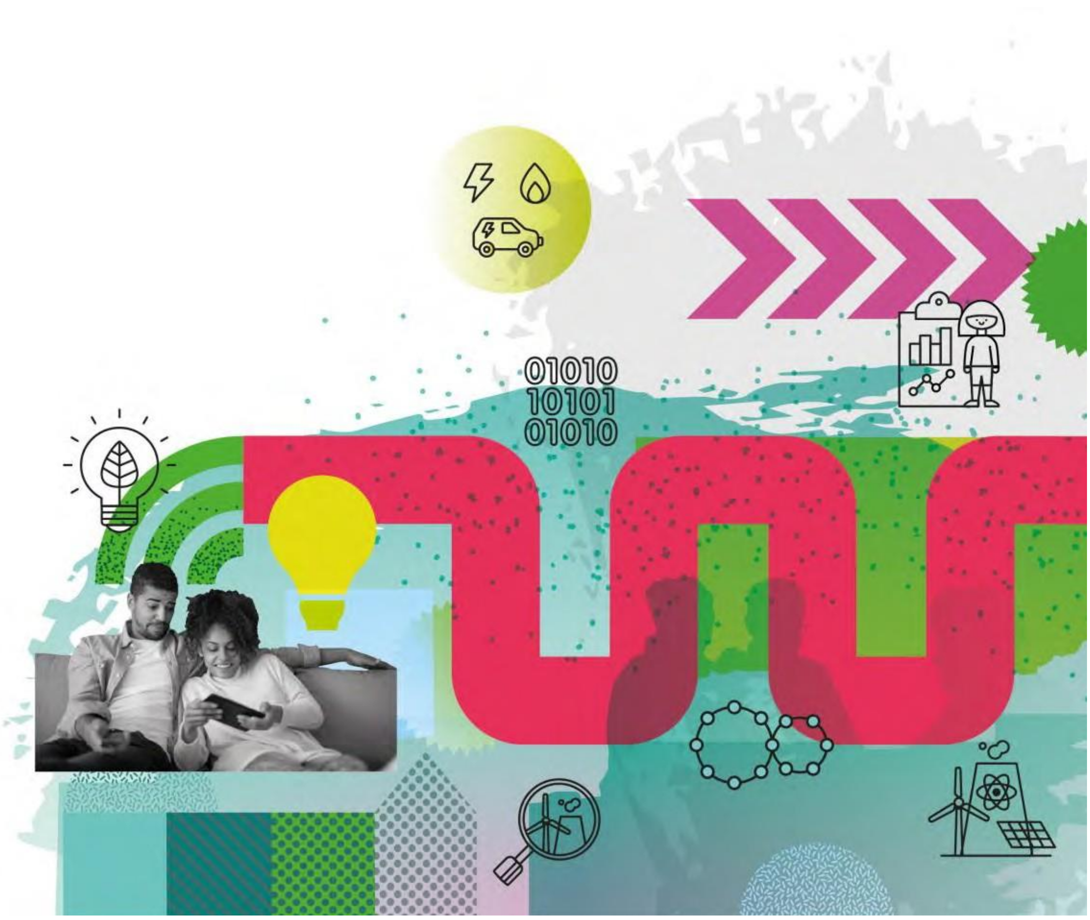
Local Energy Asset Representation for **Norfolk**

24th September 2021



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Contents

Acronyms & Initialisms

A - Amperes
ASHP - Air Source Heat Pump
BEIS - Department for Business, Energy & Industrial Strategy
CO_2 - Carbon dioxide
DCLG - Department for Communities and Local Government (now the Ministry for Housing, Communities and Local Government, MHCLG)
DfT - Department for Transport
DVLA - Driver and Vehicle Licensing Agency
ESWI - External Solid Wall Insulation
EV - Electric Vehicle
FIT - Feed In Tariff
ESC - Energy Systems Catapult
GSHP - Ground Source Heat Pump
GW - Gigawatt (1,000 MW)
GWh - Gigawatt-hour (1,000 MWh)
HV - High Voltage
I&C - Industry & Commercial
ISWI - Internal Solid Wall Insulation
$ktCO_2$ - Kilo-tonnes of carbon dioxide
kV - Kilovolts (1,000 V)
kW - Kilowatt
kWh - Kilowatt-hour
LA - Local Authority
LAEP - Local Area Energy Plan(ning)
LEAR - Local Energy Asset Representation
LEP - Local Enterprise Partnership
LPG - Liquefied Petroleum Gas
LSOA - Lower-level Super Output Area
LV - Low Voltage
MHCLG - Ministry for Housing, Communities and Local Government (formerly Department for Communities and Local Government, DCLG)
MSOA - Middle-level Super Output Area
MVA - Megavolt Amperes
MW - Megawatt (1,000 kW)
MWh - Megawatt-hour (1,000 kWh)
NCC - Norfolk County Council
PV - Photovoltaic
NAEI - National Atmospheric Emissions Inventory
ONS - Office of National Statistics
REPD - Renewable Energy Planning Database
V - Volts
VOC - Volatile Organic Compounds

**Please note: At time of writing, MHCLG is undergoing a further name change to the 'Department for Levelling Up, Housing and Communities' but this is not reflected in the table above.*

1. Introduction

Part of a world-leading network of innovation centres, Energy Systems Catapult (ESC) was set up to accelerate the transformation of the UK's energy system and ensure UK businesses and consumers capture the opportunities of clean growth. ESC is an independent, not-for-profit centre of excellence that bridges the gap between industry, government, academia, and research. We take a whole system view of the energy sector – from power, heat and transport to industry, infrastructure, and consumers – helping us to identify and address innovation priorities and market barriers to decarbonise the energy system at the lowest cost.

As part of our offering, the Local Energy Asset Representation (LEAR) was developed. LEAR is a local energy system modelling tool developed by ESC that pulls together information on energy demand, generation, storage and distribution assets, social factors like fuel poverty and characteristics like building design types and local geography, using data analysis and aspects of machine learning. It enables planners and innovators to strategically decide how they might deploy and grow low carbon businesses.

This LEAR has been created by collating and processing data from a variety of sources and using in house modelling techniques. It gives an understanding of the buildings in the local area; their annual and peak energy demands and the energy networks that serve them. It also provides some information on the levels of employment and deprivation in the area. It is not expected that the information contained in this document exactly matches the items it reports on but, rather, provides a reasonable representation of them.

This document should be read in combination with the accompanying *Local Area Energy System Representation Datasets and Methodology*[1] document to understand the data used and how it has been processed. Accompanying Excel workbooks contain the data presented graphically in this document.

[1] Issued alongside this document. Also available on request from eris@es.catapult.org.uk.

1.1 Norfolk

Norfolk County Council (NCC) commissioned ESC to produce a LEAR to help achieve their environmental goals for decarbonisation of the local economy as set out in the recently adopted environmental policy. These goals[2] are:

- *Clean air for the population;*
- *Ensuring a clean and plentiful water supply;*
- *Encouraging a thriving plant and wildlife community;*
- *Reducing the risk of harm from environmental hazards such as flooding and drought;*
- *Using resources from nature more sustainably and efficiently;*
- *Enhancing beauty, heritage and engagement with the natural environment;*
- *Mitigating and adapting to climate change;*
- *Minimising waste;*
- *Managing exposure to chemicals; and*
- *Enhancing biosecurity*

This document provides a representation of the local energy system in Norfolk covering an area of well over 5,000 km^2 and a population of around 915,000 people.

The decarbonisation of the Norfolk area is within the context of the UK's legal binding target to reach net zero emissions by 2050 and milestone of 78% reduction compared to 1990 levels by 2035 (Carbon Budget 6). Locally, three of the eight local authorities (including the Broads Authority) have declared a climate emergency setting challenging decarbonisation targets up to twenty years ahead of the UK as a whole (Table 1).

Table 1: Table of climate emergency declarations in the Norfolk County Council area.

District	Climate Emergency Declared	Notes
Breckland District Council	Yes	Net zero carbon in the district by 2035.
Broadland District Council	No	Carbon neutral before 2050.
Broads Authority	Yes	Carbon neutral by 2030
Great Yarmouth Borough Council	No	Carbon neutral before 2050.
King's Lynn & West Norfolk Borough Council	No	Aligned to the UK's commitment of net zero by 2050.
North Norfolk District Council	Yes	Net zero carbon emissions by 2030.
Norwich City Council	Yes	City Council's target to become net zero by 2030.
South Norfolk District Council	No	Aligned to the UK's commitment of net zero by 2050.
Norfolk County Council	**No**	**Net zero Council by 2030.**

[2] https://www.norfolk.gov.uk/-/media/norfolk/downloads/what-we-do-and-how-we-work/policy-performance-and-partnerships/policies-and-strategies/environment/norfolk-county-council-environmental-policy.pdf

The emissions attributed to an area varies depending upon the method used. One way is to use local authority CO_2 data which attributes the carbon to the end-use rather than where the emissions take place e.g. some of the emissions relating to electricity production are attributed to a domestic dwelling using their lighting. These emissions are broadly split into three categories: industrial, commercial, and the public sector (I&C), domestic, and transport. Table 2 shows the breakdown of these in each local authority area:

Table 2: Local Authority CO_2 Emissions

Local Authority Area	**Total 2019 [$ktCO_2$]**	**Ratio I&C : Domestic : Transport**	**Change in Emissions 2005-2018**
Breckland	734.9	24% : 26% : 50%	-43%
Broadland	609.8	25% : 32% : 43%	-26%
Great Yarmouth	349.9	23% : 37% : 40%	-57%
King's Lynn & West Norfolk	1,177.9	49% : 20% : 31%	-28%
North Norfolk	540.9	28% : 32% : 40%	-50%
City of Norwich	448.0	36% : 38% : 26%	-91%
South Norfolk	802.3	25% : 25% : 50%	-29%
TOTAL	**4,663.7**	**32% : 28% : 40%**	**-41%**

The data above are from the 'subset' dataset which gives the "territorial CO_2 emissions estimates that are within the scope of influence of Local Authorities". The subset dataset therefore excludes large industrial sites, railways, motorways, and land-use.[3]

[3] For the whole dataset, and annual updates, visit: https://data.gov.uk/dataset/723c243d-2f1a-4d27-8b61-cdb93e5b10ff/emissions-of-carbon- dioxide-for-local-authority-areas [Accessed: 31/08/2021]. Updates are typically in late-June each year. Please note: since the Broads Authority is not a local authority the emissions data is not available and hence does not appear in Table 2.

1.2 Report Structure

In order to represent an area as large as Norfolk, the region had to be split into three sub-regional areas: 'Central and West Norfolk', 'Norwich & South Norfolk' and 'Norfolk Coastal'. Figure 1 shows this graphically. The theory behind this split was to keep the number of dwellings in each sub-region to under 200,000 to simplify the modelling processes while maintaining contiguous sub-regions.

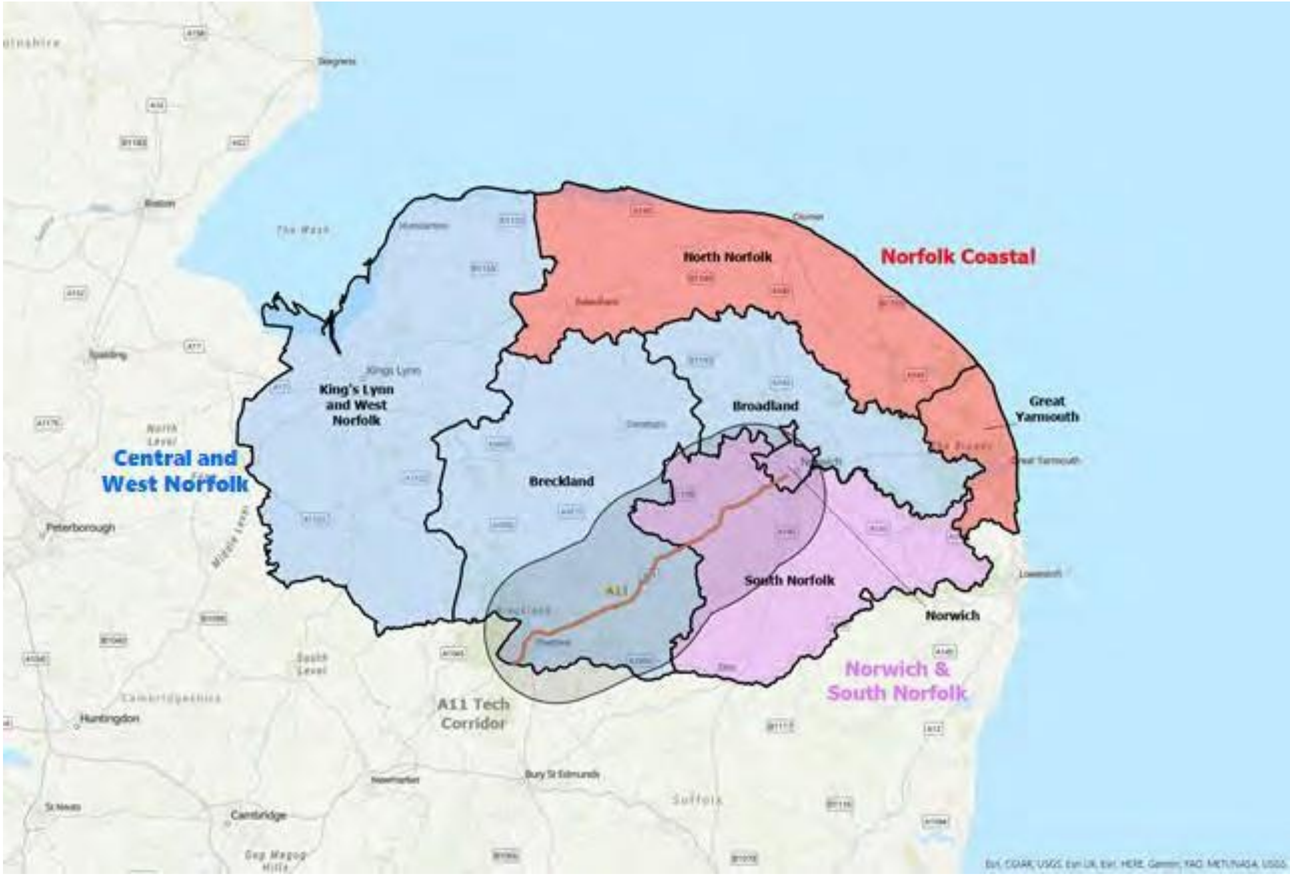


Figure 1: Norfolk was split into three sub-regions to carry out the modelling and analysis.

This LEAR report is broken into four key sections: each of the three sub-regional areas are considered before looking at some examples of insights that can be gained from the data. A circa 10km buffer has been drawn around the A11 to represent the A11 Tech Corridor.

2. Norfolk Sub-Regional Analysis

This section of the report will provide information and mapping for each of the three sub-regional areas of the Central and West Norfolk (Breckland, Broadland & King's Lynn and West Norfolk), Norwich & South Norfolk (Norwich & South Norfolk), and Norfolk Coastal (Great Yarmouth & North Norfolk). As these maps cover an area equal to 2-3 local authority areas some of the detail can be lost. More detail is provided in the Insights section of this report and all maps and data are available in the data pack which accompanies this report.

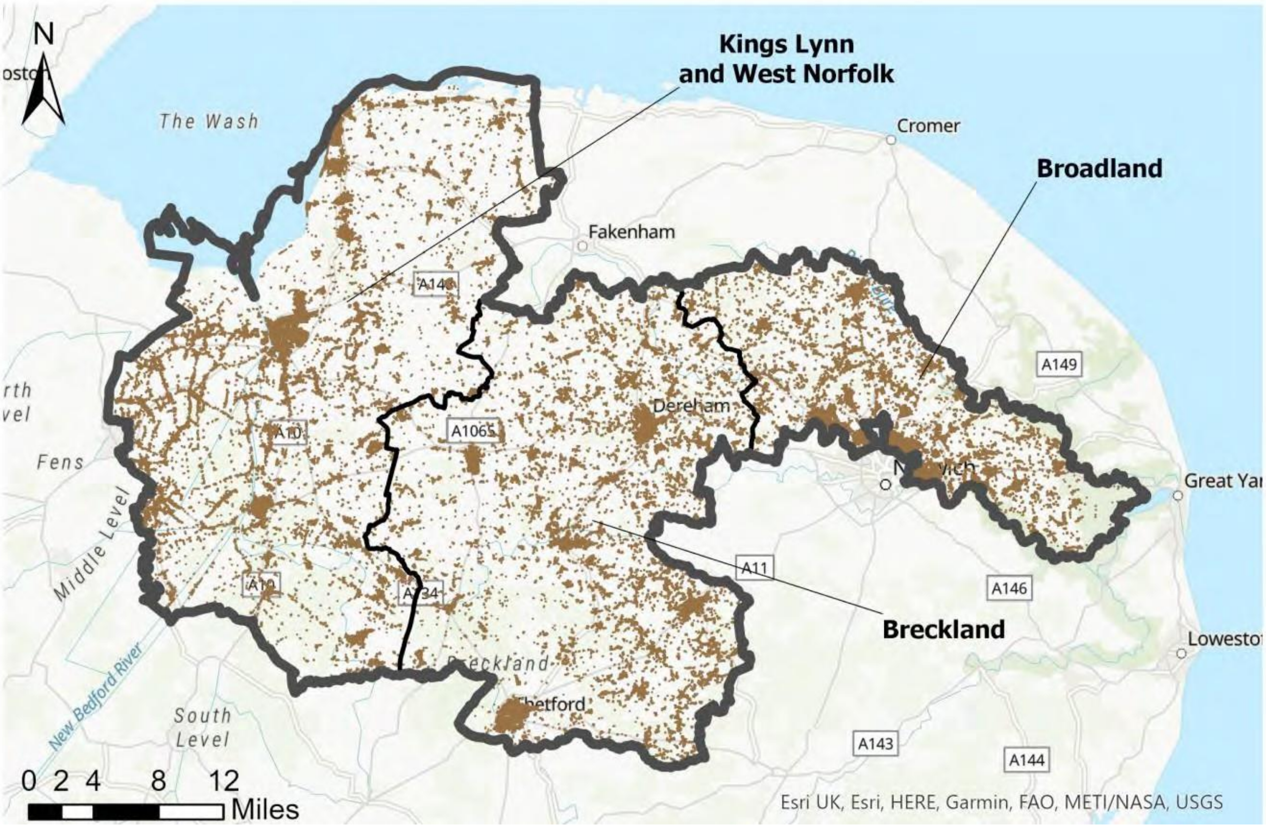
2.1 Central and West Norfolk (Breckland, Broadland & King's Lynn and West Norfolk)

The 'Central and West Norfolk' area of Norfolk has been defined in this report as covering the local authority areas of Breckland, Broadland & King's Lynn and West Norfolk which collectively cover an area of approximately 3,370 km^2 and have a population of around 424,000[4].

2.2 Building Stock

This section will provide an overview of the building stock – both domestic and non-domestic – across the Central and West Norfolk sub-region. The geographical location of the building stock will be shown, as will the relative rurality across the sub-region, and breakdowns of the domestic and non-domestic stock by category.

Figure 2 shows the building stock is fairly evenly distributed across the three districts that form the Central and West Norfolk sub-region. The larger conurbations such as King's Lynn, Thetford and Dereham can be clearly seen.



[4] https://www.norfolkinsight.org.uk/population/

Figure 2: Building stock distribution across the Central and West Norfolk sub-region.

These areas correlate well to the rural/urban classifications given in the rurality map (Figure 3).

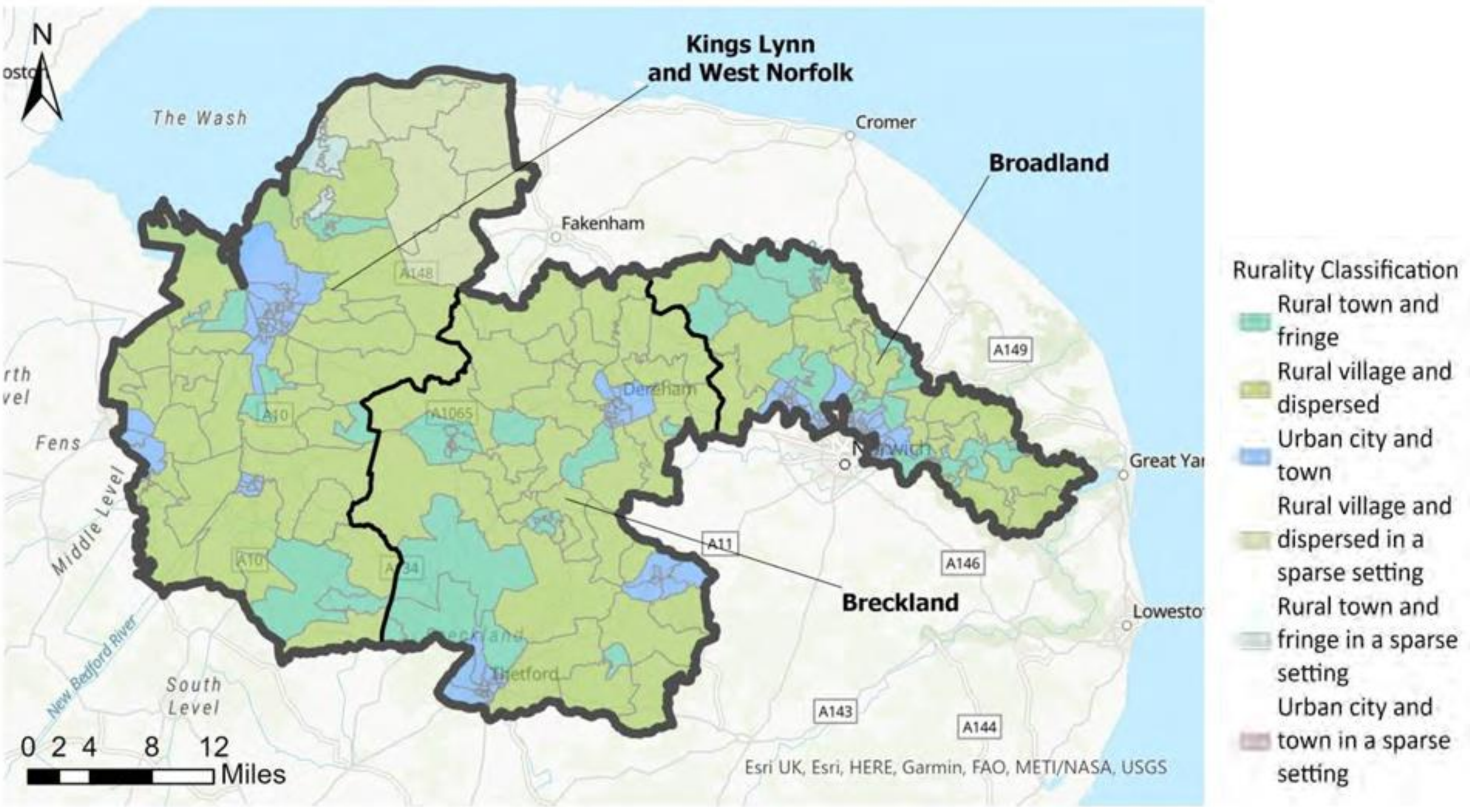


Figure 3: Rurality of the Central and West Norfolk sub-region.

Figure 3 shows the rurality of the Central and West Norfolk sub-region by Lower-level Super Output Area (LSOA). Most of the land area in Central and West Norfolk is classified as rural towns and villages with the more urban areas matching those noted in Figure 2.

Using data provided by Historic England[5], the location and grade of listed buildings; scheduled monuments; Battlefields; World Heritage Sites and Parks & Gardens can be mapped within the sub-region (Figure 4).

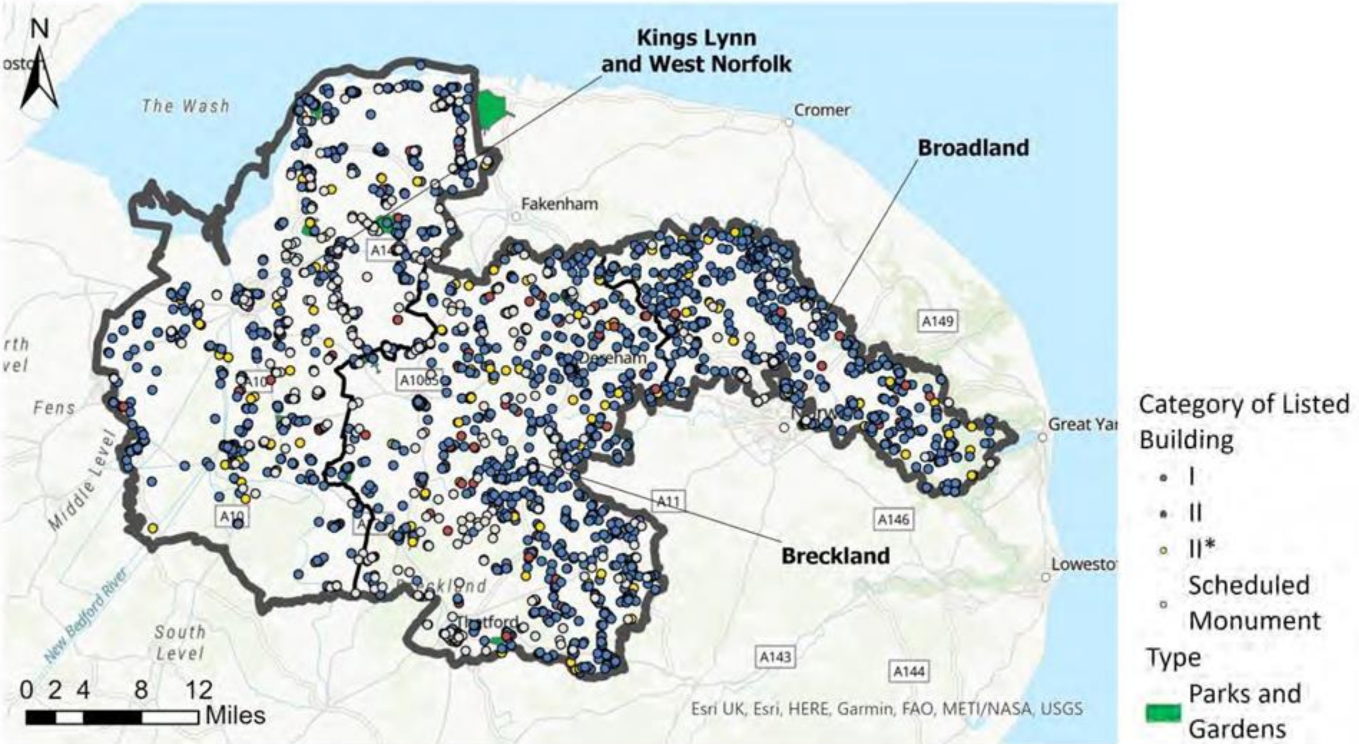


Figure 4: Location of listed buildings in the Central and West Norfolk sub-region grouped by grading according to Historic England

Figure 4 shows the large number of listed buildings, scheduled monuments, and areas of interest that could all pose a challenge to decarbonising the building stock. Table 3 shows the Listed Status of the buildings and the number of occurrences.

Table 3: Summary of listed buildings across Central and West Norfolk by grade category.

Grade Category	Number
Grade I	264
Grade II	3,578
Grade II*	315
Scheduled Monument	282

To understand the housing stock in more detail, the domestic stock has been segmented by:

- Type (converted flat, detached, purpose-built flat, semi-detached, and terrace)
- Construction date (pre-1914, 1914-1944, 1945-1964, 1965-1979, post-1980)
- Floor area [m^2] (under 50, 50-70, 70-90, 90-110, 110-200, 200-300, over 300)
- Main heating system (ASHP, biomass, electric (no storage), electric storage, gas, GSHP, oil/LPG)
- Loft insulation level [mm] (no loft, no insulation, 1-99, 100-199, over 200)
- Wall type (filled cavity, unfilled cavity, solid with ESWI, solid with ISWI, uninsulated solid)
- Window type (single glazing, double glazing, triple glazing)

5 https://historicengland.org.uk/listing/the-list/data-downloads

Table 4: Number and percentage of dwelling types across the Central and West Norfolk sub-region.

Dwelling Type	Number	Percentage
Converted Flat	3,650	2%
Detached	78,500	41%
Purpose Built Flat	21,000	11%
Semi-detached	55,500	29%
Terrace	34,000	18%
Total	**193,000**	**100%**

Due to rounding, some totals may not correspond with the sum of the separate figures.

Table 4 shows that there is a predominance of detached dwellings across the sub-region. Figure 5 shows that these are typically the most dominant in rural areas, whereas semi-detached and terraced are more common in urban areas.

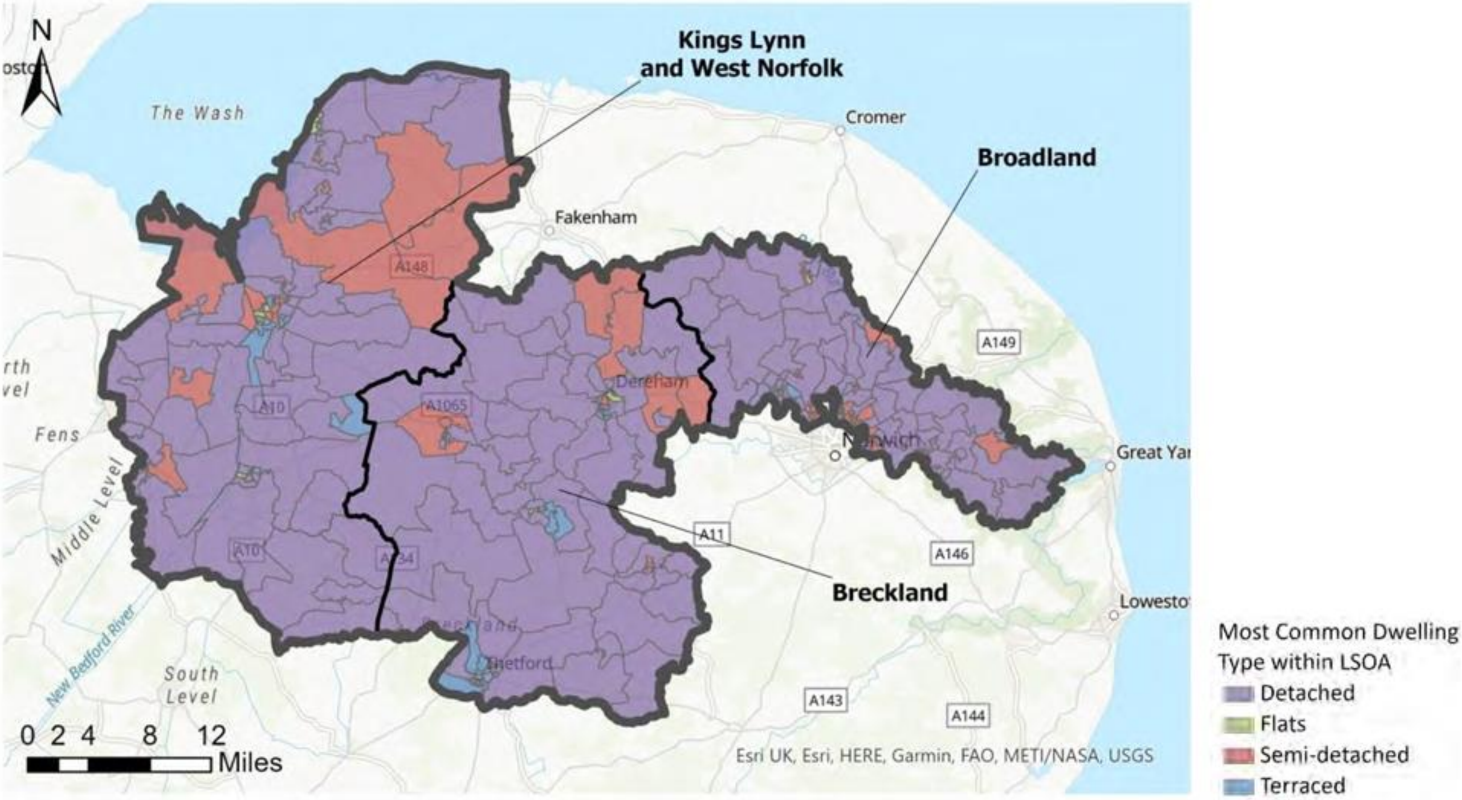


Figure 5: Most common dwelling type within each LSOA across the Central and West Norfolk sub-region.

A notable finding, shown in Table 5 is that under one-third of all domestic dwellings in the sub-region were constructed post-1964 where energy efficiency is more likely to be suited to the transition to a low carbon heating system e.g. heat pump. A significant number of dwellings that were built before 1945 will likely require more substantial intervention to bring their heat loss to a point where a heat pump could be considered.

Table 5: Number and percentage of dwellings constructed in different periods across the Central and West Norfolk sub-region.

Dwelling Construction Period	Number	Percentage
Pre-1914	15,000	8%
1914-1944	66,000	34%
1945-1964	52,000	27%
1965-1979	37,000	19%
1980-present	23,000	12%
Total	**192,000**	**100%**

Due to rounding, some totals may not correspond with the sum of the separate figures.

By combining the dwelling type and the construction period, it can be seen in Figure 6 that 1945-1964 detached and semi-detached, and 1965-1979 detached dwellings represent the largest proportion of the housing stock each covering around 13% of the domestic housing stock. This is followed closely by modern (post-1980) detached dwellings (c. 22,000 dwellings, 11%). Pre-1914 terrace dwellings represents nearly 6% of the total housing stock of the sub-region.

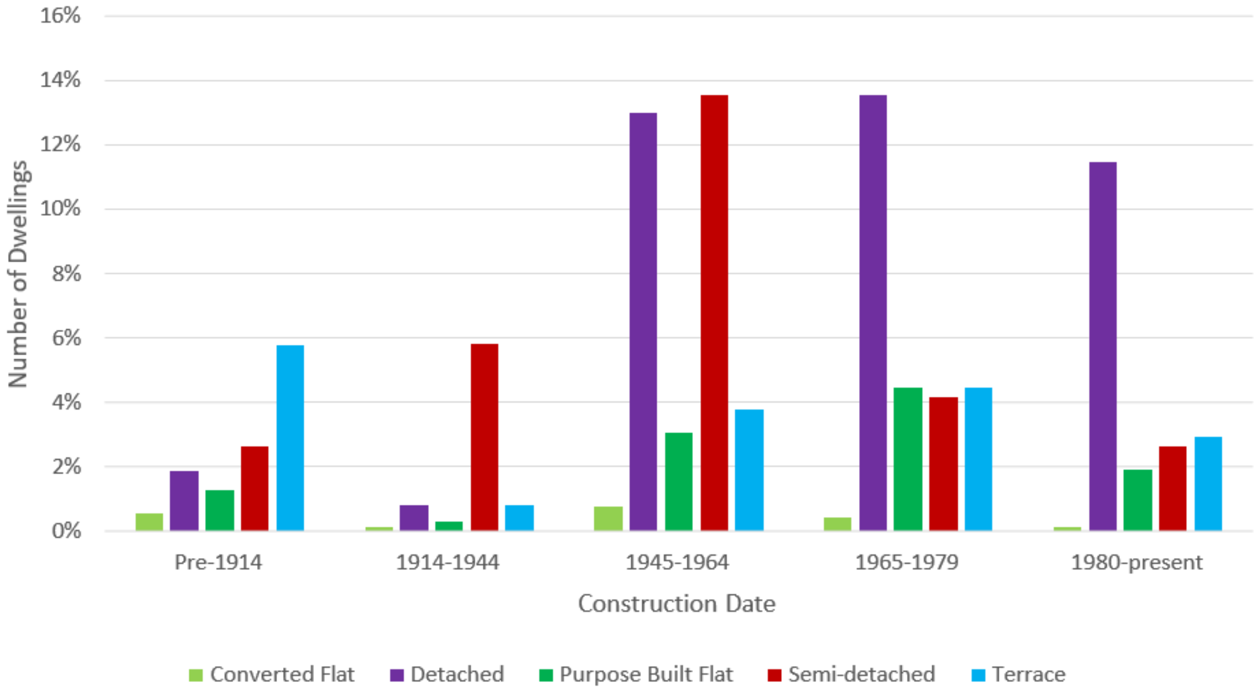


Figure 6: Estimated number of dwellings within each construction period (by dwelling type) across the Central Norwich sub-region.

This can be visualised spatially (Figure 7) to show the most prevalent construction year in each LSOA in the Central and West Norfolk sub-region.

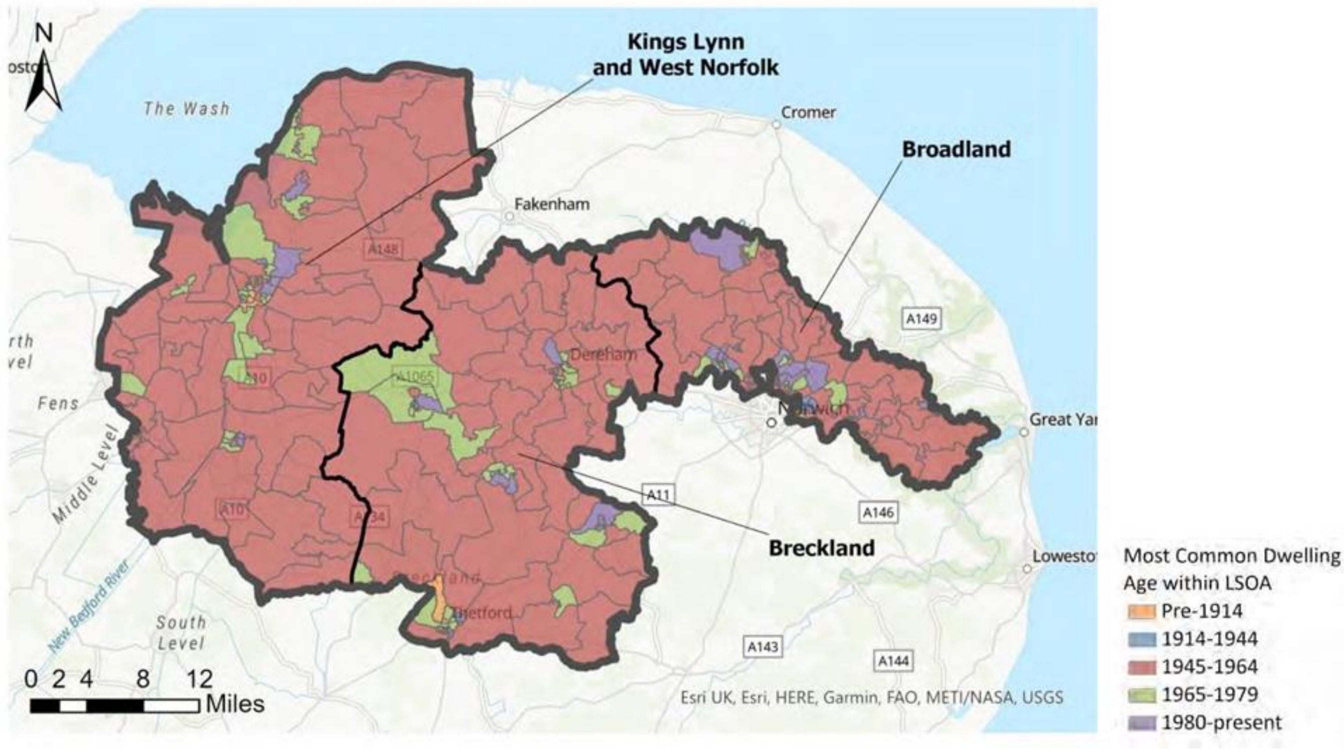


Figure 7: Most common construction period within each LSOA across the Central and West Norfolk sub-region.

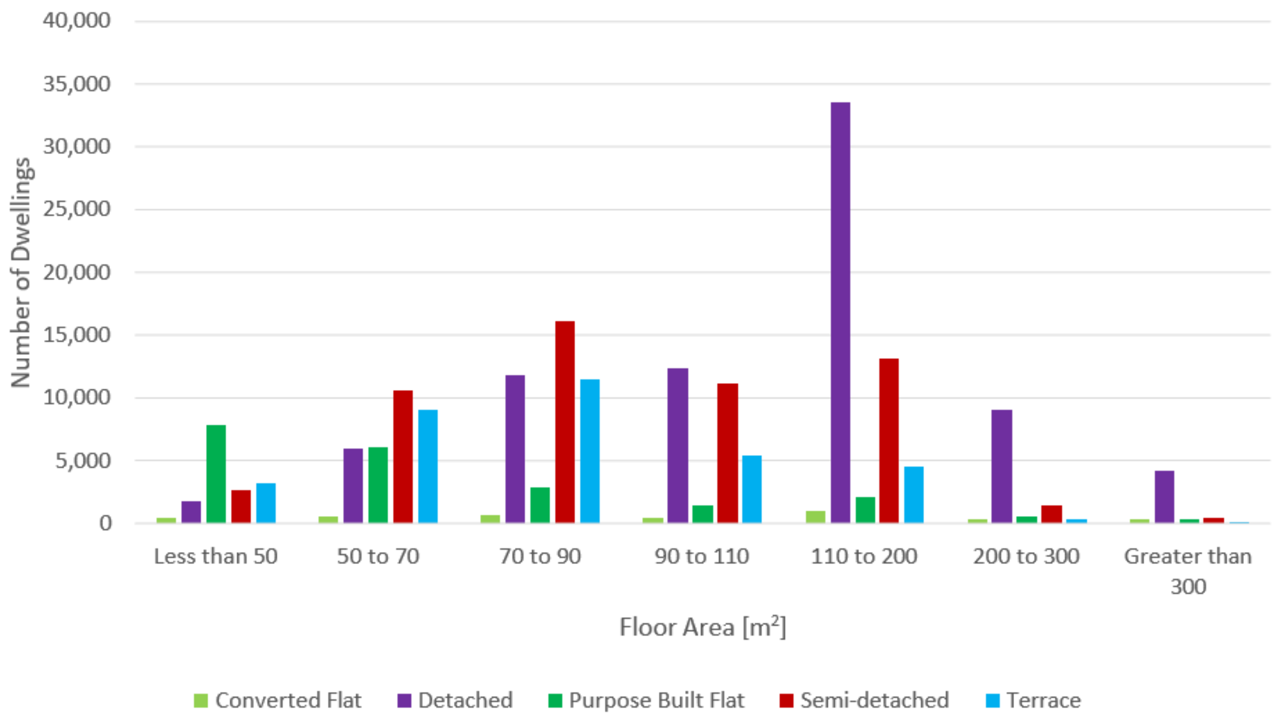


Figure 8: Estimated number of dwellings within each floor area band (by dwelling type) across the Central and West Norfolk sub- region.

Figure 8 as expected shows flats (particularly purpose-built flats) have a lower floor area than semi-detached and detached dwellings. Two-thirds of purpose-built flats have a floor area of under 70m^2 whilst nearly half of detached dwellings have a floor area of 110-200m^2.

Dwellings in the Central and West Norfolk sub-region are overwhelmingly heated using a fossil fuel boiler (86%) with the remainder being made up from electric storage heaters (11%). Electric storage heaters are often used in modern flats where heat losses are low. Oil/LPG boilers are typically used in off-gas grid areas which in turn are often rural. Figure 9 shows that around 35% of detached dwellings use oil/LPG boilers as their main heating system. Gas boilers are prevalent throughout the housing stock.

