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Decarbonising Wirral Buildings

Final Report

21 December 2020

WIRRAL

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1. Executive Summary

Wirral Council has a longstanding commitment to action on climate change. It has supported partnership efforts to develop a new climate change strategy and adopt emission reduction targets that are consistent with the latest scientific evidence underpinning the Paris Agreement. To meet these ambitious targets, Wirral needs to achieve significant reductions in its residential housing stock.

In August 2020, Wirral commissioned the Energy Saving Trust (EST) to support this work by providing housing stock data, scenario modelling and analysis services. Using EST's address-level housing stock database (Home Analytics) and SAP-based calculation software (PEAT), the following tasks were undertaken:

- Benchmarking key attributes and energy efficiency characteristics of the Wirral housing stock against regional and national averages
- Assessing the potential costs and savings of different retrofit pathways
- Producing eligibility maps to support Green Homes Grant fund targeting
- Identifying opportunities and challenges for home improvements in Wirral
- Providing tailored recommendations to help inform Wirral's climate change strategy and future decarbonisation efforts

This report summarises the findings of this work. Section 2 begins with an overview of Home Analytics, specifically the third-party datasets underpinning the data, as well as the models and validation techniques used to develop the database. Section 3 details the methodology of the scenario analysis, including a discussion of the key assumptions and parameters used in the PEAT modelling. Section 4 provides a series of maps and charts comparing the conditions of Wirral's housing stock to trends in the Northwest and England.

In Section 5, EST outlines the three scenarios considered in the analysis. These scenarios were designed in consultation with Wirral and included the following assumptions:

1. **Regulatory Standards** – assumed that all homes were improved up to a minimum standard of SAP band C (where possible).
2. **High Ambition** – assumed all homes achieved their maximum efficiency. There were no limits on SAP score, but only measures deemed to be cost-effective were considered.
3. **Fuel Switching** – this scenario was split into two variants. The realistic variant assumed that heat pumps were installed in all off-gas properties and on-gas properties that currently had a SAP band of C or higher. The upper bound variant assumed heat pumps were installed in all suitable properties.

For each scenario, EST summarises the outputs of the modelling at the Council-level. These outputs include recommended measures, investment costs, estimated SAP improvement, as well as energy, fuel bill and carbon savings associated with each scenario.

Section 6 provides a series of maps that identify areas which are likely to be eligible for the Green Homes Grant fund. This includes additional segmentation for the able-to-pay and low-income segments of the stock. Finally, Section 7 concludes with a list of the key opportunities and challenges facing Wirral and a series of evidence-based recommendations.

The main takeaways from this report are that the Council should:

- Prepare for the inevitable electrification of heat demand by adopting a fabric-first approach that prioritises wall, floor, and loft insulation in the least efficient homes in Wirral.
- Focus efforts on owner occupied homes, which account for nearly three quarters of the stock, have the lowest level of efficiency and greatest retrofit potential.
- Encourage off-grid homes to leapfrog gas by installing heat pumps. In these homes, heat pumps are already a cost-effective alternative.
- Work with the supply chain to develop the local capacity required to support mass adoption of heat pumps in the future.
- Capitalise on the extension to the Green Homes Grant scheme by working with installers and local delivery partners to target areas which have the most eligible primary measures.
- Avoid blocks of flats due to the significant logistical challenges they pose to retrofit work. A tailored plan to tackle these issues will need to be developed in the future.
- Be aware that current trends in fuel prices, heat pump efficiencies, costs, and carbon factors will make switching from gas to electricity increasingly attractive in the future.
- Be proactive. There is no time to wait for new technologies or fuels like hydrogen to scale up when heat pumps, district heating, and solar heating already exist.

2. Data Sources

This section provides an overview of EST's Home Analytics database. It describes the third-party datasets used to create the database as well as the modelling techniques EST uses to process the data, fill in gaps in the known record and validate the models.

2.1. Home Analytics

Home Analytics is an address-level database composed of known and modelled data for all homes in Great Britain. It includes over 85 fields related to building fabric, energy efficiency, renewable energy suitability and deprivation. Refined over more than seven years of development and testing, Home Analytics has been used by over 50 local authorities and housing associations across Great Britain to support area-based retrofit schemes, decarbonisation planning and fuel poverty strategies.

2.2. Third Party Datasets

The data in Home Analytics is sourced from a variety of datasets, many of which, are accessible via an Open Government License. Table 1 provides a comprehensive list of these data sources along with a brief description and examples. While many of the data sources above provide information for one or two specific variables within the database, there are five core datasets that deliver the bulk of the information and warrant further description.

Ordnance Survey (OS) AddressBase Plus is an address-level dataset which acts as the spine of the Home Analytics database. AddressBase Plus contains address details for all dwellings in Great Britain, organised by Unique Property Reference Number (UPRN). EST uses OS MasterMap Topography Layer to source secondary fields of interest such as property height and building footprint. These datasets are updated annually and available royalty-free to organisations such as Wirral, which are members of the Public Sector Geospatial Agreement (PSGA).

The EPC Register in England and Wales holds over 19 million unique property assessment records collected between 2008 and 2020. Each record contains detailed information on a property's attributes, energy efficiency characteristics and renewable energy systems, as reported by a trained energy assessor. For many fields in Home Analytics, EPCs are the only credible source of information, which makes this the primary source of Home Analytics data.

The Home Energy Efficiency Database (HEED) and Home Energy Check (HEC) database are both administered by EST. HEED is a repository of historical energy efficiency installation records, installed under government schemes between 1992 and 2012. It contains tens of millions of records with information about property attributes and building fabric. The HEC database is updated twice a year and consists of hundreds of thousands of self-reported property details from home energy advisors and users of EST's HEC tool.

Table 1 – Home Analytics data sources

Source	Date	Description	Examples
Ordnance Survey AddressBase Plus	2020	Database containing address information for all domestic buildings in Great Britain.	• UPRN • Geographic identifiers • Address
Ordnance Survey Master Map	2018	Shapefiles containing address points and building polygons, which provide the basis for our spatial models.	• Property type • Building footprint (m2) • Roof orientation
Energy Performance Certificate	2020	Energy performance certificates lodged between 2008 and 2020.	• SAP score • RdSAP energy demand, fuel bill and CO2 emissions
Home Energy Efficiency Database	2012	Historical records of energy efficiency installations that have been installed under government schemes between 1992 and 2012.	• Property age and tenure • Wall construction and insulation • Loft insulation
EST Home Energy Check	2020	Self-reported records from the Energy Saving Trust's Home Energy Check – a tool designed to help homeowners reduce their fuel bills.	• Property age • Property tenure • Glazing
Office for National Statistics	2011	Data from the 2011 Census aggregated at the COA level.	• Population in poor health
Ministry of Housing, Communities & Local Government	2019	Data on various domains of deprivation aggregated at the LSOA level.	• Index of multiple deprivation decile
Department for Work and Pensions (DWP)	2020	Benefit claimant counts at the COA level, including JSA/Universal Credit, ESA, Income Support, Disability Living Allowance and Pension Credit.	• ECO Affordable Warmth eligibility
Xoserve	2018	List of postcodes off the gas grid.	• Fuel type
Historic England / Historic Wales	2017	List of buildings that have significant historical significance.	• Listed building grade
Microgeneration Certification Scheme	2014	Irradiance dataset organised by climate region used to calculate solar PV potential (kWh per kWp)	• Solar PV potential
British Standards Institution	2016	Map of exposure zones from the code of practice for assessing exposure of walls to wind-driven rain.	• Exposure zones
Met Office	2017	5 km grid shapefile of monthly average wind speeds for 1981-2010	• Wind speed at 10m above ground level (m/s)

2.3. Data Modelling

The methods used to produce the final Home Analytics database vary depending on the underlying data sources and the fields being modelled. Typically, variables in Home Analytics are imputed using one of four types of models: spatial, statistical, derived or apportioned. Table 2 below summarises the inputs and modelling process for each type of model.

Table 2 – Overview of Home Analytics models

Model Type	Inputs	Modelling Process
Spatial	• OS MasterMap Topography Layer • OS AddressBase • Additional layers of interest (e.g. conservation areas)	• Import shapefiles with relevant map features • Develop logic and program algorithms in Python • Execute model and export output
Statistical	• Outputs from spatial models • Installation and assessment records (e.g. EPC, HEED) • OS products (e.g. AddressBase) • Additional datasets (e.g. Census)	• Merge and clean known datasets • Create neighbourhood measures • Train regression model using known data • Apply model to homes with missing records to impute values • Compare distributions to regional datasets (calibrate if necessary)
Derived	• Outputs from spatial and statistical models • Industry assumptions (e.g. suitability for renewables)	• Develop assumptions and build logical formula • Apply formula to input data fields
Apportioned	• Aggregate data (e.g. Census, IMD domains)	• Join aggregate data to AddressBase using relevant geographical code • Downscale/apportion aggregate value to address level using other variables and statistical correlations

2.4. Model Testing and Validation

Most fields in the final Home Analytics database are a combination of known records and predicted values. Depending on the model used to populate the field and the availability of a trusted test set, several different techniques and indicators are used to measure the accuracy and robustness of the final outputs. On the next page, Table 3 summarises the primary data checks EST performs while constructing the Home Analytics models.

Table 3 – Techniques for accuracy testing and validation

Model	Techniques
Spatial	• Assess accuracy by comparing modelled values to known values in trusted third party datasets (e.g. compare property type model predictions to the built form field in EPC data and property type field from Open Land Registry database) • Assess representativeness by comparing distribution of modelled values to known distributions in trusted third-party datasets (e.g. compare % of detached, semi-detached, terraced homes and flats in model to Open Land Registry data) • Cross reference modelled values with other relevant database fields to validate model assumptions/logic (e.g. count number of UPRNs within a building to ensure that the 'Number of Dwellings in Building' field is >1 for flats and equal to 1 for detached homes)
Statistical (categorical variables)	• Separate known data into a training and test set – build binomial or multinomial logistic regression model on the training set and apply to the test set • Assess choice of threshold for classifier using ROC curves and area under curve • Assess accuracy (true positive and true negative rates) by comparing model predictions to known values in test set using confusion matrix • Assess model precision (true positive rate) and specificity (true negative rate) • Assess representativeness of model by comparing distributions of categories to raw data (EPCs) and trusted third party datasets (Census, English Housing Survey) • Assess robustness by repeating this process with different training and test sets and analysing variations in the above metrics
Statistical (continuous variables)	• Separate known data into a training and test set – build log-linear model on the training set and apply to the test set • Compare model predictions to known values in test set by calculating the percentage of predictions within +/- 10, 20, 30, 40 and 50% of known values • Assess model fit using the adjusted-R^2 value • Assess representativeness of model by comparing five-figure summary to raw data (EPCs) and trusted third-party datasets • Assess robustness by repeating this process with different training and test sets and analysing variations in above metrics

