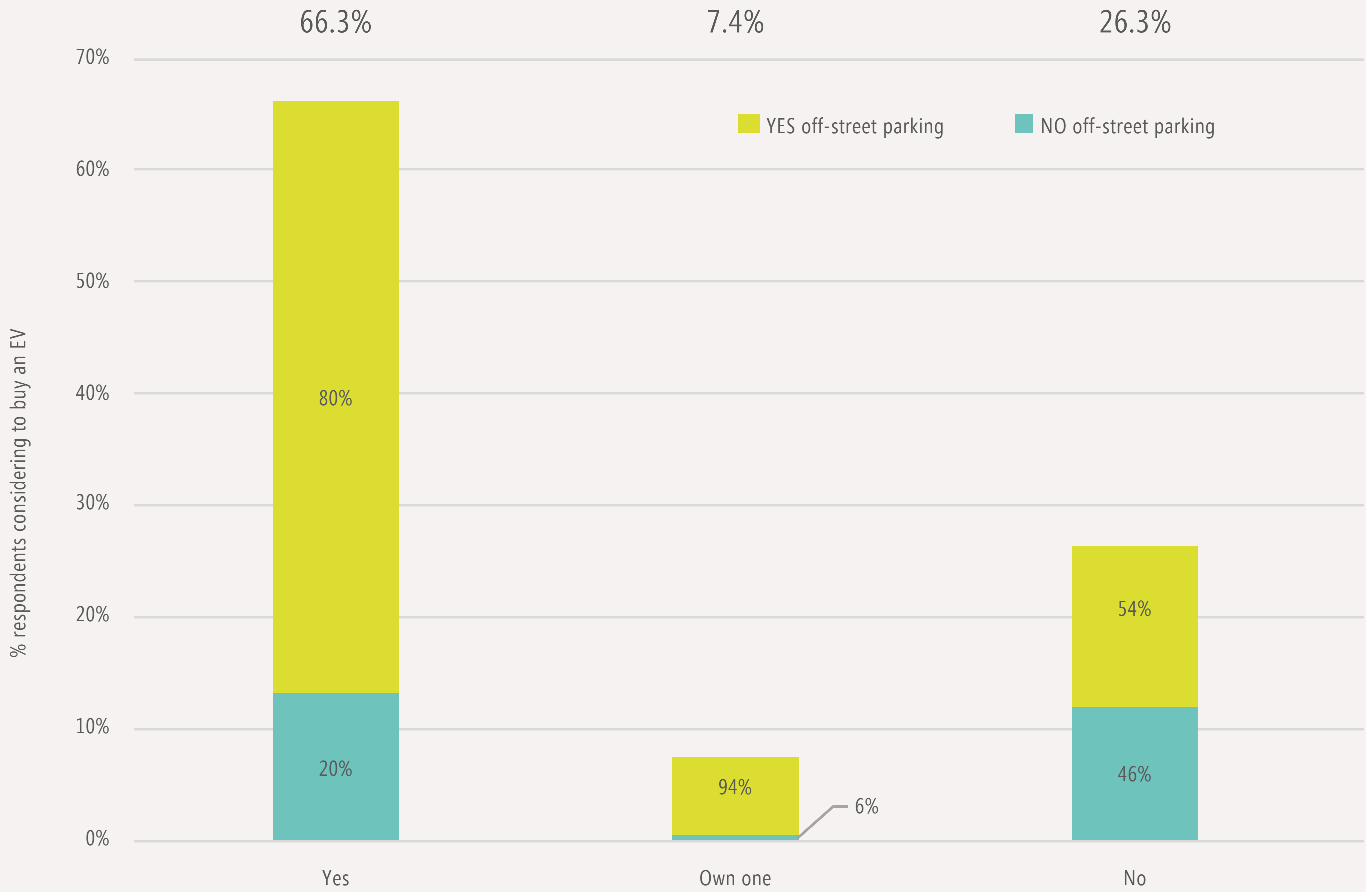




ZeroCarbon.Vote: Results

The majority of the respondents (73.7%) are either considering an EV as their next car or already own one. Of those, 80% have off-street parking.

However, only 54% for those who are not considering an EV as their next car have off-street parking.