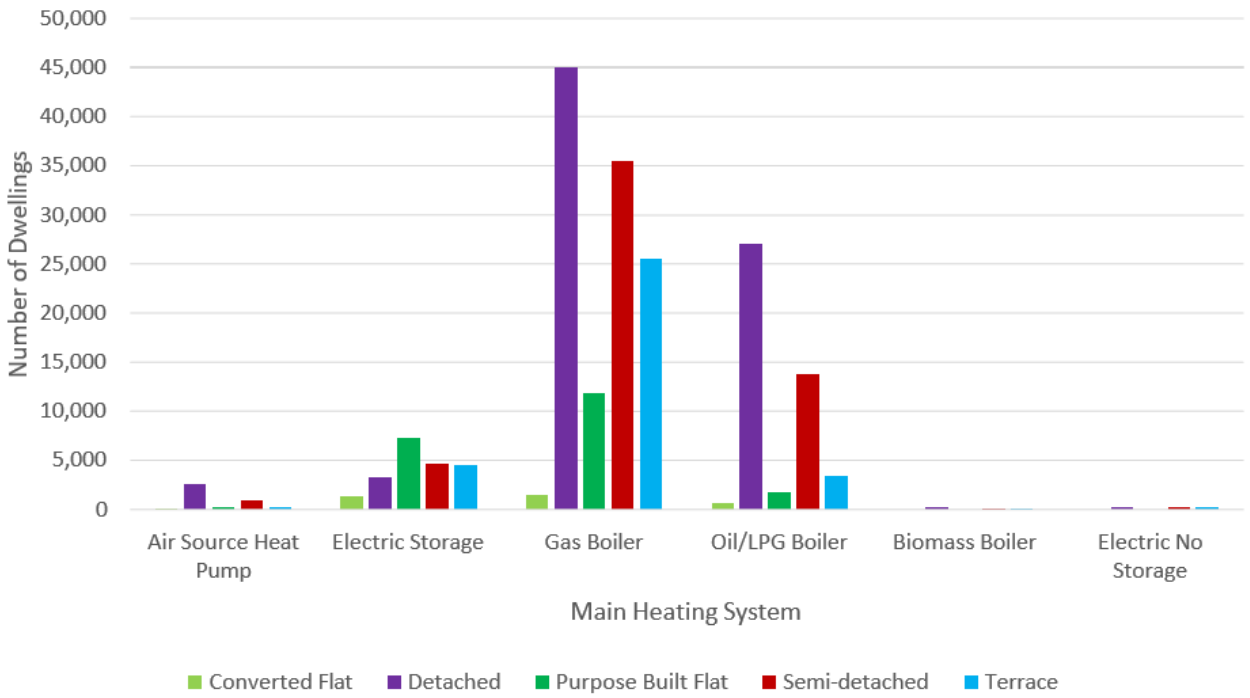


Figure 9: Estimated number of dwellings by main heating system (by dwelling type) across the Central and West Norfolk sub-region.

To make a heating system as efficient as possible insulation is required to reduce the heat loss from a dwelling.

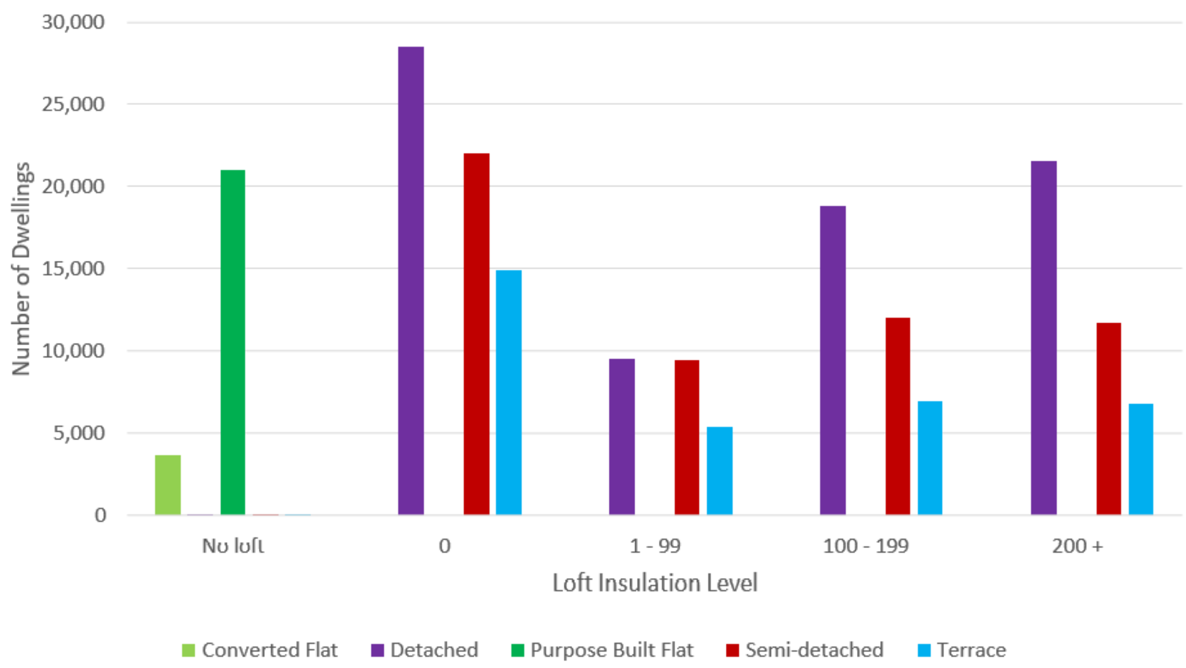


Figure 10: Estimated level [mm] of loft insulation (by dwelling type) across the Central and West Norfolk sub-region.

Figure 10 shows the level of loft insulation in each dwelling type. Flats (both converted and purpose built) are assumed not to have a loft to insulate as even those on the top-floor are unlikely to be able to access the loft space in which to add insulation. There are also a small number of detached, semi-detached, and terraced properties that are classified as having no loft; this is usually due to them having a 'room-in-roof' where the loft has been converted into part of the living area.

The expected level of loft insulation in the UK is 270mm meaning that there are at least 66% of the dwellings in the Central and West Norfolk sub-region that would benefit from additional loft insulation. Of particular concern are the larger dwellings that have no loft insulation recorded.

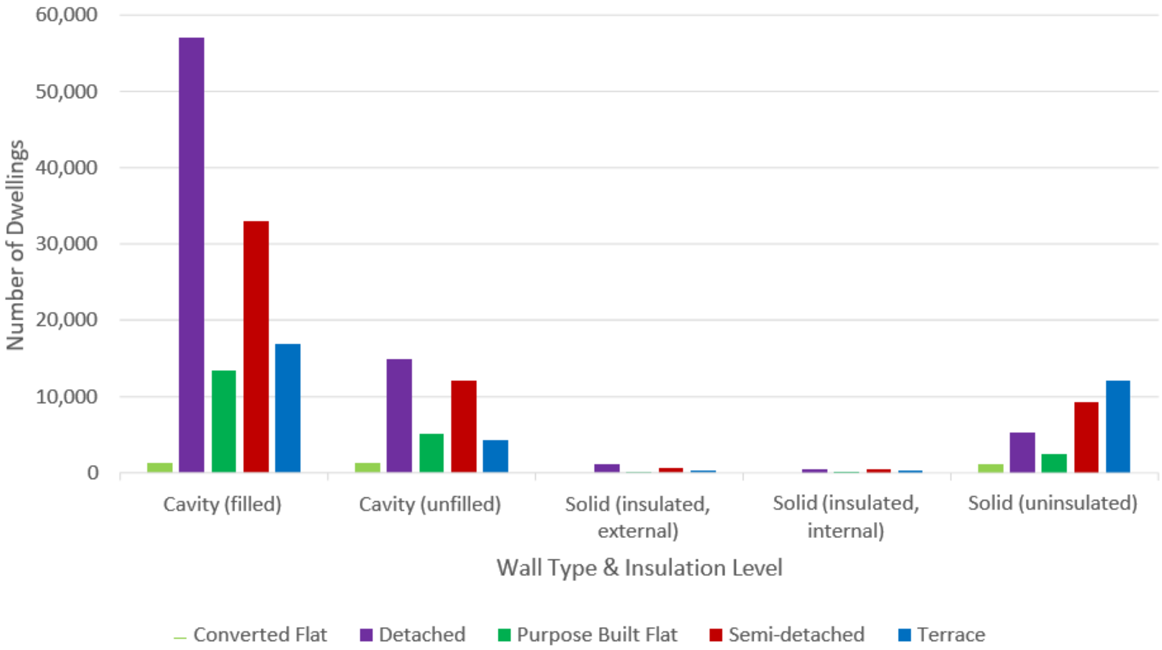


Figure 11: Estimated wall type and insulation level (by dwelling type) across the Central and West Norfolk sub-region.

Figure 11 shows that cavity walls are the most prominent wall type across the Central and West Norfolk sub-region. Of those dwellings with a cavity wall, 76% are insulated. Cavity wall insulation can be difficult on some archetypes where there are hung tiles or render on the external face of the brickwork, also around conservatories. Whilst these are deemed 'hard-to-treat' there are methods for ensuring that the cavity can be filled, albeit at a higher cost.

Figure 11 also shows that nine-out-of-ten of the solid wall properties in the Central and West Norfolk sub-region are uninsulated. This may be due to listed status, other planning restrictions, occupant behaviour/preference, or cost.

Over 95% of dwellings in the Central and West Norfolk sub-region have double glazing, including over 90% of all detached, semi-detached, and terrace dwellings, and purpose-built flats (Figure 12). Converted flats are further behind with around 15% still having single glazed windows. Triple glazing is not prevalent in the housing stock.

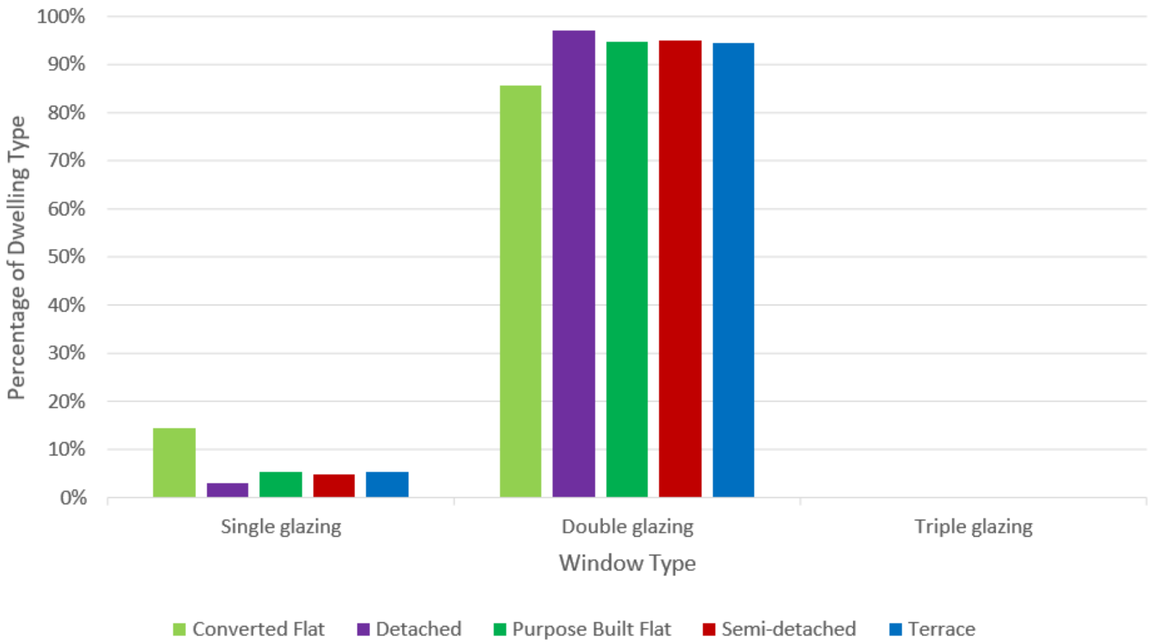


Figure 12: Estimated proportion of glazing type per dwelling type across the Central and West Norfolk sub-region.

As well as the domestic stock, the non-domestic stock needs to be considered. The breakdown of the non-domestic building stock across the Central and West Norfolk sub-region is shown in Table 6.

Table 6: Breakdown of the non-domestic building stock by type across the Central and West Norfolk sub-region.

Type	Floor Area [m²]	Percentage of total floor area	Number of non-domestic buildings	Percentage of non-domestic buildings
Retail	10,500,000	50%	43,500	58%
Factory	6,100,000	29%	16,500	22%
Warehouse	1,210,000	6%	3,750	5%
Education	1,190,000	6%	3,250	4%
Other	1,060,000	5%	4,100	5%
Office	770,000	4%	3,500	5%
Total	**21,000,000**	**100%**	**74,500**	**100%**

Due to rounding, some totals may not correspond with the sum of the separate figures.

Data from the National Atmospheric Emissions Inventory (NAEI)[6] has been used to identify large individual emission point sources i.e. emissions from a known location. As well as CO_2, this data shows air pollutants, heavy metals, base cations[7], and greenhouse gases (GHGs)[8]. The point sources included within the project boundary are shown below in Figure 13. It should be noted that this dataset is for fixed emission sources only, and that non-fixed emissions such as those from road traffic are not included.

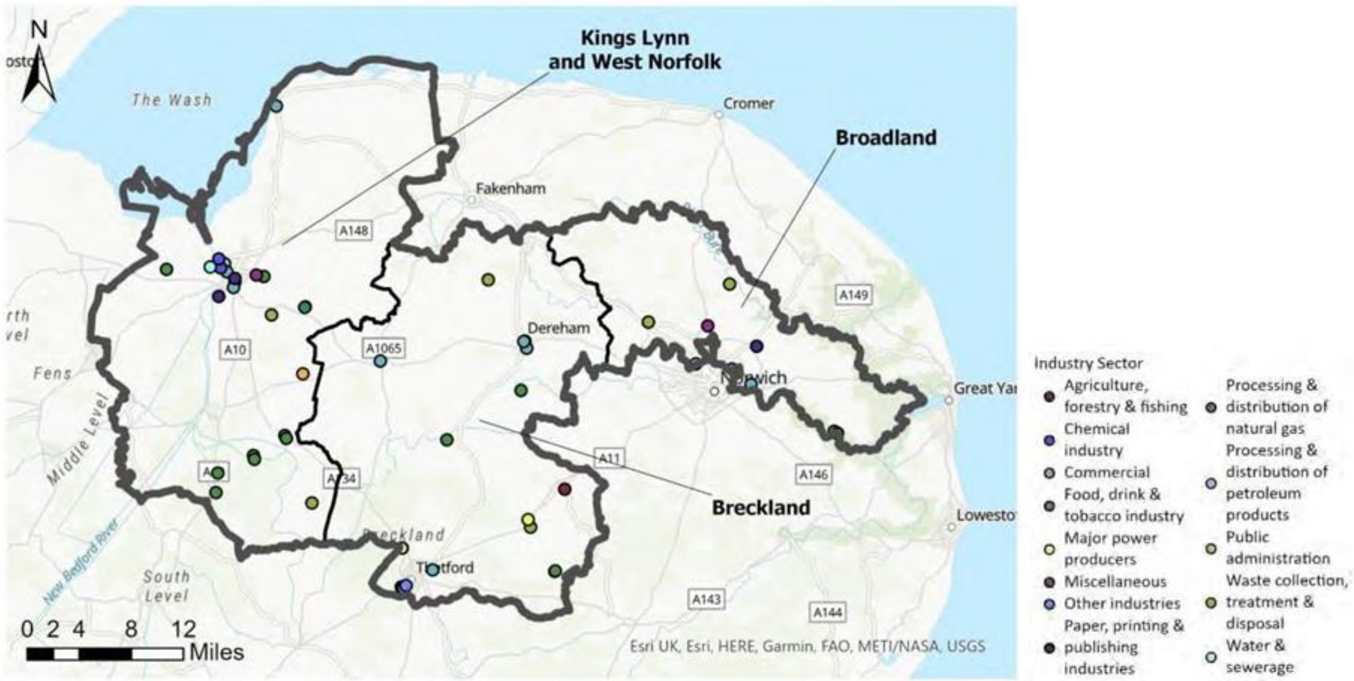


Figure 13: Individual emission sources identified by the National Atmospheric Emissions Inventory (NAEI) across the Central Norwich sub-region.

Often the high emitters are located closely together on an industrial park or similar, therefore the definition given in Figure 13 is lacking. However, the data pack accompanying this report contains the full background data providing more clarity.

[6] https://naei.beis.gov.uk/

[7] https://naei.beis.gov.uk/overview/ap-overview

[8] https://naei.beis.gov.uk/overview/ghg-overview

2.2.1 Energy Demands

This section will show the estimated annual consumption and peak demands across the Central and West Norfolk sub-region in the domestic and non-domestic sectors, and the geographic distribution by LSOA.

Table 7 and Table 8 below show the total figures for the sub-region. Please note: Electricity is supplied locally at 400V (three-phase) which is then connected to a dwelling at 230V (single-phase), therefore for the purposes of these calculations all domestic properties are assumed to be connected at 400V. Large non-domestic loads are assumed to be connected to the electricity network at 11kV; other non-domestic are connected at 400V. Total electricity demand is therefore the sum of demand at the 11kV level and 400V level. Demand from power generators and utilities are not included in these figures.

Table 7: Annual energy consumption [MWh] across the Central and West Norfolk sub-region.

Energy Type	Domestic Annual Consumption [MWh]	Non-Domestic Annual Consumption [MWh]	Total Annual Consumption [MWh]
Electricity (11kV)	0	470,000	470,000
Electricity (400V)	665,000	2,350,000	3,015,000
Gas	695,000	2,800,000	3,495,000
Oil	315,000	0	315,000

Table 8: Annual peak demand [MW] across the Central and West Norfolk sub-region.

Energy Type	Domestic Peak Demand [MW]	Non-Domestic Peak Demand [MW]	Total Peak Demand [MW]
Electricity (11kV)	0	137	137
Electricity (400V)	215	755	880
Gas	755	1,080	1,760
Oil	350	0	350

The total peak demand is not the sum of the peak demands for domestic and non-domestic buildings since the peak demands of the different sectors occur at different times.

The following maps (Figure 14 to Figure 17) show the distribution of estimated peak and annual energy consumption for both domestic and non-domestic buildings across the Central and West Norfolk sub-region. Peak demands shown on these maps may not all occur at the same time of day or time of year. For example, an area predominantly made up of domestic dwellings is likely to have a peak energy demand during the early evening in winter. In contrast, an area that is mainly made up of commercial offices will have maximum energy demand around the middle of the day. Mixed-use areas could have a different peak time depending upon the nature of their buildings.

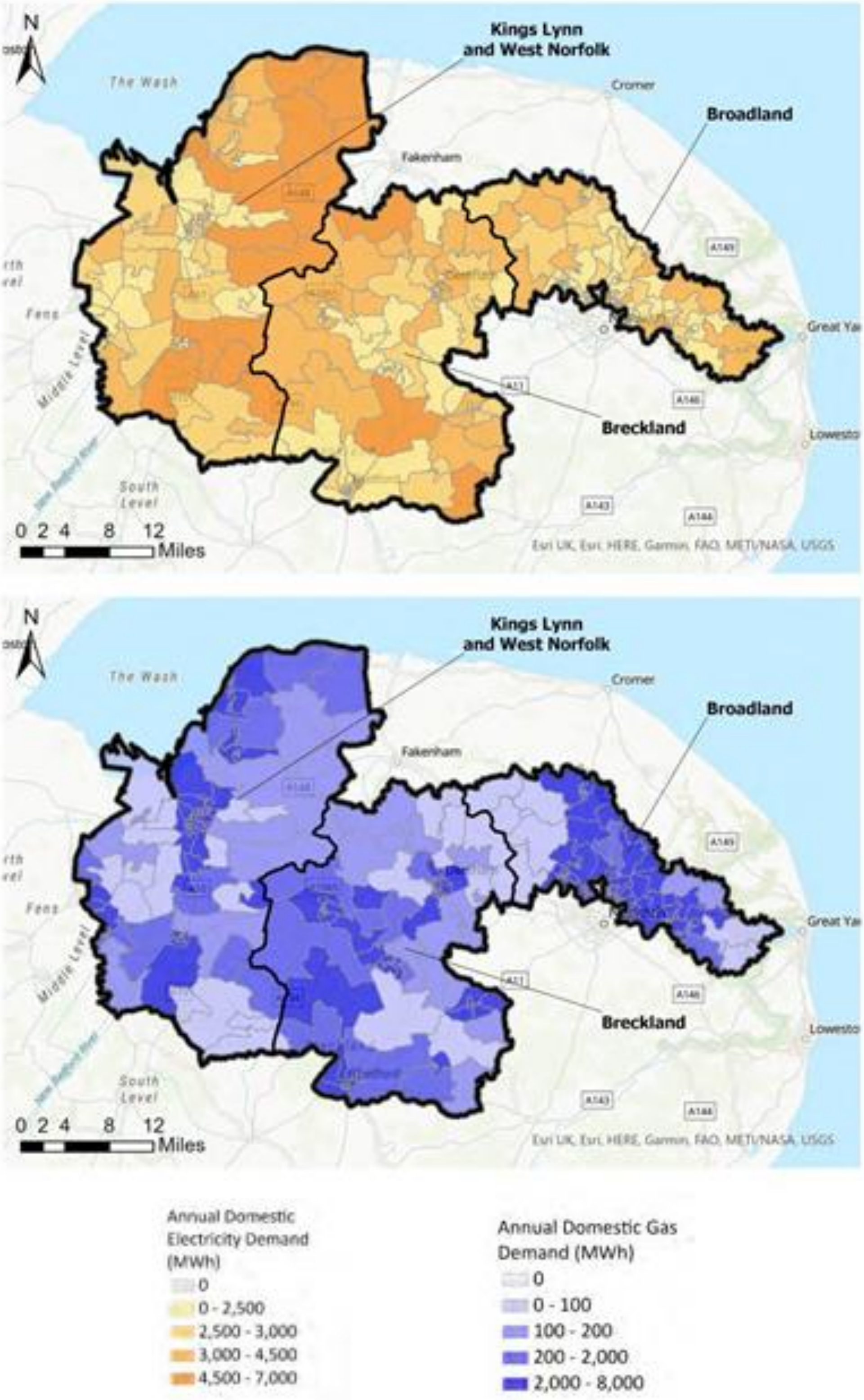


Figure 14: Estimated current domestic annual energy consumption by fuel and LSOA across the Central and West Norfolk sub- region.

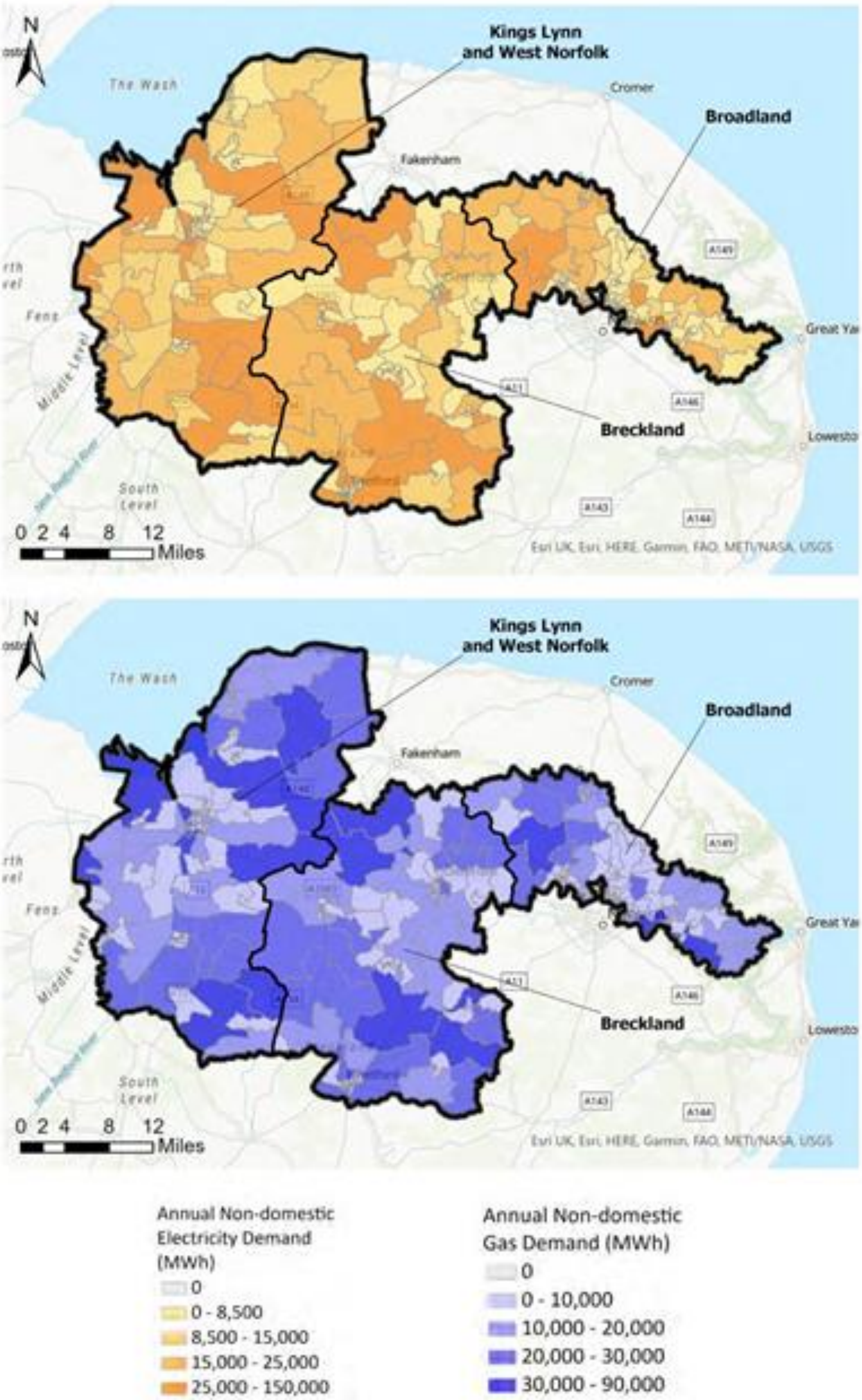


Figure 15: Estimated current non-domestic annual energy consumption by fuel and LSOA across the Central and West Norfolk sub- region.

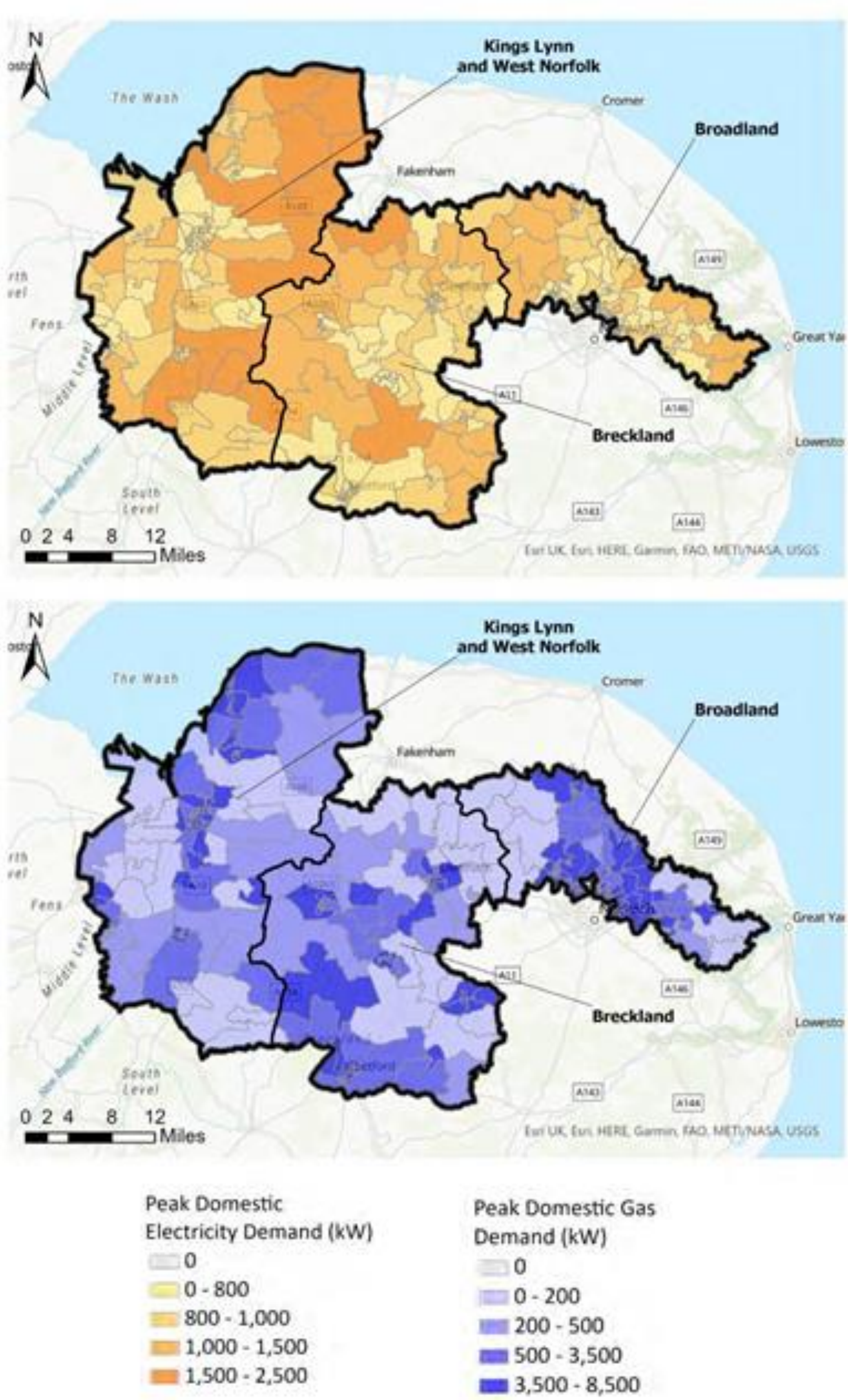


Figure 16: Estimated current domestic peak energy demand by fuel and LSOA across the Central and West Norfolk sub-region.

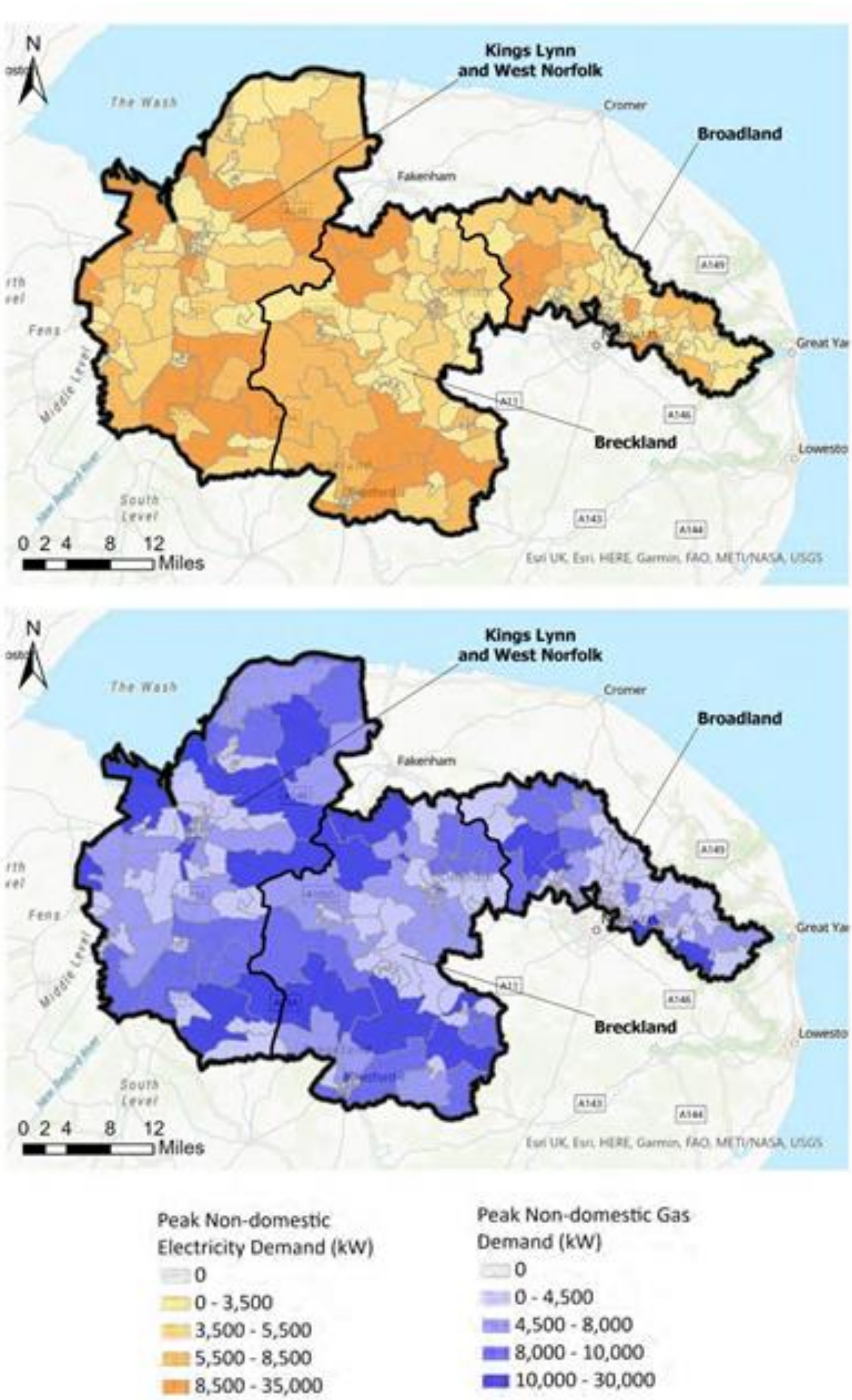


Figure 17: Estimated current non-domestic peak energy demand by fuel and LSOA across the Central and West Norfolk sub-region.

Figure 18 shows an estimate of the total electricity demand profile for the Central and West Norfolk sub-region for different days of the year representing the lowest typical demand and the highest. The peak day is also shown, which is used to determine a worst-case scenario on the network. Electricity demand includes heat, lighting, appliances, and electric vehicle charging when charge points are known to exist in the local area. The profile is for domestic and non-domestic buildings combined.

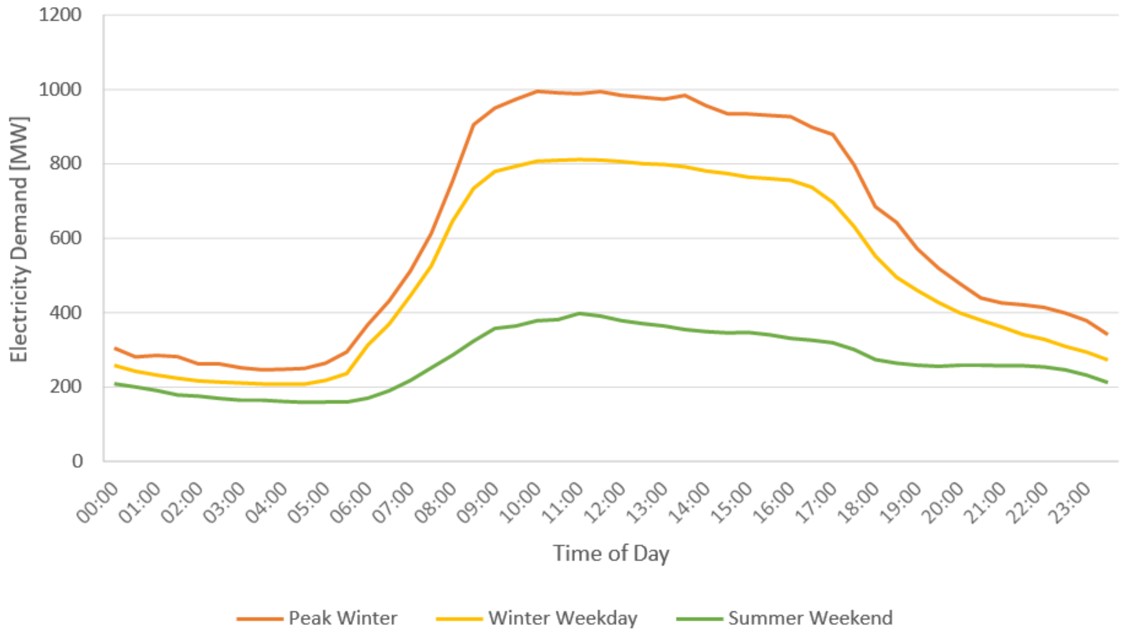


Figure 18: Estimated electricity demand profiles for different days of the year across the Central and West Norfolk sub-region.

As expected, the demand is far lower on a summer weekend when compared to a winter weekday.

Summer weekend represents the lowest end of demand profile; being summer means there is less need for heating, and weekend suggests that office/factory buildings are using less electricity, in contrast to a typical winter weekday.

The area between these two demand profiles demonstrates the typical demand i.e. the electricity demand will likely be within this middle section at any given time.

Figure 19 shows the estimated gas demand profile, and Figure 20 shows the estimated oil demand profile, for the Central and West Norfolk sub-region for the same days. Gas and oil demand include both heat and hot water and covers domestic and non-domestic buildings combined.

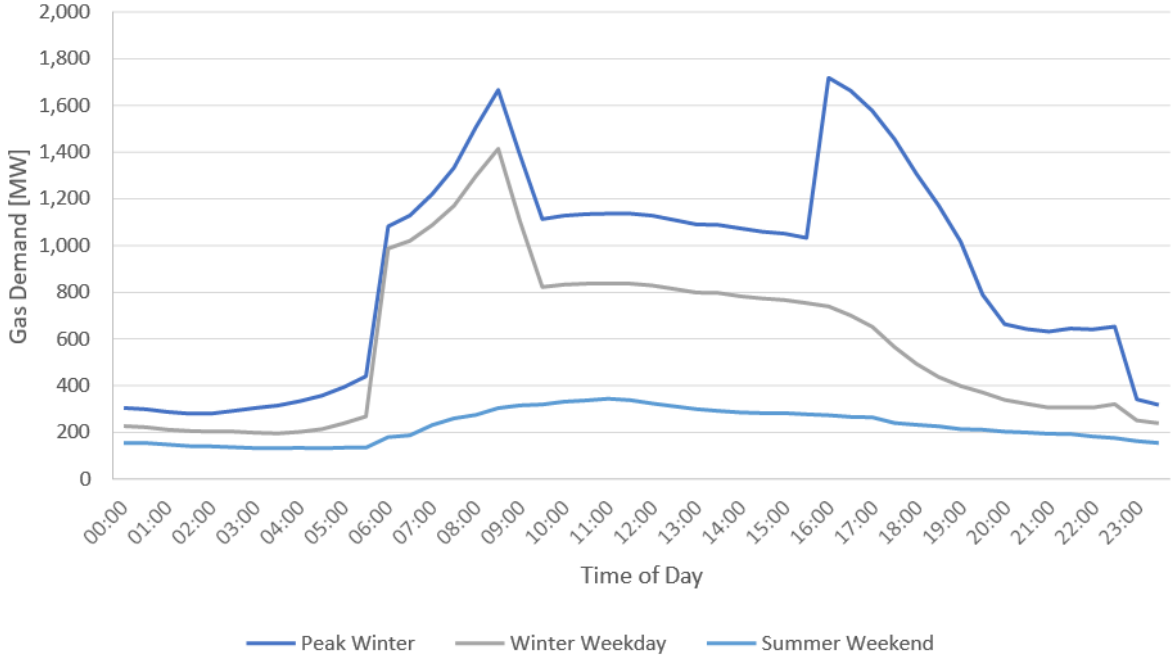


Figure 19: Estimated gas demand profiles for different days of the year across the Central and West Norfolk sub-region.

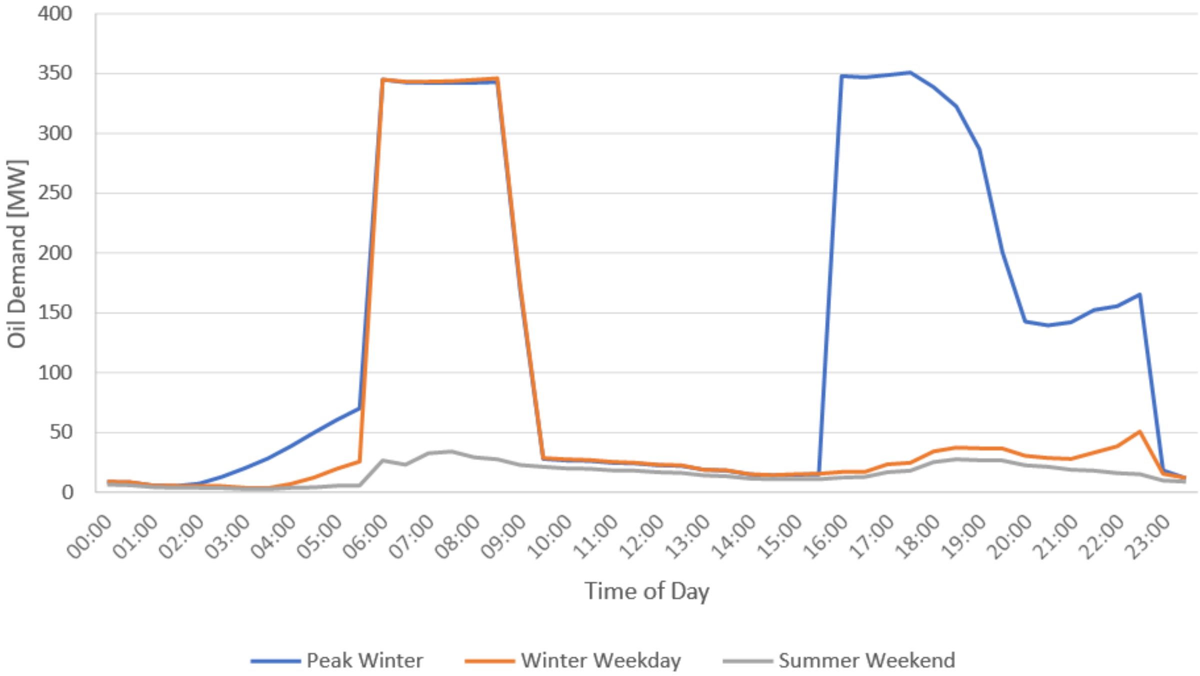


Figure 20: Estimated oil demand profiles for different days of the year across the Central and West Norfolk sub-region.

2.2.2 Energy Networks

A good understanding of the energy networks is vital to formulating a forward plan for the decarbonisation of any area. For example, identifying dwellings that are not on the gas network can help to focus a heat pump roll-out programme thus reducing the risk of competing heating vectors such as hydrogen or heat networks being a more financially viable option in the future. To identify those off-gas areas, Xoserve[9] postcode data was used (mapped in Figure 21) before being cross-referenced with Ordnance Survey records to calculate how many dwellings are estimated to be on- or off-gas (Table 9).

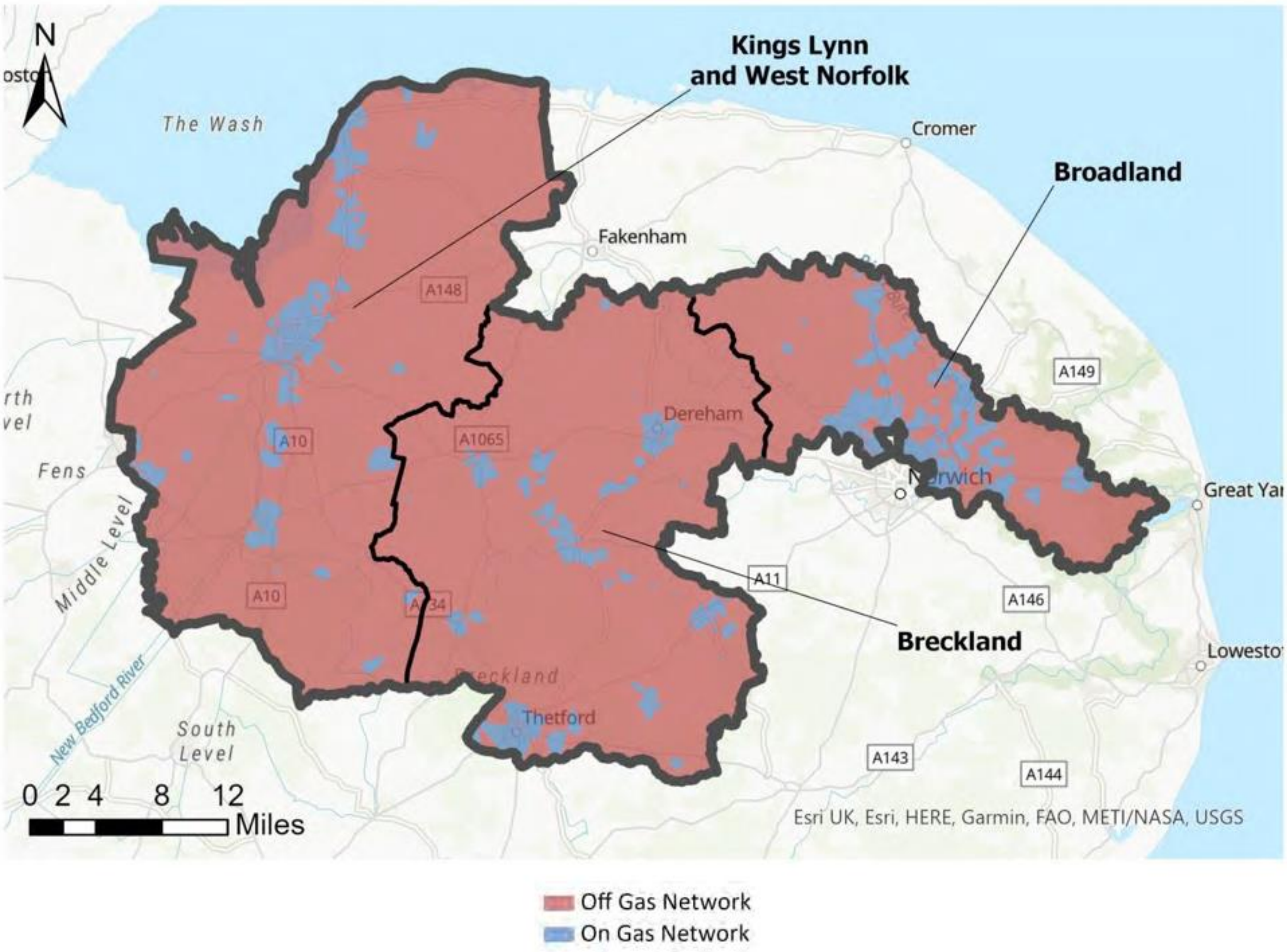


Figure 21: On-gas and off-gas areas of the Central and West Norfolk Norwich sub-region.