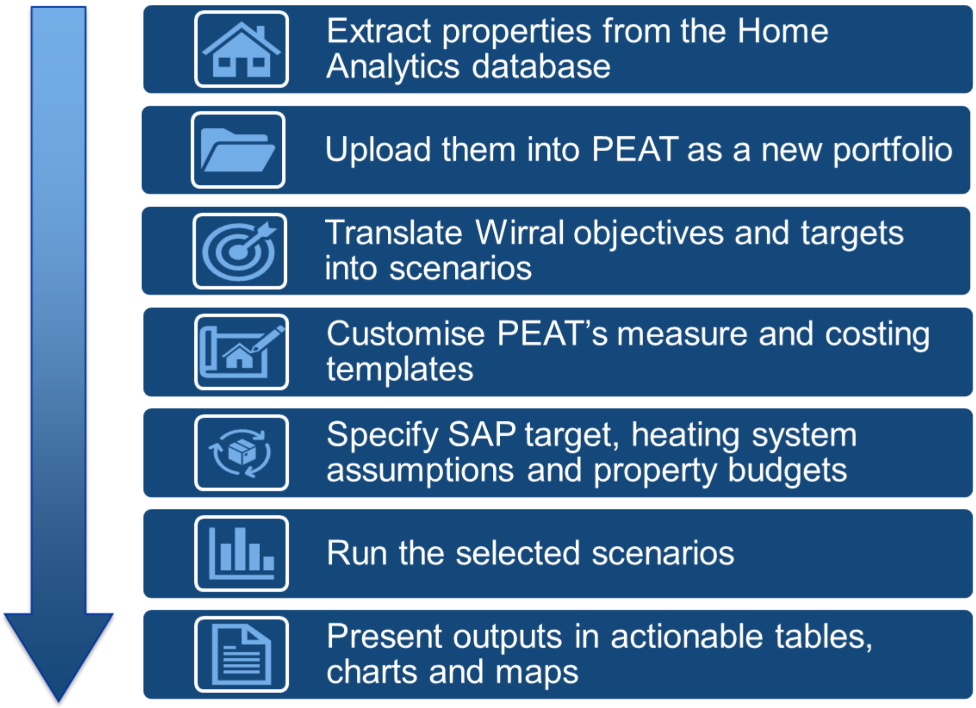
3. Methodology

This section outlines the methodology and assumptions EST used to analyse potential retrofit pathways in Wirral. It begins with a description of EST's Portfolio Energy Assessment Tool (PEAT) as well as the Dynamic Engine, which serves as the underlying inference engine. It then discusses the key PEAT parameters that Wirral and EST used to define the scenarios explored in the modelling.

3.1. Portfolio Energy Assessment Tool

PEAT is a browser-based tool which translates Home Analytics data into SAP inputs. These inputs are then fed into the Dynamic Engine – EST's proprietary SAP calculation engine – which combines property information with assumptions about system efficiency, cost-effectiveness, fuel prices and carbon factors, to recommend a package of retrofit measures for each home. Figure 1 illustrates the PEAT workflow for this analysis.

Figure 1 – PEAT Workflow



The first step involved identifying all residential properties in the Home Analytics database that were within Wirral's administrative boundary and extracting them into a spreadsheet. In some cases, the data extract was further segmented into on- and off-gas properties to allow for different heating system assumptions to be applied within PEAT (see Section 3.5). Next, these properties were uploaded into PEAT, creating a series of new portfolios for Wirral.

After discussing the Council's objectives and carbon emission reduction targets, EST and Wirral agreed on three different PEAT scenarios (see Section 5 for details). To implement the logic and assumptions for these scenarios, EST updated the measure and costing templates and specified a SAP target score, heating system and property budget, where appropriate.

With PEAT as the user interface, EST then processed each portfolio of properties through the Dynamic Engine. For each property included in the analysis, PEAT returned a list of recommended measures, individual measure costs, cumulative retrofit cost, energy consumption and fuel bill savings, CO2 emission reductions as well as the SAP score improvement attributable to the recommended measure package. If a SAP target was specified, then the output also flagged whether the property had achieved it.

Finally, EST compiled these outputs for all properties within each scenario and prepared a series of tables, charts and maps analysing the results. These are discussed in more depth in Section 5.

3.2. Measure Template

When processing PEAT scenarios, EST imports a standard list of building fabric measures and low carbon technologies for PEAT to consider. This measure template defines the scope of the modelling by enabling certain measures to be 'turned off' for specific scenarios. Table 4 provides a list of the measures considered within the Wirral PEAT scenarios.

Table 4 – PEAT Measure Template

Category	Measure
Lighting	Replace last 10 percent with CFL
	Replace last 20 percent with CFL
	Replace last 30 percent with CFL
	Replace last 40 percent with CFL
	Replace 50 percent with CFL
	Replace 40 percent with CFL
	Replace 30 percent with CFL
	Replace 20 percent with CFL
	Replace 10 percent with CFL
	Replace all low energy light bulbs
Windows and Doors	Draught proofed windows
	Draught proofed external doors
	A-rated glazing (uPVC)
	A-rated glazing (uPVC) for roof
	New insulated uPVC external doors
Wall Insulation	Cavity wall insulation
	Hard to treat cavity wall insulation
	Hard to treat cavity wall insulation - bead
	Internal wall insulation
	External wall insulation
	Room in roof walls and sloping parts, 100mm insulation

Loft Insulation	Loft insulation Loft insulation top-up Insulation for flat roofing
Floor insulation	Solid floor insulation Suspended wooden floor insulation
Hot Water Insulation	Hot water cylinder insulation Hot water cylinder insulation and new hot water controls New hot water controls (cylinder stat and water heater timer) Insulating jacket, new hot water controls and pipework insulation Additional insulating jacket for existing foam insulated tank Additional insulating jacket for existing foam insulated tank and new hot water controls New hot water cylinder
Heating Systems and Controls	Mains gas combi-condensing boiler Mains gas condensing boiler Oil combi-condensing boiler Oil condensing boiler Oil combi-condensing boiler (plus oil storage tank) Oil condensing boiler (plus oil storage tank) LPG combi condensing boiler LPG condensing boiler Biomass boiler (wood pellets) Air source heat pump Ground source heat pump Pellet stove with back boiler, with DHW Modern storage heaters Mains gas condensing warm air system LPG condensing warm air system Secondary heating log stove Radiators and distribution system Underfloor Heating Storage heater distribution (No distribution system) Warm air distribution Thermostatic radiator valves Thermostatic radiator valves, for use linked community system Thermostatic radiator valves, for flat rate community system Additional thermostatic controls, warm air systems Modern storage heating controls Time and temperature zone control for radiator systems Time and temperature zone control for underfloor heating Hot water from combi Electric immersion Hot water cylinder with electric immersion back-up Dual electric immersion 3.5kW Solar panels 5.5kW mast mounted wind turbine Solar hot water system

While all potential measures were included in the template for the Wirral analysis, it is important to note that PEAT only recommended measures for a property if the following criteria were met:

1. The property had not surpassed its SAP target or per property budget (if selected).
2. The property was deemed suitable for the measure (e.g. cavity wall insulation could only be recommended for a property that had an uninsulated cavity wall).
3. Any measures that were higher in the cost-effectiveness hierarchy had already been considered.
4. The selected measure was deemed cost-effective based on the property's attributes and any other measures already recommended.

As a result, it is possible that in some scenarios even though a measure is included in the measure template, it might not be recommended.

3.3. Costing Template

Alongside the measure template, PEAT uses a costing template to assign appropriate costs to each measure. These costs can take two forms (fixed costs and variable costs) depending on the measure. This allows PEAT to scale the cost of a recommended measure to the size of the property (e.g. the cost of floor insulation will be higher in homes with larger floor areas).

For the purposes of this analysis, EST used default cost assumptions for all measures, which are drawn from a variety of sources such as purchasing websites, energy sector literature, SPONS price books (for both measures and labour costs) and direct contact with installers. The costing template was updated prior to the analysis to reflect the latest data for 2020.

It is important to note that PEAT does not account for changes in costs over time. When running scenarios, PEAT assumes installation costs, fuel prices and fuel bill savings are based on today's costs. As low carbon heating technologies achieve economies of scale, they are anticipated to decrease in price over time. Therefore, by using 2020 costs, PEAT likely overestimates long-term installation costs. Conversely, fuel prices are expected to increase over time, as the cost of carbon is further internalised within the price of gas, suggesting that PEAT likely understates the potential fuel bill savings associated with the recommended retrofit work.

3.4. SAP Target

Another parameter that can be modified within each PEAT scenario is the target SAP score. Setting a SAP target constrains PEAT in two key ways. First, it ensures that only properties below the target SAP score are considered for retrofits. Secondly, it prevents PEAT from recommending more measures than is necessary for a property to achieve the target.

In practice, this means that for each property that is currently below the selected SAP target, PEAT cycles through the list of measures, in order of cost-effectiveness. Each time a measure is recommended, the SAP score is recalculated for the property. If the new SAP score remains below the SAP target, PEAT continues to the next measure in the measure template. If the recalculated SAP score meets or exceeds the SAP target, PEAT moves on to the next property.

Implementing a SAP target is a useful way to model a future standard or regulation. For the purposes of this analysis, EST applied a SAP target in one scenario (Regulatory Standards). The other two scenarios (High Ambition, Fuel Switching) did not have a target because they were designed to assess the maximum potential for energy efficiency improvements and carbon reductions within the stock.

3.5. Heating System

Assumptions around heating system upgrades are important when assessing different approaches to decarbonisation. To this end, PEAT provides three options for dictating how heating systems are treated within the model. The first option (default heating) assumes the most cost-effective heating system will be recommended for each property. Due to the relatively low cost of gas, this will often result in on-gas properties having a modern gas boiler recommended rather than a heat pump or other low carbon heating option.

The second option (heat pumps) ignores traditional heating system upgrades and only considers air source heat pumps (ASHPs) or ground source heat pumps (GSHPs). With this option selected, all properties that are suitable for a heat pump will have it recommended, regardless of cost-effectiveness. EST used this option in the Fuel Switching scenario to model a case where all properties switched to electric heating via heat pumps.

The third option (default heating then heat pumps) is a hybrid of the first two options. If a property is eligible for a standard heating system (e.g. boiler replacement) then this will be considered first. If the property is not eligible, or a heat pump is deemed to be more cost-effective, then PEAT will recommend a heat pump instead. EST used this option for the Regulatory Standards and High Ambition models. Given current assumptions on heat pump efficiencies and fuel prices, this resulted in similar outcomes to the first option, where heat pumps were only deemed cost-effective for off-gas properties because of the fuel price differential between electricity and other non-gas fuels such as oil and LPG.

3.6. Property Budgets

During project scoping, EST and the Wirral project team discussed the potential for constraining the number of measures that PEAT would recommend in each scenario, by implementing property-level budgets. Since the main objective of the analysis was to identify potential retrofit pathways and assess their costs and savings in relation to the Council's medium and long-term CO2 emissions targets, property budgets were deemed to be overly restrictive. Therefore, EST did not limit any PEAT scenario based on the total costs of the recommended measure packages.

4. Stock Overview

This section provides an overview of the existing residential building stock in Wirral, based on key property attributes, energy efficiency characteristics, renewable energy suitability measures and SAP characteristics. The Wirral figures are presented alongside regional and national averages to provide geographical context for the observed trends.