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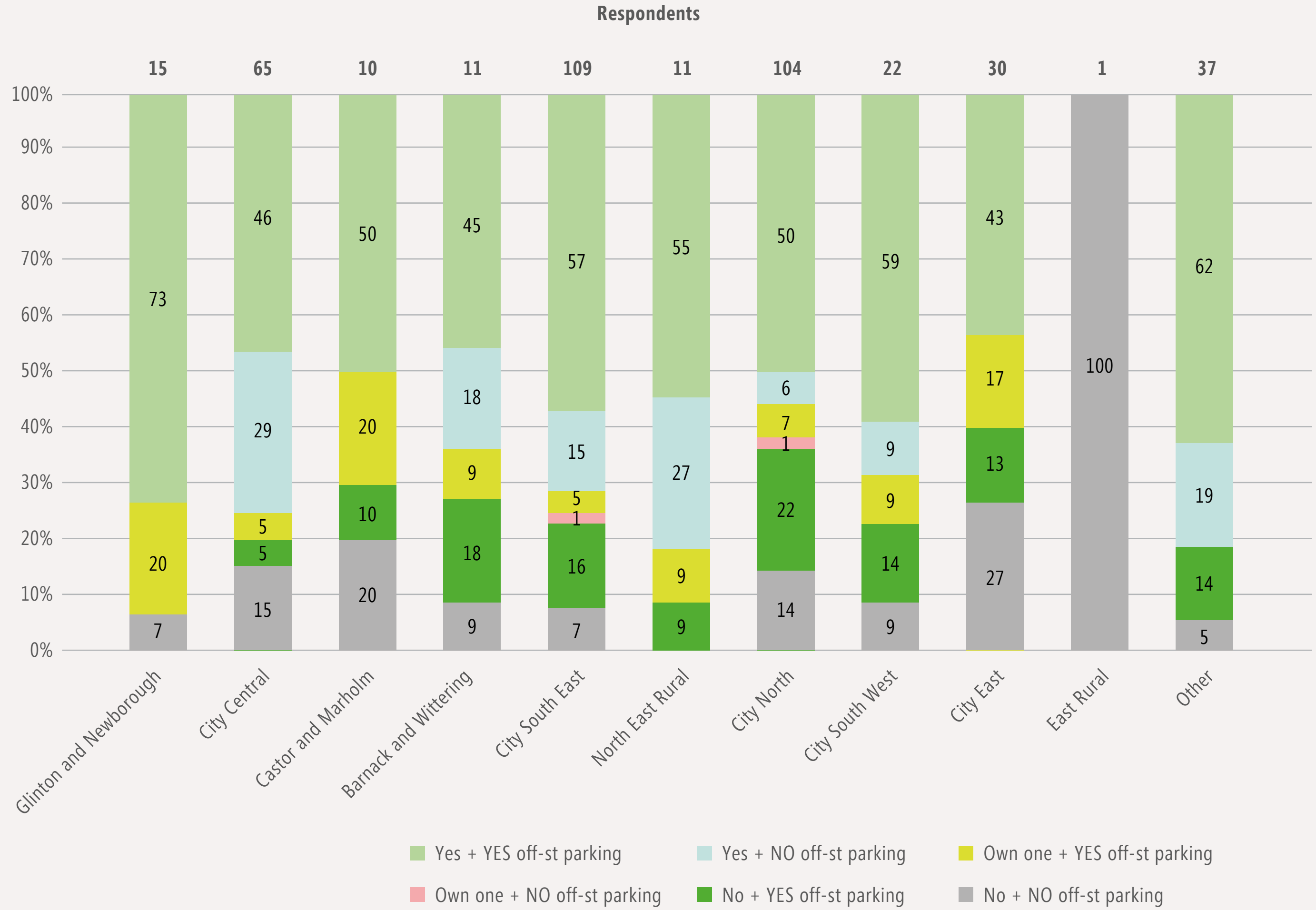
ZeroCarbon.Vote: Results

City Central reported the largest percentage of respondents with NO off-street parking: 44.6%

City East and City North have the largest percentage of respondents that are not considering an EV as their next car.

Note: Low number of votes in some zones



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