Table 9: Estimate of on-gas and off-gas dwellings across the Central and West Norfolk sub-region (rounded to nearest 5,000)

Off or On Gas Dwellings	Number
Off-Gas Dwellings	**73,000**
On-Gas Dwellings	**120,000**

Comparing Figure 21 and Table 9 leads to the conclusion that the off-gas grid areas are sparsely populated. This is confirmed by comparing to Figure 2 showing the location of the building stock.

9 https://www.xoserve.com/wp-content/uploads/Off-Gas-Postcodes-V2.xlsx

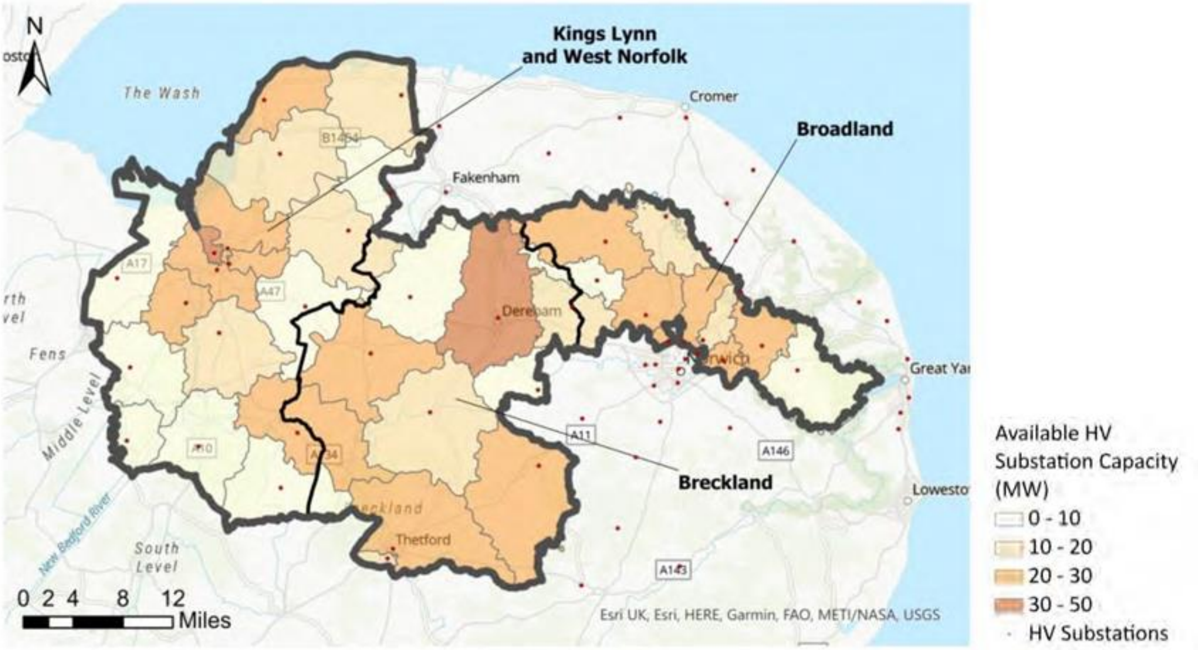


Figure 22: Available high-voltage substation capacity across the Central and West Norfolk sub-region.

Figure 22 shows an estimate of the available capacity on each 33kV-to-11kV substation and the extent of the area served by each substation. Capacity is calculated by subtracting the combined peak electrical demand on buildings in each area from the rated capacity of each substation. Those substations shown outside of the Central and West Norfolk boundary may serve buildings within it. Substations outside of the boundary have been included since it is likely some may serve assets within the project boundary. This is seen by new polygons that begin next to the project boundary. It should be noted that available capacity of areas on the Norfolk boundary may be overestimated since the demands of buildings outside of the county have not been modelled.

Where network connection is important from a project planning perspective the actual areas served should be established in conversation with the local Distribution Network Operator, (DNO) UK Power Networks. These capacity estimates are intended to give an indication of the capacity available on different parts of the network within the local energy system representation area and are not a substitute for detailed network modelling and analysis conducted by the local DNO. Substations identified as generation only in the DNO data are assumed to have no available capacity. Substations are not included in the analysis where DNO data on locations and capacities are unavailable. Where capacity data is unavailable, but locations are available, the 11kV-to-400kV capacity was set to the most prevalent substation capacity across all of Norfolk. Where capacity data is only available in MVA, it is assumed that capacity in MVA is equal to capacity in MW, unless power factors are available.

Figure 23 shows an estimate of the number of buildings, both domestic and non-domestic connected to each 33kV-to-11kV substation. As with capacity, the extent has been calculated as the area closest to each substation.

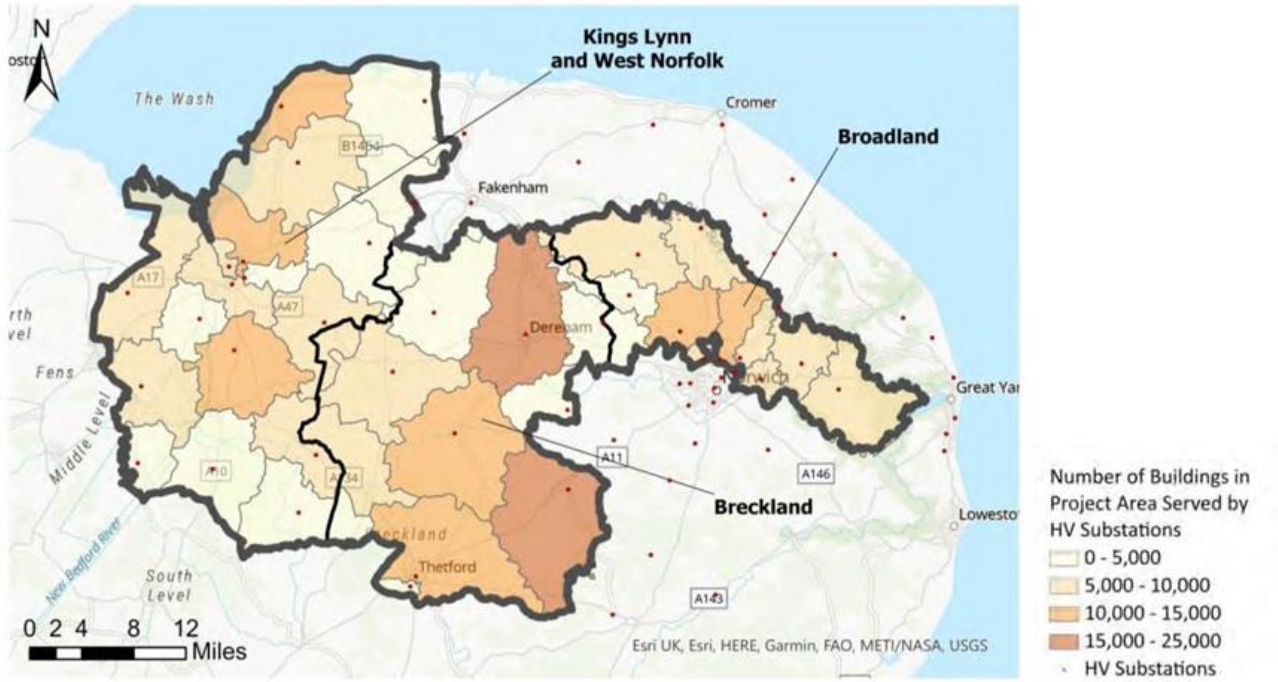


Figure 23: Number of buildings within the Central and West Norfolk sub-region served by each high-voltage substation.

2.2.3 Embedded Generation

The Renewable Energy Planning Database (REPD) was used to identify large scale embedded generation across the Central and West Norfolk sub-region. These sites, and the associated technologies, are shown in Figure 24. Data on domestic feed-in tariffs from BEIS are used to identify the amount of domestic solar photovoltaic (PV). The total installed capacity for each technology along with an estimate of the annual electricity generated in the local area is given in Table 10. Table 10 shows the proportion of annual electricity demand across the Central and West Norfolk sub-region estimated to be met currently using local embedded generation. Additional embedded generation technologies may be present in the area but not reported here if they are not recorded in the REPD or if they are below 100 kW.

Table 10: Estimated renewable energy capacity and estimated generation as a proportion of electricity demand in the Central Norwich sub-region.

Renewable Tech	Installed Capacity [MW]	Annual Generation [GWh]	Proportion of Annual Demand
Domestic Solar PV	35.5	72	2.1%
Other Solar PV	156.7	142	4.1%
Wind Onshore	48.8	113	3.2%
Biomass	82.7	465	13.4%
Landfill Gas	5.3	23.5	0.7%
Anaerobic Digestion with CHP enabled	1	5.2	0.1%
Anaerobic Digestion without CHP enabled	1.5	7.85	0.2%

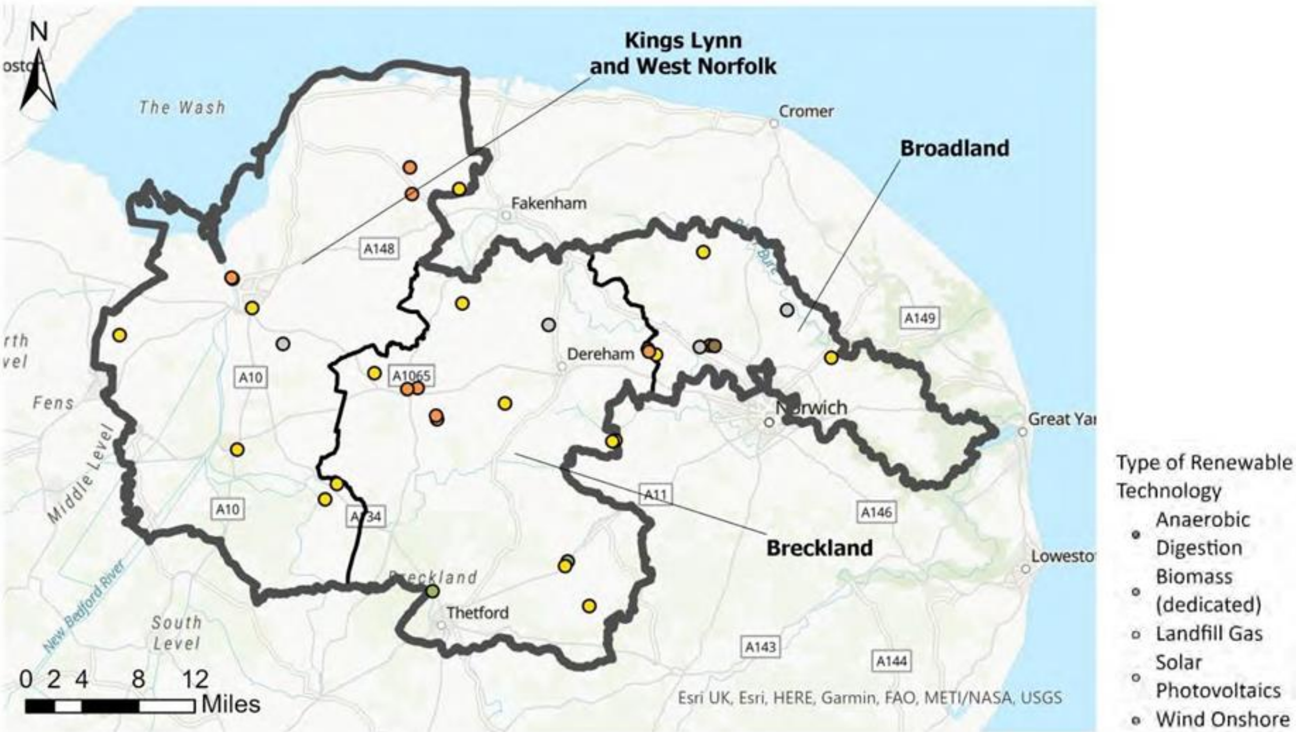


Figure 24: Existing embedded generation in the Central and West Norfolk sub-region according to REPD database (October 2020).

As can be seen from Table 10, biomass is the largest contributor to the annual demand of any installed renewable technology. Solar PV also presents high contributions to annual demand; although not all installations of solar PV are registered for the feed-in tariff (FIT), and not all FITs were given to solar PV, the majority will be and therefore Ofgem's Feed-in Tariff Installation Report[10] is a useful way of identifying the overall capacity and number of registrations in each LSOA. Figure 25 and Figure 26 show the installed capacity of renewables and number of registrations respectively.

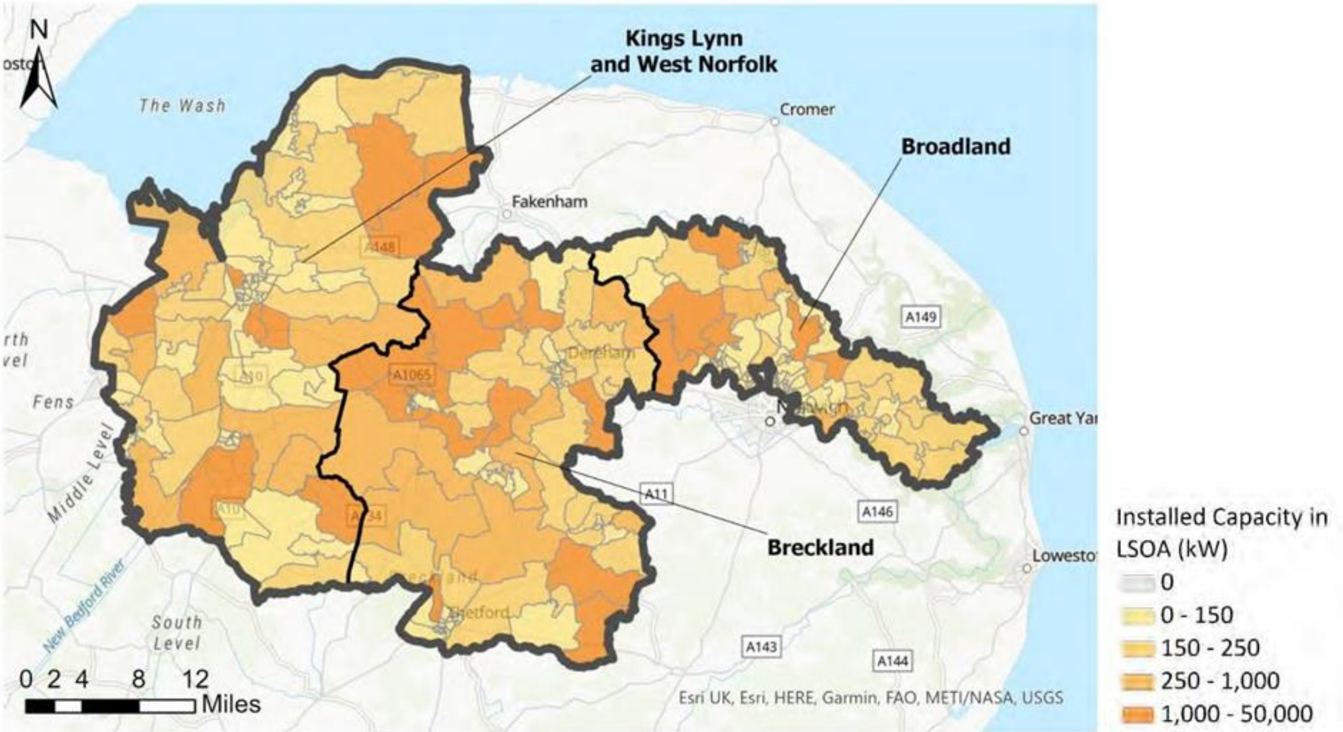


Figure 25: Aggregated capacity of renewable installations registered for FIT within each LSOA of the Central and West Norfolk sub- region.

10 https://www.ofgem.gov.uk/environmental-programmes/fit/contacts-guidance-and-resources/public-reports-and-data-fit/installation-reports

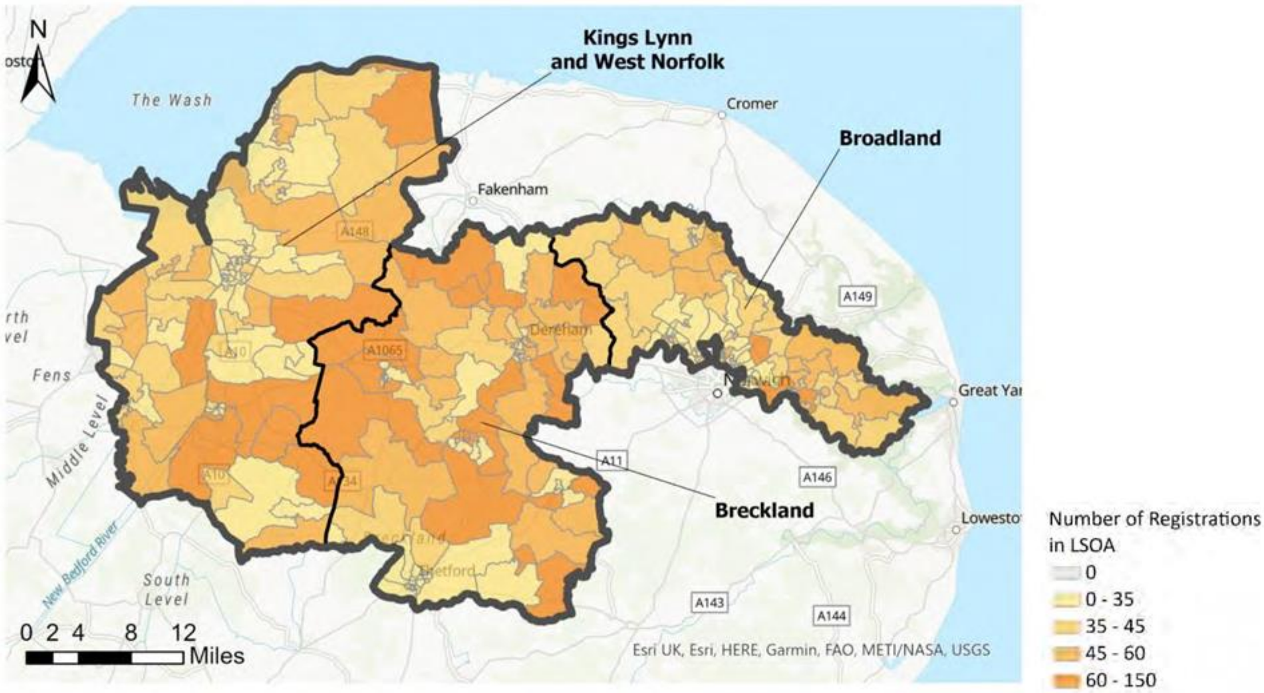


Figure 26: Number of renewable installations registered for FIT within each LSOA of the Central and West Norfolk sub-region.

To assess the potential for domestic on-roof solar PV within the Central and West Norfolk sub-region, the footprint and orientation of all dwellings have been analysed to calculate the potential generating capacity. These results are then aggregated to 200m radius areas to identify places best suited for mass deployment. The dwellings identified as suitable for rooftop solar PV in each of the three best areas are shown in Figure 27 to Figure 29.

As a purely spatial exercise this analysis does not consider local planning constraints and should not be used as a replacement for a detailed feasibility study or installation design.

Figure 27: Dwellings identified as suitable for rooftop PV panels. (Location: Toftwood, Dereham)

Figure 28: Dwellings identified as suitable for rooftop PV panels. (Location: West Winch, King's Lynn)

Figure 29: Dwellings identified as suitable for rooftop PV panels. (Location: Sprowston, Broadland)

In total these three areas alone have a total potential solar PV capacity of 3.359 MW.

2.2.4 Domestic & Public EV Charging

Data from the Zap-Map®[11] has been used to identify the locations and power outputs of public Electric Vehicle (EV) chargepoints across the Central and West Norfolk sub-region. The locations and the speed of the chargepoints are shown in Figure 30. In total there are 131 public chargepoints with a combined capacity of 4,791kW. The locations and the speed of the chargepoints are shown in Figure 31.

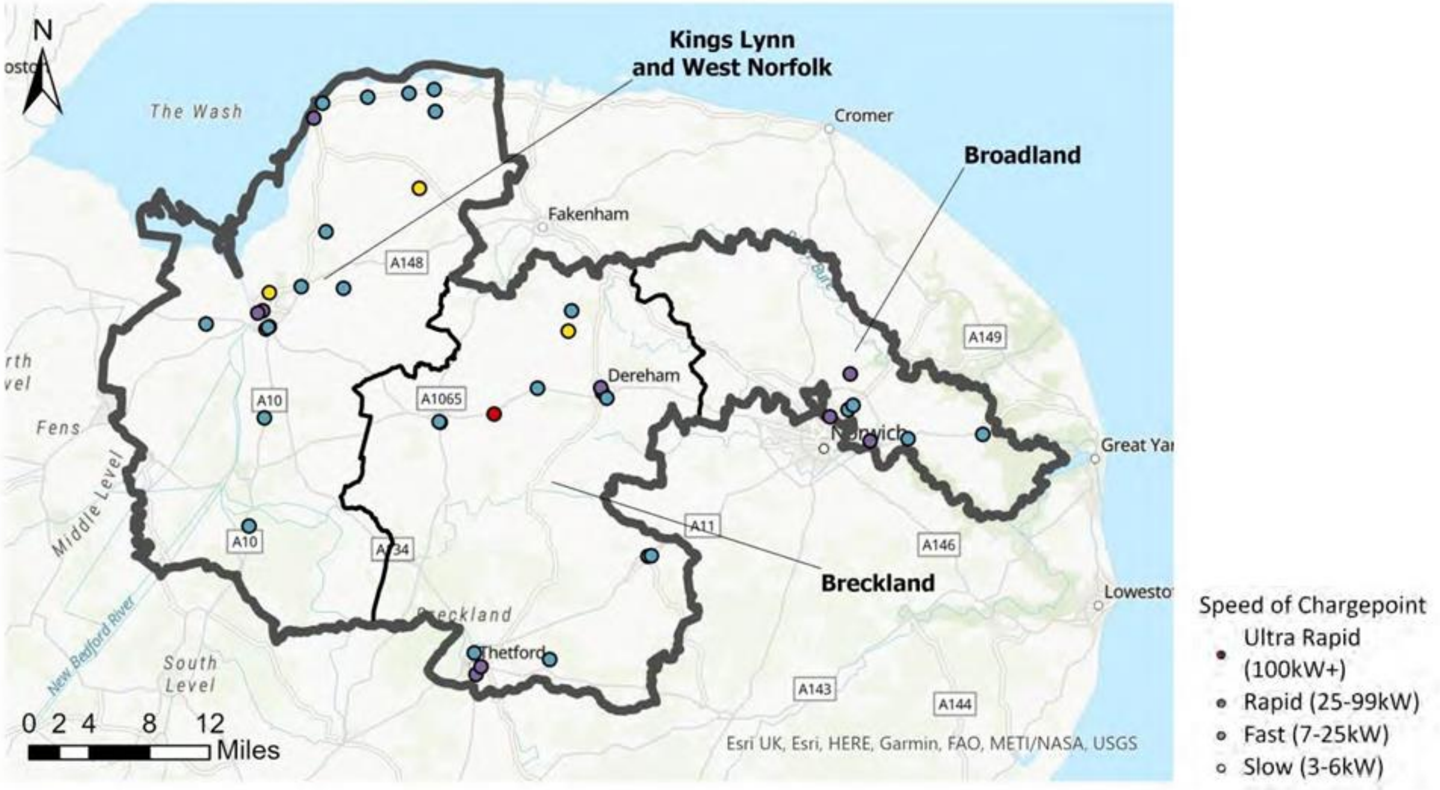


Figure 30: Location of public chargepoints according to Zap-Map® (December 2020)

Chargepoint data provided by Zap-Map®

The Driver and Vehicle Licensing Authority (DVLA) publishes data on the numbers and types of different vehicles registered within different Local Authority Areas. This gives an indication of the number of EVs that might be registered within the sub-region as shown in Table 11.

EV chargepoints in King's Lynn & West Norfolk District Council area include 45-50kW chargers in Hunstanton as well as King's Lynn town. In addition, there is an ultra-rapid (100kW) chargepoint available in Necton, Breckland District Council.

It should be noted that leased vehicles will be registered to the leasing company which may not be based within the project area.

Using National Travel Survey data representative charge profiles have been generated for both public and domestic charge points. The estimated peak demands for domestic chargepoints are shown in Table 11.

[11] https://www.zap-map.com/

Table 11: Summary of plug-in vehicles[12] registered in the Central and West Norfolk sub-region according to data from DfT

Number of Plug-in Vehicles	Percentage of Total Vehicles	Estimated Peak Demand [kW]
797	0.65%	**1096**

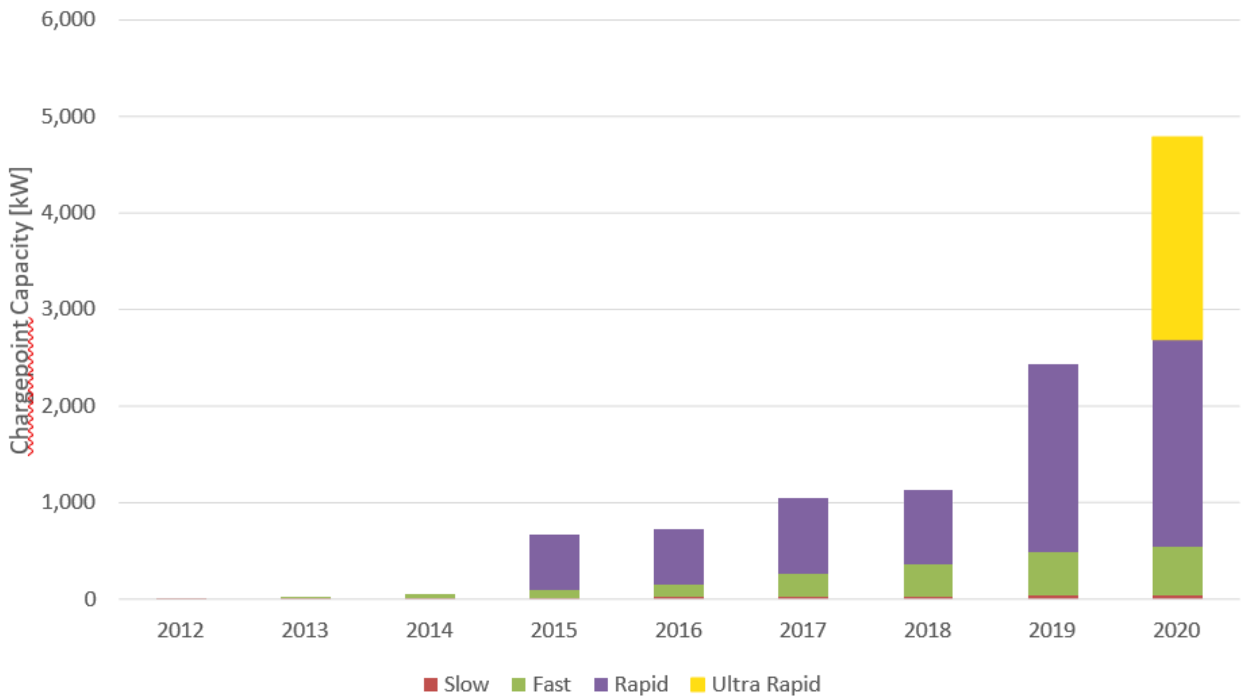


Figure 31: Chargepoint connector total capacity (kW) within the Central and West Norfolk Norwich sub-region over time.

Using the date that each chargepoint was added to the Zap-Map database the uptake of chargepoints in the area can be analysed. Figure 31 shows this uptake in total kW rating of connectors within the Central and West Norfolk sub-region by charger type.

Ordnance Survey Mastermap Topography and Land Registry INSPIRE polygons have been used to identify houses which have space for off-street parking. This is done 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. This 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. Figure 33 shows the results of this analysis aggregated by road.

[12] Plug-in vehicles are all models identified as being fully electric or plug-in hybrid.

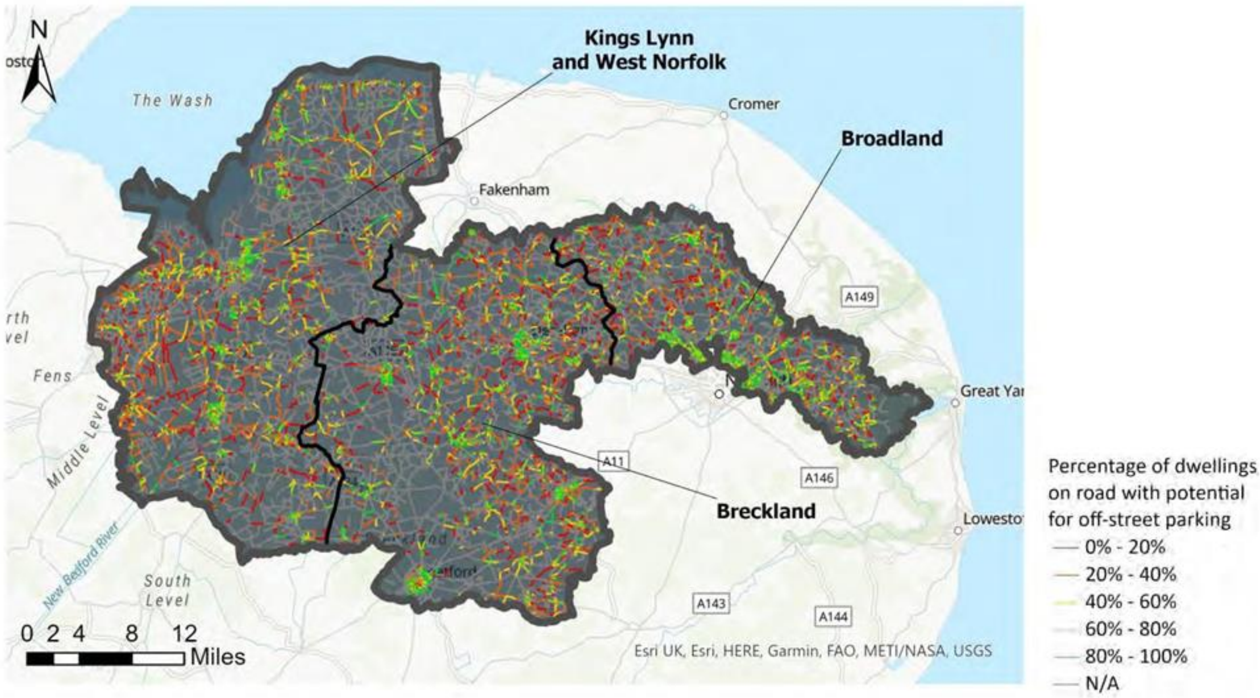


Figure 32: Percentage of dwellings with off-street parking on each road within the Central and West Norfolk Norwich sub-region.

As a purely spatial exercise this analysis does not consider local planning constraints and should not be used as a replacement for a detailed feasibility study.

2.2.5 Social Data

National data have been used to provide an indication of fuel poverty (Figure 33) and multiple deprivation (Figure 34) across the Central and West Norfolk sub-region.

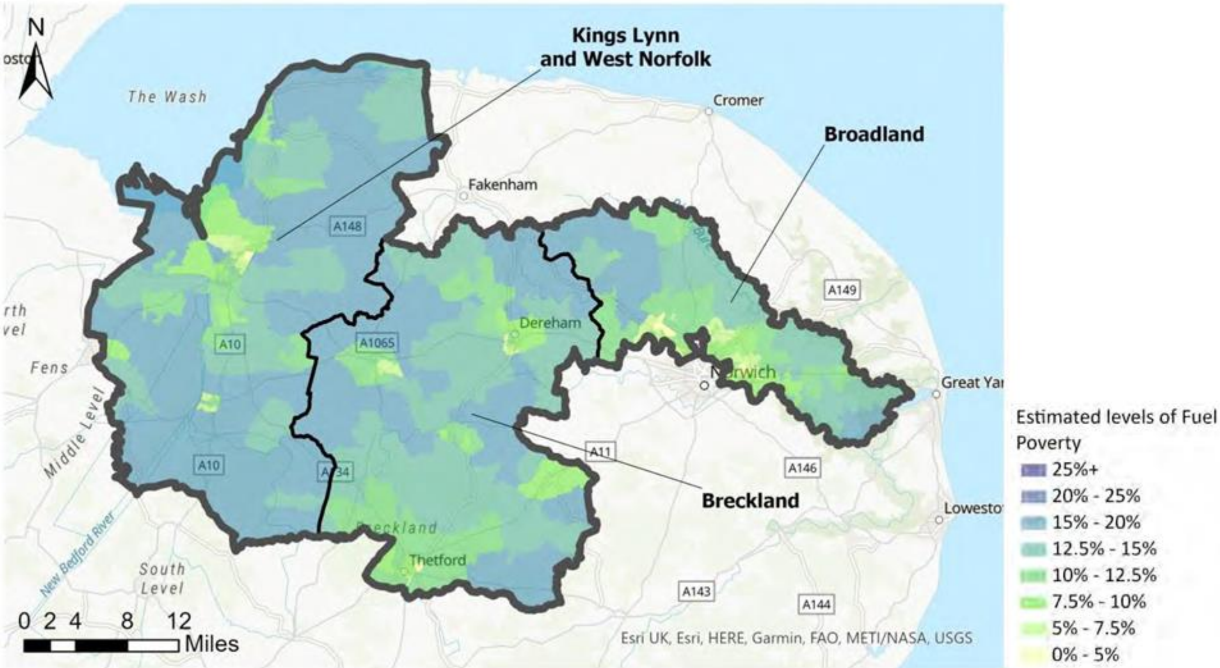


Figure 33: Estimated levels of fuel poverty according to 2020 BEIS data

Using the ranked Index of Multiple Deprivation[13] data published by The Department for Communities and Local Government (DCLG) at LSOA level it is possible to compare localised levels of deprivation within the Central and West Norfolk sub-region against the rest of England. For mapping purposes these are shown by octile, with values falling in octile 1 being within the most deprived 1/8th of the country and values falling in octile 8 being within the least deprived 1/8th of the country.

13 https://www.gov.uk/government/statistics/english-indices-of-deprivation-2015
For descriptions of the underlying indicators used in the indices of deprivation please refer to this document: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/467775/File_8_ID_2015_Underlying_indicator_s.xlsx

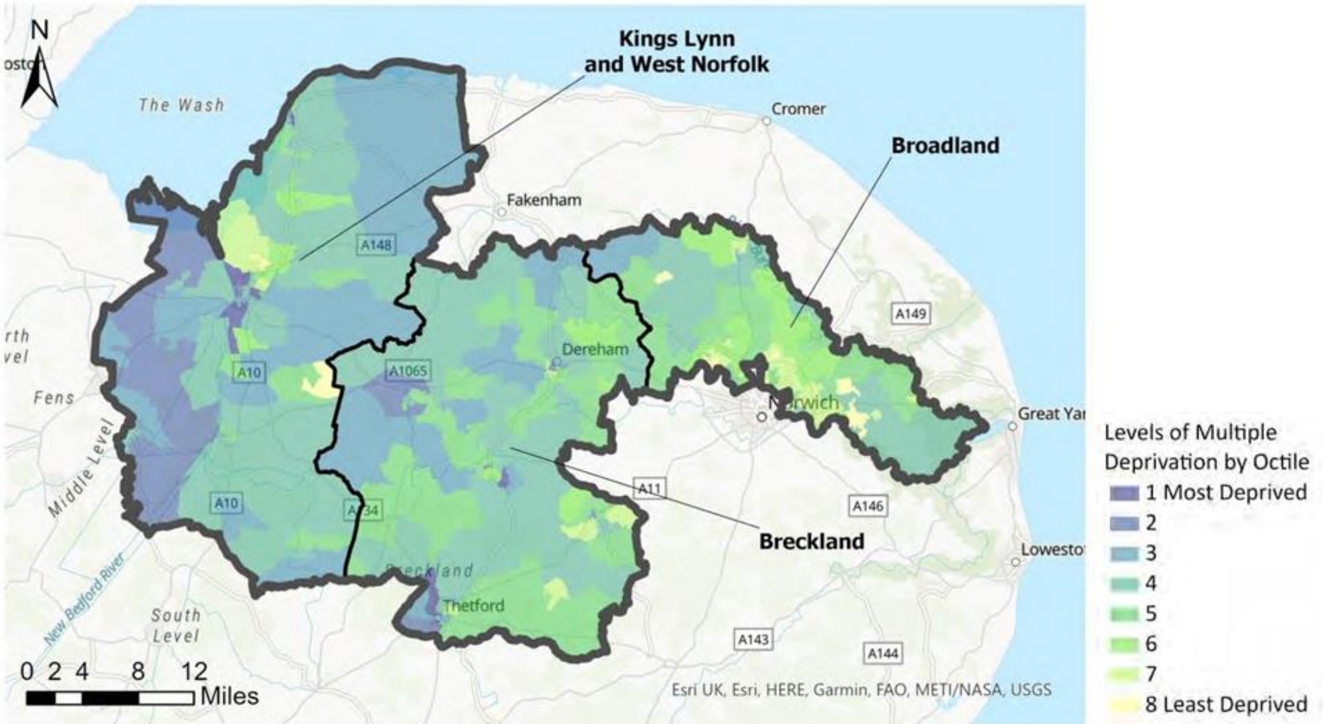


Figure 34: Ranking of English indices of deprivation 2019

The multiple indices that make up the IMD can be found in the accompanying data/maps to this report.

2.3 Norwich & South Norfolk

The sub-regional area of 'Norwich & South Norfolk' has been defined in this report as covering the local authority areas of South Norfolk and City of Norwich which collectively cover an area of approximately 950km^2 and has a population of around 285,000[14].

2.3.1 Building Stock

This section will provide an overview of the building stock – both domestic and non-domestic – across the Norwich & South Norfolk sub-region. The geographical location of the building stock will be shown, as will the relative rurality across the sub-region, and breakdowns of the domestic and non-domestic stock by category.

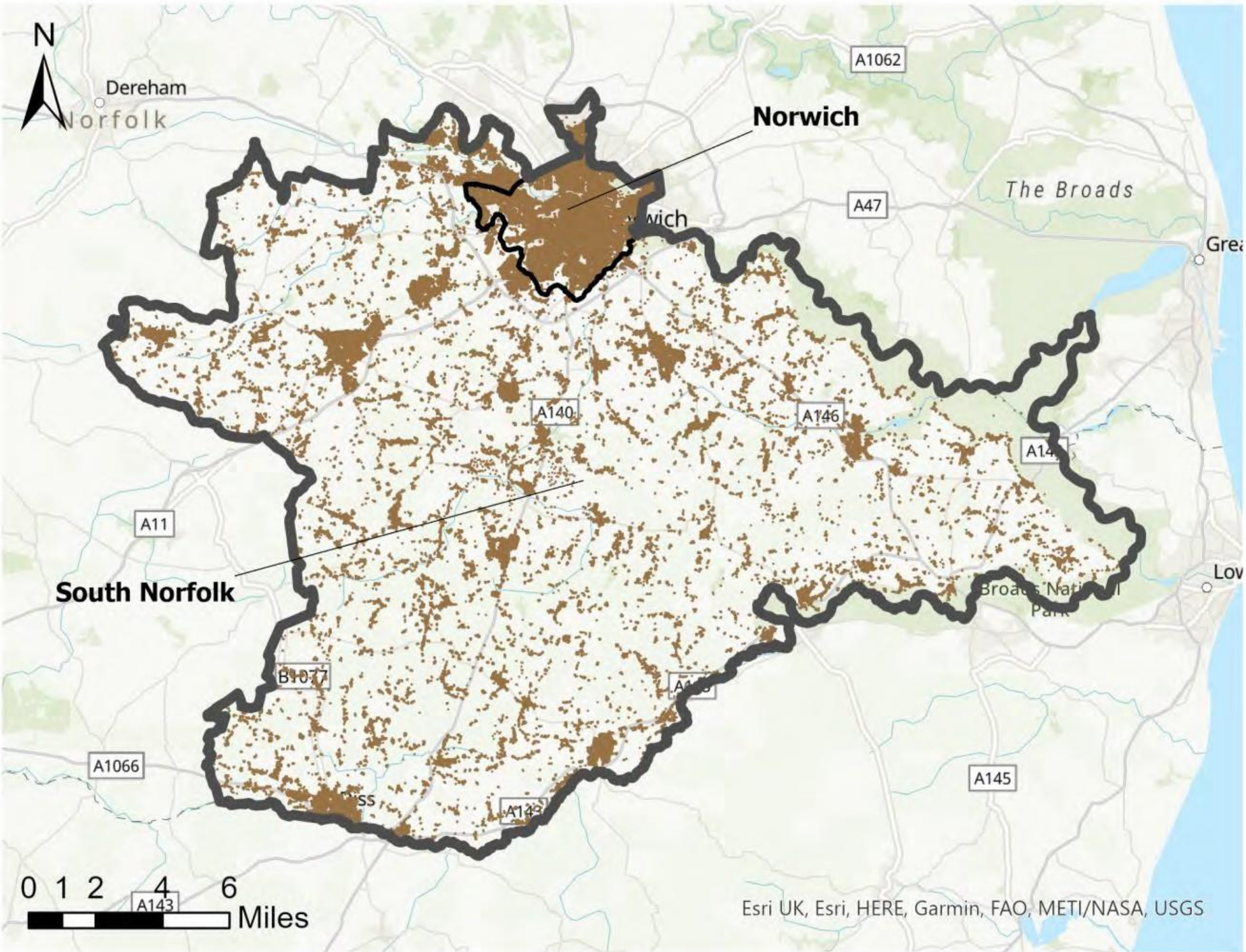


Figure 35: Building stock distribution across the Norwich & South Norfolk sub-region.

Figure 35 shows that across the Norwich & South Norfolk sub-region, the building stock is densely populated across the City of Norwich. Across South Norfolk, the building stock is distributed into clusters around conurbations including Wymondham and Diss with the building stock being less densely situated elsewhere.

These areas correlate well to the rural/urban classifications given in the rurality map (Figure 6936).