4.1. Property Attributes

4.1.1. Property Type

The most common type of residential property in Wirral is semi-detached houses (Figure 2). They account for 40% of the stock, which is significantly greater than the regional (34%) and national (27%) average. Flats and detached homes in the Northwest are less common (20%) compared to the rest of England (26%) and the Wirral stock is characteristic of this trend.

Flats typically pose unique challenges to retrofit activities as wall, floor and loft insulation is more intrusive than in a semi-detached or detached house and cannot be installed easily or cost-effectively without buy-in from an entire building or block of owners. The fact that Wirral has relatively more semi-detached houses and fewer flats suggests that it should be easier to install energy efficiency measures, both from a logistical and cost-saving perspective.

Figure 2 – Property type of Wirral buildings compared to Northwest and England

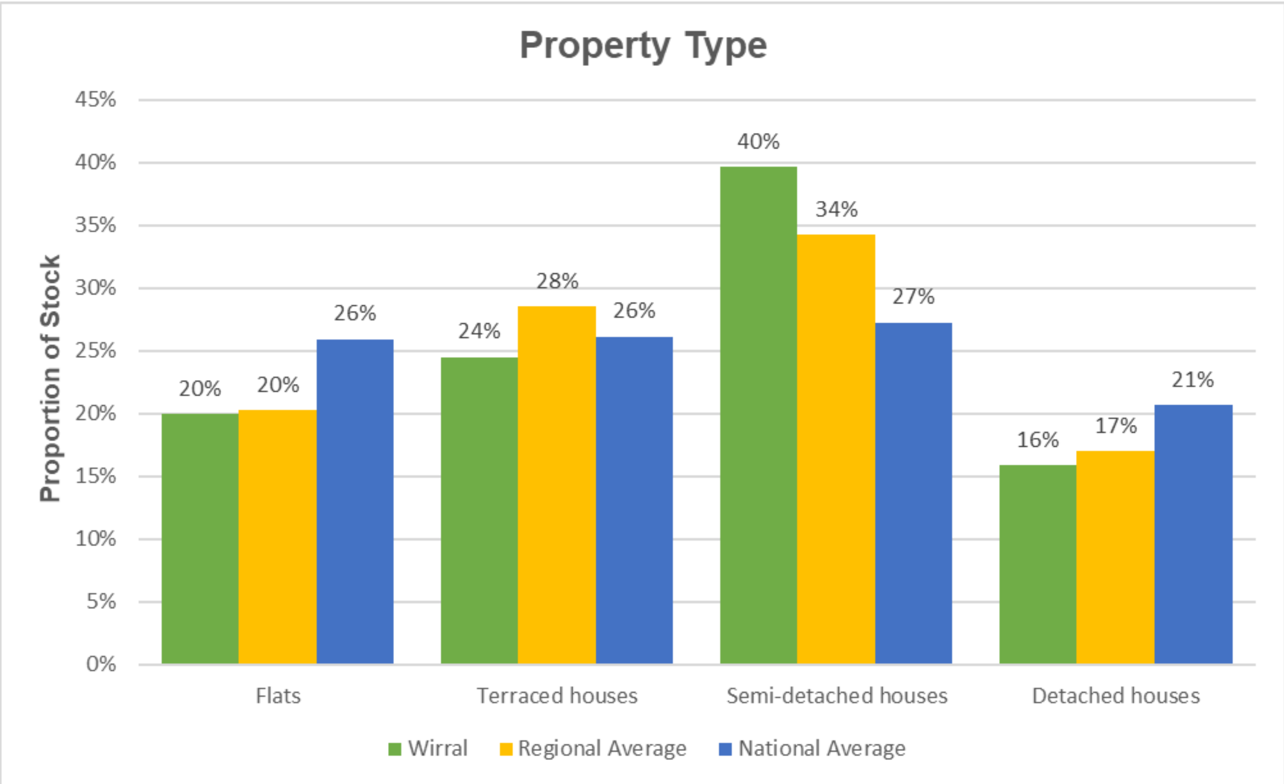


Figure 3 – Distribution of blocks of flats in Wirral by lower super output area (LSOA)

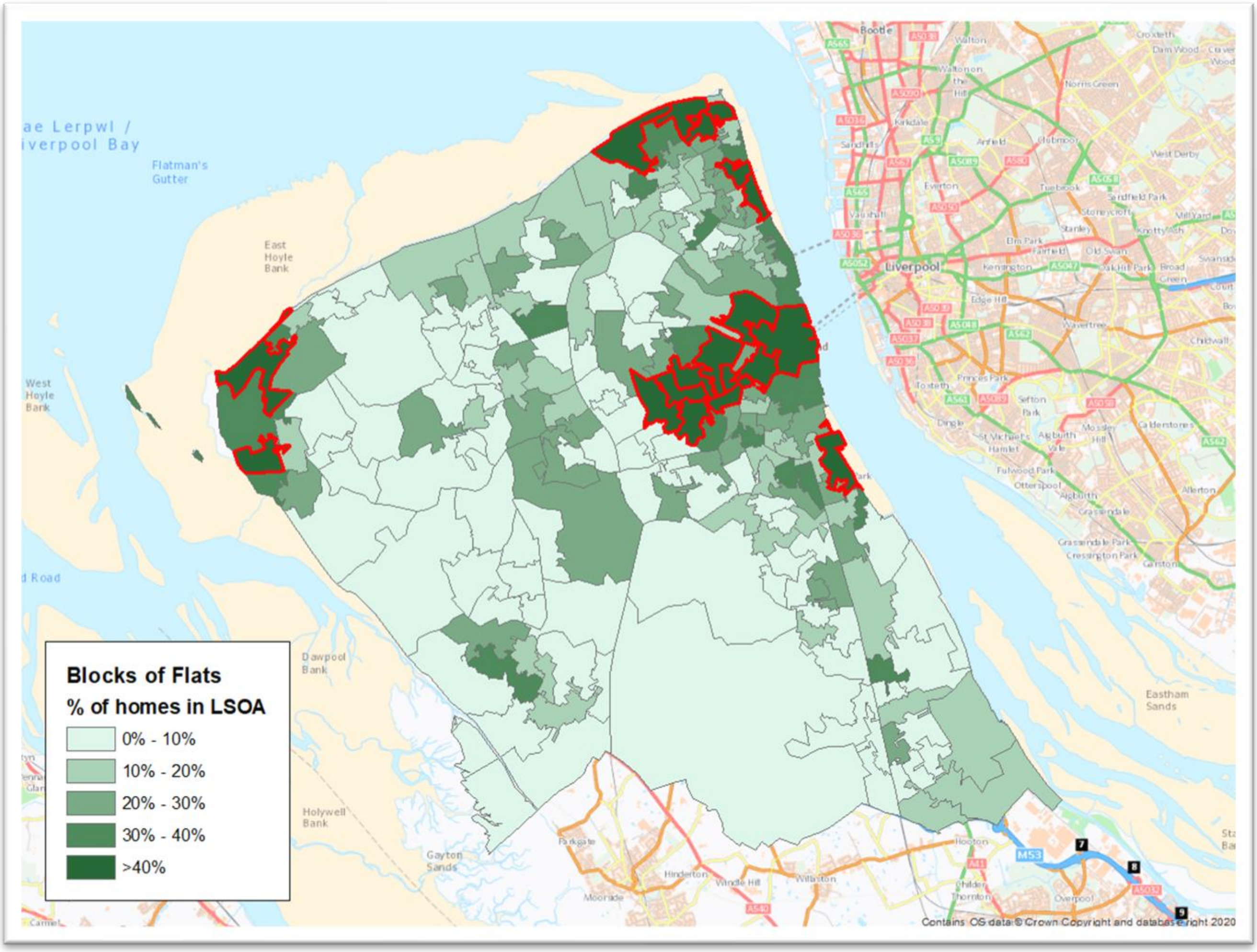


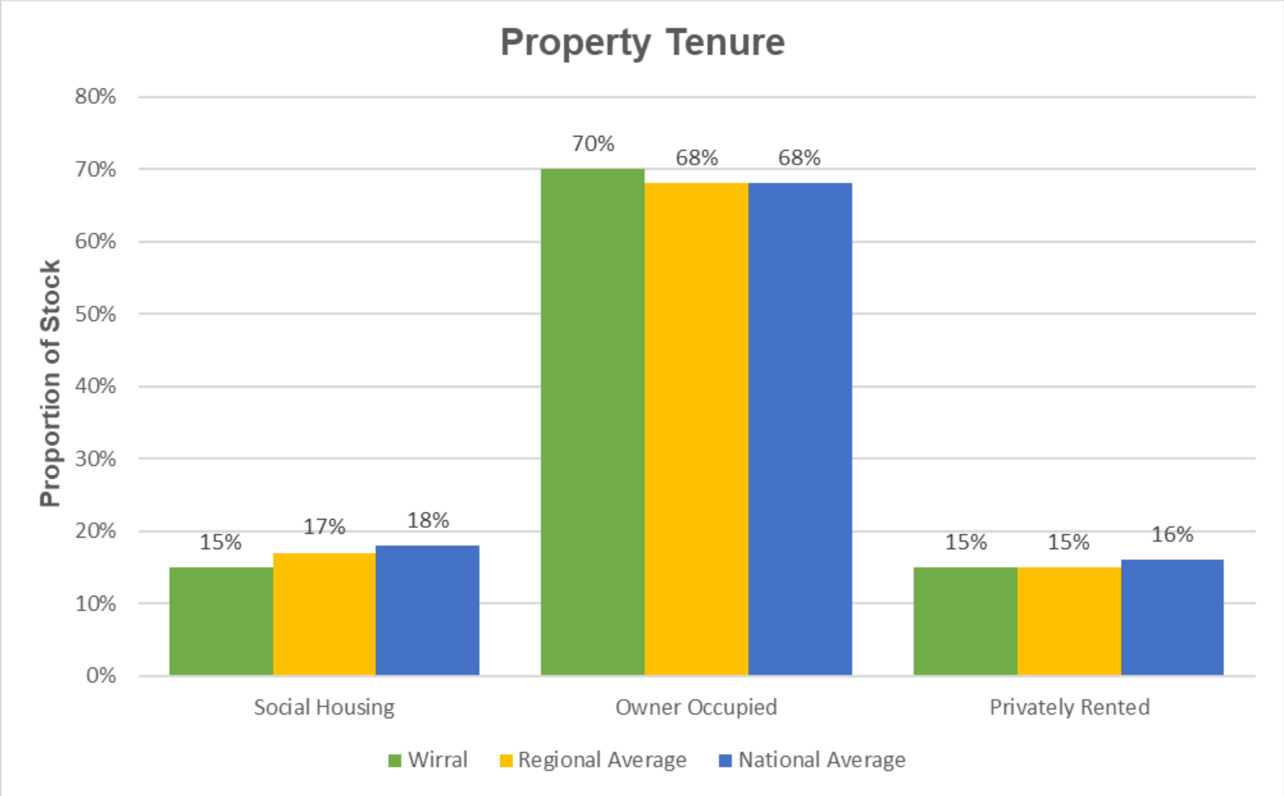
Figure 3 shows the distribution of flats by LSOA. The areas outlined in red have more than twice the concentration of flats (>40%) compared to the Wirral average (20%). Retrofit planning in these areas may benefit from an alternative approach, compared to the surrounding LSOAs.

4.1.2. Property Tenure

As Figure 4 shows, the distribution of property tenures within Wirral generally follows the trend observed across the Northwest region and England. Approximately 85% of properties are privately owned or rented; the remaining 15% are managed by social housing providers. In the case of Wirral, social housing is provided almost exclusively by housing associations.

New regulations and standards should drive the social housing sector to improve energy efficiency and – where practical, cost-effective and affordable – raise properties up to a SAP band of C. However, this does not address the majority of homes under private ownership in Wirral, which make up the bulk of the housing stock. These homes will need tailored schemes and funding mechanisms (e.g. Green Homes Grant) to encourage efficiency and promote decarbonisation.

Figure 4 – Property tenure of Wirral buildings compared to Northwest and England

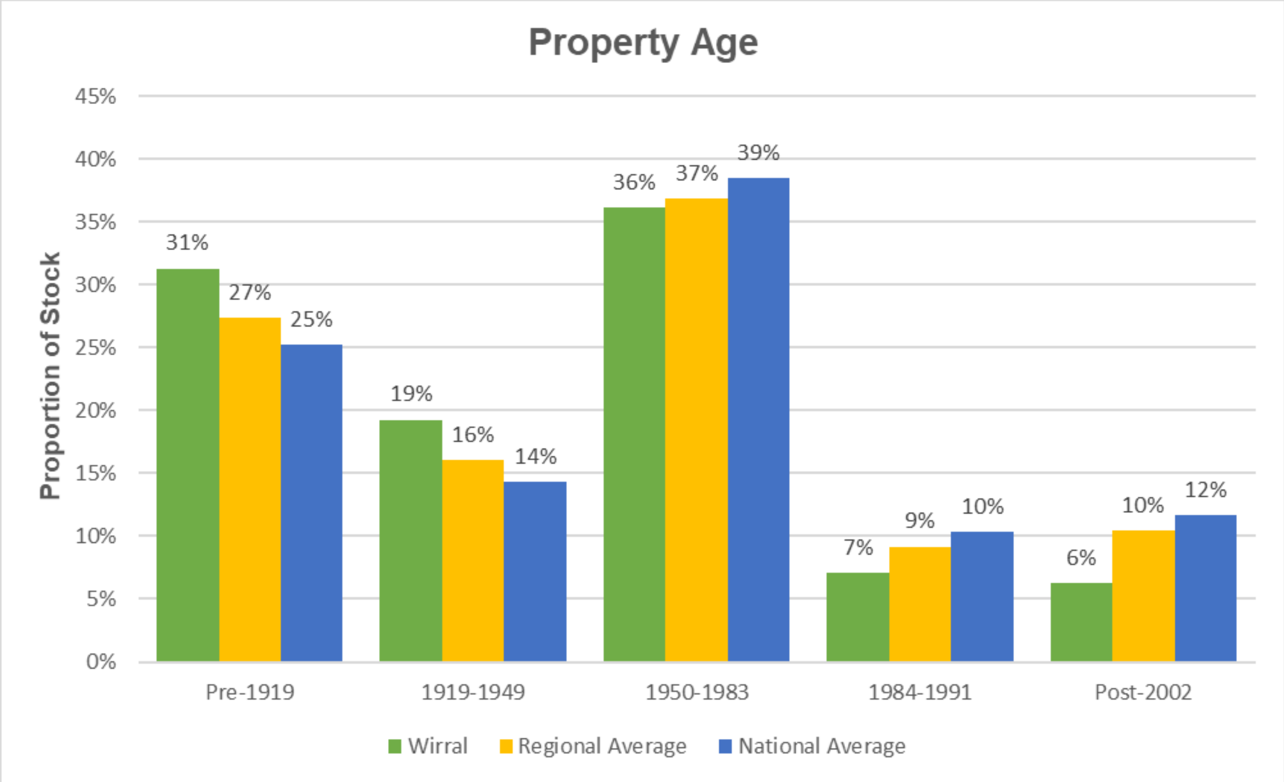


4.1.3. Property Age

The residential building stock in Wirral is older than the regional and national average. As Figure 5 shows, half the homes in Wirral were built before 1950, compared to 43% in the Northwest region and only 39% nationally. More than 85% of houses were built before 1984.

Due to more stringent building regulations, improvements in construction materials and the steadily declining costs of renewable technology, energy efficiency tends to improve over time. Since Wirral has a higher proportion of older properties, its baseline level of efficiency is below average and its associated emissions are above average. This means there are significant opportunities for decarbonisation through basic upgrades to the building fabric.

Figure 5 – Property age of Wirral buildings compared to Northwest and England

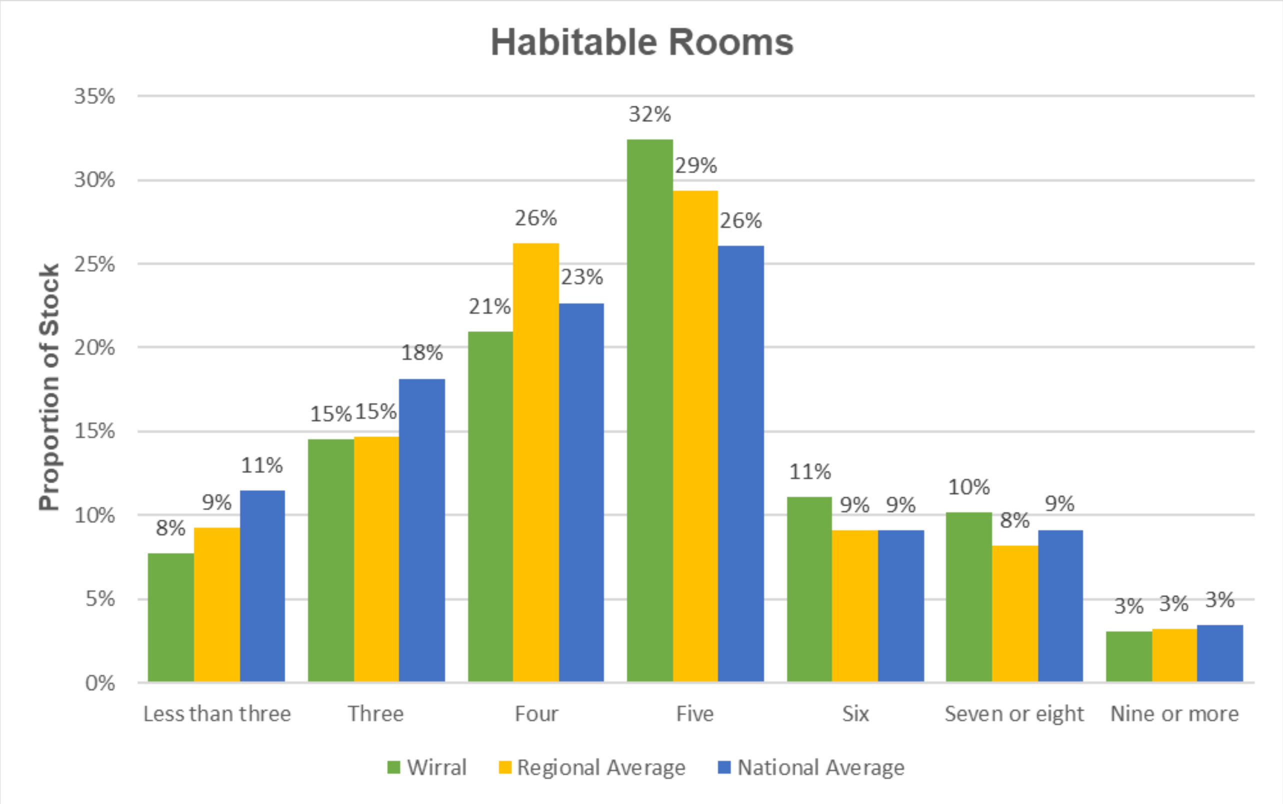


4.1.4. Habitable Rooms

The number of habitable rooms a dwelling has is typically correlated with its energy consumption and total carbon emissions. This is because bigger homes (all other things being equal) have higher space heating demands. They can also accommodate more occupants which will increase energy demand within the building. As Figure 6 shows, Wirral's stock follows regional and national patterns of distribution, across habitable room categories.

The only minor deviation from this pattern is that 44% of homes in Wirral have less than five habitable rooms, compared to the regional and national averages of 50% and 52% respectively. To put it another way, homes in Wirral are, on average, a little larger. This finding is reinforced by the observation that there are relatively fewer flats and more semi-detached homes within the council boundaries.

Figure 6 – Habitable rooms in Wirral buildings compared to Northwest and England



4.2. Energy Efficiency Characteristics

4.2.1. Wall Construction and Insulation

A building's wall construction can be a useful proxy for energy efficiency because it dictates the cost and complexity of installing insulation, and therefore, the likelihood that the building has already had this work carried out. As Figure 7 shows, residential buildings in Wirral have nearly an even split between cavity walls (51%) and walls made of solid brick or stone (46%). This is a significant deviation from the national average and even more so from the regional trend, where cavity walls account for upwards of 74% of the stock.

Solid brick and stone were more commonly used in properties built before the 1920s, so given that a larger than average portion of Wirral's stock was built during this time, it is not surprising that there are more solid wall properties.

Filling cavity walls with insulation is a significantly cheaper and less intrusive process than retrofitting solid walls with internal or external wall insulation. Consequently, Wirral has a lower proportion of properties with insulated walls (48%) compared to England (60%) and the rest of the Northwest (63%) (Figure 8). This trend is more pronounced when comparing insulation rates between wall types. While cavity walls, timber frame and system-built walls have a combined insulation rate of 78%, only 12% of solid walls are insulated (Figure 9).