[14] https://www.norfolkinsight.org.uk/population/

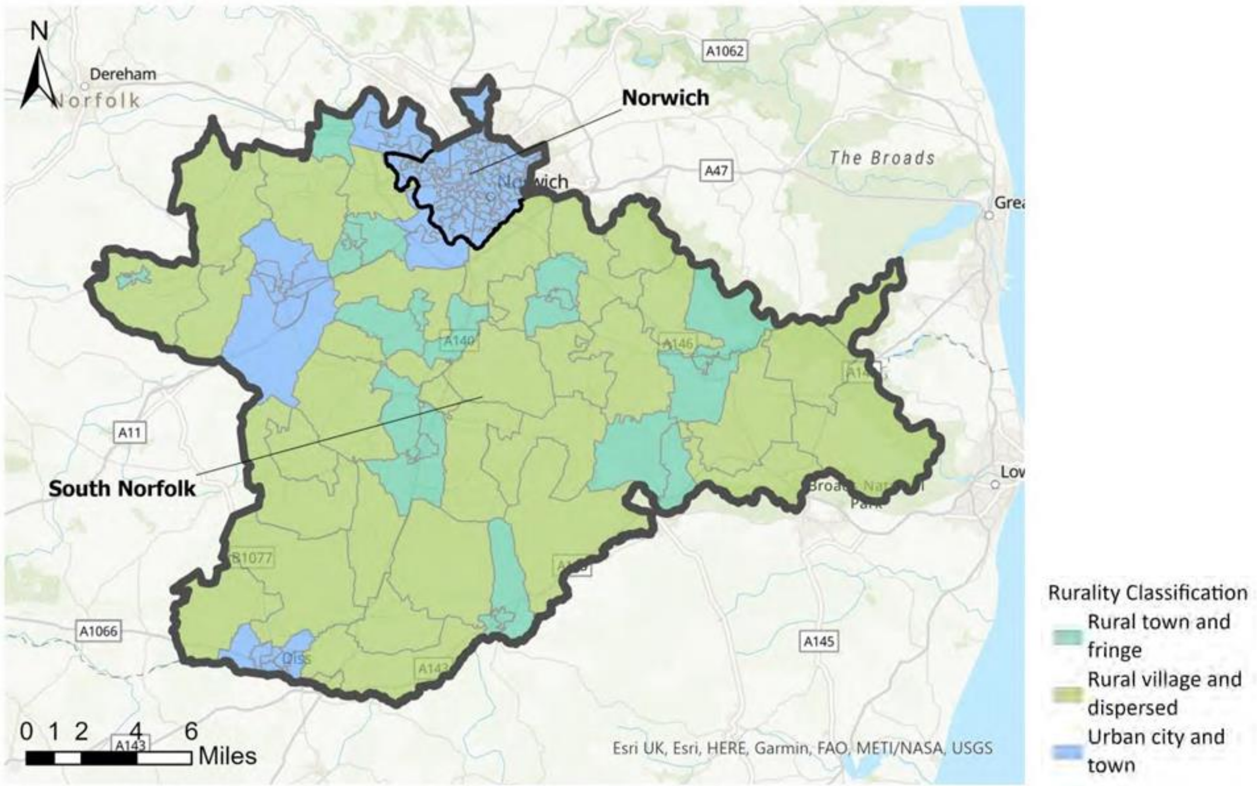


Figure 36: Rurality of the Norwich & South Norfolk sub-region.

Figure 36 shows the rurality of the Norwich & South Norfolk sub-region by Lower-level Super Output Area (LSOA). Most of the land area in the Norwich & South Norfolk sub-region is classified as rural towns and villages with the more urban areas matching those noted in Figure 36.

Using data provided by Historic England[15], the location and grade of listed buildings; scheduled monuments; Battlefields; World Heritage Sites and Parks & Gardens can be mapped within the sub-region (Figure 37).

15 https://historicengland.org.uk/listing/the-list/data-downloads

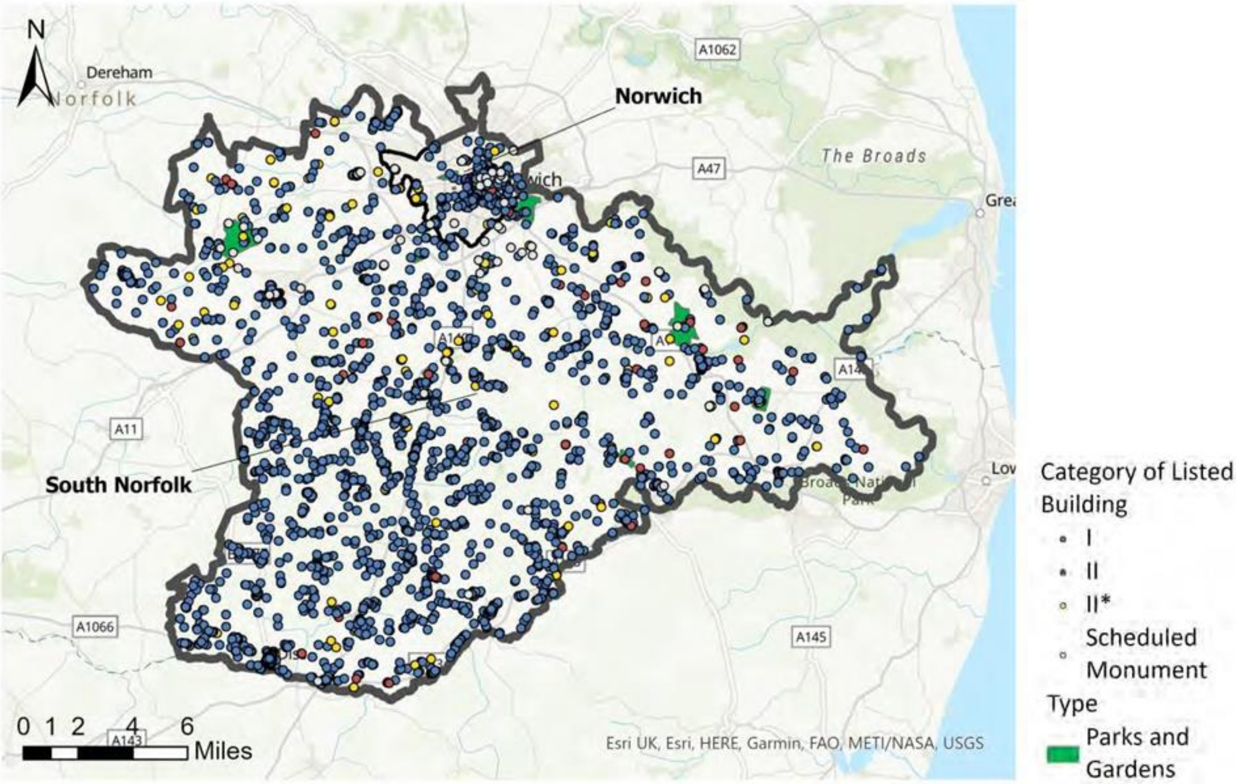


Figure 37: Location of listed buildings in the Norwich & South Norfolk sub-region grouped by grading according to Historic England

Figure 37 shows the large number of listed buildings, scheduled monuments, and areas of interest clustered in similar locations to the building stock as a whole. This could all pose a challenge to decarbonising the building stock. Table 12 shows the Listed Status of the buildings and the number of occurrences.

Table 12: Summary of listed buildings across Norwich & South Norfolk by grade category.

Grade Category	Number
Grade I	163
Grade II	3,545
Grade II*	277
Scheduled Monument	59

To understand the housing stock in more detail, the domestic stock has been segmented by:

- Type (converted flat, detached, purpose-built flat, semi-detached, and terrace)
- Construction date (pre-1914, 1914-1944, 1945-1964, 1965-1979, post-1980)
- Floor area [m^2] (under 50, 50-70, 70-90, 90-110, 110-200, 200-300, over 300)
- Main heating system (ASHP, biomass, electric (no storage), electric storage, gas, GSHP, oil/LPG)
- Loft insulation level [mm] (no loft, no insulation, 1-99, 100-199, over 200)
- Wall type (filled cavity, unfilled cavity, solid with ESWI, solid with ISWI, uninsulated solid)
- Window type (single glazing, double glazing, triple glazing)

Table 13: Number and percentage of dwelling types across the Norwich & South Norfolk sub-region.

Dwelling Type	Number	Percentage
Converted Flat	1,520	1%
Detached	37,000	32%
Purpose Built Flat	21,500	18%
Semi-detached	31,500	27%
Terrace	25,500	22%
Total	117,000	100%

Due to rounding, some totals may not correspond with the sum of the separate figures.

Table 13 shows that larger dwelling types are more prevalent across the sub-region. The prevalence of the dwelling types in each LSOA area (Figure 38) shows that detached dwellings are typically the most dominant in rural areas, whereas semi-detached are more common in urban areas, with flats being most common in the Norwich LSOAs. The City of Norwich also shows a high proportion of terraced buildings and purpose-built flats.

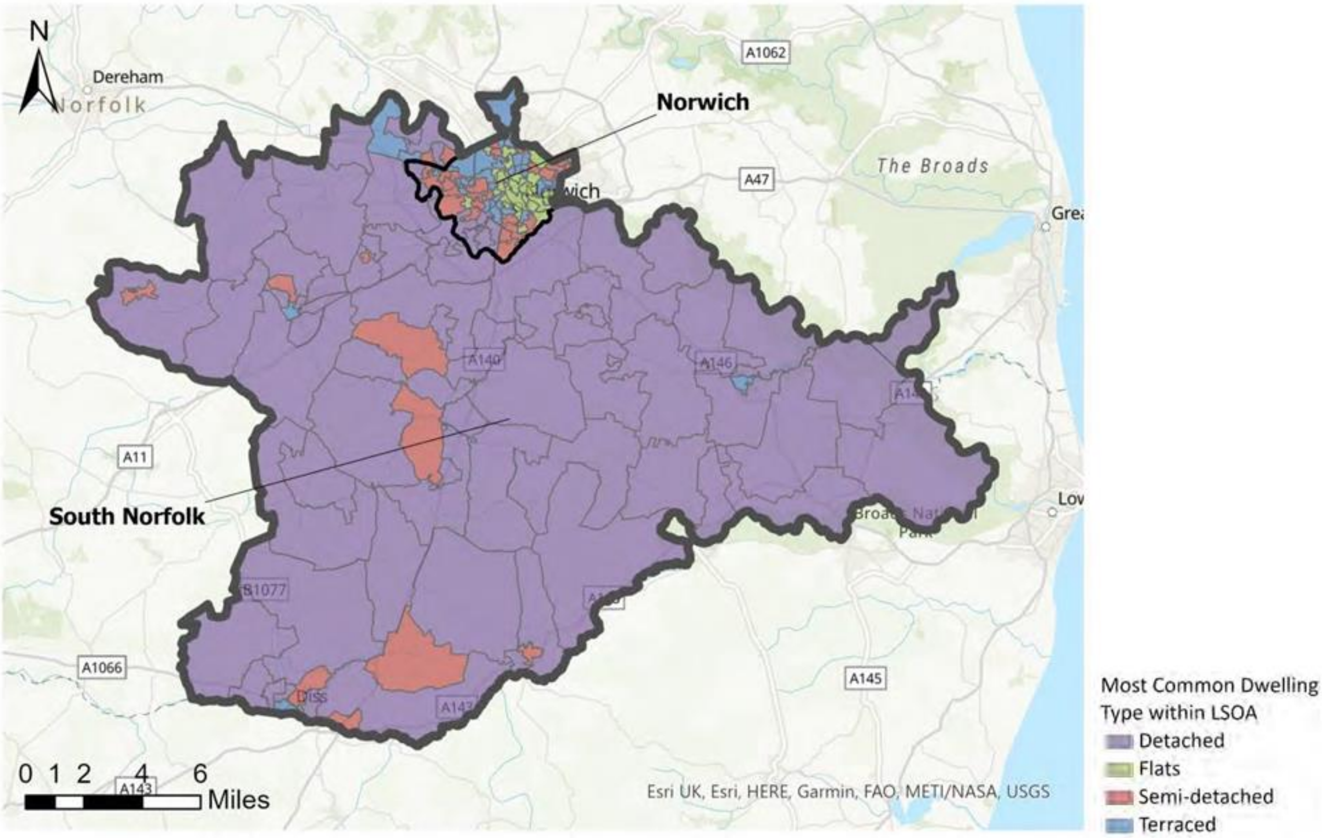


Figure 38: Most common dwelling type within each LSOA across the Norwich & South Norfolk sub-region.

A notable finding, shown in Table 14 is that over 50% of dwellings in the Norwich & South Norfolk sub-region were constructed between 1945 and 1979.

Table 14: Number and percentage of dwellings constructed in different periods across the Norwich & South Norfolk sub-region.

Dwelling Construction Period	Number	Percentage
Pre-1914	21,000	18%
1914-1944	9,300	8%
1945-1964	33,000	28%
1965-1979	34,000	29%
1980-present	19,300	16%
Total	117,000	100%

Due to rounding, some totals may not correspond with the sum of the separate figures.

By combining the dwelling type and the construction period, it can be seen in Figure 39 that around 12% of all dwellings in the sub-region are 1945-1964 semi-detached dwellings. Terraced dwellings tend to be much older with around 50% being built prior to 1914. Detached dwellings are being built more commonly in recent years with 58% of all detached dwellings having been built after 1965. A boom in purpose built flats can also be seen with almost 12,500 constructed between 1965 and 1979.

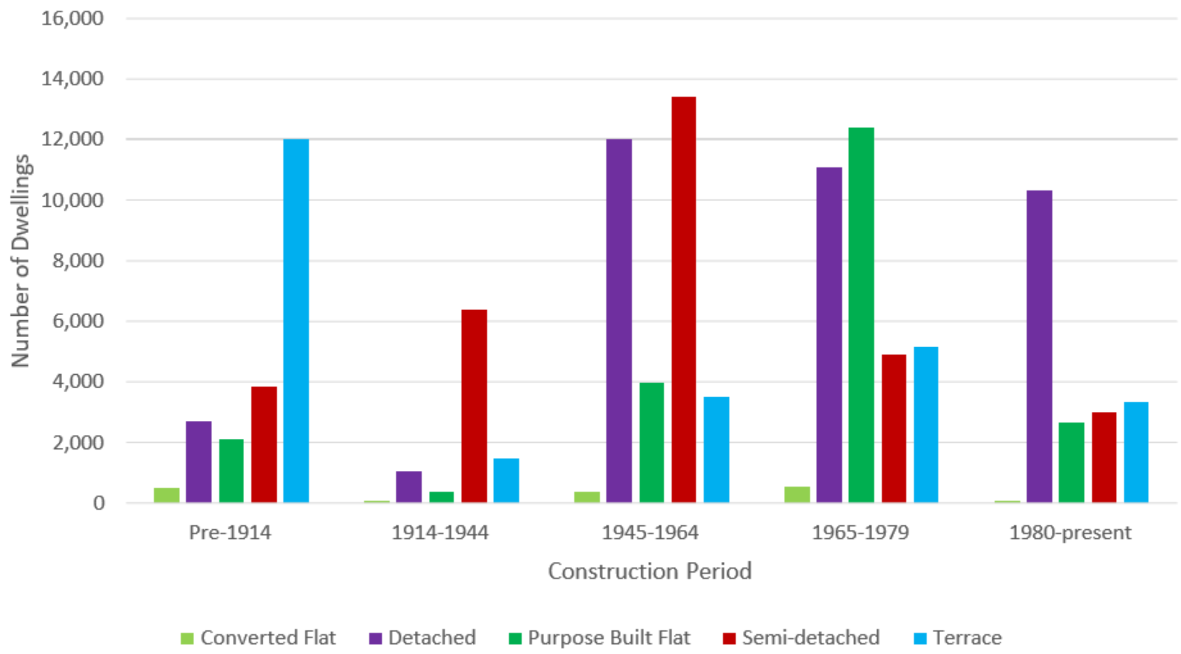


Figure 39: Estimated number of dwellings within each construction period (by dwelling type) across the Norwich & South Norfolk sub-region.

This can be visualised spatially (Figure 40) to show the most prevalent construction year in each LSOA in the Norwich & South Norfolk sub-region. Figure 40 shows a prevalence of 1945-1979 built dwellings in many of the larger LSOAs. In the centre of the urban areas, pre-1914 dwellings are more prevalent which we know from Figure 39 are likely to be terraced dwellings.

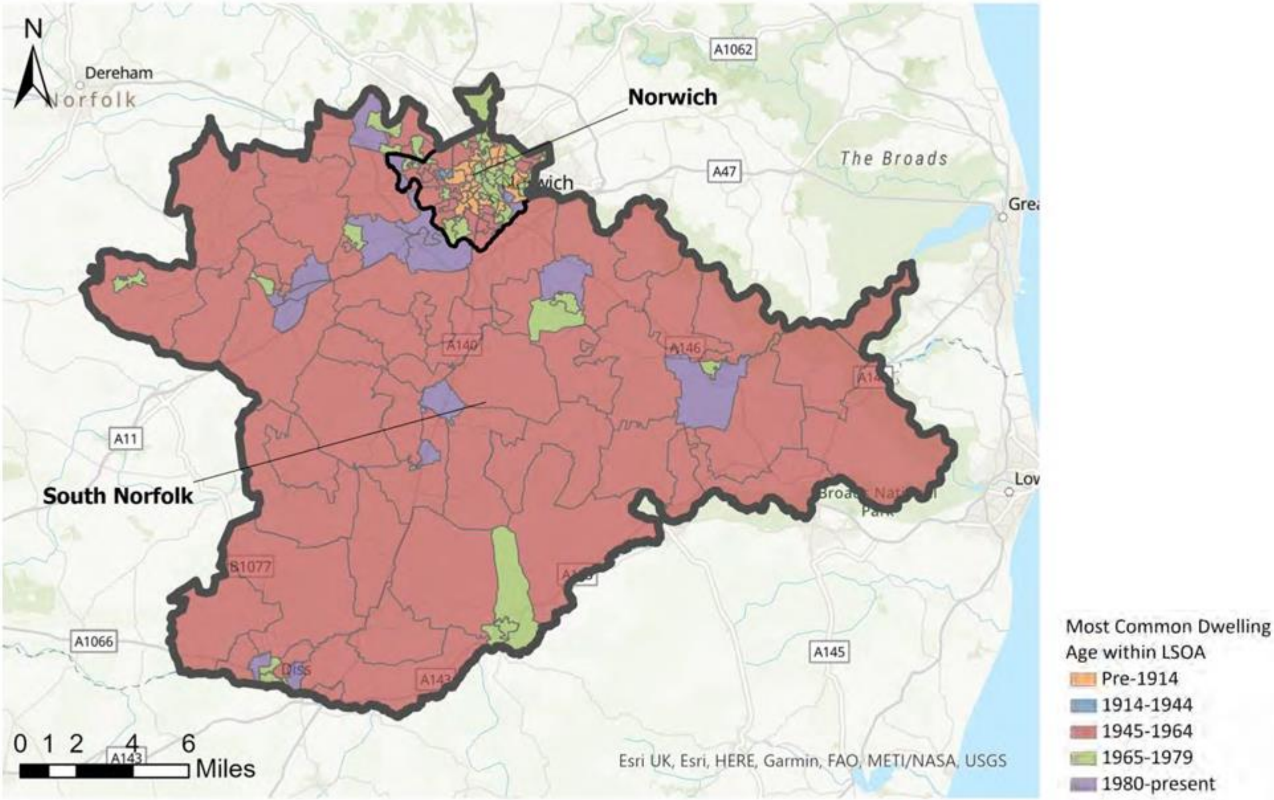


Figure 40: Most common construction period within each LSOA across the Norwich & South Norfolk sub-region.

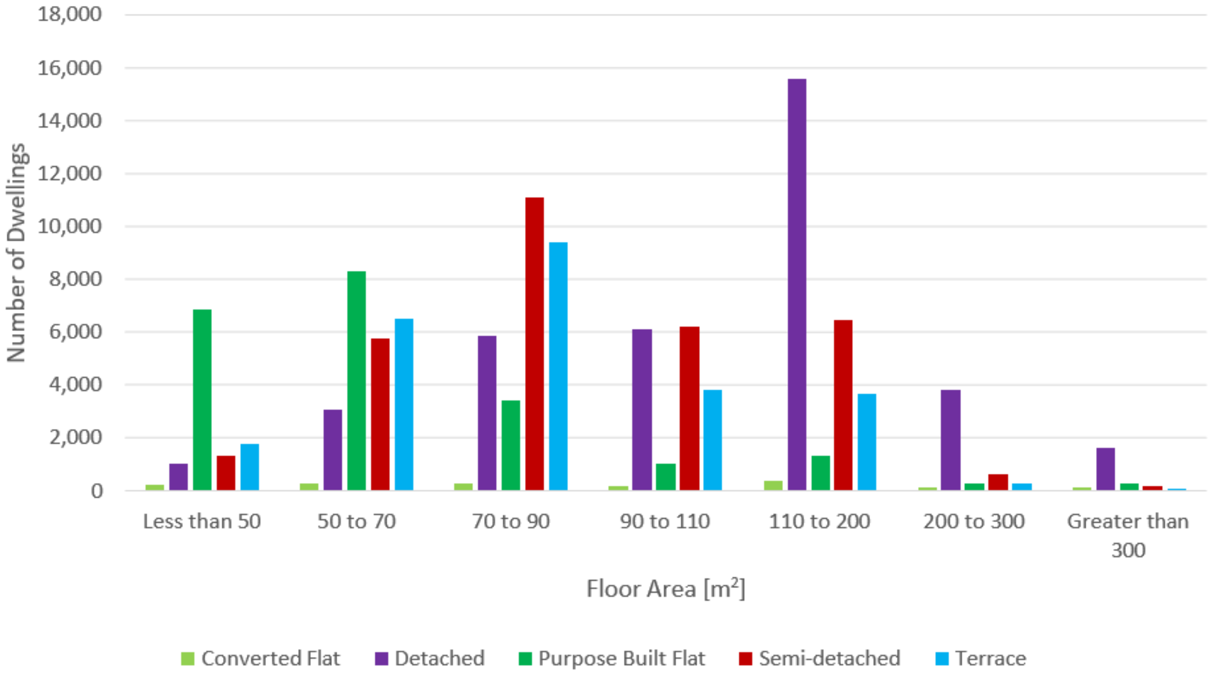


Figure 41: Estimated number of dwellings within each floor area band (by dwelling type) across the Norwich & South Norfolk sub- region.

From Figure 41, as expected, flats (particularly purpose-built flats) typically have a lower floor area than semi- detached and detached dwellings. Over two-thirds of purpose-built flats have a floor area of under 70m^2 whilst 42% of detached dwellings have a floor area of between 110 and 200m^2.

Dwellings in the Norwich & South Norfolk sub-region are overwhelmingly heated using a fossil fuel boiler (91%) with the remainder being made up from electric storage heaters (7%). Electric storage heaters are often used in modern flats where heat losses are low. Oil/LPG boilers are typically used in off-gas grid areas which in turn are often rural.

Figure 42 below shows that almost 30% of detached dwellings use oil/LPG boilers as their main heating system. Gas boilers are prevalent throughout the housing stock.

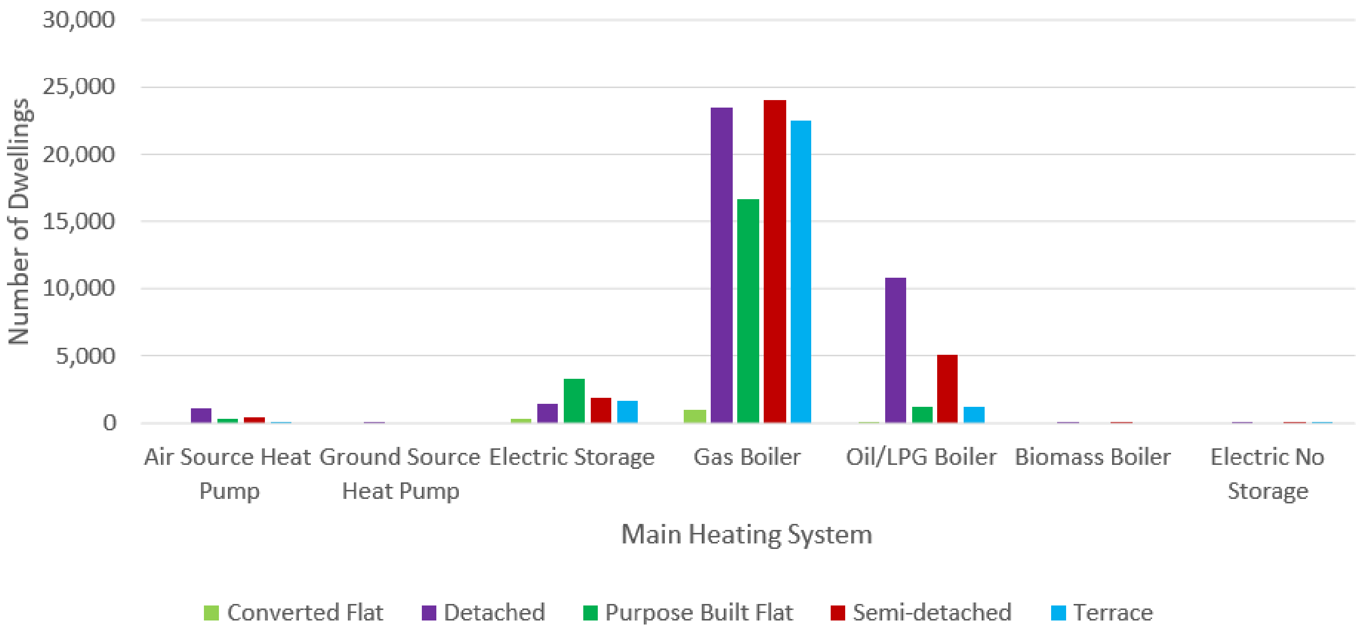


Figure 42: Estimated number of dwellings by main heating system (by dwelling type) across the Norwich & South Norfolk sub-region.

To make a heating system as efficient as possible insulation is required to reduce the heat loss from a dwelling.

Figure 43 shows the level of loft insulation in each dwelling type. Flats (both converted and purpose built) are assumed not to have a loft to insulate as even those on the top-floor are unlikely to be able to access the loft space in which to add insulation. There are also a small number of detached, semi-detached, and terraced properties that are classified as having no loft; this is usually due to them having a ‘room-in-roof’ where the loft has been converted into part of the living area.

The expected level of loft insulation in the UK is 270mm meaning that there are a significant proportion (63%) of those with a loft who would benefit from additional insulation. 46% of terraced houses have no loft insulation whatsoever (Figure 43).

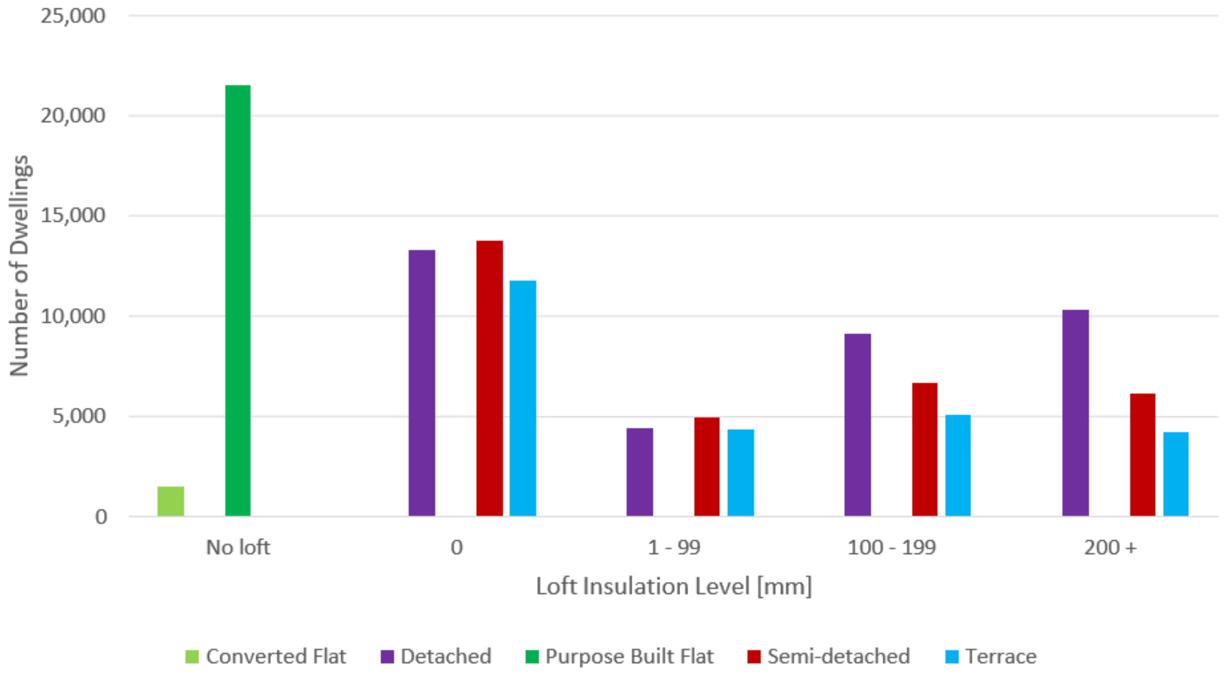


Figure 43: Estimated level of loft insulation (by dwelling type) across the Norwich & South Norfolk sub-region.

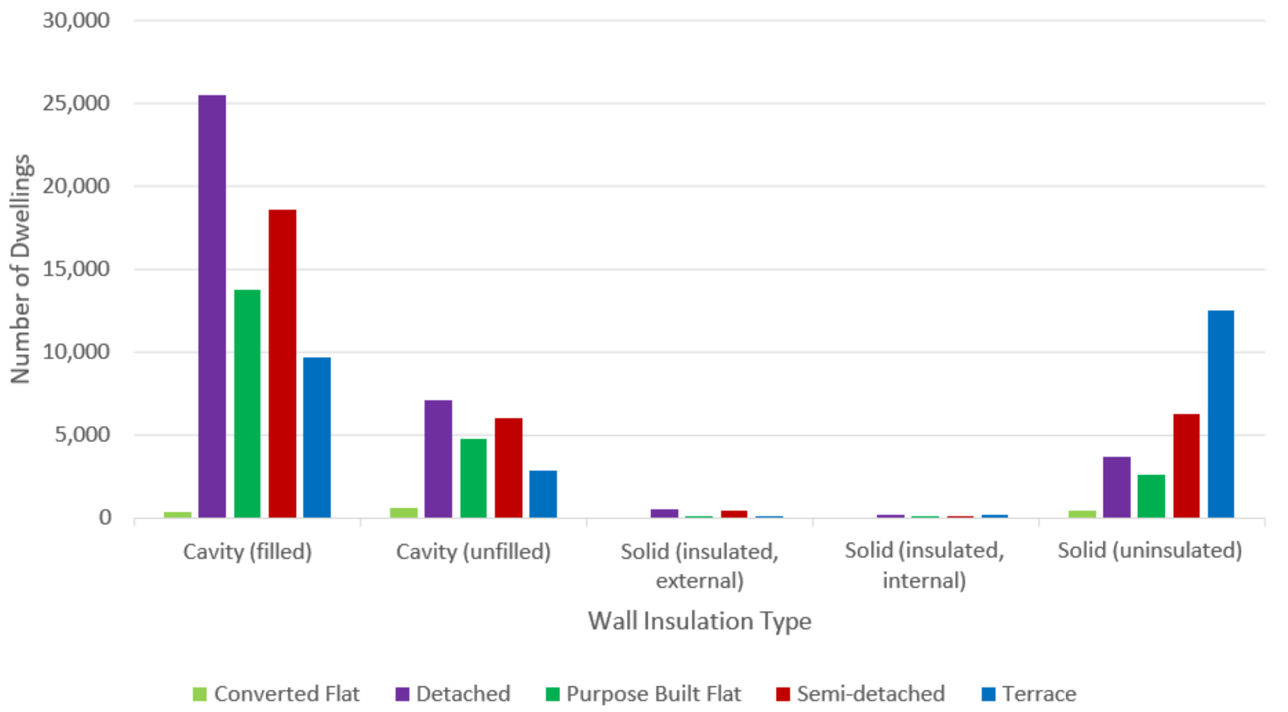


Figure 44: Estimated wall type and insulation level (by dwelling type) across the Norwich & South Norfolk sub-region.

Figure 44 shows that cavity walls are the most prominent (76%) wall type across the Norwich & South Norfolk sub-region. Of those dwellings with a cavity wall, around three-in-four are insulated. Cavity wall insulation can be difficult on some archetypes where there are hung tiles or render on the external face of the brickwork, also around conservatories. Whilst these are deemed 'hard-to-treat' there are methods for

ensuring that the cavity can be filled, albeit at a higher cost.

Figure 44 also shows that 93% of the solid wall properties in the Norwich & South Norfolk sub-region are uninsulated. This may be due to listed status, other planning restrictions, occupant behaviour/preference, or cost.

94% of dwellings in the Norwich & South Norfolk sub-region have double glazing (Figure 45). Triple glazing is not prevalent in the housing stock.

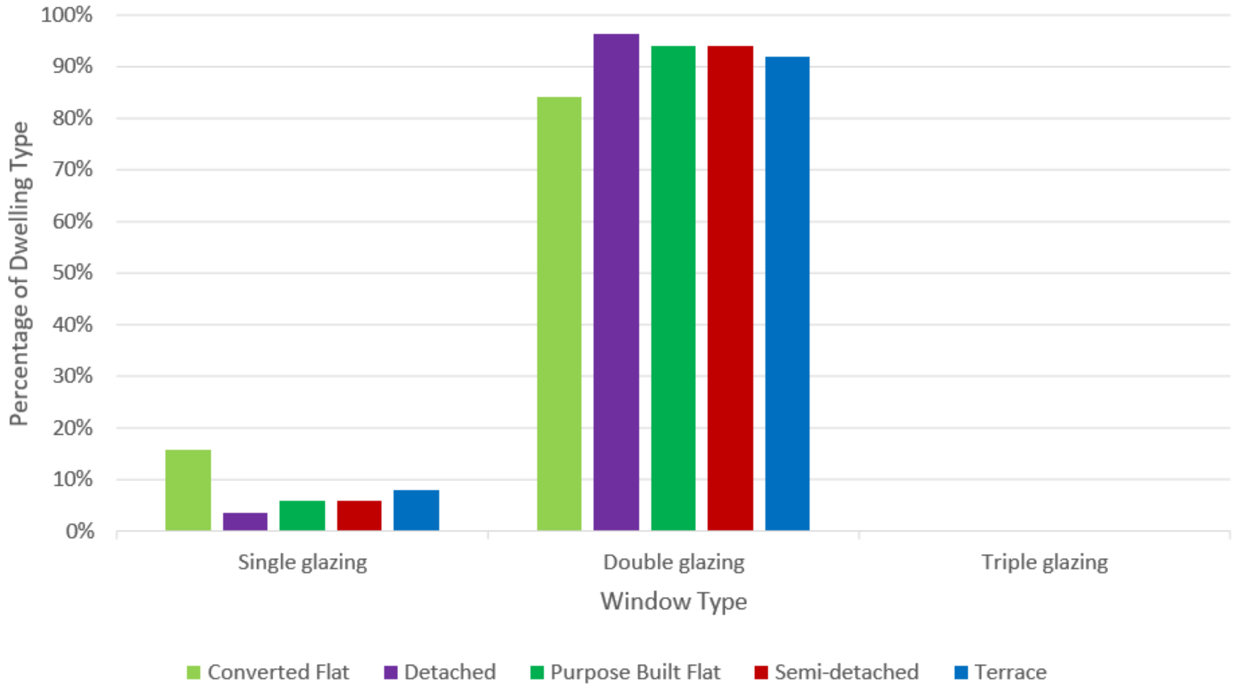


Figure 45: Estimated proportion of glazing type per dwelling type across the Norwich & South Norfolk sub-region.

As well as the domestic stock, the non-domestic stock needs to be considered. The breakdown of the non-domestic building stock across the Norwich & South Norfolk sub-region is shown in Table 15.

Table 15: Breakdown of the non-domestic building stock by type across the Norwich & South Norfolk sub-region.

Type	Floor Area [m²]	Percentage of total floor area	Number of non-domestic buildings	Percentage of non-domestic buildings
Retail	4,200,000	39%	19,100	40%
Factory	3,100,000	29%	8,750	19%
Office	1,140,000	11%	5,400	11%
Other	1,000,000	9%	10,100	21%
Education	890,000	8%	2,050	4%
Warehouse	390,000	4%	1,880	4%
Total	**10,800,000**	**100%**	**47,500**	**100%**

Due to rounding, some totals may not correspond with the sum of the separate figures.

Data from the National Atmospheric Emissions Inventory (NAEI)[16] has been used to identify large individual emission point sources i.e. emissions from a known location. As well as CO_2, this data shows air pollutants, heavy metals, and base cations[17], and greenhouse gases (GHGs)[18]. The point sources included within the project boundary are shown below in Figure 46. It should be noted that this dataset is for fixed emission sources only, and that non-fixed emissions such as those from road traffic are not included.

[16] https://naei.beis.gov.uk/
[17] https://naei.beis.gov.uk/overview/ap-overview
[18] https://naei.beis.gov.uk/overview/ghg-overview

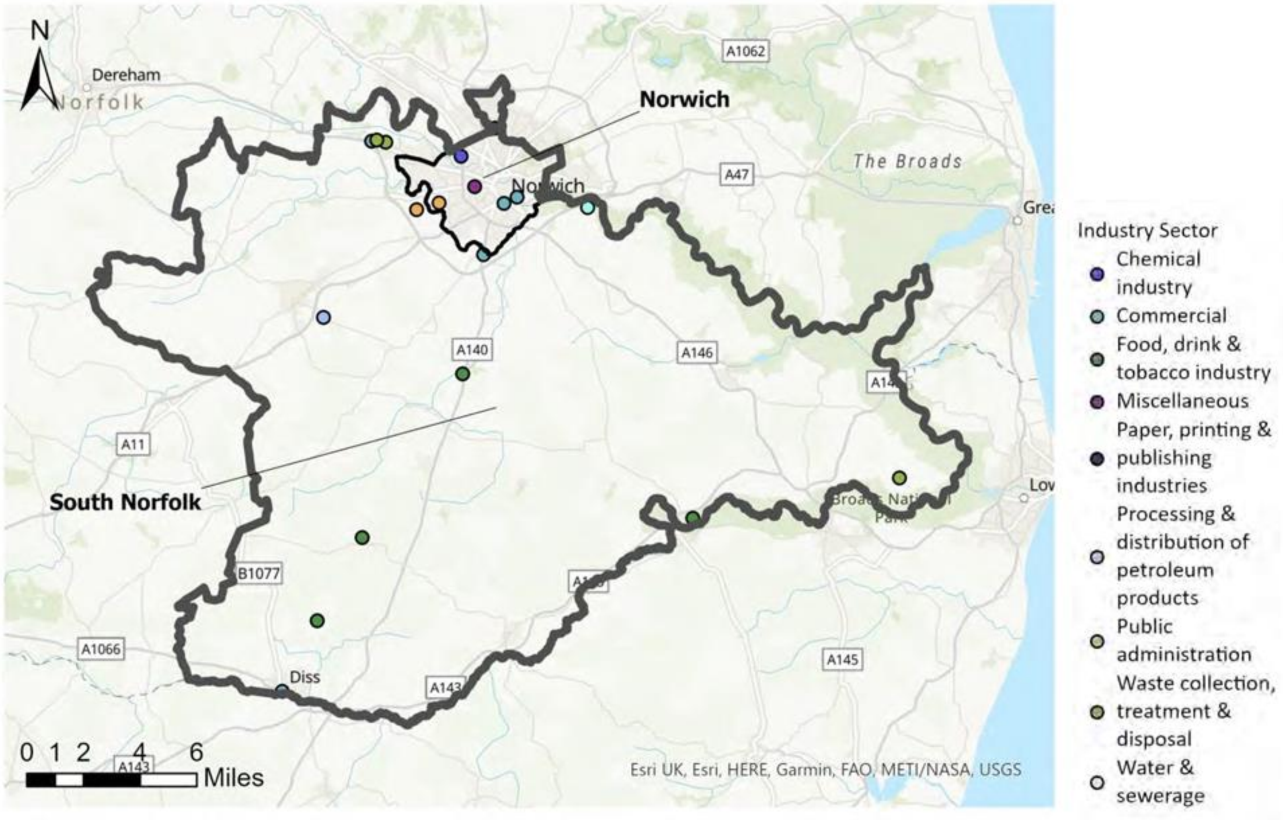


Figure 46: Individual emission sources identified by the National Atmospheric Emissions Inventory (NAEI) across the Norwich & South Norfolk sub-region.

Often the high emitters are located closely together on an industrial park or similar, therefore the definition given in Figure 46 is lacking. However, the data pack accompanying this report contains the full background data providing more clarity.

2.3.2 Energy Demands

This section will show the estimated annual consumption and peak demands across the Norwich & South Norfolk sub-region in the domestic and non-domestic sectors, and the geographic distribution by LSOA.

Table 16 and Table 17 below show the total figures for the sub-region. Please note: Electricity is supplied locally at 400V (three-phase) which is then connected to a dwelling at 230V (single-phase), therefore for the purposes of these calculations all domestic properties are assumed to be connected at 400V. Large non-domestic loads are assumed to be connected to the electricity network at 11kV; other non-domestic are connected at 400V. Total electricity demand is therefore the sum of demand at the 11kV level and 400V level. Demand from power generators and utilities are not included in these figures.

Table 16: Annual energy consumption [MWh] across the Norwich & South Norfolk sub-region.

Energy Type	Domestic Annual Consumption [MWh]	Non-Domestic Annual Consumption [MWh]	Total Annual Consumption [MWh]
Electricity (11kV)	0	225,000	225,000
Electricity (400V)	370,000	1,360,000	1,730,000
Gas	485,000	1,690,000	2,175,000
Oil	120,000	0	120,000

Table 17: Annual peak demand [MW] across the Norwich & South Norfolk sub-region.

Energy Type	Domestic Peak Demand [MW]	Non-Domestic Peak Demand [MW]	Total Peak Demand [MW]
Electricity (11kV)	0	65	65
Electricity (400V)	119	435	500
Gas	525	645	1,110
Oil	133	0	133

The total peak demand is not the sum of the peak demands for domestic and non-domestic buildings since the peak demands of the different sectors occur at different times.

The following maps (Figure 47 to Figure 50) show the distribution of estimated peak and annual energy consumption for both domestic and non-domestic buildings across the Norwich & South Norfolk sub-region. Peak demands shown on these maps may not all occur at the same time of day or time of year. For example, an area predominantly made up of domestic dwellings is likely to have a peak energy demand during the early evening in winter. In contrast, an area that is mainly made up of commercial offices will have maximum energy demand around the middle of the day. Mixed-use areas could have a different peak time depending upon the nature of their buildings.

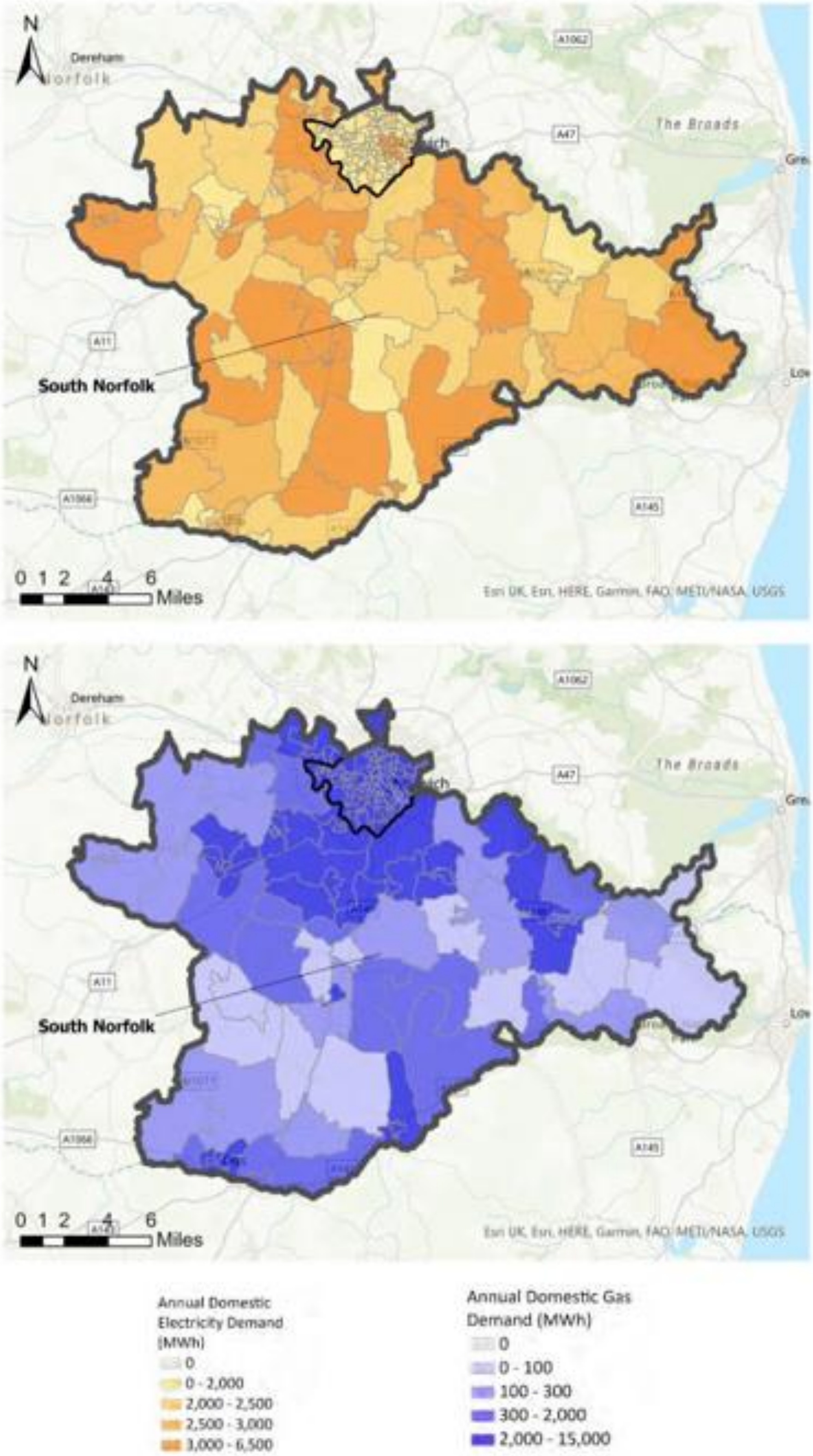


Figure 47: Estimated current domestic annual energy consumption by fuel and LSOA across the Norwich & South Norfolk sub-region.