Figure 7 – Wall construction type of Wirral buildings compared to Northwest and England

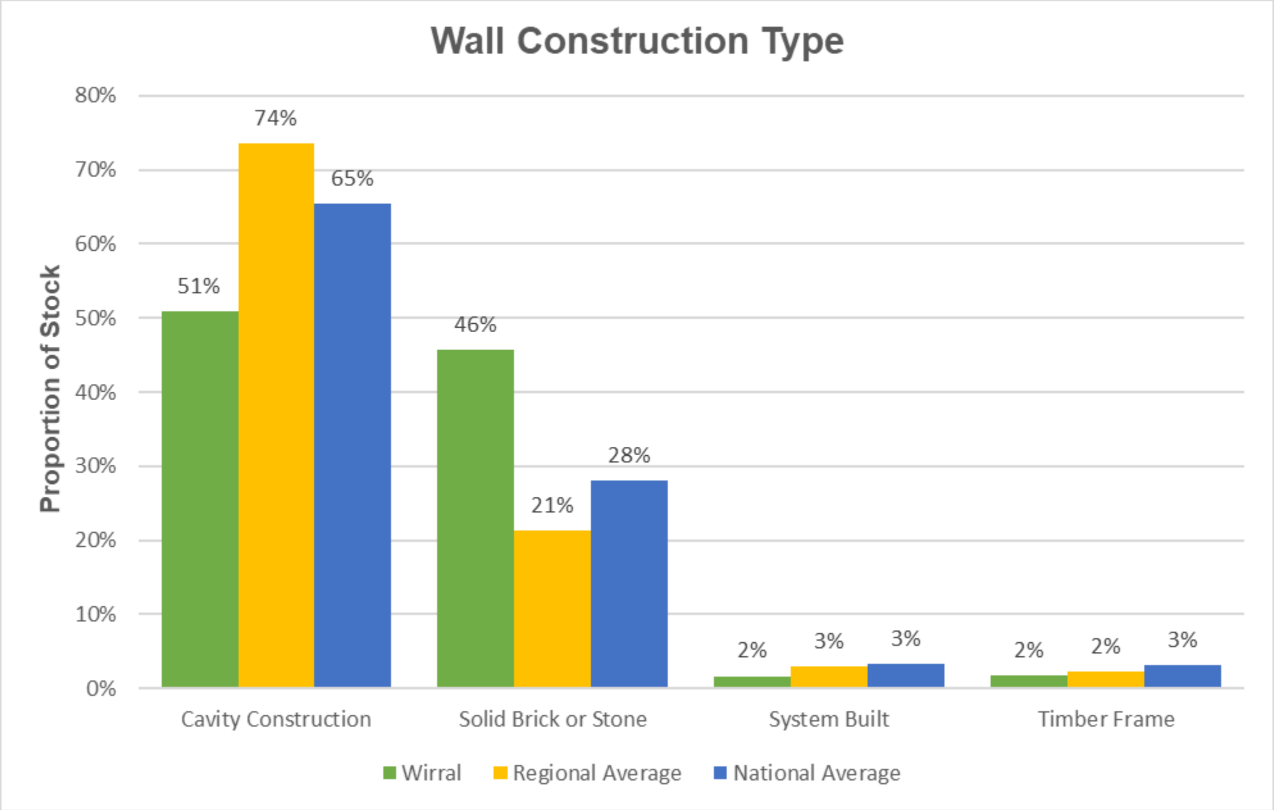


Figure 8 – Wall insulation of Wirral buildings compared to Northwest and England

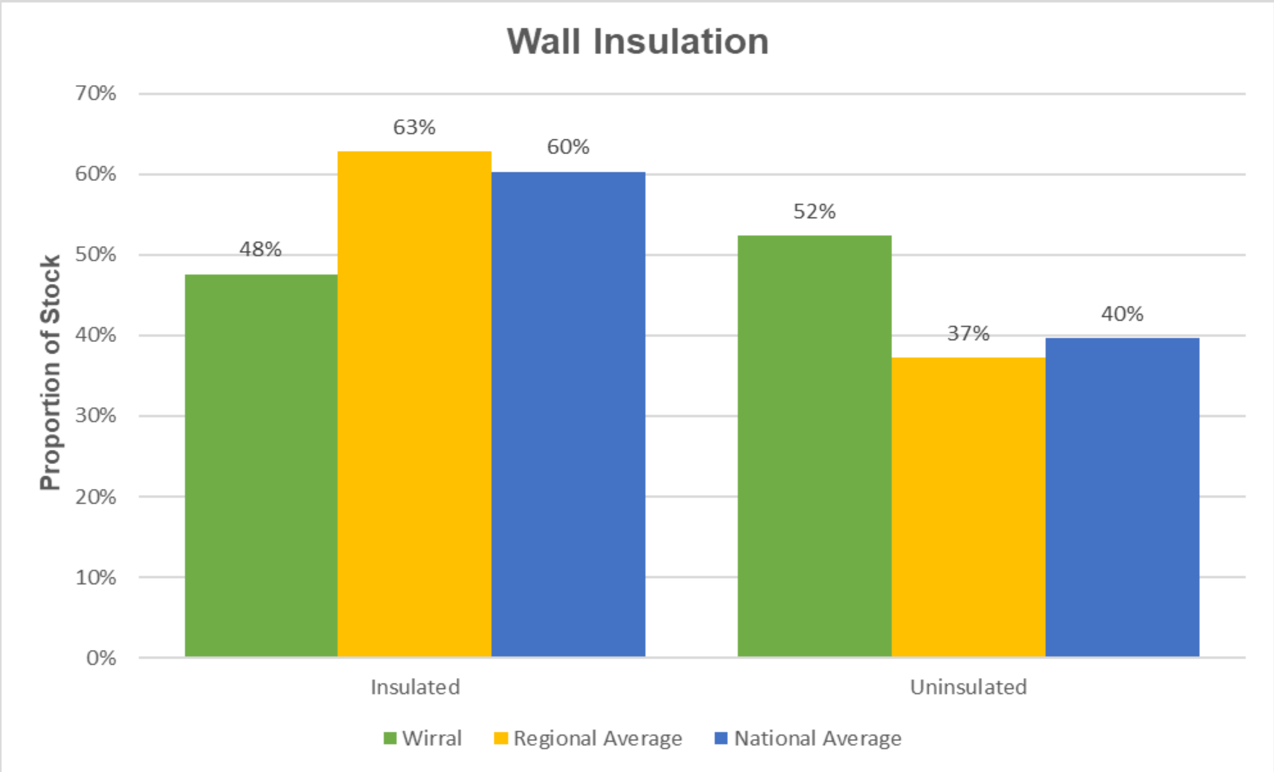
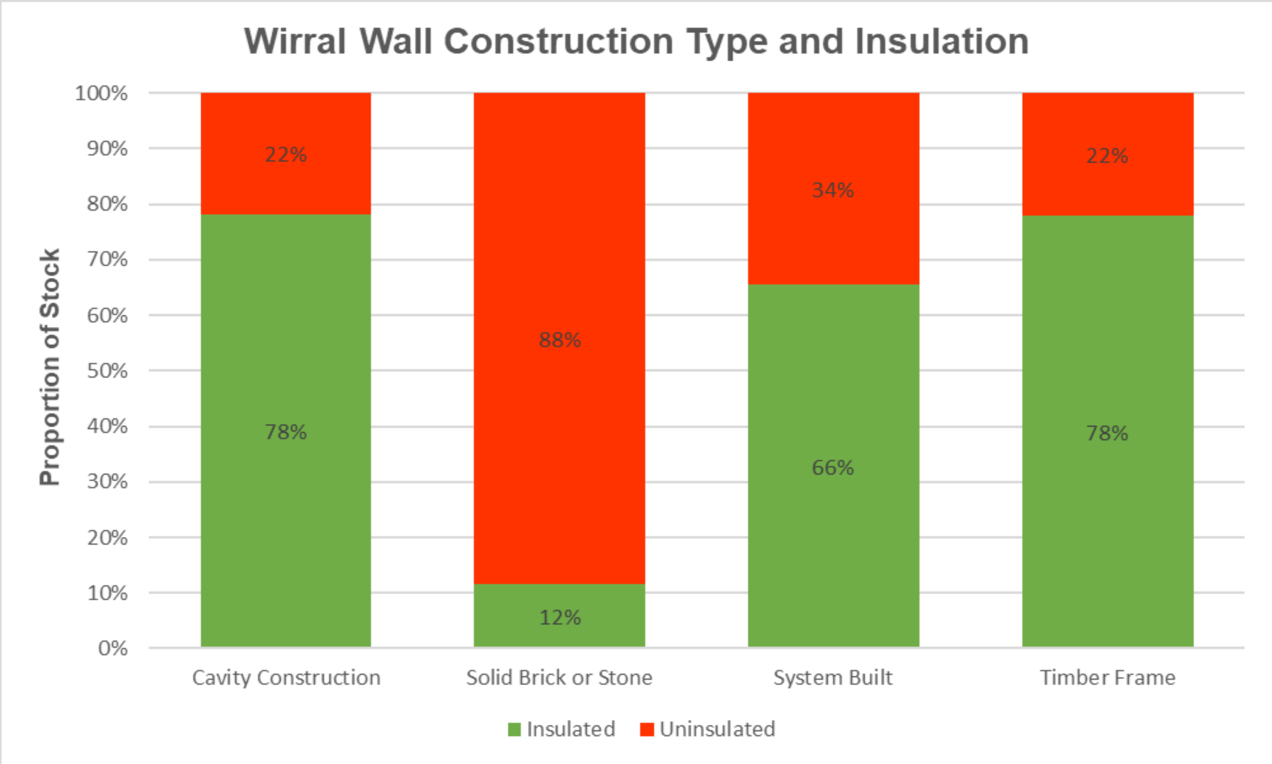


Figure 9 – Wirral wall insulation by construction type

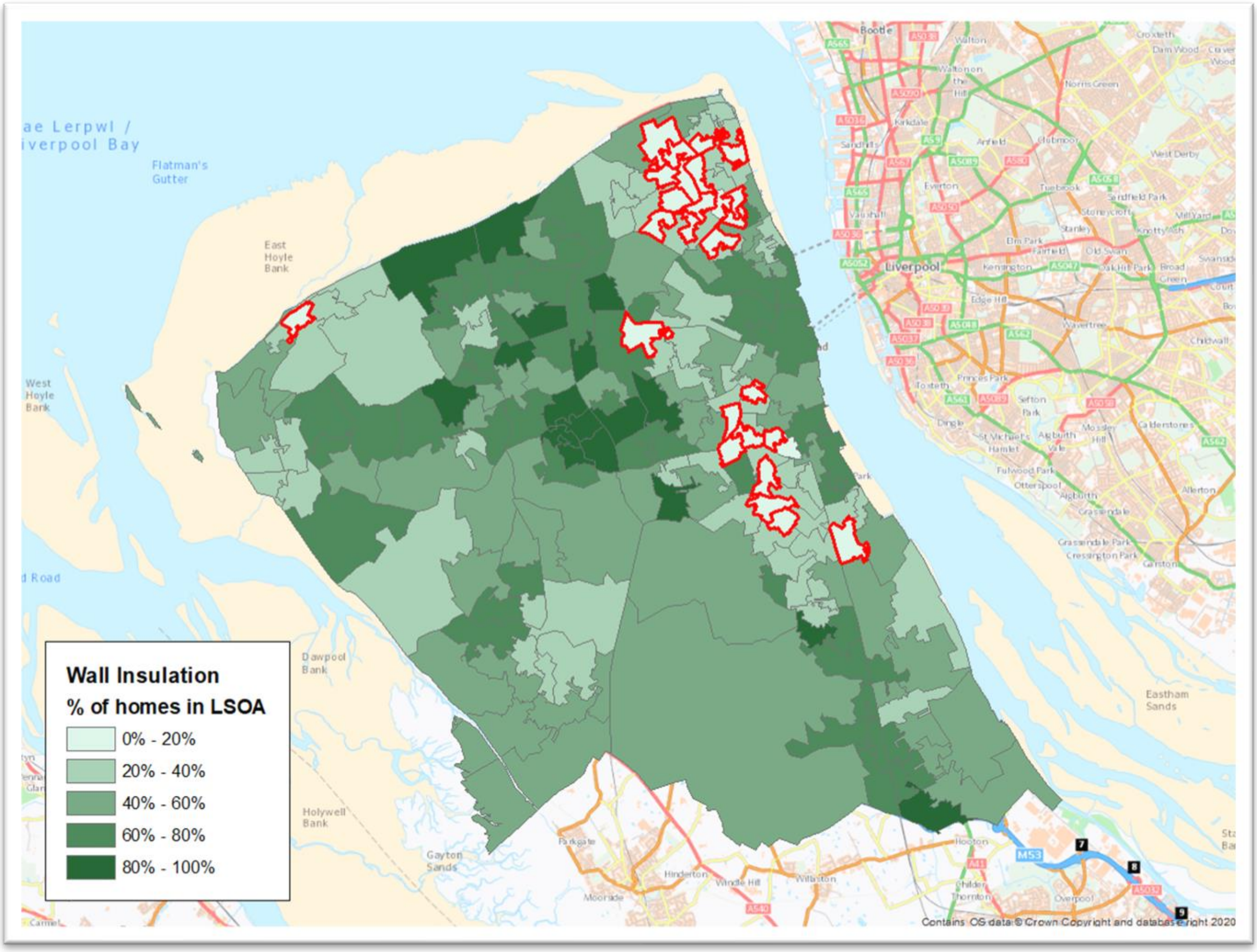


The cost of insulating a solid wall will vary by property. For a typical semi-detached home in Great Britain, this will range from £7,400 for internal wall insulation to £13,000 for external wall insulation. The high cost of these measures represents a fundamental barrier to uptake and underscores the importance of tapping into available funding programmes, like the Green Homes Grant, to help subsidise this work.

Wall insulation is a critical step to improving energy efficiency and reducing carbon emissions. If the building fabric remains uninsulated, other measures will be less effective at retaining heat within the home, thereby reducing their cost-effectiveness. Therefore, solid wall insulation and to a lesser extent, cavity wall insulation, should be central to the decarbonisation plan in Wirral.

Figure 10 maps the current distribution of wall insulation in Wirral by LSOA. Less than 20% of the homes in the LSOAs outlined in red have insulated walls, which is significantly lower than the Wirral average (48%). While there are many opportunities for this type of home improvement in Wirral, these LSOAs provide the best opportunities for targeting.

Figure 10 – Distribution of homes in Wirral with wall insulation by LSOA



4.2.2. Loft Insulation

A quarter of a property's heat can be lost through an uninsulated roof. The process of insulating a loft, attic or flat roof is easier than insulating a solid wall and will be effective for at least 40 years, if correctly installed. By sealing the building environment and reducing the amount of heat that escapes, loft insulation not only lowers a property's energy consumption and fuel bill, but also reduces its carbon footprint.

As Figure 11 shows, half of Wirral's properties have at least 150mm of loft insulation installed, which is higher than both the regional (46%) and national (39%) averages. Approximately 13% of homes do not have lofts (i.e. dwellings within the lower floors of a block of flats) and therefore, are not a focus for loft insulation measures. This leaves about 37% of properties that have no insulation or an inadequate level of insulation and will require significant top-ups.

Figure 11 – Loft Insulation of Wirral buildings compared to Northwest and England

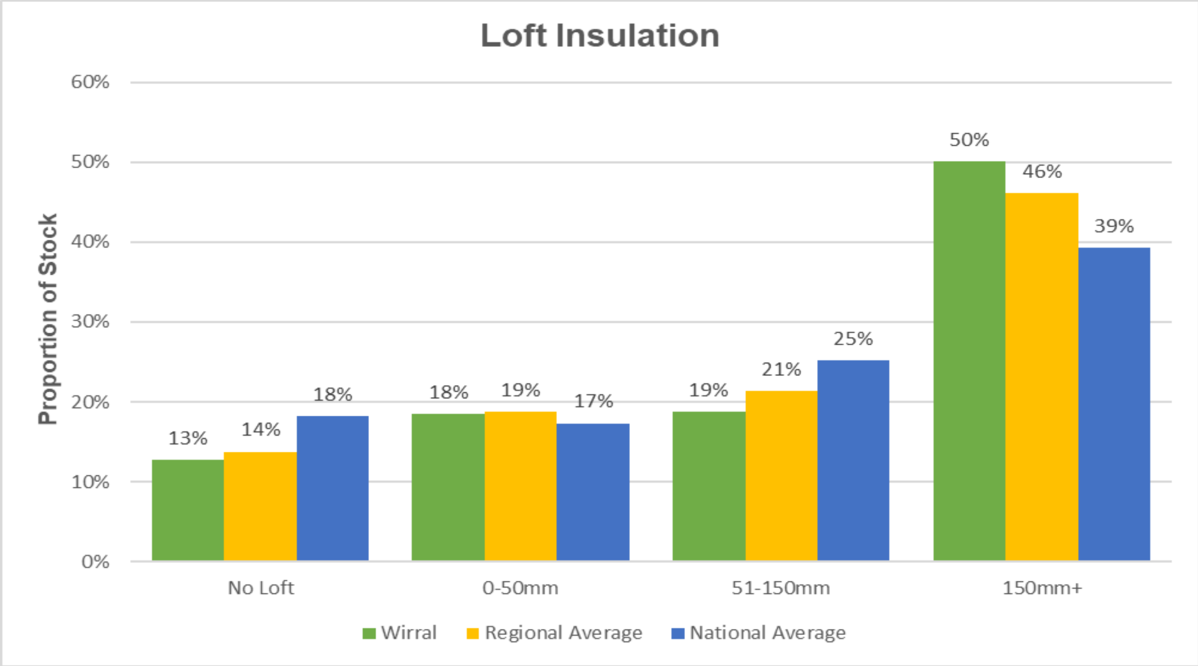
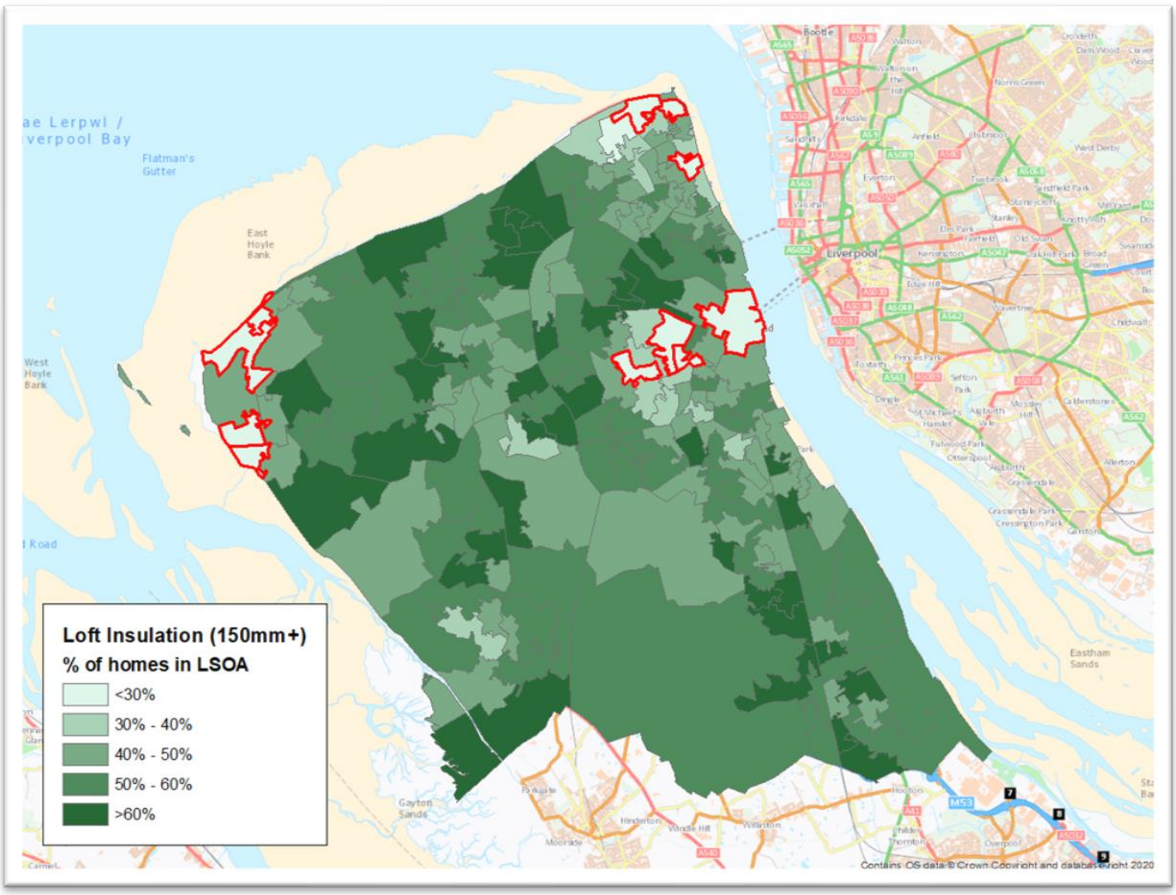


Figure 12 – Distribution of homes in Wirral with 150mm+ loft Insulation by LSOA



Recommended loft insulation depth has increased over time. The current guidance is that a property should have a minimum of 270mm of insulation. While a large percentage of Wirral's properties are approaching this value, there will likely be some opportunities for minor loft insulation top-ups to further improve their efficiency.