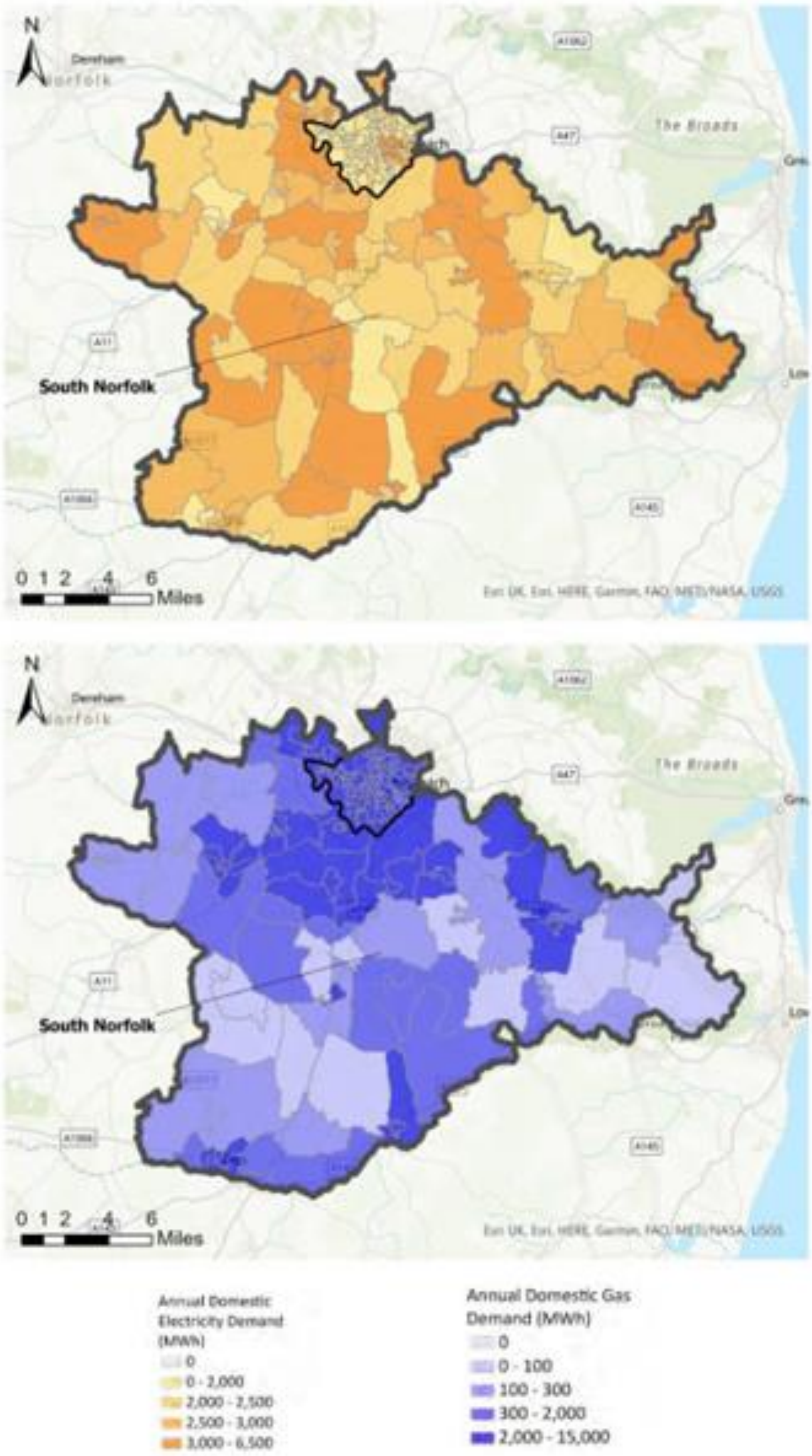


Figure 48: Estimated current non-domestic annual energy consumption by fuel and LSOA across the Norwich & South Norfolk sub- region.

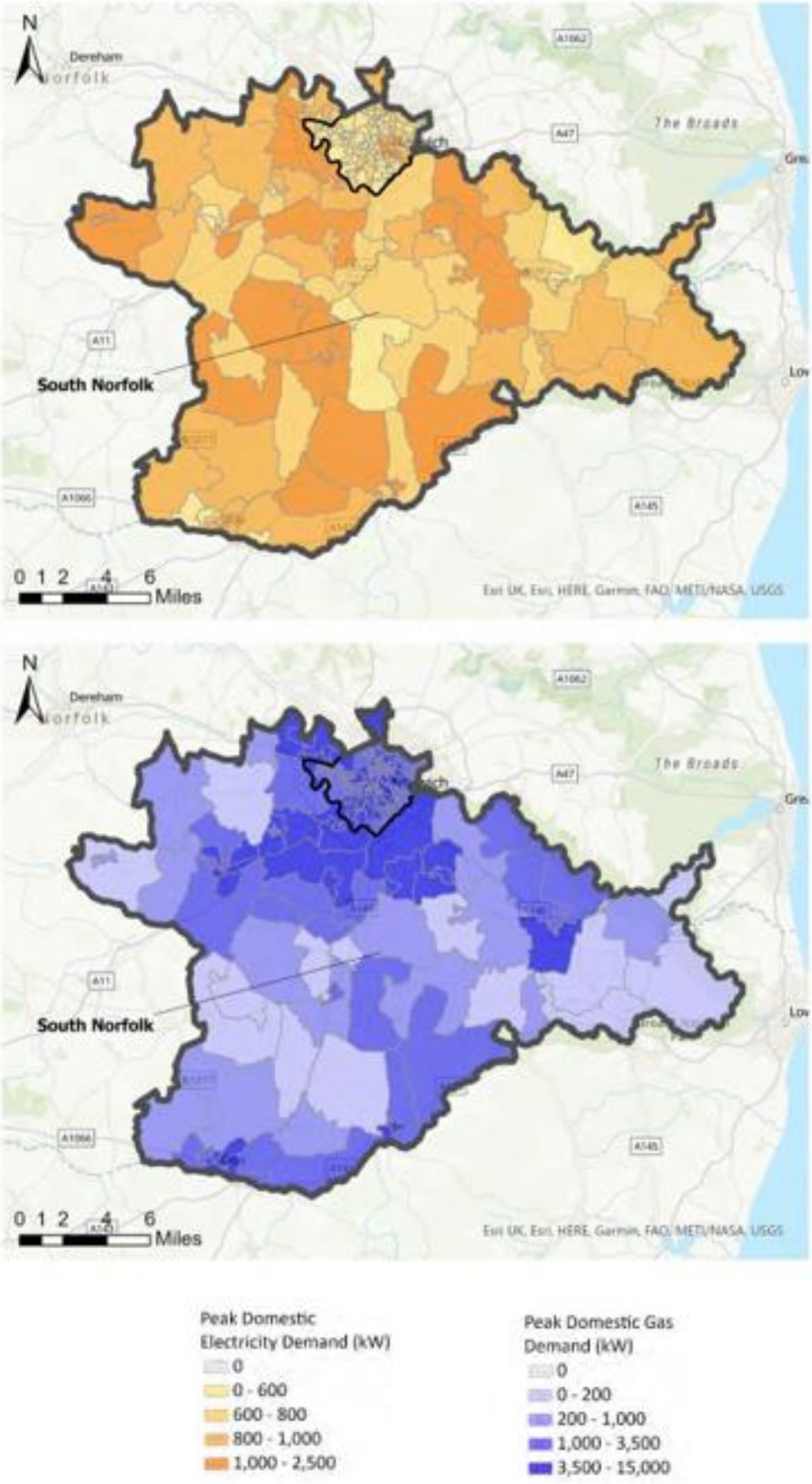


Figure 49: Estimated current domestic peak energy demand by fuel and LSOA across the Norwich & South Norfolk sub-region.

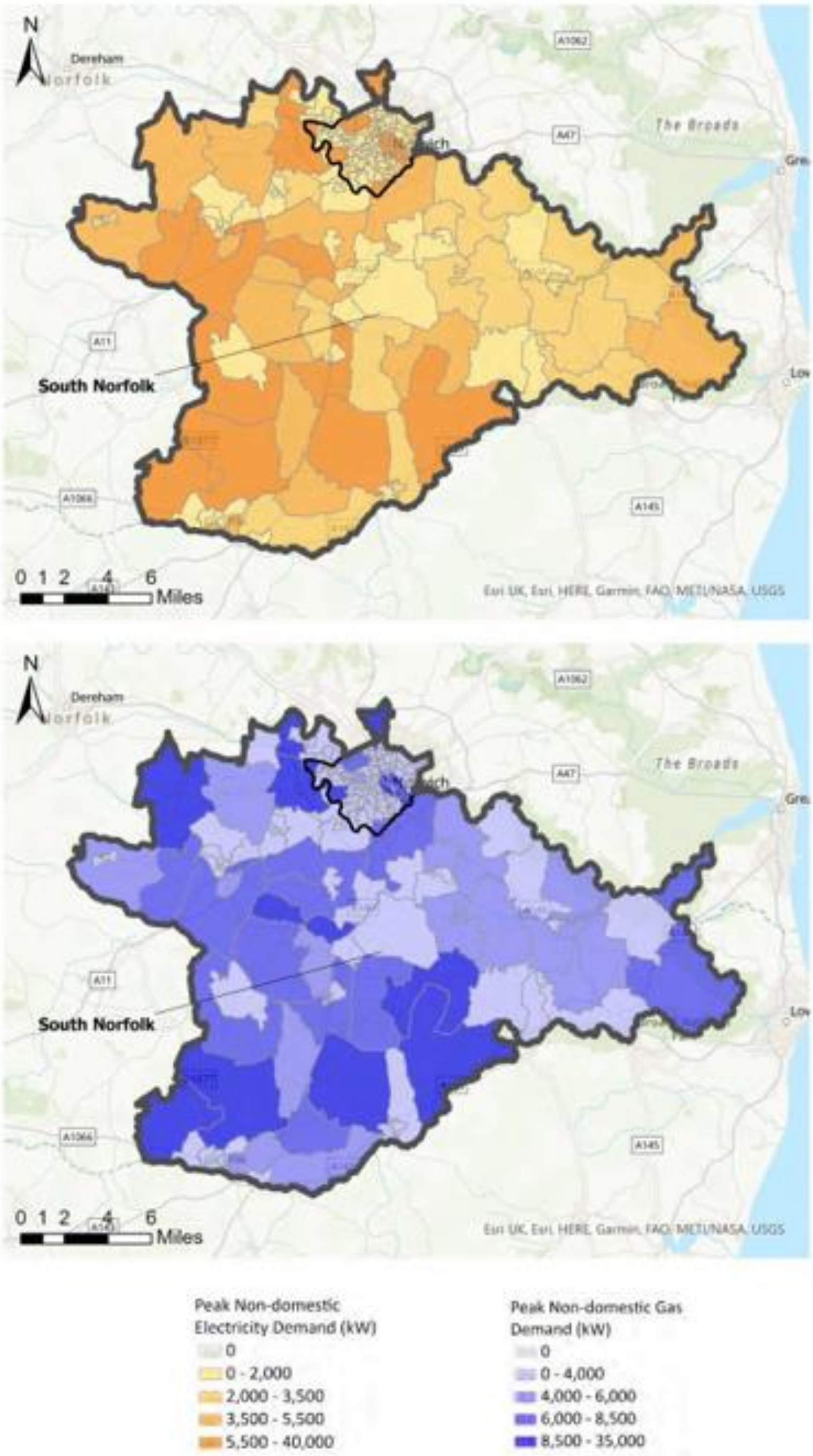


Figure 50: Estimated current non-domestic peak energy demand by fuel and LSOA across the Norwich & South Norfolk sub-region.

Figure 51 shows an estimate of the total electricity demand profile for the Norwich & South Norfolk sub-region for different days of the year representing the lowest typical demand and the highest. The peak day is also shown, which is used to determine a worst-case scenario on the network. Electricity demand includes heat, lighting, appliances, and electric vehicle charging when chargepoints are known to exist in the local area. The profile is for domestic and non-domestic buildings combined.

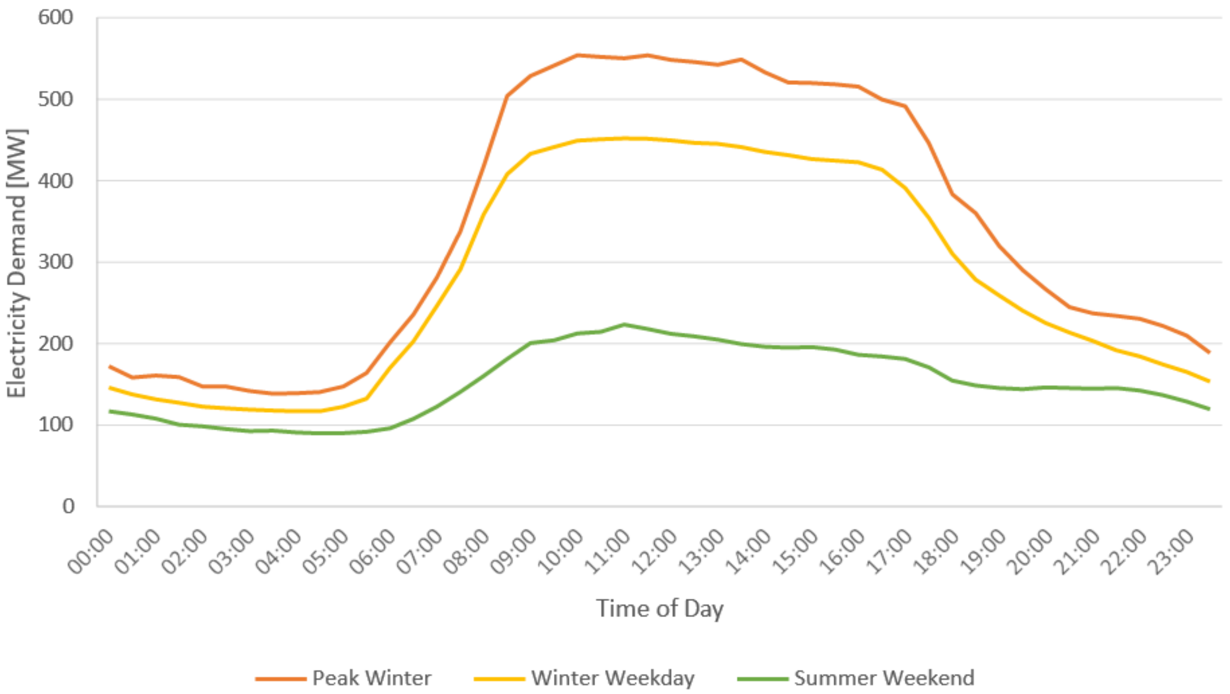


Figure 51: Estimated electricity demand profiles for different days of the year across the Norwich & South Norfolk sub-region.

As expected, the demand is far lower on a summer weekend when compared to a winter weekday.

Summer weekend represents the lowest end of demand profile; being summer means there is less need of heating, and weekend suggests that office/factory buildings are using less electricity, in contrast to a typical winter weekday.

The area between these two demand profiles demonstrates the typical demand i.e. the electricity demand will likely be within this middle section at any given time.

Figure 52 shows the estimated gas demand profile, and Figure 53 shows the estimated oil demand profile, for the Norwich & South Norfolk sub-region for the same days. Gas and oil demand include both heat and hot water and covers domestic and non-domestic buildings combined.

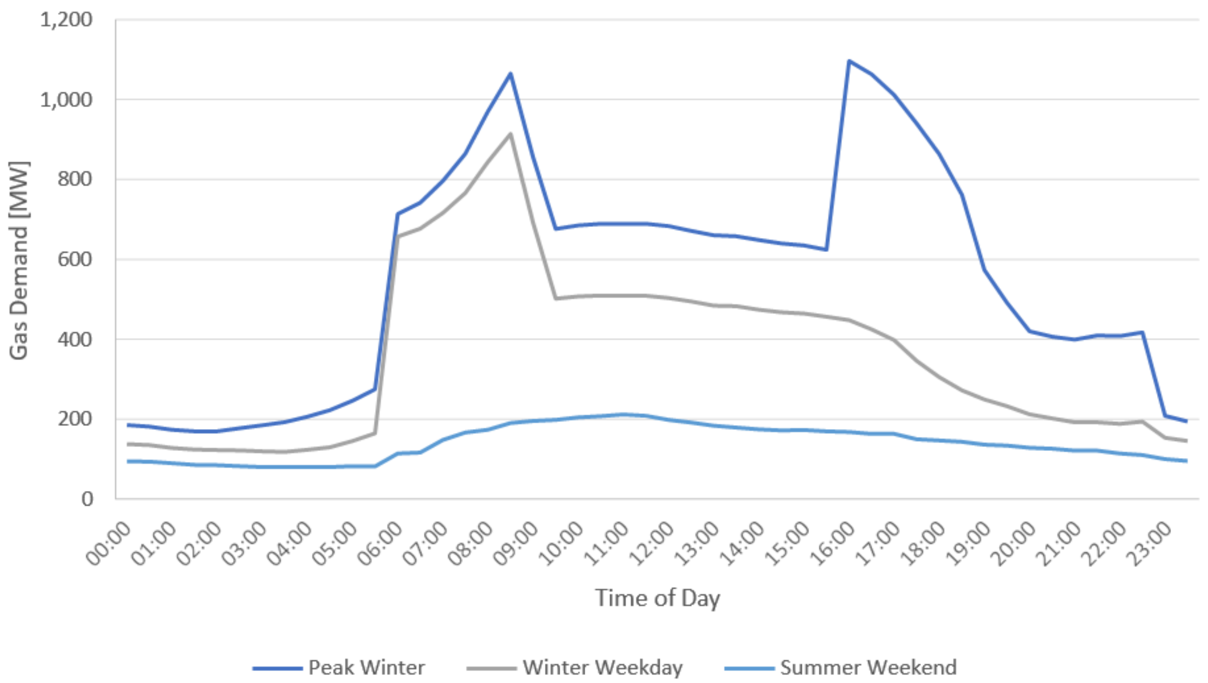


Figure 52: Estimated gas demand profiles for different days of the year across the Norwich & South Norfolk sub-region.

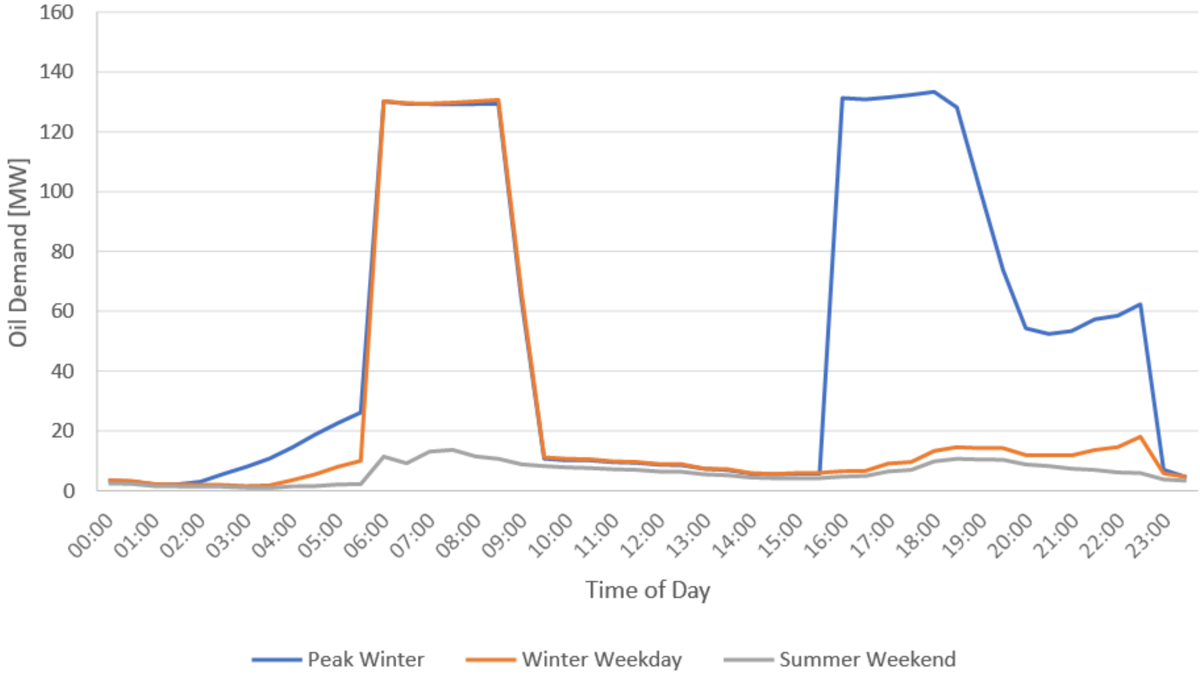


Figure 53: Estimated oil demand profiles for different days of the year across the Norwich & South Norfolk sub-region.

2.3.3 Energy Networks

A good understanding of the energy networks is vital to formulating a forward plan for the decarbonisation of any area. For example, identifying dwellings that are not on the gas network can help to focus a heat pump roll-out programme thus reducing the risk of competing heating vectors such as hydrogen or heat networks being a more financially viable option in the future. To identify those off-gas areas, Xoserve[19] postcode data was used (mapped in Figure 54) before being cross-referenced with Ordnance Survey records to calculate how many dwellings are estimated to be on- or off-gas (Table 18).

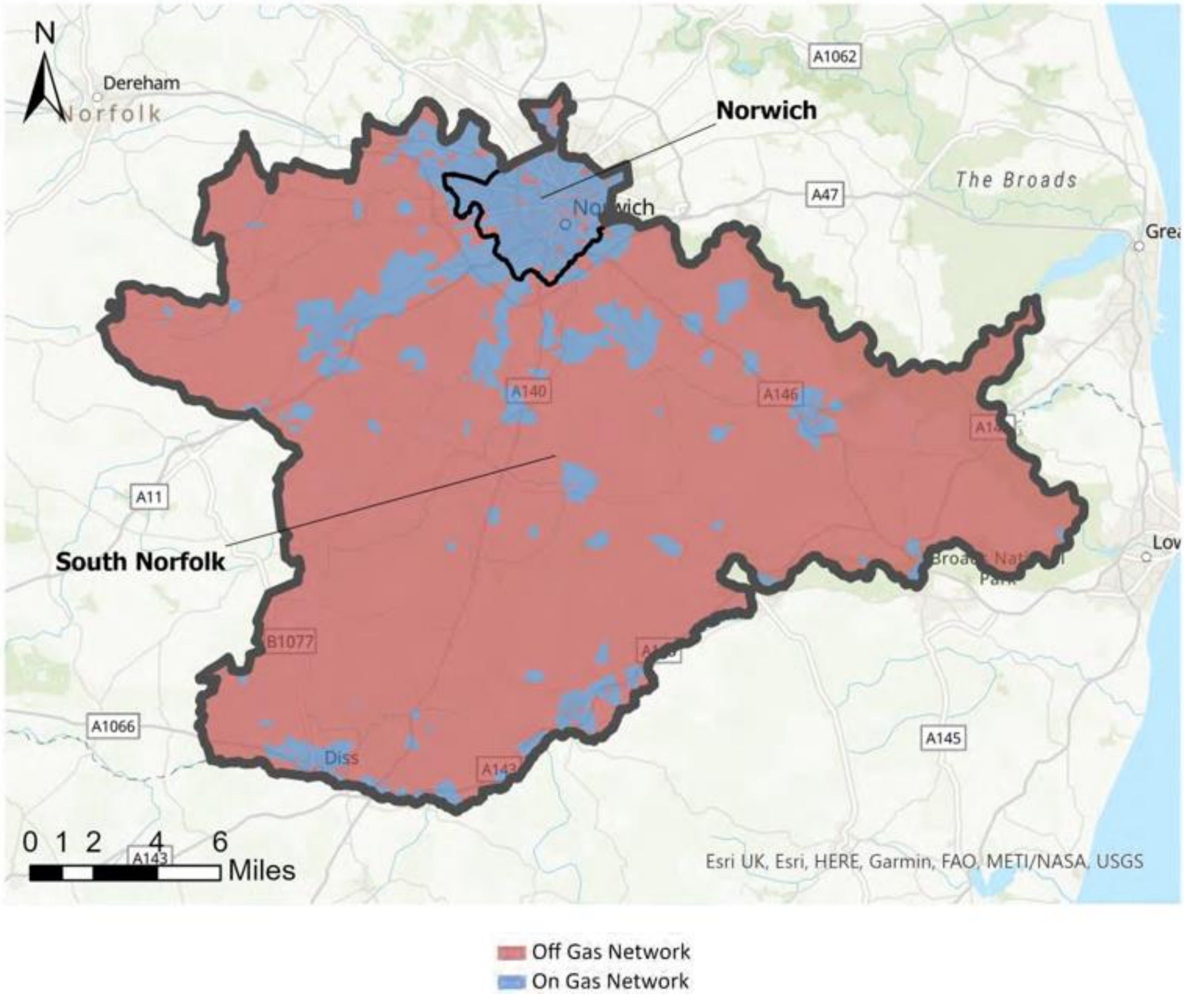


Figure 54: On-gas and off-gas areas of the Norwich & South Norfolk sub-region.

Table 18: Estimate of on-gas and off-gas dwellings across the Norwich & South Norfolk sub-region (rounded to nearest 5,000)

On or Off Gas Dwellings	**Number**
Off-Gas Dwellings	**30,000**
On-Gas Dwellings	**90,000**

19 https://www.xoserve.com/wp-content/uploads/Off-Gas-Postcodes-V2.xlsx

Comparing Figure 54 and Table 18 leads to the conclusion that the off-gas grid areas are sparsely populated. This is confirmed by comparing to the location of the building stock.

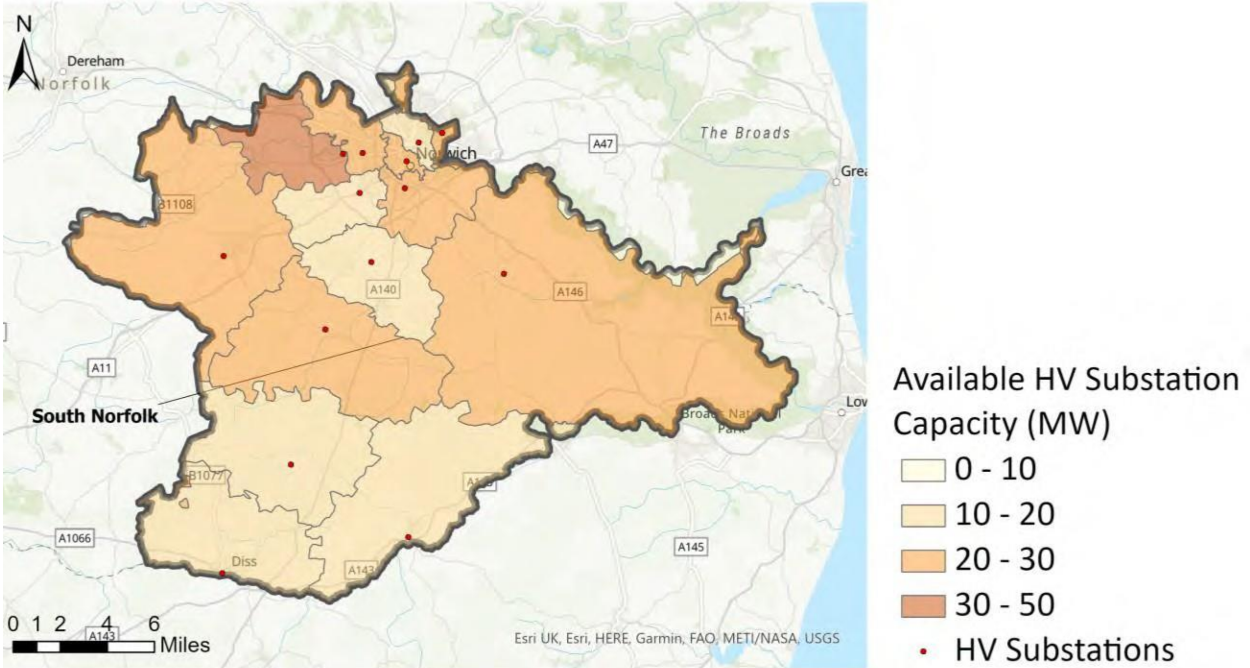


Figure 55: Available high-voltage substation capacity across the Norwich & South Norfolk sub-region.

Figure 55 shows an estimate of the available capacity on each 33kV-to-11kV substation and the extent of the area served by each substation. Capacity is calculated by subtracting the combined peak electrical demand on buildings in each area from the rated capacity of each substation. Those substations shown outside of the Norwich & South Norfolk boundary may serve buildings within it. Substations outside of the boundary have been included since it is likely some may serve assets within the project boundary. This is seen by new polygons that begin next to the project boundary. It should be noted that available capacity of areas on the Norfolk boundary may be overestimated since the demands of buildings outside of the county have not been modelled.

Where network connection is important from a project planning perspective the actual areas served should be established in conversation with the local Distribution Network Operator, (DNO) UK Power Networks. These capacity estimates are intended to give an indication of the capacity available on different parts of the network within the local energy system representation area and are not a substitute for detailed network modelling and analysis conducted by the local DNO. Substations identified as generation only in the DNO data are assumed to have no available capacity. Substations are not included in the analysis where DNO data on locations and capacities are unavailable. Where capacity data is unavailable, but locations are available, the 11kV-to-400kV capacity was set to the most prevalent substation capacity across all of Norfolk. Where capacity data is only available in MVA, it is assumed that capacity in MVA is equal to capacity in MW, unless power factors are available.

Figure 56 shows an estimate of the number of buildings, both domestic and non-domestic connected to each 33kV-to-11kV substation. As with capacity, the extent has been calculated as the area closest to each substation.

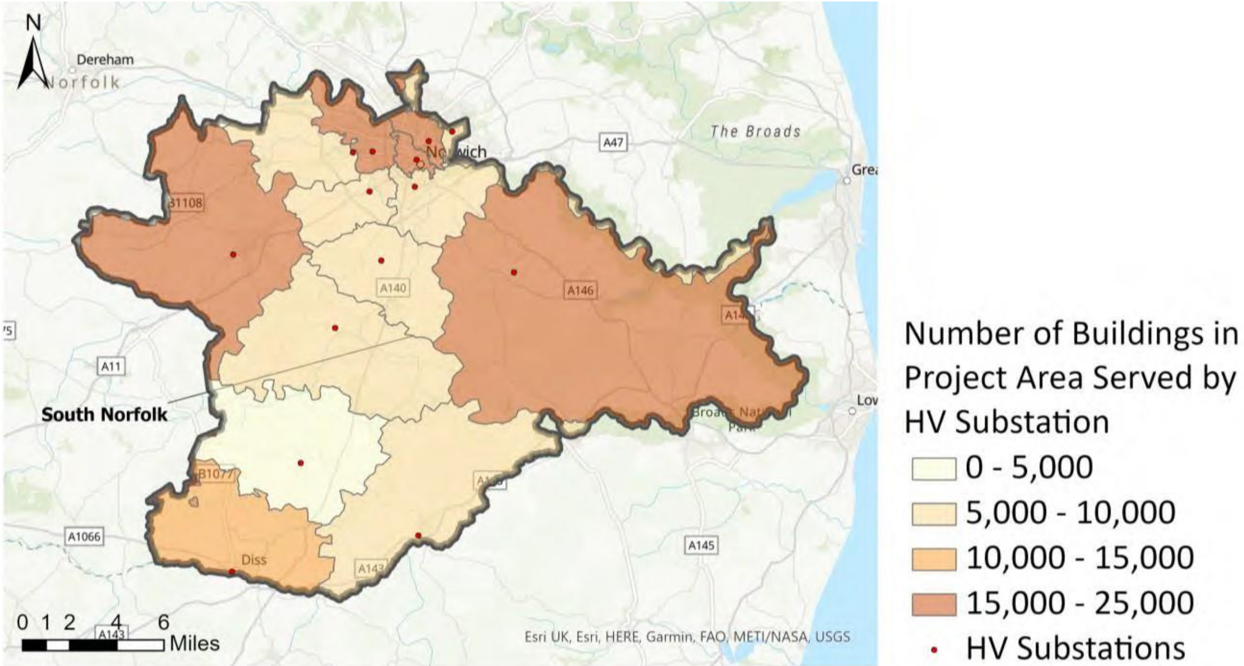


Figure 56: Number of buildings within the Norwich & South Norfolk sub-region served by each high-voltage substation.

2.3.4 Embedded Generation

The Renewable Energy Planning Database (REPD) was used to identify large scale embedded generation across the Norwich & South Norfolk sub-region. These sites, and the associated technologies, are shown in Figure 57. Data on domestic feed-in tariffs from BEIS are used to identify the amount of domestic solar photovoltaic (PV). The total installed capacity for each technology along with an estimate of the annual electricity generated in the local area is given in Table 19. Table 19 shows the proportion of annual electricity demand in the project area estimated to be met currently using local embedded generation. Additional embedded generation technologies may be present in the area but not reported here if they are not recorded in the REPD or if they are below 100kW.

Table 19: Estimated renewable energy capacity and estimated generation as a proportion of electricity demand in the Norwich & South Norfolk sub-region.

Renewable Tech	Installed Capacity [MW]	Annual Generation [GWh]	Proportion of Annual Demand
Domestic Solar PV	21.1	43	2.2%
Other Solar PV	39.2	35.5	1.8%
Landfill Gas	21.1	43	2.2%

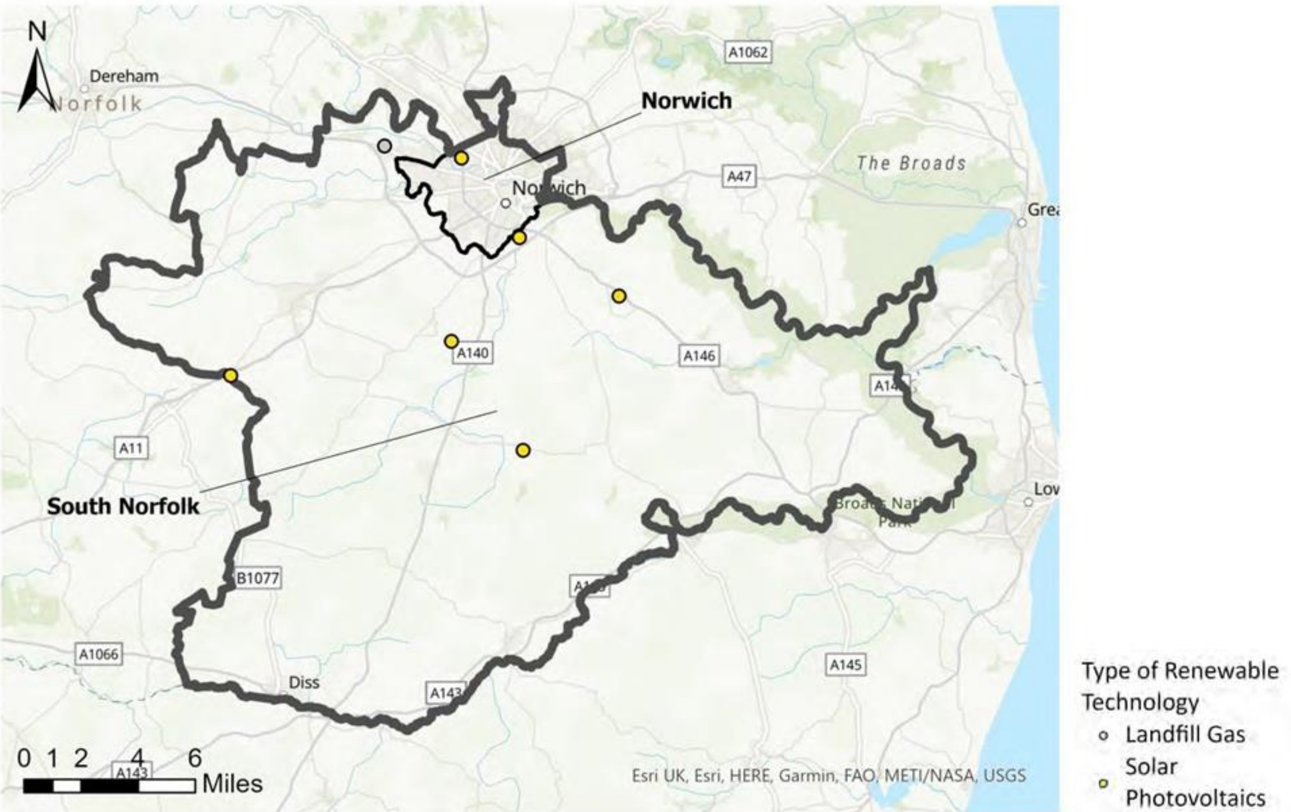


Figure 57: Existing embedded generation in the Norwich & South Norfolk sub-region according to REPD database (October 2020).

As can be seen from Table 19 domestic solar PV contributes over 2% to the annual demand of the sub-region. Although not all installations of solar PV are registered for the feed-in tariff (FIT), and not all FITs were given to solar PV, the majority will be and therefore Ofgem's Feed-in Tariff Installation Report[20] is a useful way of identifying the overall capacity and number of registrations in each LSOA. Figure 58 and Figure 59 show the installed capacity of renewables and number of registrations respectively.

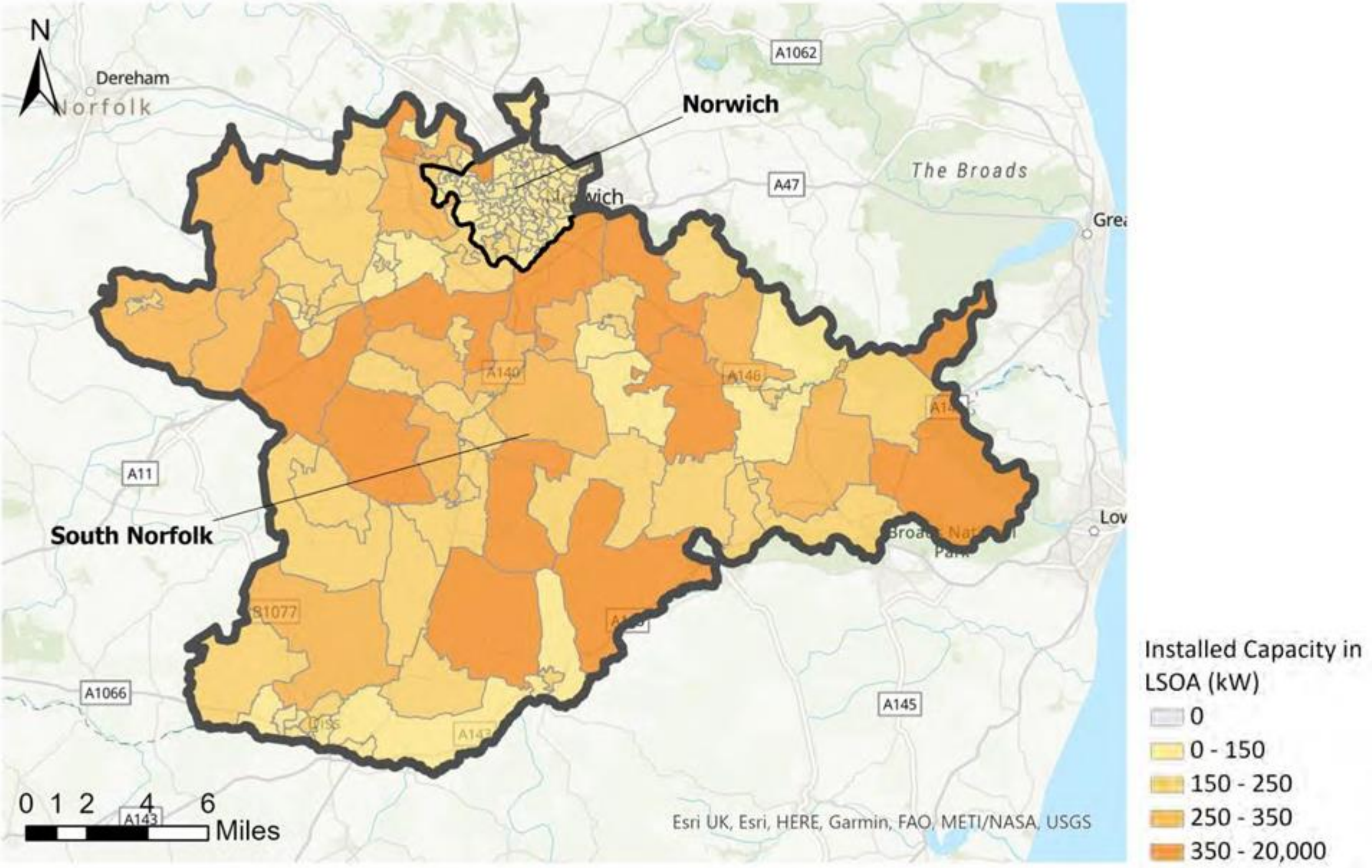


Figure 58: Aggregated capacity of renewable installations registered for FIT within each LSOA of the Norwich & South Norfolk sub- region.

20 https://www.ofgem.gov.uk/environmental-programmes/fit/contacts-guidance-and-resources/public-reports-and-data-fit/installation-reports

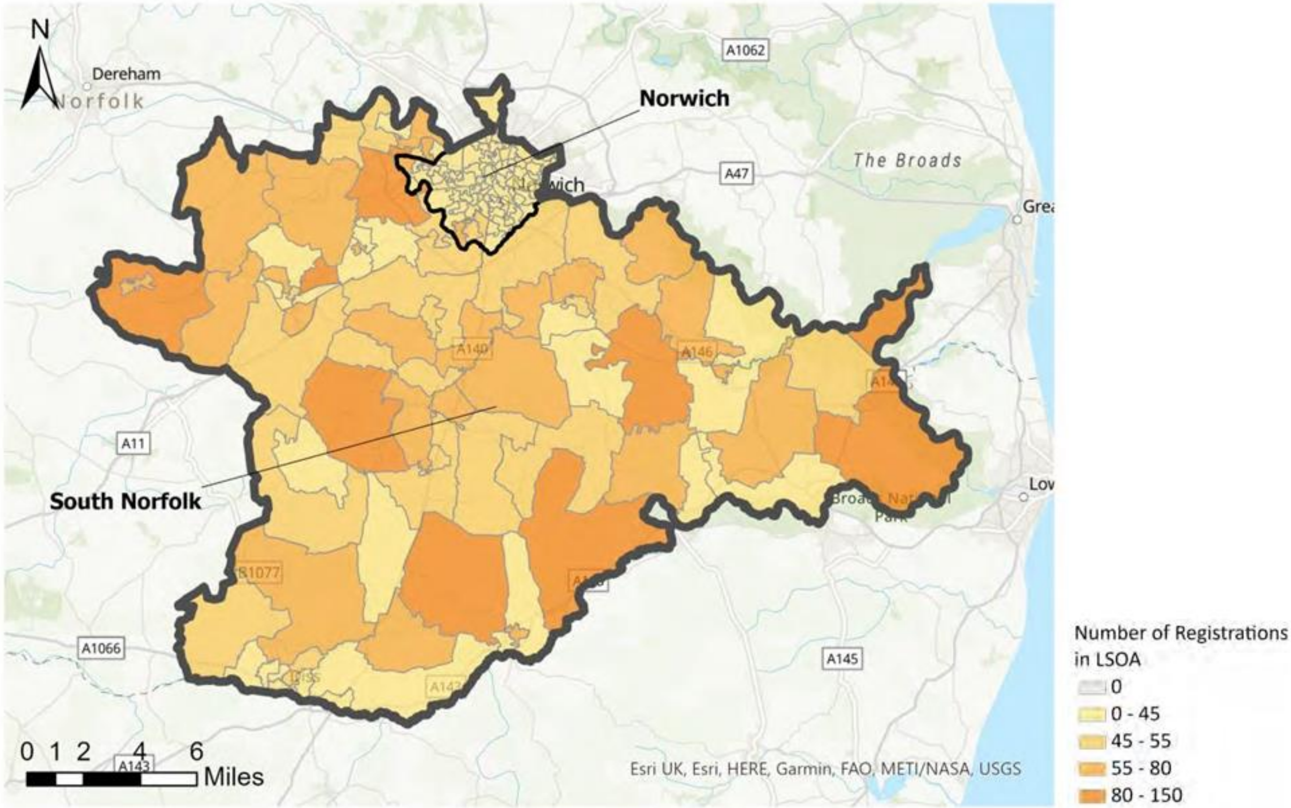


Figure 59: Number of renewable installations registered for FIT within each LSOA of the Norwich & South Norfolk sub-region.