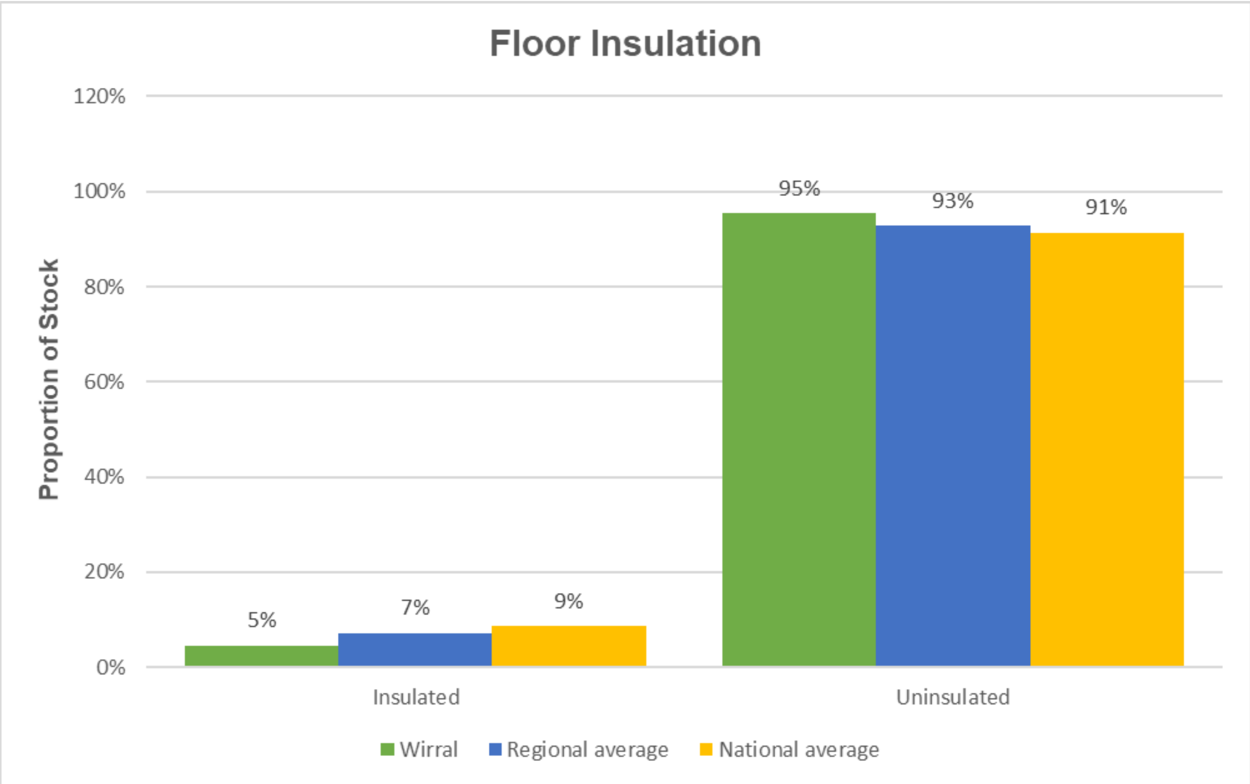
Figure 12 maps the current distribution of homes with at least 150mm loft insulation by LSOA. Less than 30% of the homes in the LSOAs outlined in red have loft insulation of at least 150mm, which is significantly lower than the Wirral average (50%). There are many opportunities for insulation top-ups in Wirral, but these LSOAs are likely to provide some the best opportunities for targeting.

It is also important to note that some of these LSOAs, particularly those in the Claughton / Birkenhead area, have a higher-than-average proportion of flats (see Figure 3). Since most dwellings within a block of flats do not have a loft, Home Analytics classifies them as 'no loft'. This classification may contribute to the lower loft insulation levels observed in these specific areas.

4.2.3. Floor Type and Insulation

Insulating the ground floor in a building is an effective way to keep it warm. Floor insulation can also help reduce heat demand when the floor is above an unheated space like a garage or a cold cellar. The type of floor insulation required will depend on the floor construction type. Most homes (especially newer ones) have a ground floor made of solid concrete, while older ones may have suspended timber floors.

Figure 13 – Floor insulation of Wirral buildings compared to Northwest and England



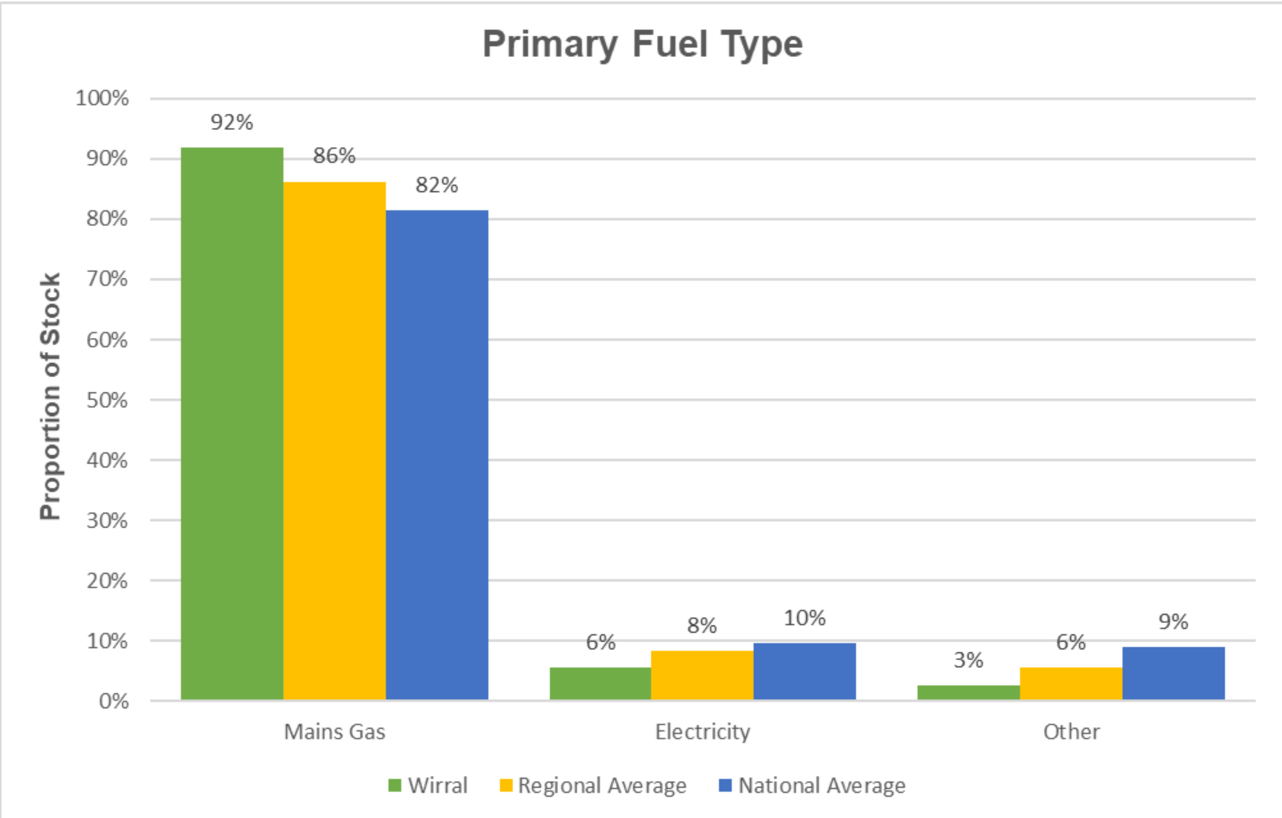
In Wirral, a little over half of the residential dwellings (52%) have solid floors, while 35% have suspended timber and 13% are positioned above unheated spaces. As Figure 13 shows, only 5% of all dwellings have floor insulation. While this is quite low, it aligns with the regional and national trend. Uptake of floor insulation has been historically low because the associated savings are modest, when compared to alternative insulation upgrades (e.g. wall and loft insulation).

Although floor insulation has largely been ignored to this point, it does represent an untapped opportunity for improving energy efficiency and reducing carbon emissions. Floor insulation is a primary measure covered under the Green Homes Grant scheme and is therefore, eligible for funding. Depending on the home, floor insulation can be less expensive than other forms of insulation, which may make it a more attractive option.

4.2.4. Primary Fuel Type

As Figure 14 shows, a large majority of Wirral properties (92%) use mains gas as their primary heating fuel, with only 6% on electricity and 3% on other fuel types (e.g. LPG, oil, biomass/solid fuel). This follows a similar pattern when compared to the regional and national level but leans more heavily towards gas (+10% more than England average). This has several important implications to the types of heating system upgrades that will be possible in Wirral.

Figure 14 – Primary fuel type of Wirral buildings compared to Northwest and England



For example, renewable heating systems such as biomass boilers, air source heat pumps, and ground source heat pumps are typically not cost-effective if a property already has an efficient boiler running on mains gas. This suggests there will likely be fewer renewable heating systems recommended in Wirral, in favour of modern condensing boiler upgrades.

This also has significance to the council's decarbonisation targets and strategy. While mains gas has many benefits (e.g. cheaper fuel bills, high efficiency, lower carbon content than oil or coal) it is still a fossil fuel, and therefore, emits carbon dioxide when burned. As the national electricity grid shifts more towards renewable energy sources, the potential to electrify heating will become more feasible, but in the short and medium term, replacing gas systems with alternative heating systems is unlikely to be a cost-effective use of funds and may also have unintended consequences, such as higher fuel bills and a higher risk of fuel poverty.