To assess the potential for domestic on-roof solar PV within the Norwich & South Norfolk sub-region, the footprint and orientation of all dwellings have been analysed to calculate the potential generating capacity. These results are then aggregated to 200m radius areas to identify places best suited for mass deployment. The dwellings identified as suitable for rooftop solar PV in each of the three best areas are shown in Figure 60 to Figure 62.

As a purely spatial exercise this analysis does not consider local planning constraints and should not be used as a replacement for a detailed feasibility study or installation design.

Figure 60: Dwellings identified as suitable for rooftop PV panels. (Location: North-east Norwich)

Figure 61: Dwellings identified as suitable for rooftop PV panels. (Location: Lynch Green, Hethersett)

Figure 62: Dwellings identified as suitable for rooftop PV panels. (Location: New Costessey, Norwich)

In total these three areas alone have a total potential solar PV capacity of 2.771 MW.

2.3.5 Domestic & Public EV Charging

Data from the Zap-Map®[21] has been used to identify the locations and power outputs of public Electric Vehicle (EV) chargepoints across the Norwich & South Norfolk sub-region. The locations and the speed of the chargepoints are shown in Figure 63. In total there are 126 public chargepoints with a combined capacity of 2,306kW.

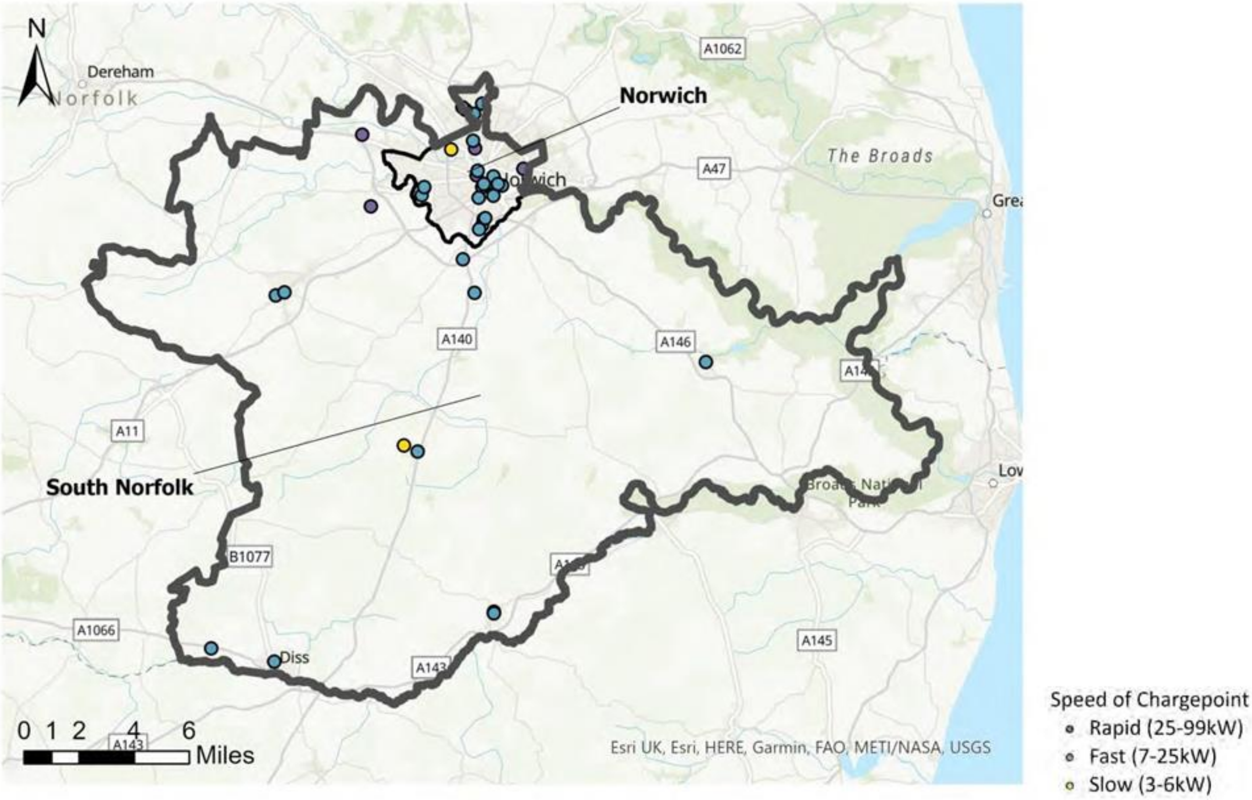


Figure 63: Location of public chargepoints according to Zap-Map® (December 2020)

ZAP MAP®

Chargepoint data provided by Zap-Map®

The Driver and Vehicle Licensing Authority (DVLA) publishes data on the numbers and types of different vehicles registered within different Local Authority Areas. This gives an indication of the number of EVs that might be registered within the sub-region as shown in Table 20.

It should be noted that leased vehicles will be registered to the leasing company which may not be based within the project area.

Using National Travel Survey data representative charge profiles have been generated for both public and domestic charge points. The estimated peak demands for domestic chargepoints are shown in Table 20.

[21] https://www.zap-map.com/

Table 20: Summary of plug-in vehicles[22] registered in the Norwich & South Norfolk sub-region according to data from DfT

Number of Plug-in Vehicles	Percentage of Total Vehicles	Estimated Peak Demand [kW]
854	0.81%	1,470

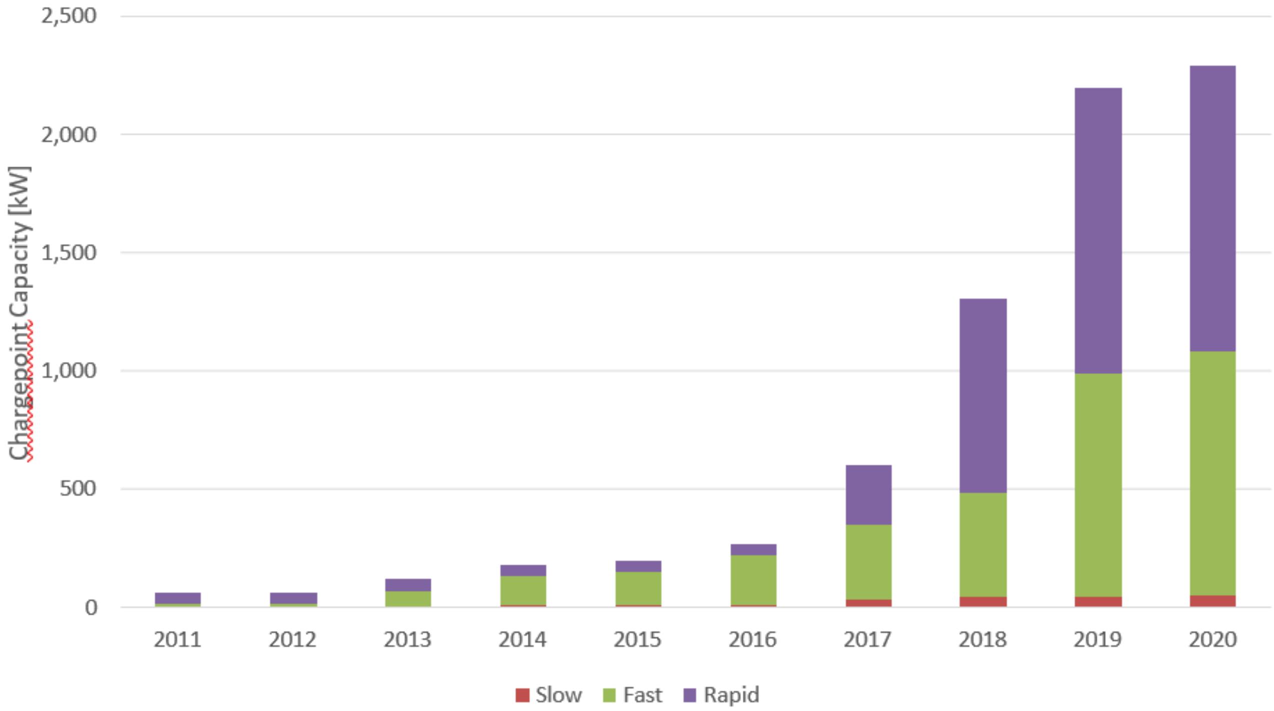


Figure 64: Chargepoint connector total capacity (kW) within the Norwich & South Norfolk sub-region over time.

[22] Plug-in vehicles are all models identified as being fully electric or plug-in hybrid.

Using the date that each chargepoint was added to the Zap-Map database the uptake of chargepoints in the area can be analysed.

Figure 64 shows this uptake in total kW rating of connectors within the Norwich & South Norfolk sub-region by charger type.

Ordnance Survey Mastermap Topography and Land Registry INSPIRE polygons have been used to identify houses which have space for off-street parking. This is done 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. This 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. Figure 65 shows the results of this analysis aggregated by road.

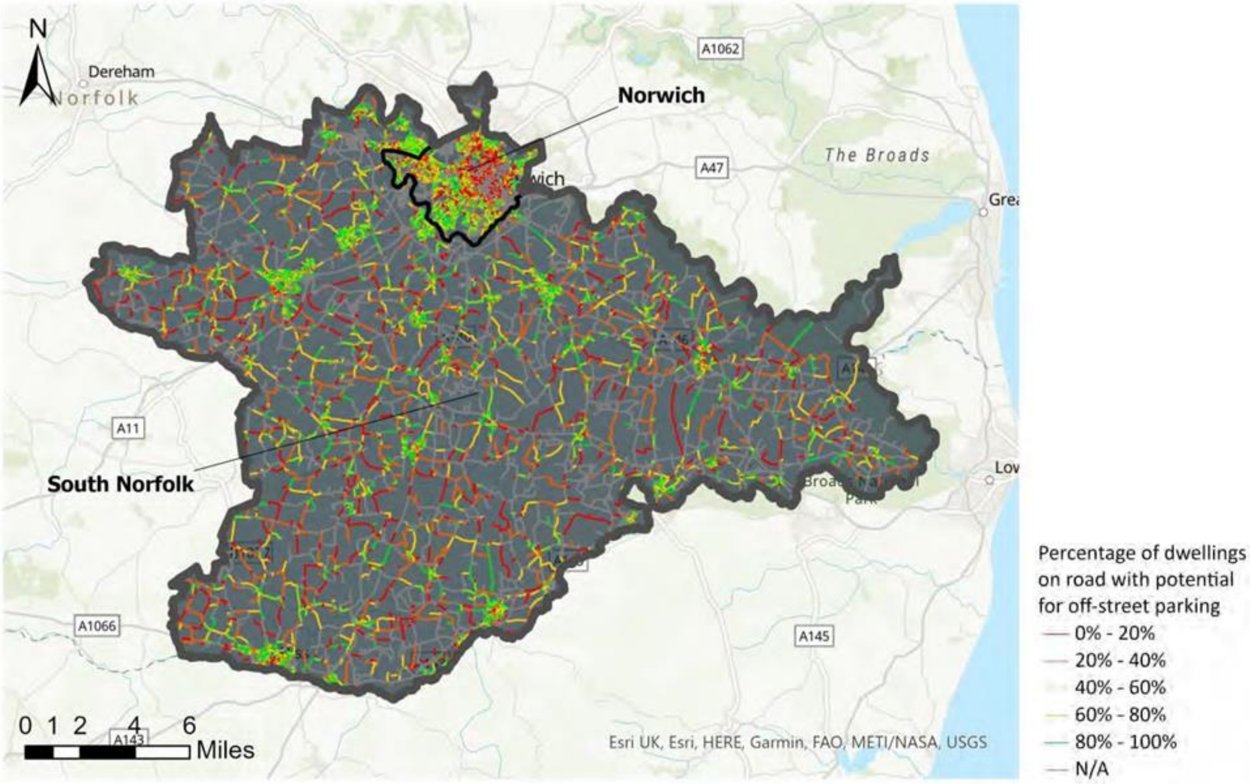


Figure 65: Percentage of dwellings with off-street parking on each road within the Norwich & South Norfolk sub-region.

As a purely spatial exercise this analysis does not consider local planning constraints and should not be used as a replacement for a detailed feasibility study.

2.3.6 Social Data

National data have been used to provide an indication of fuel poverty (Figure 66) and multiple deprivation (Figure 67) across the Norwich & South Norfolk sub-region.

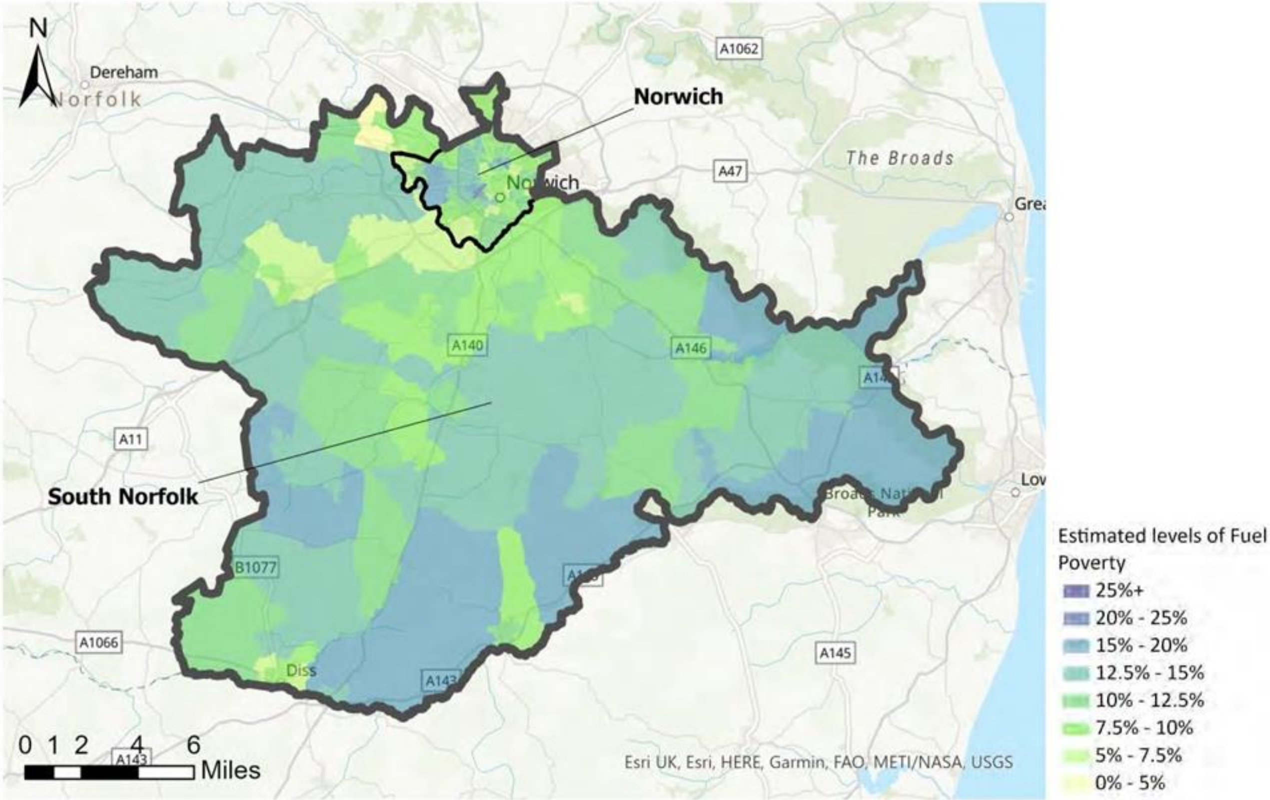


Figure 66: Estimated levels of fuel poverty according to 2020 BEIS data

Using the ranked Index of Multiple Deprivation[23] data published by The Department for Communities and Local Government (DCLG) at LSOA level it is possible to compare localised levels of deprivation within the Norwich & South Norfolk sub-region against the rest of England. For mapping purposes these are shown by octile, with values falling in octile 1 being within the most deprived 1/8th of the country and values falling in octile 8 being within the least deprived 1/8th of the country.

[23] https://www.gov.uk/government/statistics/english-indices-of-deprivation-2015
For descriptions of the underlying indicators used in the indices of deprivation please refer to this document: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/467775/File_8_ID_2015_Underlying_indicator s.xlsx

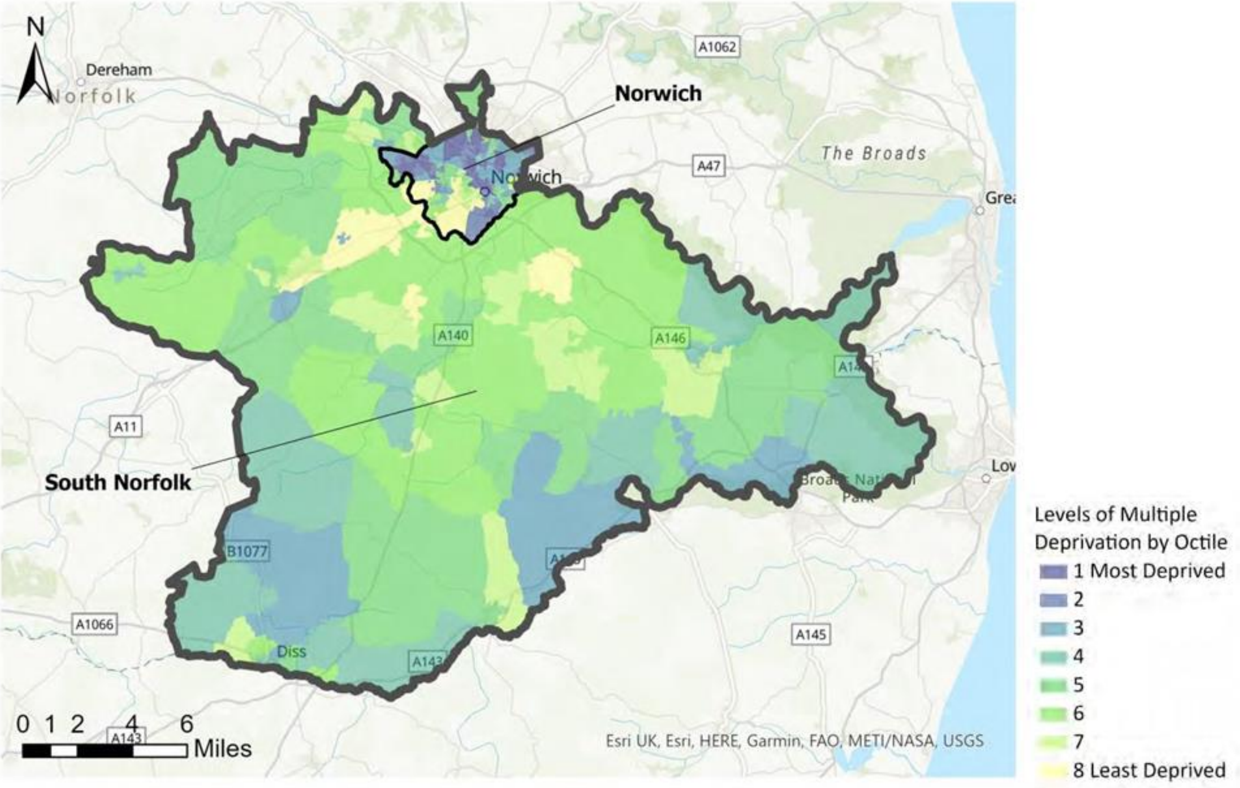


Figure 67: Ranking of English indices of deprivation 2020

The multiple indices that make up the IMD can be found in the accompanying data/maps to this report.

2.4 Norfolk Coastal (Great Yarmouth & North Norfolk)

The sub-regional area of 'Norfolk Coastal' has been defined in this report as covering the local authority areas of Great Yarmouth and North Norfolk which together cover an area of around 1,180km^2 and have a population of around 204,000[24].

2.4.1 Building Stock

This section will provide an overview of the building stock – both domestic and non-domestic – across the Norfolk Coastal sub-region. The geographical location of the building stock will be shown, as will the relative rurality across the sub-region, and breakdowns of the domestic and non-domestic stock by category.

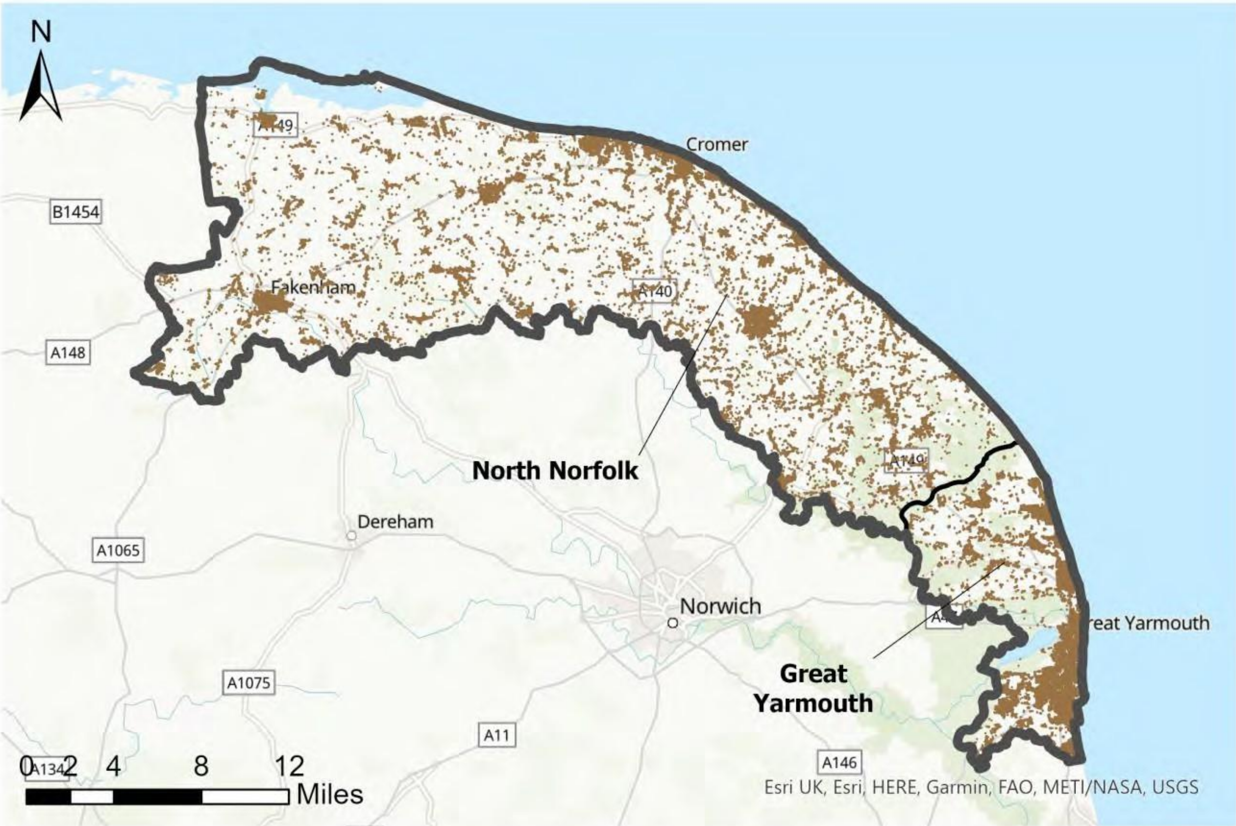


Figure 68: Building stock distribution across the Norfolk Coastal sub-region.

Figure 68 shows that across the Norfolk Coastal sub-region, the building stock is distributed into clusters around conurbations including Great Yarmouth, North Walsham and Cromer with the building stock being less densely situated elsewhere.

These areas correlate well to the rural/urban classifications given in the rurality map (Figure 69).

[24] https://www.norfolkinsight.org.uk/population/

Figure 69: Rurality of the Norfolk Coastal sub-region.

Figure 69 shows the rurality of the Norfolk Coastal sub-region by Lower-level Super Output Area (LSOA). Most of the land area in the Norfolk Coastal sub-region is classified as rural towns and villages with the more urban areas matching those noted in Figure 68.

Using data provided by Historic England[25], the location and grade of listed buildings; scheduled monuments; Battlefields; World Heritage Sites and Parks & Gardens can be mapped within the sub-region (Figure 70).

[25] https://historicengland.org.uk/listing/the-list/data-downloads

Figure 70: Location of listed buildings in the Norfolk Coastal sub-region grouped by grading according to Historic England

Figure 70 shows the large number of listed buildings, scheduled monuments, and areas of interest clustered in similar locations to the building stock. This could all pose a challenge to decarbonising the building stock. Table 21 shows the Listed Status of the buildings and the number of occurrences.

Table 21: Summary of listed buildings across Norfolk Coastal by grade category.

Grade Category	Number
Grade I	107
Grade II	2,394
Grade II*	249
Scheduled Monument	96

To understand the housing stock in more detail, the domestic stock has been segmented by:

- Type (converted flat, detached, purpose-built flat, semi-detached, and terrace)
- Construction date (pre-1914, 1914-1944, 1945-1964, 1965-1979, post-1980)
- Floor area [m^2] (under 50, 50-70, 70-90, 90-110, 110-200, 200-300, over 300)
- Main heating system (ASHP, biomass, electric (no storage), electric storage, gas, GSHP, oil/LPG)
- Loft insulation level [mm] (no loft, no insulation, 1-99, 100-199, over 200)
- Wall type (filled cavity, unfilled cavity, solid with ESWI, solid with ISWI, uninsulated solid)
- Window type (single glazing, double glazing, triple glazing)

Table 22: Number and percentage of dwelling types across the Norfolk Coastal sub-region.

Dwelling Type	Number	Percentage
Converted Flat	900	1%
Detached	36,000	35%
Purpose Built Flat	14,100	14%
Semi-detached	25,000	25%
Terrace	25,000	25%
Total	101,000	100%

Due to rounding, some totals may not correspond with the sum of the separate figures.

Table 22 shows that larger dwelling types are more prevalent across the sub-region. The prevalence of the dwelling types in each LSOA area (Figure 71) shows that detached dwellings are typically the most dominant in rural areas, whereas flats, terrace and semi-detached are more common in urban and town areas.

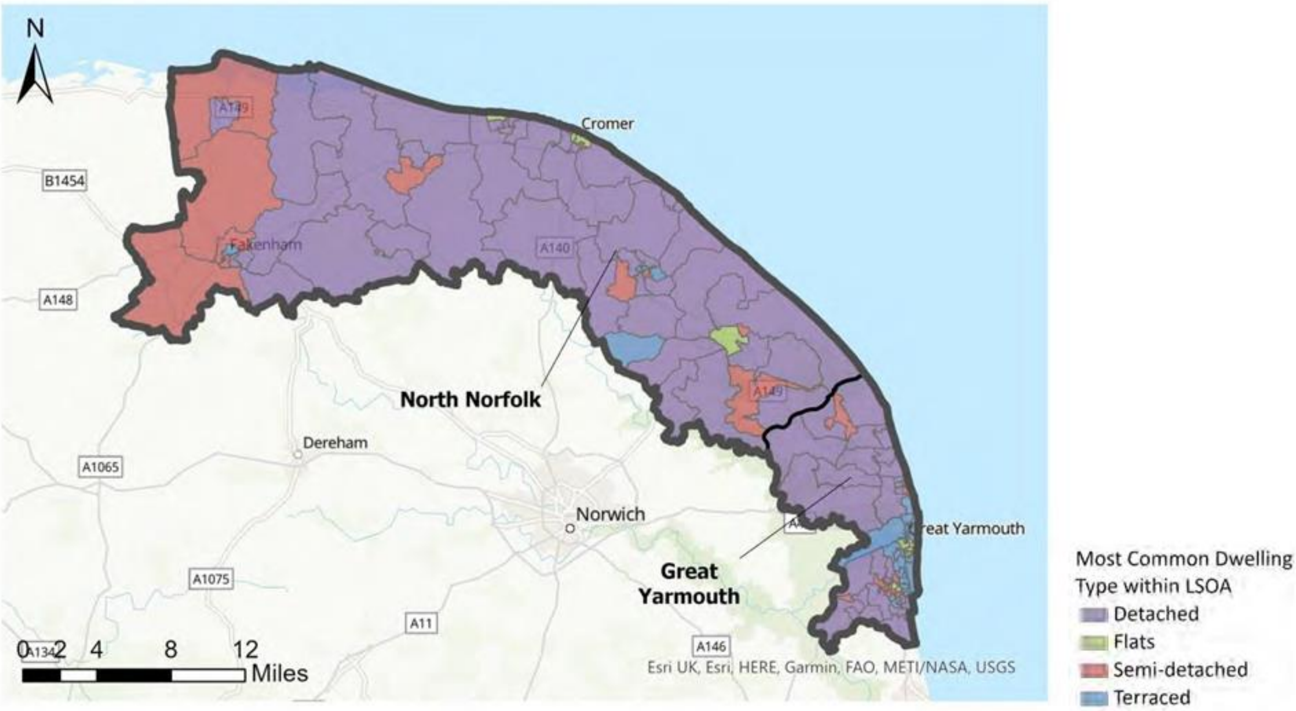


Figure 71: Most common dwelling type within each LSOA across the Norfolk Coastal sub-region.

A notable finding, shown in Table 23 is that almost a quarter all domestic dwellings are over a century old which will likely require more substantial intervention to bring their heat loss to a point where a heat pump could be considered.

Table 23: Number and percentage of dwellings constructed in different periods across the Norfolk Coastal sub-region.

Dwelling Construction Period	Number	Percentage
Pre-1914	22,000	22%
1914-1944	7,600	8%
1945-1964	30,000	30%
1965-1979	26,500	26%
1980-present	15,100	15%
Total	**101,000**	**100%**

Due to rounding, some totals may not correspond with the sum of the separate figures.

By combining the dwelling type and the construction period, it can be seen in Figure 72 that over half of the pre-1914 dwellings are terraced. Detached and semi-detached dwellings are more prevalent in the post-war (1945-1964) period.

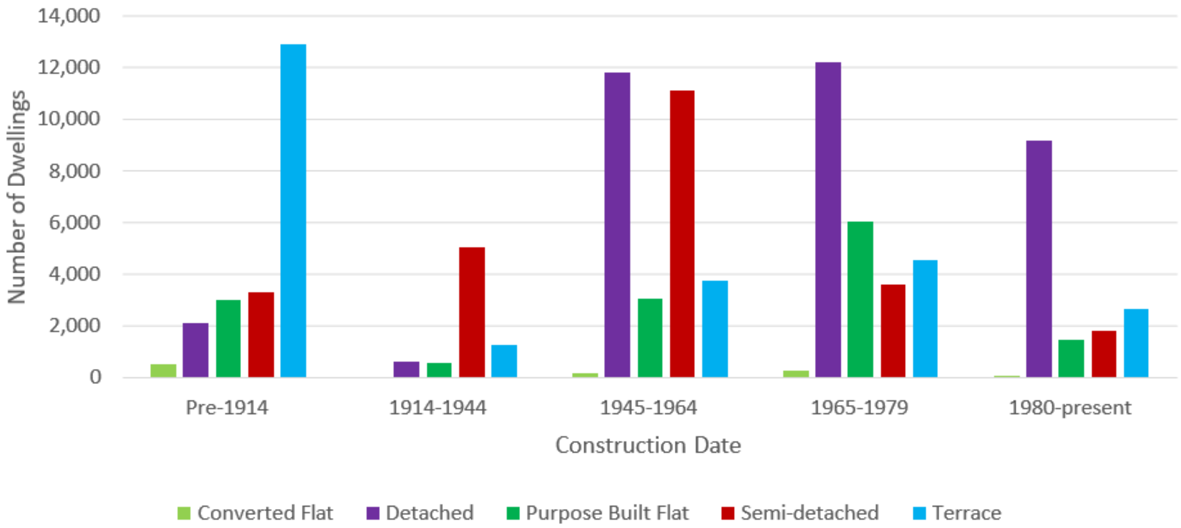


Figure 72: Estimated number of dwellings within each construction period (by dwelling type) across the Norfolk Coastal sub-region.

This can be visualised spatially (Figure 73) to show the most prevalent construction year in each LSOA in the Norfolk Coastal sub-region. Figure 73 shows a prevalence of 1945-1964 built dwellings in many of the larger LSOAs.

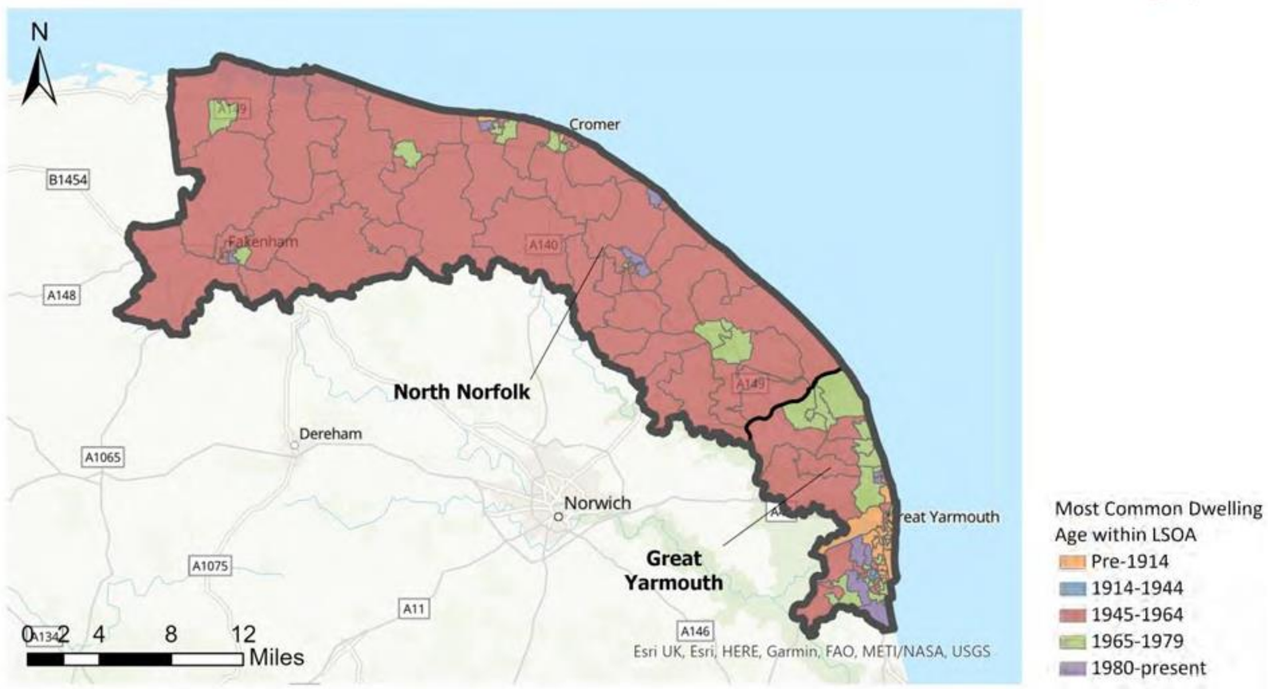


Figure 73: Most common construction period within each LSOA across the Norfolk Coastal sub-region.

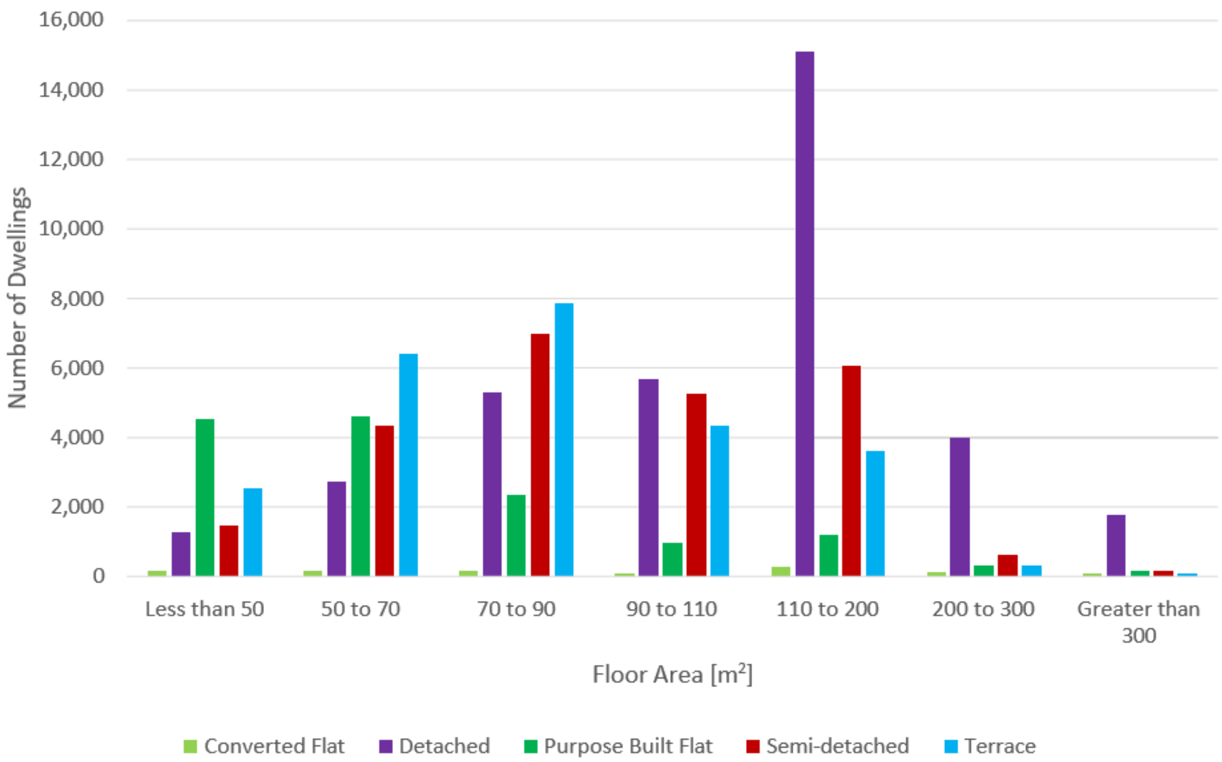


Figure 74: Estimated number of dwellings within each floor area band (by dwelling type) across the Norfolk Coastal sub-region.

From Figure 74, as expected, flats (particularly purpose-built flats) typically have a lower floor area than other dwellings. More than half of purpose-built flats have a floor area of under 70m^2 whilst the majority of detached dwellings have a floor area of 110-200m^2.

Dwellings in the Norfolk Coastal sub-region are overwhelmingly heated using a fossil fuel boiler (86%) with the remainder being made up from electric storage heaters (11%). Electric storage heaters are often used relatively high or medium-density housing areas where heat losses are low. Oil/LPG boilers are typically used in off-gas grid areas which in turn are often rural. Figure 75 below shows that over one-third of detached dwellings use oil/LPG boilers as their main heating system. Gas boilers are prevalent throughout the housing stock.

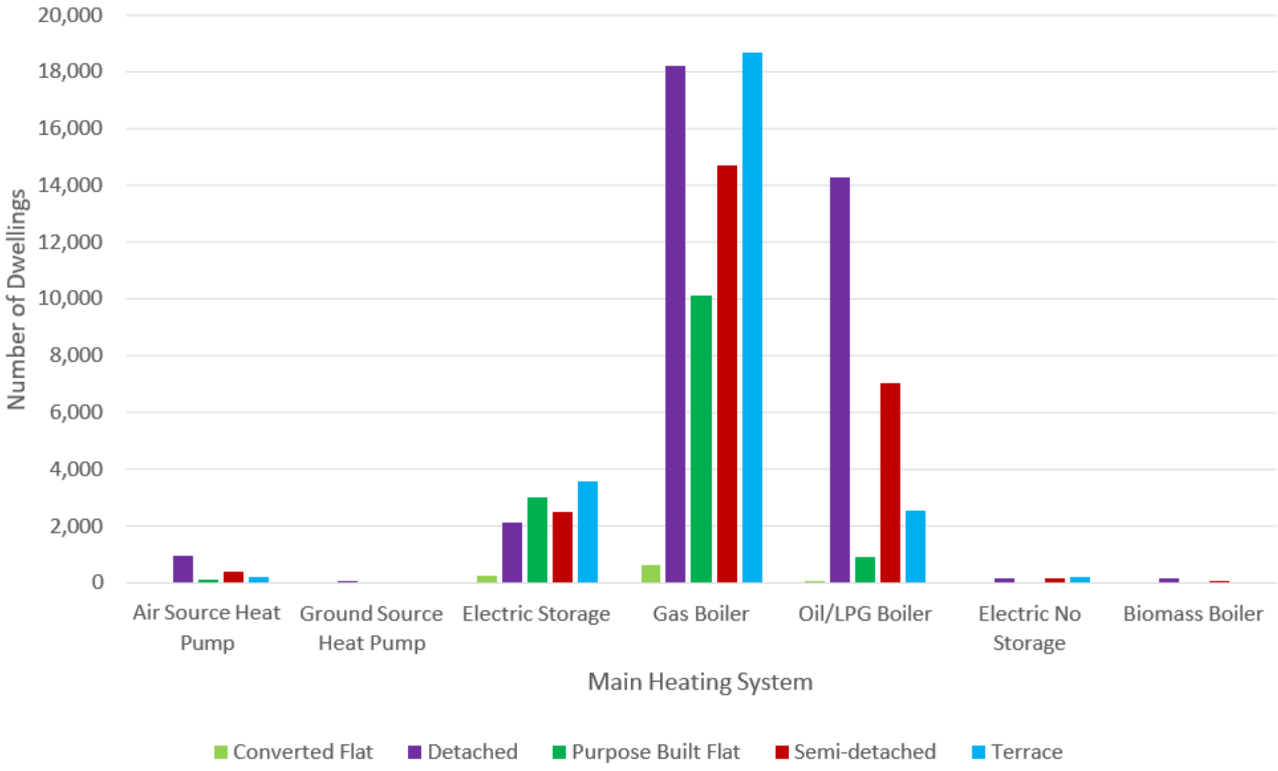


Figure 75: Estimated number of dwellings by main heating system (by dwelling type) across the Norfolk Coastal sub-region.

To make a heating system as efficient as possible insulation is required to reduce the heat loss from a dwelling. Figure 76 shows the level of loft insulation in each dwelling type. Flats (both converted and purpose built) are assumed not to have a loft to insulate as even those on the top-floor are unlikely to be able to access the loft space in which to add insulation. There are also a small number of detached, semi-detached, and terraced properties that are classified as having no loft; this is usually due to them having a 'room-in-roof' where the loft has been converted into part of the living area.

The expected level of loft insulation in the UK is 270mm meaning that at least 66% of the dwellings in the Norfolk Coastal sub-region that would benefit from additional loft insulation. In particular, where detached, semi-detached, and terraced dwellings have under 100mm of loft insulation (48%, 57% and 58% of dwellings respectively).

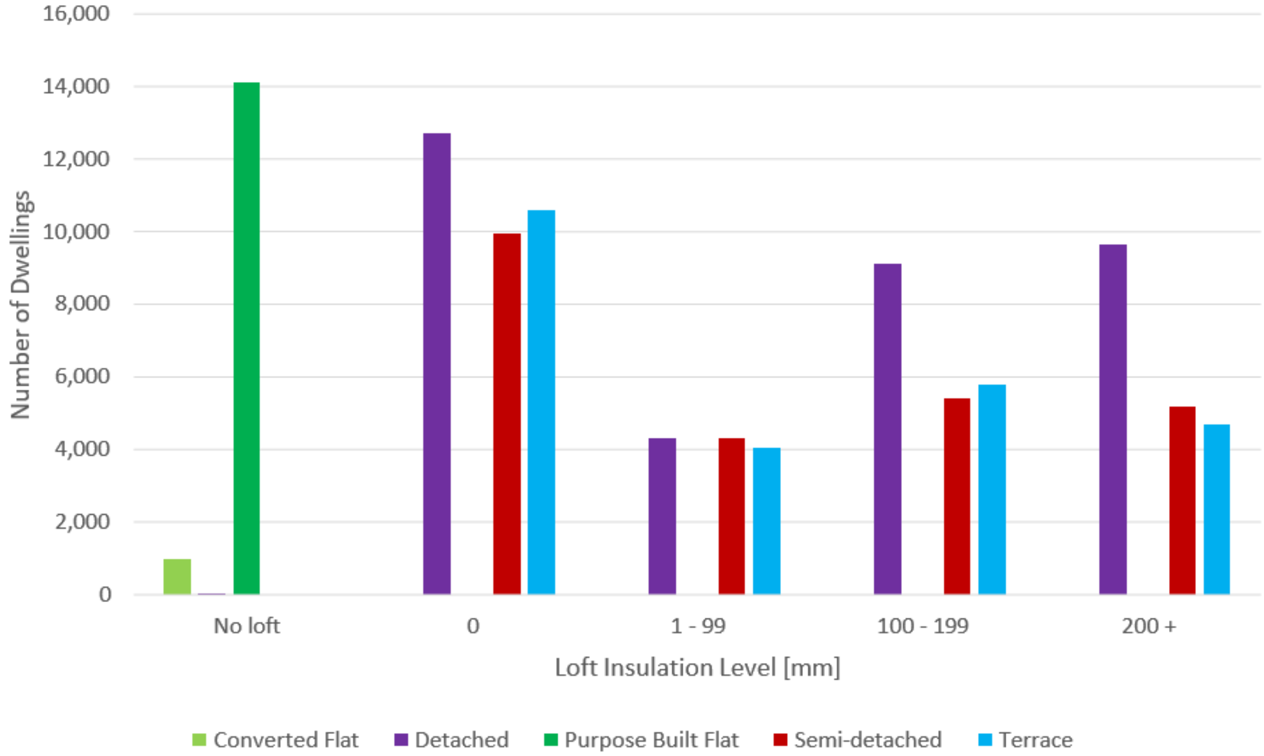


Figure 76: Estimated level of loft insulation (by dwelling type) across the Norfolk Coastal sub-region.

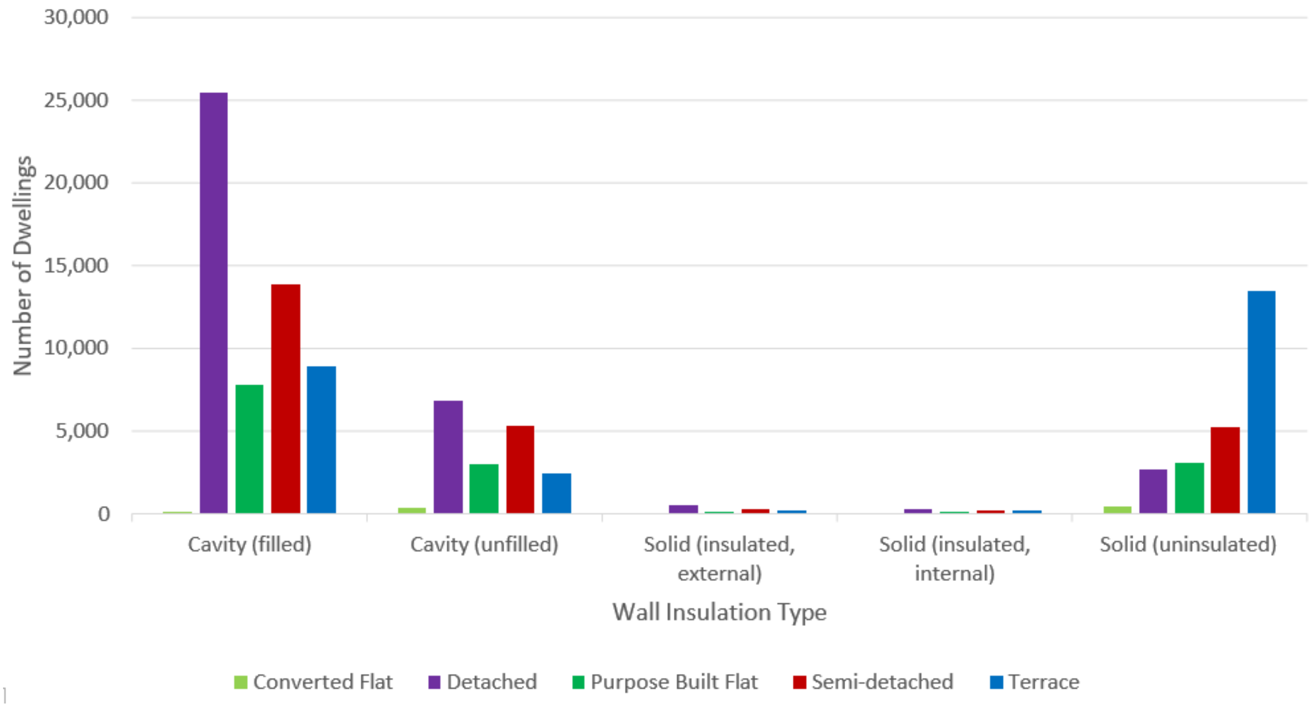


Figure 77: Estimated wall type and insulation level (by dwelling type) across the Norfolk Coastal sub-region.

Figure 77 shows that cavity walls are the most prominent wall type across the Norfolk Coastal sub-region, of which 76% being insulated. Cavity wall insulation can be difficult on some archetypes where there are hung tiles or render on the external face of the brickwork, also around conservatories. Whilst these are deemed 'hard-to-treat' there are methods for ensuring that the cavity can be filled, albeit at a higher cost. Figure 77 also shows that 93% of the solid wall properties in the Norfolk Coastal sub-region are uninsulated. This may be due to listed status, other planning restrictions, occupant behaviour, preference, or cost.

More than 94% of dwellings in the Norfolk Coastal sub-region have double glazing, including over 96% of all detached dwellings (Figure 78). Converted flats have the highest prevalence of single glazing. Triple glazing is not prevalent in the housing stock.

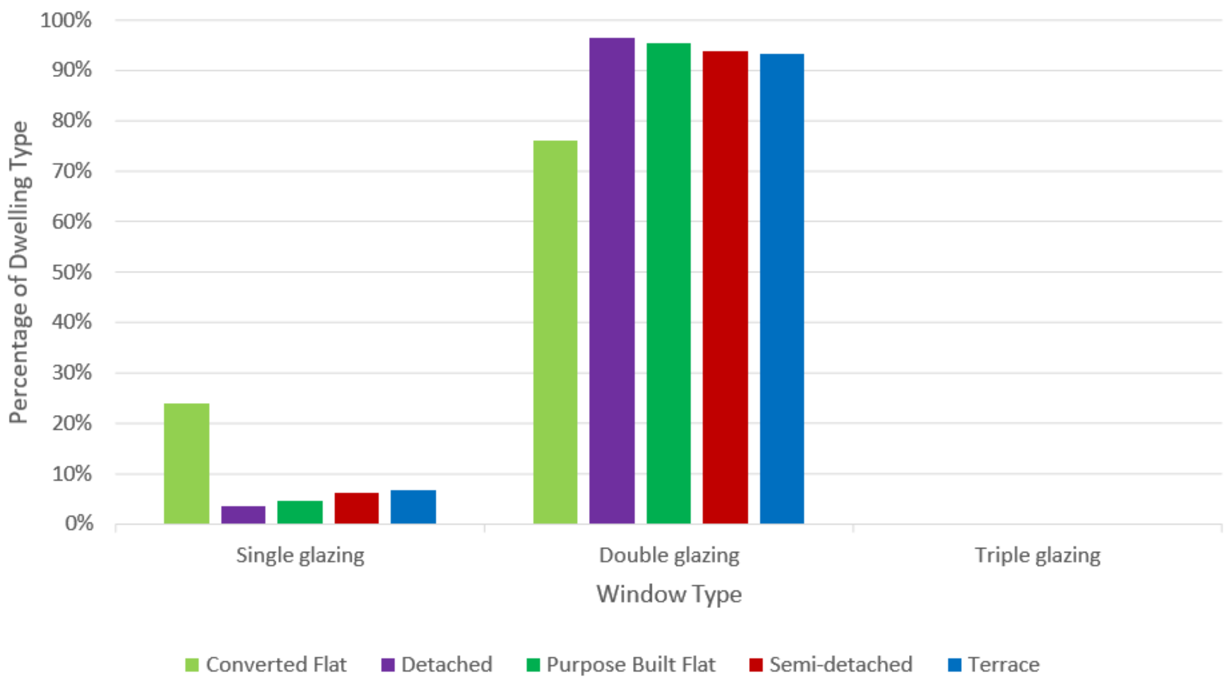


Figure 78: Estimated proportion of glazing type per dwelling type across the Norfolk Coastal sub-region.

As well as the domestic stock, the non-domestic stock needs to be considered. The breakdown of the non-domestic building stock across the Norfolk Coastal sub-region is shown in Table 24

Type	Floor Area [m²]	Percentage of total floor area	Number of non-domestic buildings	Percentage of non-domestic buildings
Retail	4,600,000	52%	25,000	64%
Factory	2,450,000	28%	7,300	19%
Education	510,000	6%	1,390	4%
Office	385,000	4%	1,630	4%
Warehouse	315,000	4%	1,510	4%
Other	620,000	7%	2,400	6%
Total	**8,900,000**	**100%**	**39,000**	**100%**

Table 24: Breakdown of the non-domestic building stock by type across the Norfolk Coastal sub-region.

Due to rounding, some totals may not correspond with the sum of the separate figures.

Data from the National Atmospheric Emissions Inventory (NAEI)[26] has been used to identify large individual emission point sources i.e. emissions from a known location. As well as CO_2, this data shows air pollutants, heavy metals, and base cations[27], and greenhouse gases (GHGs)[28]. The point sources included within the project boundary are shown below in Figure 79. It should be noted that this dataset is for fixed emission sources only, and that non-fixed emissions such as those from road traffic are not included.

Figure 79: Individual emission sources identified by the National Atmospheric Emissions Inventory (NAEI) across the Norfolk Coastal sub-region.

Often the high emitters are located closely together on an industrial park or similar, therefore the definition given in Figure 79 is lacking. However, the data pack accompanying this report contains the full background data providing more clarity.

26 https://naei.beis.gov.uk/
27 https://naei.beis.gov.uk/overview/ap-overview
28 https://naei.beis.gov.uk/overview/ghg-overview

2.4.2 Energy Demands

This section will show the estimated annual consumption and peak demands across the Norfolk Coastal sub-region in the domestic and non-domestic sectors, and the geographic distribution by LSOA.

Table 25 and Table 26 below show the total figures for the sub-region. Please note: Electricity is supplied locally at 400V (three-phase) which is then connected to a dwelling at 230V (single-phase), therefore for the purposes of these calculations all domestic properties are assumed to be connected at 400V. Large non-domestic loads are assumed to be connected to the electricity network at 11kV; other non-domestic are connected at 400V. Total electricity demand is therefore the sum of demand at the 11kV level and 400V level. Demand from power generators and utilities are not included in these figures.

Table 25: Annual energy consumption [MWh] across the Norfolk Coastal sub-region.

Energy Type	Domestic Annual Consumption [MWh]	Non-Domestic Annual Consumption [MWh]	Total Annual Consumption [MWh]
Electricity (11kV)	0	114,000	114,000
Electricity (400V)	345,000	1,120,000	1,465,000
Gas	345,000	1,470,000	1,815,000
Oil	158,000	0	158,000

Table 26: Annual peak demand [MW] across the Norfolk Coastal sub-region.

Energy Type	Domestic Peak Demand [MW]	Non-Domestic Peak Demand [MW]	Total Peak Demand [MW]
Electricity (11kV)	0	33	33
Electricity (400V)	112	360	420
Gas	375	570	900
Oil	176	0	176

The total peak demand is not the sum of the peak demands for domestic and non-domestic buildings since the peak demands of the different sectors occur at different times.

The following maps (Figure 80 to Figure 83) show the distribution of estimated peak and annual energy consumption for both domestic and non-domestic buildings across the Norfolk Coastal sub-region. Peak demands shown on these maps may not all occur at the same time of day or time of year. For example, an area predominantly made up of domestic dwellings is likely to have a peak energy demand during the early evening in winter. In contrast, an area that is mainly made up of commercial offices will have maximum energy demand around the middle of the day. Mixed-use areas could have a different peak time depending upon the nature of their buildings.

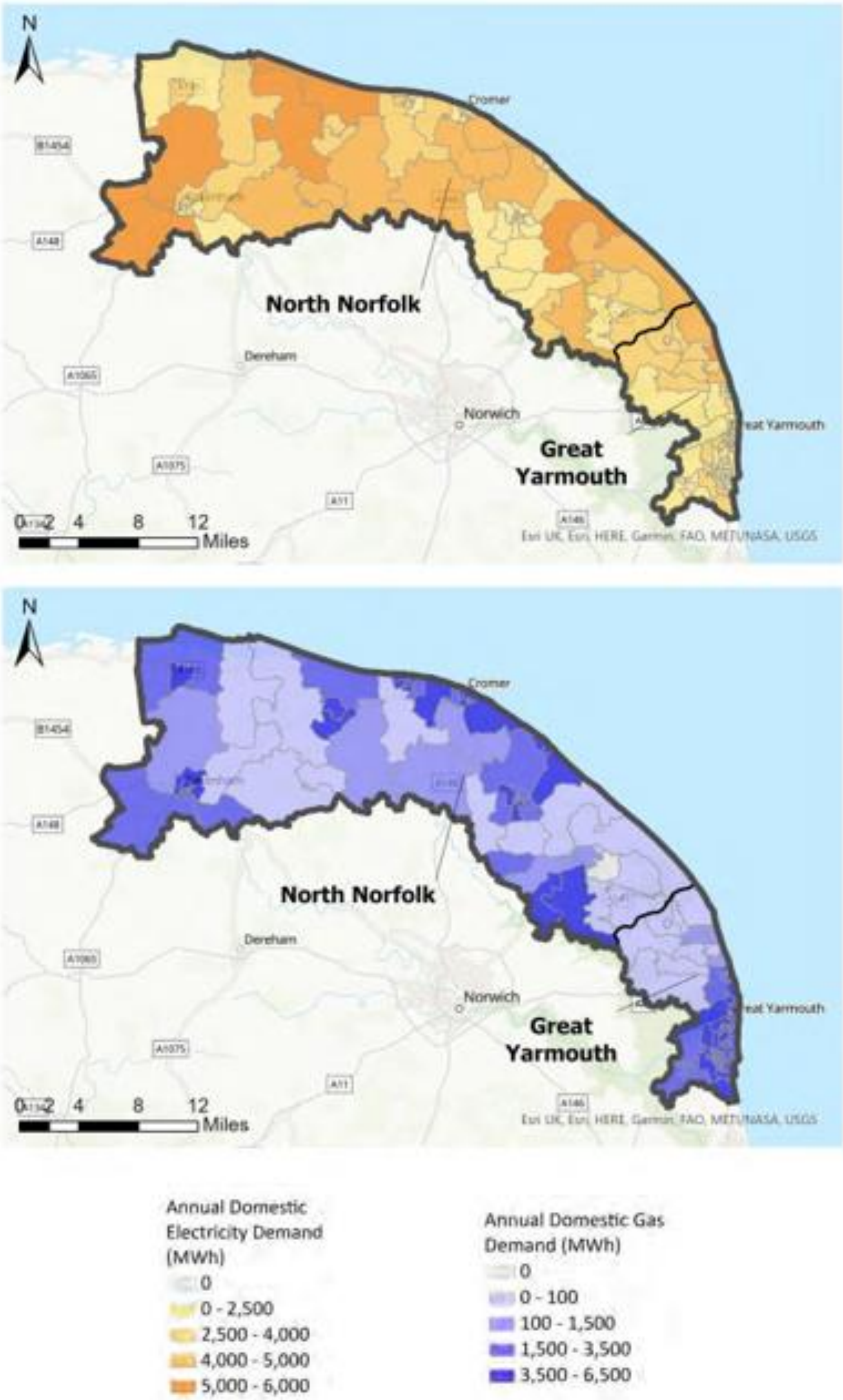


Figure 80: Estimated current domestic annual energy consumption by fuel and LSOA across the Norfolk Coastal sub-region.

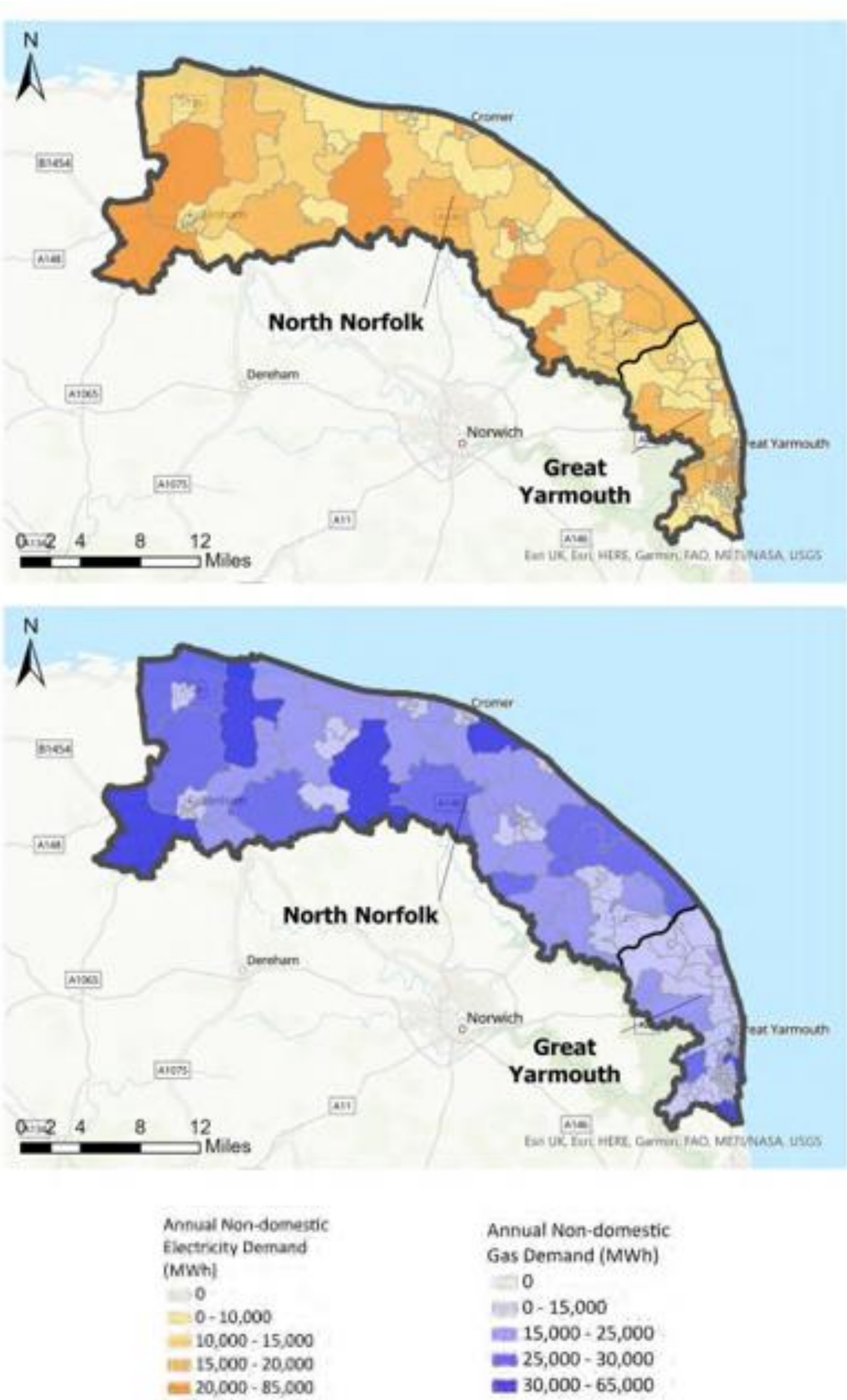


Figure 81: Estimated current non-domestic annual energy consumption by fuel and LSOA across the Norfolk Coastal sub-region.

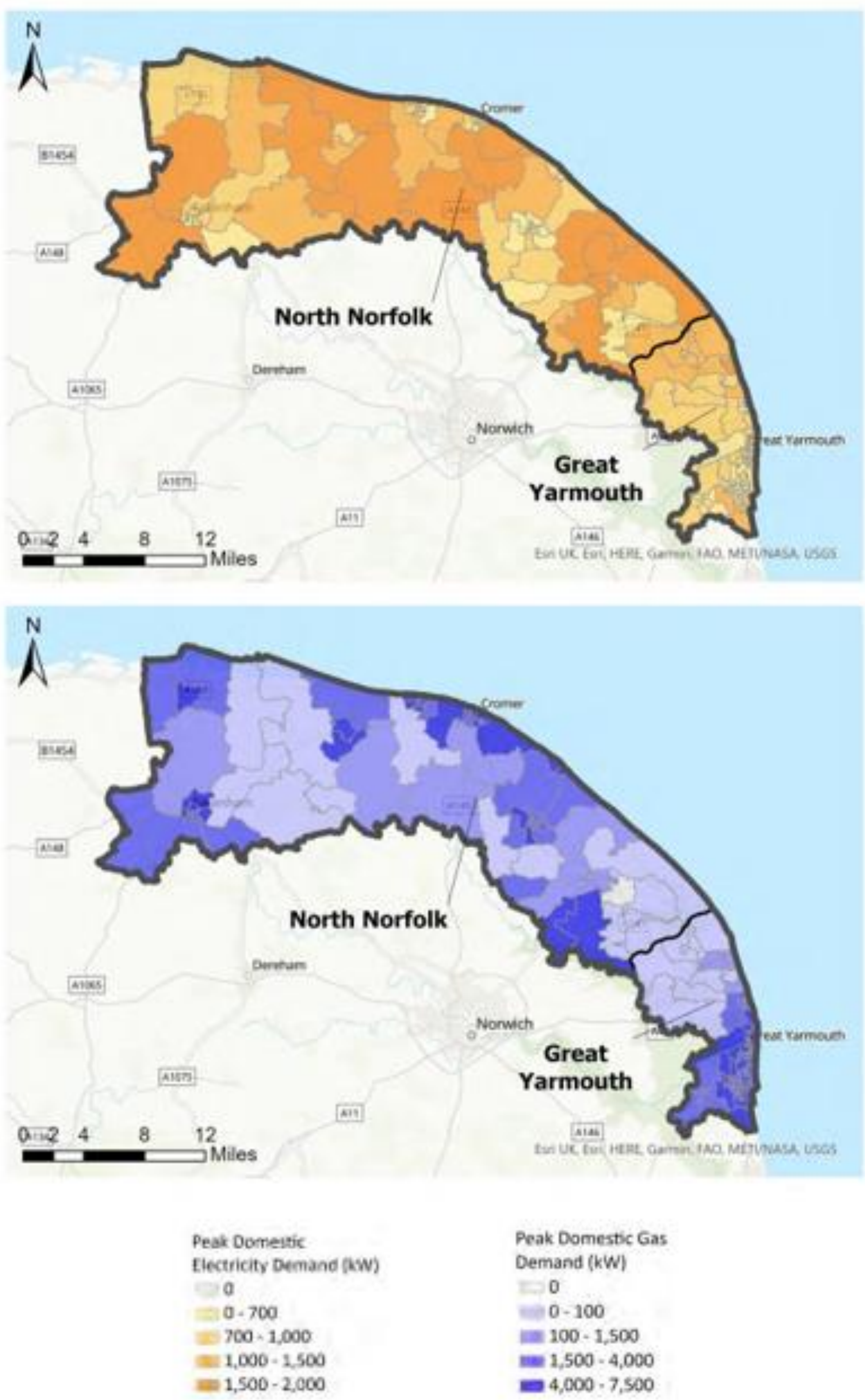


Figure 82: Estimated current domestic peak energy demand by fuel and LSOA across the Norfolk Coastal sub-region.

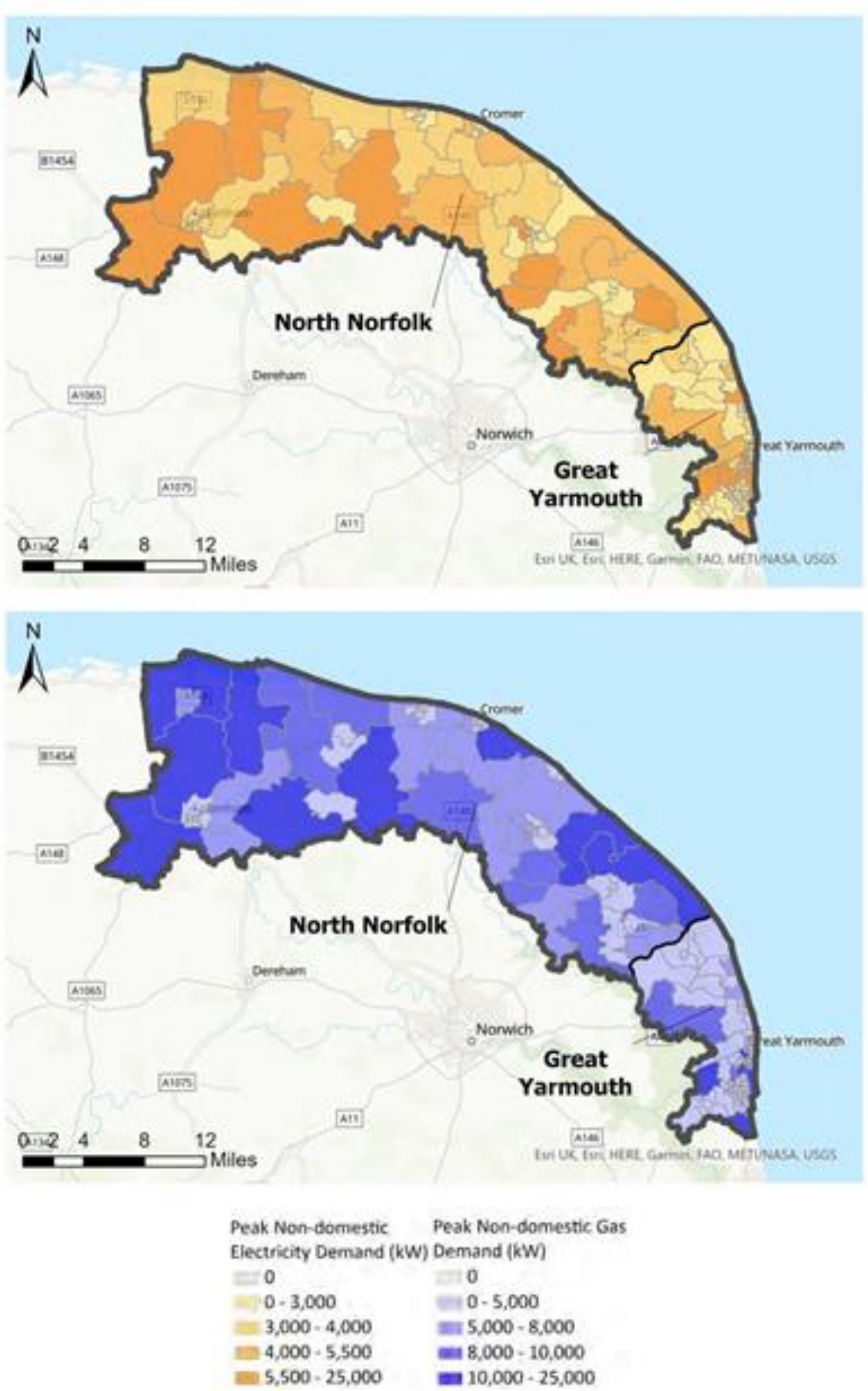


Figure 83: Estimated current non-domestic peak energy demand by fuel and LSOA across the Norfolk Coastal sub-region.

Figure 84 shows an estimate of the total electricity demand profile for the Norfolk Coastal sub-region for different days of the year representing the lowest typical demand and the highest. The peak day is also shown, which is used to determine a worst-case scenario on the network. Electricity demand includes heat, lighting, appliances, and electric vehicle charging when chargepoints are known to exist in the local area. The profile is for domestic and non-domestic buildings combined.

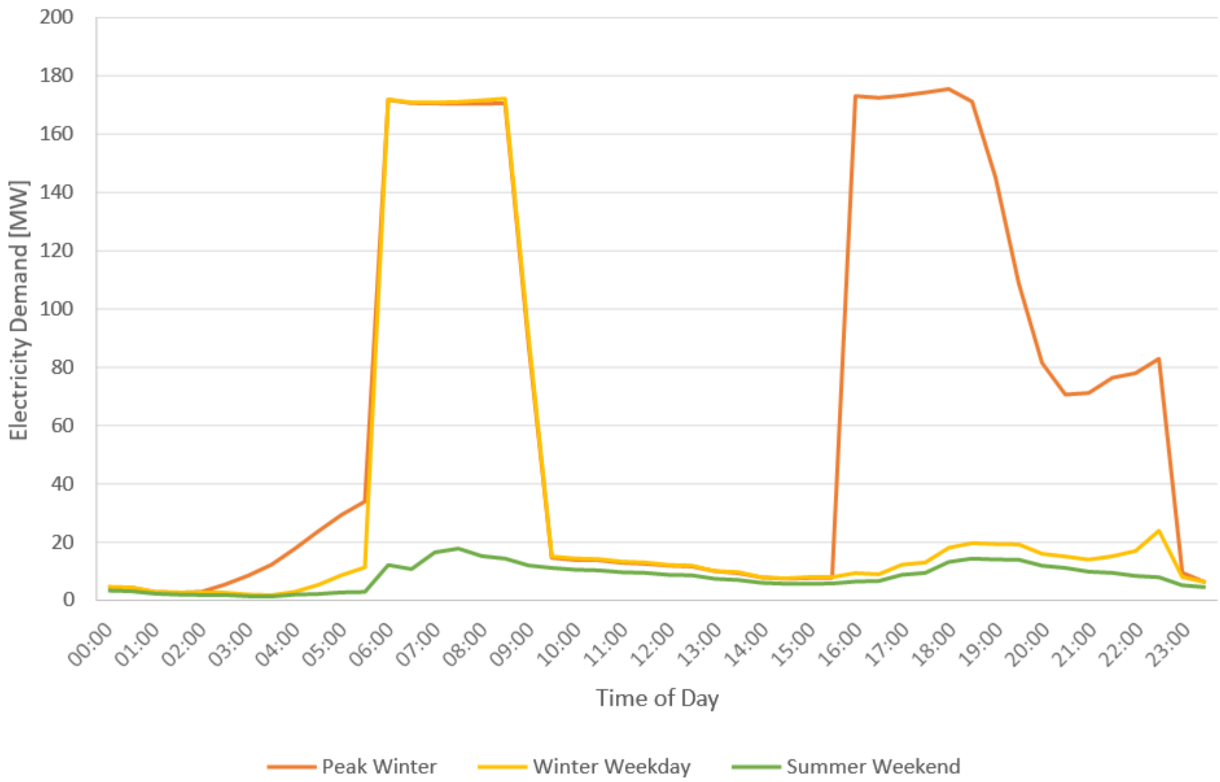


Figure 84: Estimated electricity demand profiles for different days of the year across the Norfolk Coastal sub-region.

As expected, the demand is far lower on a summer weekend when compared to a winter weekday.

Summer weekend represents the lowest end of demand profile; being summer means there is less need of heating, and weekend suggests that office/factory buildings are using less electricity, in contrast to a typical winter weekday.

The area between these two demand profiles demonstrates the typical demand i.e. the electricity demand will likely be within this middle section at any given time.

Figure 85 shows the estimated gas demand profile, and Figure 86 shows the estimated oil demand profile, for the Norfolk Coastal sub-region for the same days. Gas and oil demand include both heat and hot water and covers domestic and non-domestic buildings combined.

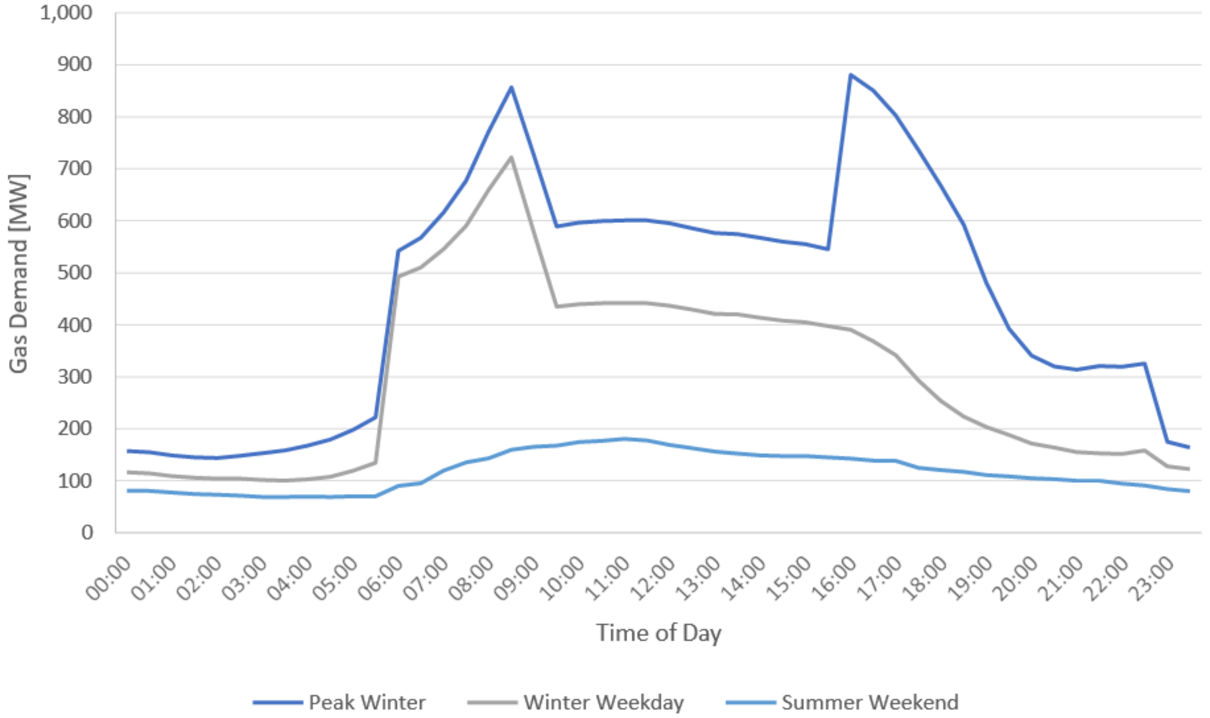


Figure 85: Estimated gas demand profiles for different days of the year across the Norfolk Coastal sub-region.

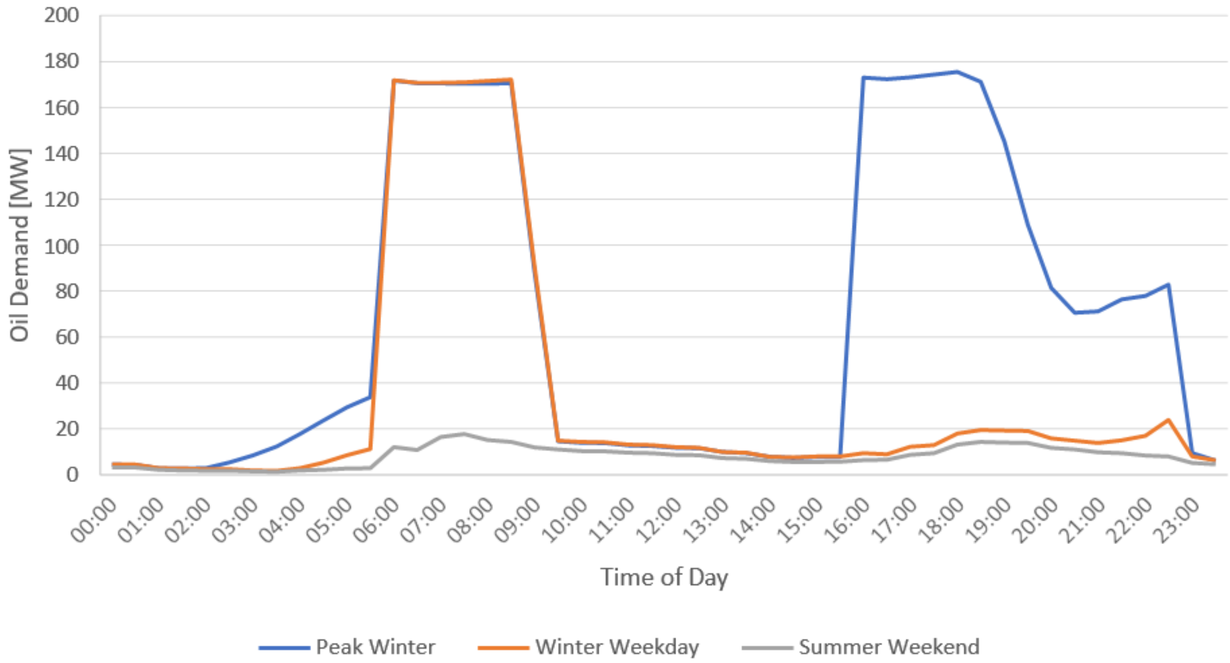


Figure 86: Estimated oil demand profiles for different days of the year across the Norfolk Coastal sub-region.

2.4.3 Energy Networks

A good understanding of the energy networks is vital to formulating a forward plan for the decarbonisation of any area. For example, identifying dwellings that are not on the gas network can help to focus a heat pump roll-out programme thus reducing the risk of competing heating vectors such as hydrogen or heat networks being a more financially viable option in the future. To identify those off-gas areas, Xoserve[29] postcode data was used (mapped in Figure 87) before being cross-referenced with Ordnance Survey records to calculate how many dwellings are estimated to be on- or off-gas Table 27).

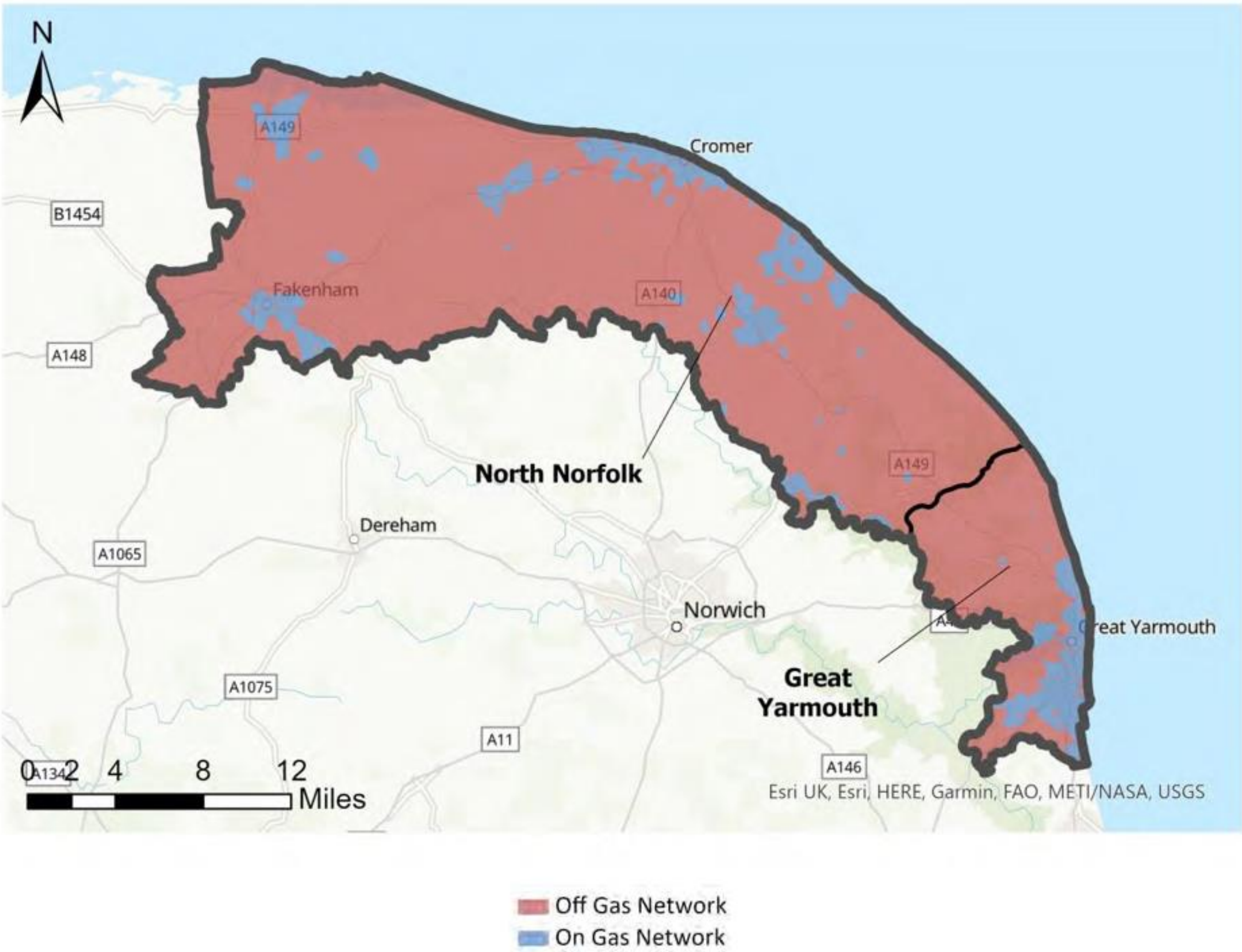


Figure 87: On-gas and off-gas areas of the Norfolk Coastal sub-region.

Table 27: Estimate of on-gas and off-gas dwellings across the Norfolk Coastal sub-region (rounded to nearest 5,000)

On or Off Gas Dwellings	**Number**
Off-Gas Dwellings	**40,000**
On-Gas Dwellings	**65,000**

Comparing Figure 87 and Table 27 leads to the conclusion that the off-gas grid areas are sparsely populated. This is confirmed by comparing to Figure 68 showing the location of the building stock.

[29] https://www.xoserve.com/wp-content/uploads/Off-Gas-Postcodes-V2.xlsx

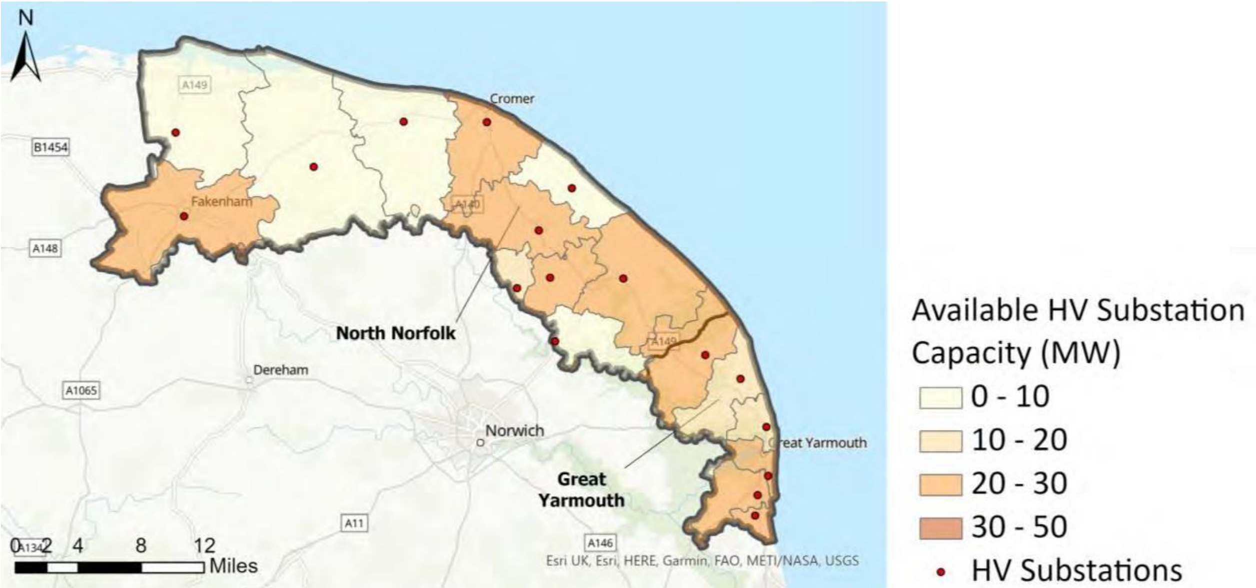


Figure 88: Available high-voltage network capacity across the Norfolk Coastal sub-region.

Figure 88 shows an estimate of the available capacity on each 33kV-to-11kV substation and the extent of the area served by each substation. Capacity is calculated by subtracting the combined peak electrical demand on buildings in each area from the rated capacity of each substation. Those substations shown outside of the Norfolk Coastal boundary may serve buildings within it. Substations outside of the boundary have been included since it is likely some may serve assets within the project boundary. This is seen by new polygons that begin next to the project boundary. It should be noted that available capacity of areas on the Norfolk boundary may be overestimated since the demands of buildings outside of the county have not been modelled.

Where network connection is important from a project planning perspective the actual areas served should be established in conversation with the local Distribution Network Operator, (DNO) UK Power Networks. These capacity estimates are intended to give an indication of the capacity available on different parts of the network within the local energy system representation area and are not a substitute for detailed network modelling and analysis conducted by the local DNO. Substations identified as generation only in the DNO data are assumed to have no available capacity. Substations are not included in the analysis where DNO data on locations and capacities are unavailable. Where capacity data is unavailable, but locations are available, the 11kV-to-400kV capacity was set to the most prevalent substation capacity across all of Norfolk. Where capacity data is only available in MVA, it is assumed that capacity in MVA is equal to capacity in MW, unless power factors are available.

Figure 89 shows an estimate of the number of buildings, both domestic and non-domestic connected to each 33kV-to-11kV substation. As with capacity, the extent has been calculated as the area closest to each substation.

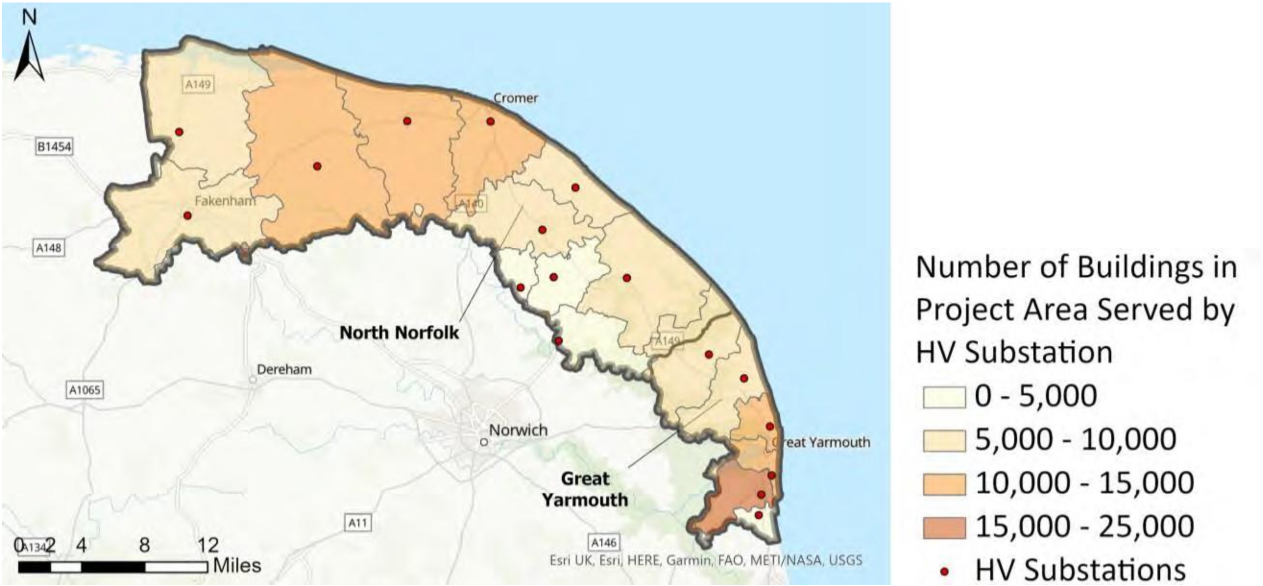


Figure 89: Number of buildings within the Norfolk Coastal sub-region served by each high-voltage substation.

2.4.4 Embedded Generation

The Renewable Energy Planning Database (REPD) was used to identify large scale embedded generation across the Norfolk Coastal sub-region. These sites, and the associated technologies, are shown in Figure 90. Data on domestic feed-in tariffs from BEIS are used to identify the amount of domestic solar photovoltaic (PV). The total installed capacity for each technology along with an estimate of the annual electricity generated in the local area is given in Table 28. Table 28 shows the proportion of annual electricity demand in the project area estimated to be met currently using local embedded generation. Additional embedded generation technologies may be present in the area but not reported here if they are not recorded in the REPD or if they are below 100 kW.

Table 28: Estimated renewable energy capacity and estimated generation as a proportion of electricity demand in the Norfolk Coastal sub-region.

Renewable Tech	Installed Capacity [MW]	Annual Generation [GWh]	Proportion of Annual Demand
Domestic PV	16.8	34	2.2%
Solar Photovoltaics	176.2	160	10.1%
Wind Onshore	2.5	5.75	0.4%
Anaerobic Digestion	2	10.4	0.7%

Figure 90: Existing embedded generation in the Norfolk Coastal sub-region according to REPD database (October 2020).

As can be seen from Table 28, domestic solar PV is a significant contributor towards meeting the annual demand. Although not all installations of solar PV are registered for the feed-in tariff (FIT), and not all FITs were given to solar PV, the majority will be and therefore Ofgem's Feed-in Tariff Installation Report[30] is a

[30] https://www.ofgem.gov.uk/environmental-programmes/fit/contacts-guidance-and-resources/public-reports-and-data-fit/installation-reports

useful way of identifying the overall capacity and number of registrations in each LSOA. Figure 91 and Figure 92 show the installed capacity of renewables and number of registrations respectively.

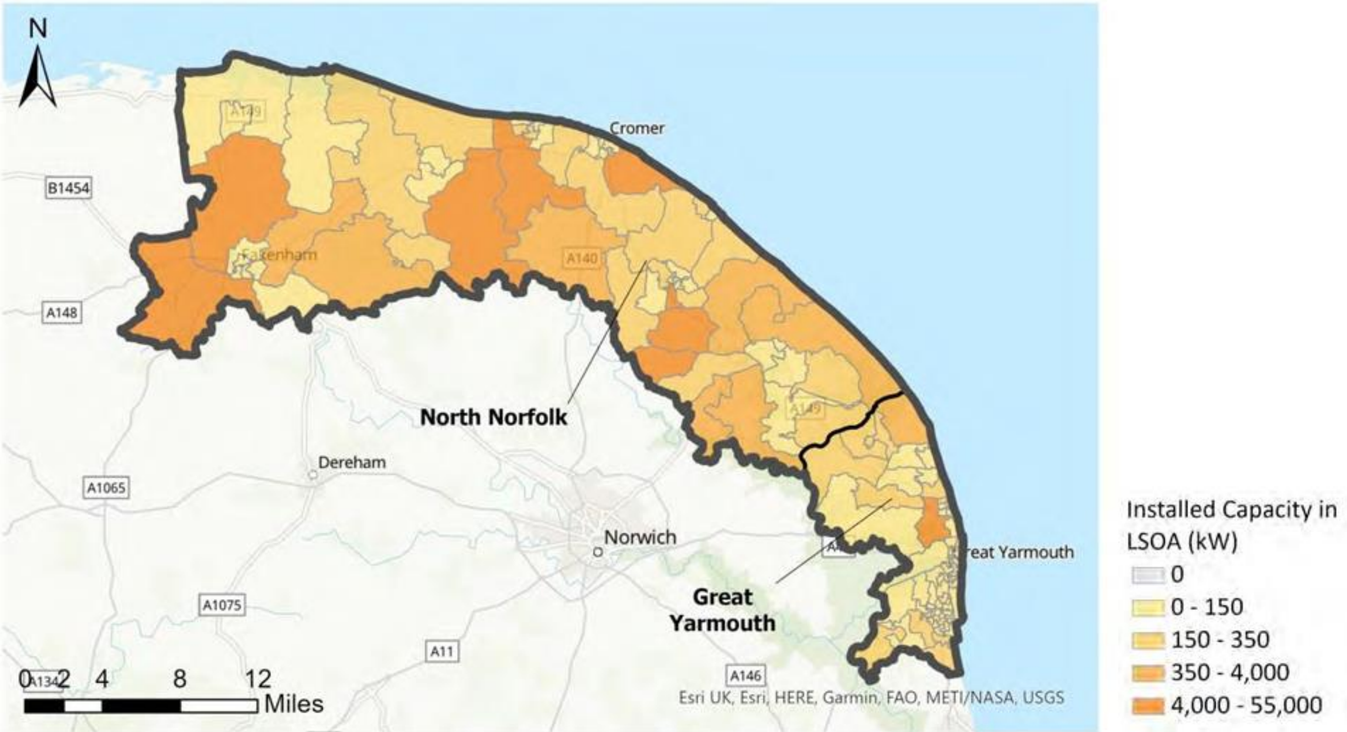


Figure 91: Aggregated capacity of renewable installations registered for FIT within each LSOA of the Norfolk Coastal sub-region.

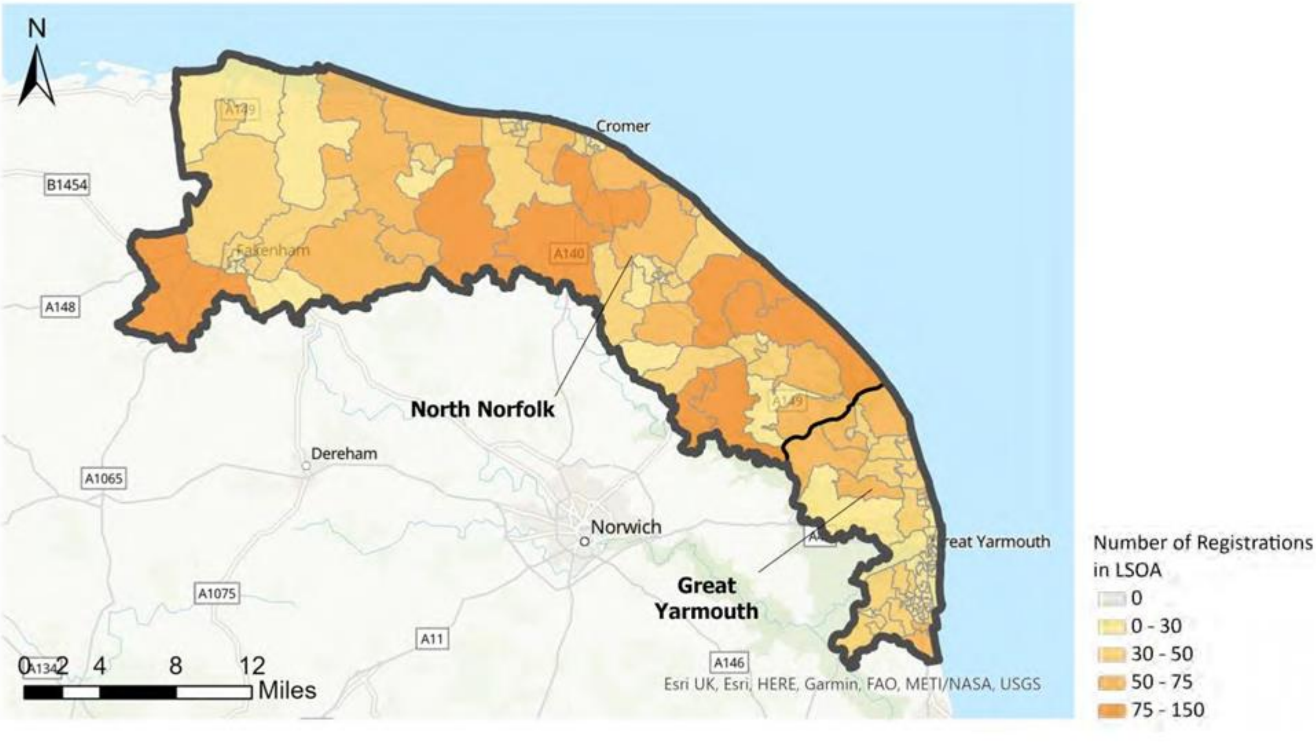


Figure 92: Number of renewable installations registered for FIT within each LSOA of the Norfolk Coastal sub-region.

To assess the potential for domestic on-roof solar PV within the Norfolk Coastal sub-region, the footprint and orientation of all dwellings have been analysed to calculate the potential generating capacity. These results are then aggregated to 200m radius areas to identify places best suited for mass deployment. The dwellings identified as suitable for rooftop solar PV in each of the three best areas are shown in Figure 93 to Figure 95.

As a purely spatial exercise this analysis does not consider local planning constraints and should not be used as a replacement for a detailed feasibility study or installation design.

Figure 93: Dwellings identified as suitable for rooftop PV panels. (Location: Bradwell, Great Yarmouth)

Figure 94: Dwellings identified as suitable for rooftop PV panels. (Location: Caister-on-Sea, Great Yarmouth)

Figure 95: Dwellings identified as suitable for rooftop PV panels. (Location: Patch Meadow, North Walsham)

In total these three areas alone have a total potential solar PV capacity of 2.96MW.

2.4.5 Domestic & Public EV Charging

Data from the Zap-Map®[31] has been used to identify the locations and power outputs of public Electric Vehicle (EV) chargepoints across the Norfolk Coastal sub-region. The locations and the speed of the chargepoints are shown in Figure 96. In total there are 90 public chargepoints with a combined capacity of 1,436kW.

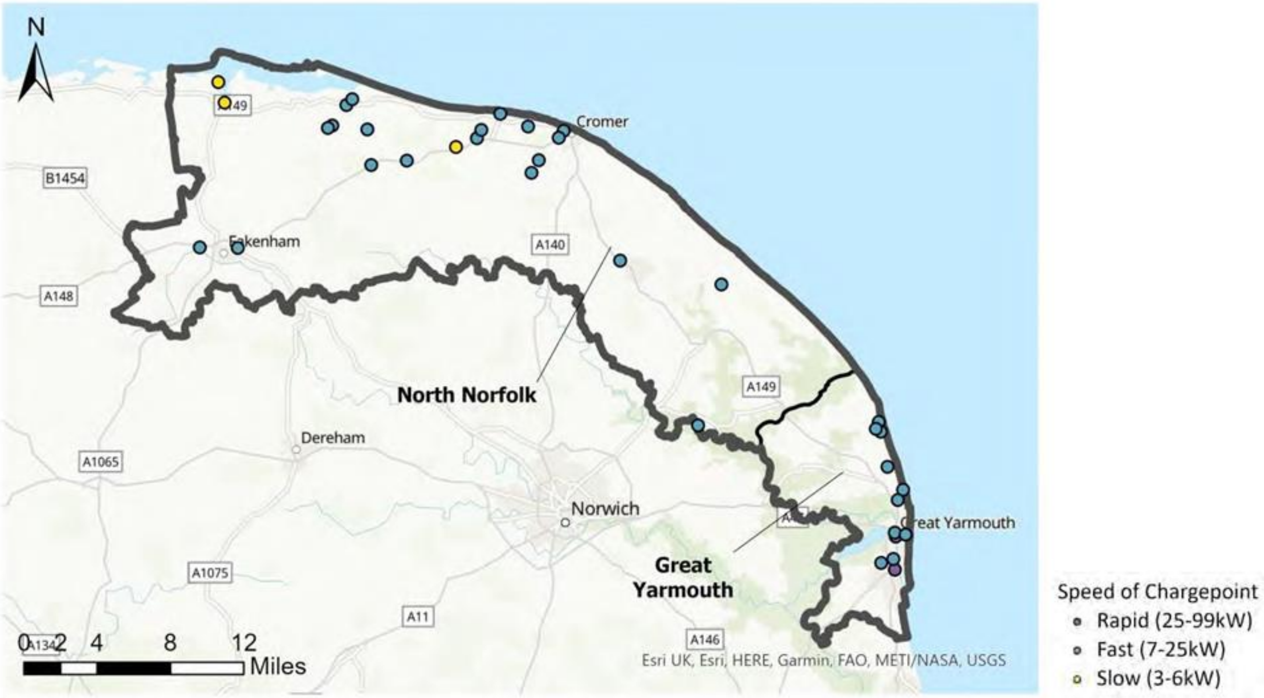


Figure 96: Location of public chargepoints according to Zap-Map® (December 2020)

Chargepoint data provided by Zap-Map®

The Driver and Vehicle Licensing Authority (DVLA) publishes data on the numbers and types of different vehicles registered within different Local Authority Areas. This gives an indication of the number of EVs that might be registered within the sub-region as shown in Table 29.

It should be noted that leased vehicles will be registered to the leasing company which may not be based within the project area.

Using National Travel Survey data representative charge profiles have been generated for both public and domestic charge points. The estimated peak demands for domestic chargepoints are shown in Table 29.

Table 29: Summary of plug-in vehicles[32] registered in the Norfolk Coastal sub-region according to data from DfT

Number of Plug-in Vehicles	Percentage of Total Vehicles	Estimated Peak Demand [kW]
483	0.43%	634

[31] https://www.zap-map.com/
[32] Plug-in vehicles are all models identified as being fully electric or plug-in hybrid.

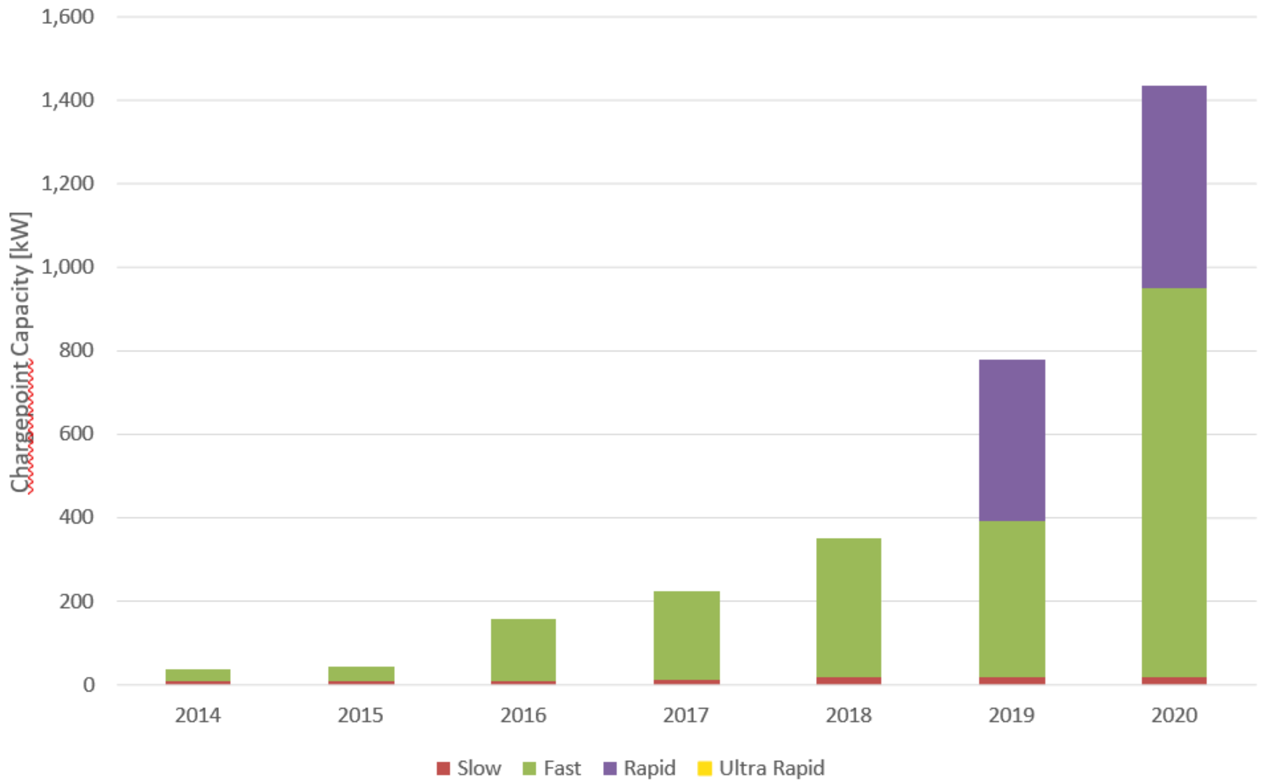


Figure 97: Chargepoint connector total capacity (kW) within the Norfolk Coastal sub-region over time.

Using the date that each chargepoint was added to the Zap-Map database the uptake of chargepoints in the area can be analysed. Figure 97 shows this uptake in total kW rating of connectors within the Norfolk Coastal sub-region by charger type.

The locations of the latest public chargepoints to be installed within the Great Yarmouth District Council are:

- Fullers Hill car park
- St. Nicholas Park long stay car park
- The Market Place
- Greyfriars
- Beach Coach Station

The above locations were chosen due to their high population (including both visitors and residents). Fullers Hill is a rapid chargepoint whilst the rest have a fast, 22kW rating.

Ordnance Survey Mastermap Topography and Land Registry INSPIRE polygons have been used to identify houses which have space for off-street parking. This is done 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. This 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. Figure 98 shows the results of this analysis aggregated by road.

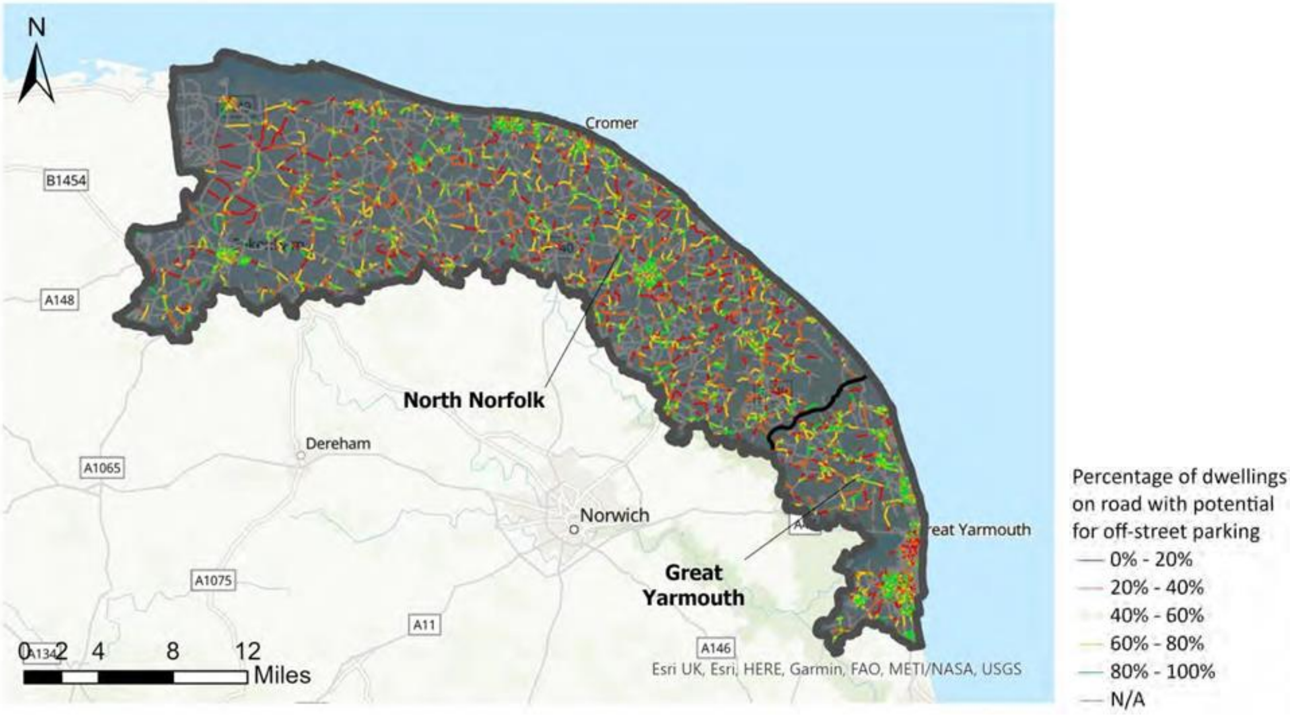


Figure 98: Percentage of dwellings with off-street parking on each road within the Norfolk Coastal sub-region.

As a purely spatial exercise this analysis does not consider local planning constraints and should not be used as a replacement for a detailed feasibility study.

2.4.6 Social Data

National data have been used to provide an indication of fuel poverty (Figure 99) and multiple deprivation (Figure 100) across the Norfolk Coastal sub-region.

Figure 99: Estimated levels of fuel poverty according to 2020 BEIS data

Using the ranked Index of Multiple Deprivation[33] data published by The Department for Communities and Local Government (DCLG) at LSOA level it is possible to compare localised levels of deprivation within the Norfolk Coastal sub-region against the rest of England. For mapping purposes these are shown by octile, with values falling in octile 1 being within the most deprived 1/8th of the country and values falling in octile 8 being within the least deprived 1/8th of the country.

33 https://www.gov.uk/government/statistics/english-indices-of-deprivation-2015
For descriptions of the underlying indicators used in the indices of deprivation please refer to this document: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/467775/File_8_ID_2015_Underlying_indicator_s.xlsx

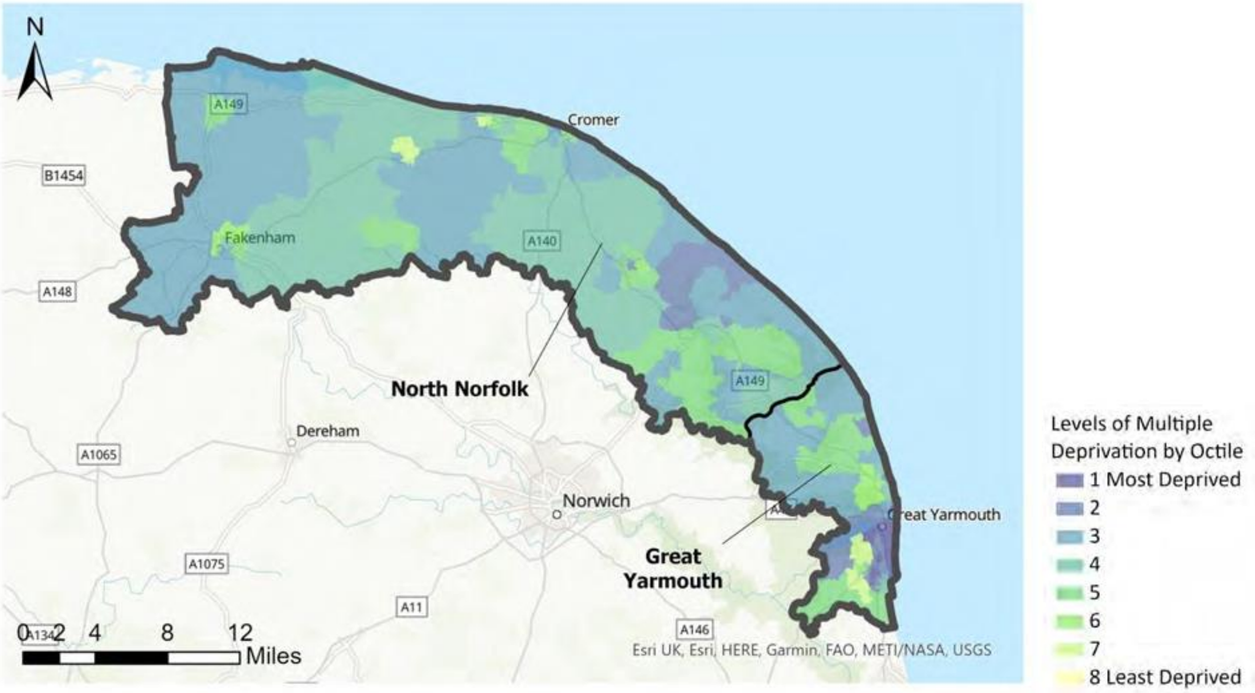


Figure 100: Ranking of English indices of deprivation 2020

The multiple indices that make up the IMD can be found in the accompanying data/maps to this report.

3. Local Insights

3.1 A11 Tech Corridor

Figure 101 shows the A11 Tech Corridor across Norfolk. The vision for the Tech Corridor is[34]:

> *"To be internationally recognised as a top-tier destination for technology firms looking to establish, grow and cluster, for highly skilled workers looking for a rewarding career with a strong purpose and a rich quality of life, and for businesses and investors seeking the next high-value, sustainable opportunity".*

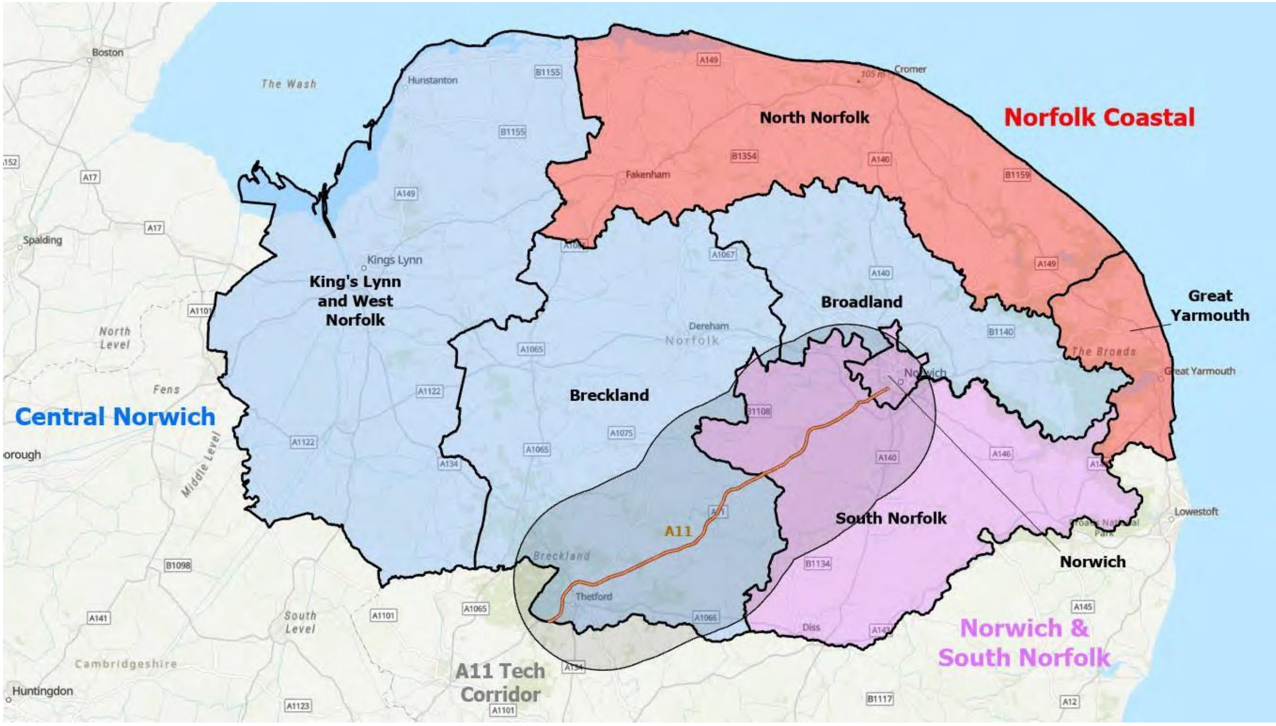


Figure 101: Project area showing Norfolk County and the A11 Tech Corridor with a 10km buffer boundary

Across Norfolk, the A11 Tech Corridor ranges from Thetford to the City of Norwich with a 10km buffer. This 10km boundary crosses the Breckland, South Norfolk, and the City of Norwich. Development sites have been provided as part of this research to show the areas with allocated sites and their proposed land use (Figure 102).

[34] https://www.techcorridor.co.uk/articles/tech-corridor-programmes/

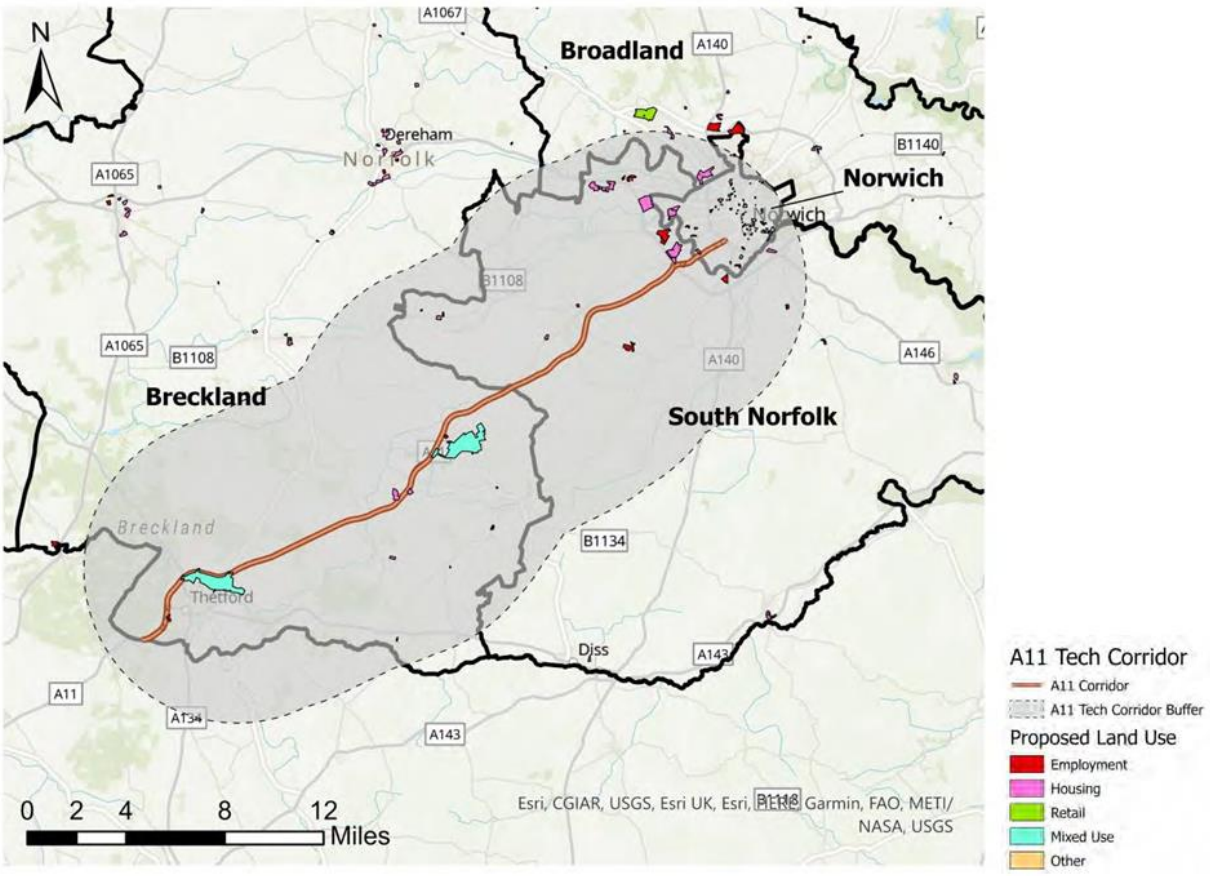


Figure 102: Development sites within 10km of the A11

As shown in the map, there are a high number of development sites where proposed land use is allocated to housing and residential dwellings. Thetford and Attleborough both have large mixed-use development sites which fall under pre-submission allocation within the Breckland District. Mixed-use sites are typically a combination of housing and employment sites. Retail development sites are not prevalent throughout the A11 Tech Corridor area.

3.2 Solar PV

Figure 103 shows the an area of New Costessey in the City of Norwich which has been identified as a good target area for the roll out of solar PV. Many of the dwellings in this area are detached and oriented towards the south-east or south-west making them good candidates for large domestic solar PV systems. The red boxes shown in Figure 103 highlight some of these dwellings and Figure 104 shows a snapshot of the same area from Google Maps where previously installed solar PV can be seen. Whilst this supports the model there is still a need for site surveys to be carried out by trained installers. An example of this is that one of the dwellings highlighted as suitable has a hipped roof and although this does not preclude the dwelling from installing solar PV, the shape of the roof means that it is likely that a lower capacity of PV system would need to be installed and potentially having this spread across multiple roofs increasing the capital cost and reducing the yield/£ invested.

Figure 103: Dwellings identified as suitable for rooftop PV panels. (Location: New Costessey, Norwich)

Figure 104: Google Street view of current dwellings located in New Costessey, Norwich.

4. Data Metrics

Using comparisons between different data sets and considering the completeness of individual data sets it is possible to get an indication of the quality, accuracy and completeness of this local energy system representation. The following table shows a selection of data metrics which provide these indications for different aspects of this representation.

Based on a number of local area energy system representations, a RAG rating has been developed for comparison of each data metric against other project areas and the national average. This provides specific indicators for which categories of national data may require additional local knowledge under a full detailed Local Area Energy Plan.

Data metrics are an average across the three sub-regions to give an overall metric for Norfolk.

4.1 Map Data Quality and Accuracy

Data Metric	Description	Value
Basic Land and Property Unit (BLPU) completeness (%)	Percentage of buildings that have a BLPU status code. This code shows the current status of a building including whether it is live or inactive. Subsequently this infers whether it would have an energy demand. For example, a value of 40% signifies that for this many properties in the area it is known whether they are live or no longer active. This will not be known for the remaining 60%, and therefore energy demands, and energy networks may lose accuracy.	90.75%
Classification code completeness (%)	Percentage of buildings with a classification code that indicates their use. If a high number of buildings are unclassified this indicates poor quality, or badly maintained map data. Since the local area representation is built on the map poor quality raises concerns around the quality of that representation. In addition, low levels of completeness mean that building use is likely to be mis-classified leading to poor representation of buildings, energy demands and energy networks.	100%
Active buildings (%)	Percentage of records with a BLPU code that is not inactive or unoccupied buildings. If high numbers of buildings are classified as active this increases confidence on estimates of local energy demand.	84.46%
Commercial classification code (%)	Percentage of buildings with a commercial classification code. Due to large variability in non-domestic building construction methods and uses estimating energy demand for these buildings is inherently more uncertain than for domestic buildings. If most buildings in the project area have a domestic classification, then energy demand estimates are expected to be better than if most buildings are non- domestic.	10.05%
Land classification code (%)	Percentage of buildings with a "land" classification code. In theory this should be zero. If a high number of buildings are classified as land this indicates poor quality, or badly maintained data. Since the local area representation is built on the map poor quality data raises concerns around the quality of that representation.	4.99%
"Other" classification code (%)	Percentage of buildings with a classification code of “other”. If a high number of buildings are classified as other this indicates poor quality, or badly maintained data. Since the local area representation is built on the map poor quality data raises concerns around the quality of that representation.	0.84%
Parent shell classification code (%)	Percentage of buildings with a “parent shell” classification code. In these cases, cross references are not available within the OS data meaning that it is not possible to associate the map data with other data sources such as the Valuation Office Agency. This means that there is less confidence in the quality of data associated with these buildings resulting in less confidence that local building stock is correctly represented and that estimates of energy use and network capacity are accurate.	6.66%
Residential classification code (%)	Percentage of buildings with a residential classification code. Due to large variability in non-domestic building construction methods and uses estimating energy demand for these buildings is inherently more uncertain than for domestic buildings. If most buildings in the project area have a domestic classification, then energy demand estimates are expected to be better than if most buildings are non-domestic.	76.43%

Unclassified code (%)	Percentage of buildings with a classification code of "Unclassified". If many buildings are unclassified this indicates poor quality, or badly maintained data. Since the local area representation is built on the map poor quality data raises concerns around the quality of that representation. In addition, if use cannot be identified with certainty this will lead to poor understanding of the local building stock and poor-quality energy demand estimates.	0.24%
Dual use classification code (%)	Percentage of buildings with a dual use classification code. It is more difficult to correctly estimate the energy use of dual use buildings as the floor area used for different purposes may not be known. If many buildings are dual use, then understanding of local building stock will be less good and energy demand estimates will be of lower quality.	0.47%
Non-domestic addresses with Valuation Office Agency mappings (%)	Percentage of buildings with a commercial classification code that can be linked with Valuation Office Agency data. The Valuation Office Agency data provides information on buildings that pay business rates. It categorises how a building is used and the floor area within a building that is used for different purposes. When most non-domestic buildings can be mapped to an entry in the Valuation Office Agency data this allows a better understanding of the local stock and better-quality estimates of energy use.	57.45%
Building points correctly assigned to building Toids (%)	Percentage of Building Points[35] correctly assigned Building Toids. Where building points exist but are not contained within Building Toids[36] this can indicate poor quality, or badly maintained map data. Since the local area representation is built on the map data poor quality data raises concerns around the quality of that representation. Furthermore, it is likely that buildings will be mis-classified or omitted from the analysis in these cases resulting in reduced understanding of the local building stock and associated energy demand and network capacity analyses. In addition, if a Building Point is assigned to a non-building Toid then the information associated with that Building Point cannot be used as the size of the building is not known. This means that understanding of local building stock and energy demand estimates will be of lower quality.	83.37%
Buildings with height data (%)	Percentage of buildings with height data. Height data is used to understand the number of storeys in a building and so the total building floor area. If height data is missing from a building, then the number of storeys will be estimated using LIDAR data and the quality of the energy use may be less accurate.	80.53%

[35] Within the OS data all buildings that have an address should be represented by a building point as well as some geometry that shows the building's footprint (the associated Building Toid).

[36] Within the OS data all buildings should be represented by some geometry that shows their footprint. This is the Building Toid.

4.2 Building Data Completeness and Quality

Data Metric	Description	Value
Proportion of domestic buildings with Energy Performance Certificate (%)	Energy Performance Certificates provide information on a variety of factors that are important when estimating the energy consumption of a house such as whether there is wall insulation. If Energy Performance Certificates are available for a large proportion of domestic buildings, then this provides a better understanding of local building stock and improves energy demand estimates.	52.07%
Proportion of domestic buildings where building type from analysis of map data matches building type from Energy Performance Certificates (%)	Domestic building type can be identified by analysing the map geometry for each Building Toid. Where this matches the building type given by the Energy Performance Certificate there is high confidence that the building has been correctly categorised. This indicates that there is a good understanding of local building stock and that energy use estimates will be of better quality.	84.58%
Percentage difference between domestic building ages and London Datastore data	London Datastore data provides information on housing age aggregated to Lower Super Output Area level. If the percentage difference between the proportions of different domestic building ages and the London Datastore data is low, then this gives high confidence in the building age predictions used in the project and that energy use estimates will be of better quality.	17.70%
Percentage difference between local building types and Office of National Statistics census data	National census data provides information on housing type aggregated to Lower Super Output Area level. If the percentage difference between the proportions of different house types in the project area and the ONS data is low, then this gives high confidence that there is a good understanding of local building stock and that energy use estimates will be of better quality.	13.17%
Comparison of Non-domestic use category between Valuation Office Agency and Ordnance Survey	The use category of non-domestic buildings is provided in the Ordnance Survey data with a commercial classification code and in the Valuation Office Agency data. Where these use categories agree this gives confidence that the use of the building has been correctly identified and reduces uncertainty associated with estimates of energy use.	97.09%

4.3 Other Data Comparisons

Data Metric	Description	Value
Social Data Scaling (%)	Social data is provided by the Office for National Statistics at Lower Super Output Area Level[37]. In cases where the project boundary cuts across a Lower Super Output Area the social data is calculated by proportioning the data based on the number of buildings contained in both the project area and the Lower Super Output Area compared to those in the whole Lower Super Output Area. For projects where this apportionment has been performed for a large number of Lower Super Output Areas it is likely that social metrics produced will be less accurate than in cases where little or no data points have been apportioned. This metric shows the percentage of buildings within the project area that belong to a proportioned LSOA.	0.21%
Annual gas demand comparison to BEIS data (%, LEAR/BEIS)	Total annual gas demand is published by BEIS at Medium Super Output Area level. This can be used to give an estimate of demand within the project area. Where this value compares closely with the demand estimate calculated for this work then there is good confidence in the value. Where there is a significant difference then confidence in the demand estimate is reduced. A number less than 100% means the demand modelled in LEAR is lower than BEIS reported demand. A number greater than 100% means the demand modelled in LEAR is higher than BEIS reported demand. It should be noted that the way buildings are categorised in the BEIS data, and the associated modelling used to calculate aggregate demand is different to the approach adopted here and is also likely to contain sources of error. This comparison gives an indication of confidence but should not be used to assess whether either number is a better estimate.	167%
Annual electricity demand comparison to BEIS data (%, LEAR/BEIS)	Total annual electricity demand is published by BEIS at Medium Super Output Area level. This can be used to give an estimate of demand within the project area. Where this value compares closely with the demand estimate calculated for this work then there is good confidence in the value. Where there is a significant difference then confidence in the demand estimate is reduced. A number less than 100% means the demand modelled in LEAR is lower than BEIS reported demand. A number greater than 100% means the demand modelled in LEAR is higher than BEIS reported demand. It should be noted that the way buildings are categorised in the BEIS data, and the associated modelling used to calculate aggregate demand is different to the approach adopted here and is also likely to contain sources of error. This comparison gives an indication of confidence but should not be used to assess whether either number is a better estimate.	199%

[37] Lower Super Output Areas are used by the Office for National Statistics to report national census data. Each Lower Super Output Area has a population of less than 3,000 people or 1,200 households.

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

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