Figure 15 – Distribution of homes in Wirral using mains gas by LSOA

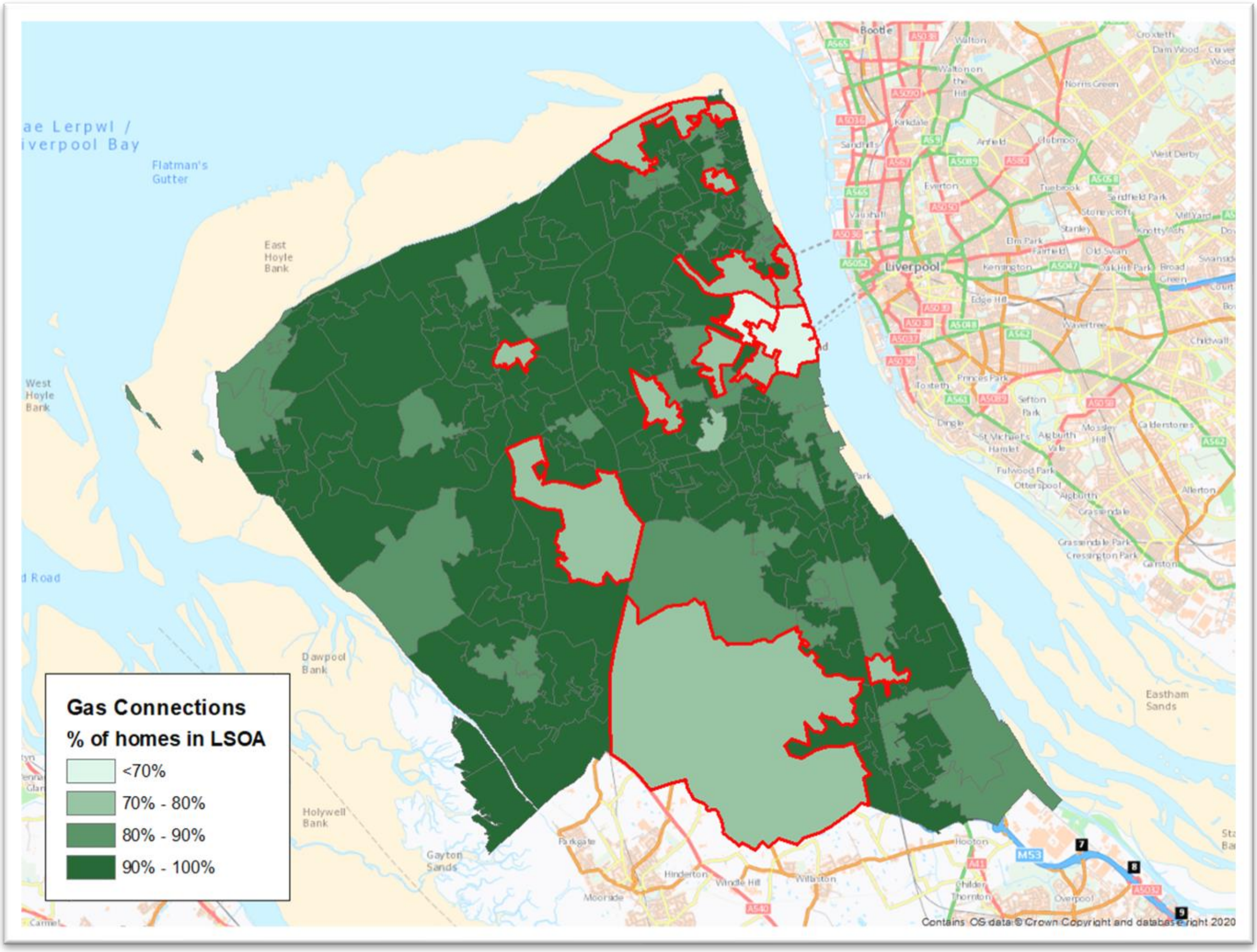


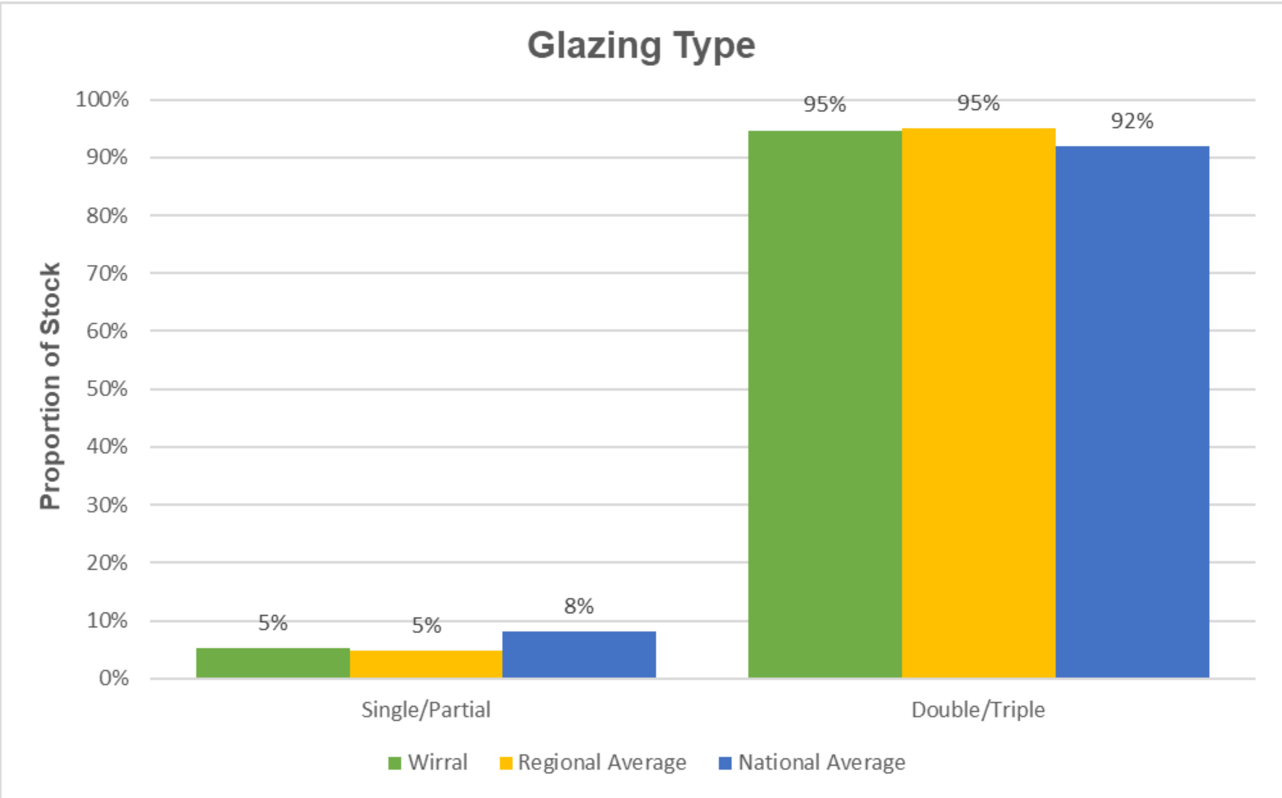
Figure 15 above shows the current distribution of homes that using mains gas as their primary fuel type. In the LSOAs outlined in red, less than 80% of their dwellings are on gas, which is below the Wirral average. This indicates that there are neighbourhoods within these LSOAs, which are not currently connected to the gas grid and are likely using higher priced fuels. These areas could provide cost-effective opportunities for the early adoption of low carbon heating systems, such as heat pumps.

4.2.5. Glazing Type

In Wirral, nearly 95% of properties have doors and windows that are predominantly double or tripled glazed, which is characteristic of the regional trend and slightly higher than the national average (Figure 16). Due to the adoption of more stringent building standards, the lower relative installation costs of glazing compared to other insulation measures and the focus of early retrofit and grant funding schemes on glazing, there are very few properties left with single or partial glazing.

For buildings with double glazing, there will be the potential to install more efficient glazing (e.g. A-rated uPVC) however, this will have a very modest impact on energy savings, relative to other potential measures.

Figure 16 – Primary glazing type of Wirral buildings compared to Northwest and England

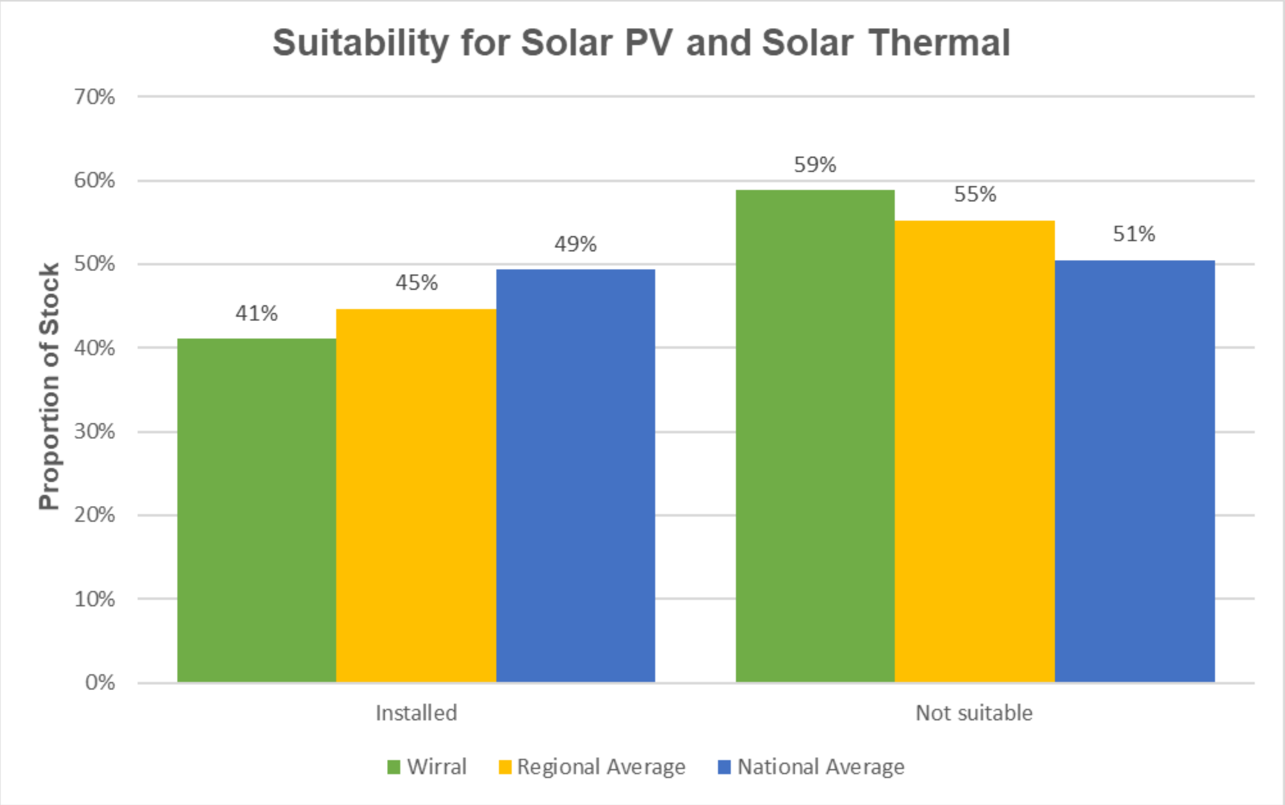


4.3. Renewable Energy Suitability

4.3.1. Solar PV and Solar Thermal

Solar PV and solar thermal systems are forms of decentralised, renewable energy that have the potential to create significant reductions in carbon emissions. As Figure 17 shows, approximately 41% of residential properties in Wirral are suitable for the installation of solar systems. This is lower than both the regional (45%) and national average (49%). Although this suitability metric accounts for roof orientation, property type and listed building status, it does not account for roof pitch/shape, obstructions (e.g. chimneys) or shading and therefore, likely overestimates the potential for solar PV and solar thermal in Wirral.

Figure 17 – Solar PV / thermal suitability of Wirral buildings compared to Northwest and England



4.3.2. Heat Pumps

Air source and ground source heat pumps are alternative heating systems that can be used to dramatically lower a home's energy consumption, fuel bill and carbon emissions. Heat pumps need electricity to run, but because they are extracting renewable heat from the air or ground, the heat output is greater than the electricity input, making them an energy efficient method for heating a home.

Given their substantial installation cost, heat pumps are typically only considered in properties that are using a primary fuel other than mains gas and which are already well-insulated. While a heat pump can replace a gas boiler, this is not always cost-effective. Modern gas boilers are highly efficient and significantly cheaper than electricity, which means replacing them with heat pumps can, in some cases, increase a property's fuel bill and reduce its SAP rating.

According to Home Analytics, less than 1% of properties in Wirral are suitable for heat pumps. This indicator is extremely low because it assumes that only large, insulated properties that are more than 23m from the gas grid (i.e. too far to be connected) qualify as suitable. Even if the size and insulation requirements were relaxed, only 6% of properties would be eligible, as the remainder are already on mains gas.

This highlights a key tradeoff between cost-effectiveness and carbon reductions. In the long term, properties using mains gas will need to shift to zero-emission sources for Wirral to achieve deep reductions in its emissions. However, in the short and medium term, switching from gas to electricity-powered heat pumps may not be cost-effective because it involves a high installation and running cost. To further examine the cost implications and potential carbon savings of mass adoption of heat pumps, Wirral and EST agreed to explore a Fuel Switching scenario which is discussed in Section 5.

4.3.3. Biomass Boilers

Installing biomass boilers can be a sensible option for homes in rural areas that are not connected to the gas grid, have access to wood products and have space to store them. Generating heat from biomass can be a more cost-effective and environmentally sustainable option than burning oil or coal, but it depends on how the wood is sourced. For example, a household with access to free waste wood will lower its fuel costs and emissions by switching to biomass, while a home paying for freshly cut wood that is delivered by a company, may not realise the same fuel bill and CO_2 savings.

According to Home Analytics, the potential for biomass boilers in Wirral is negligible (<1%). This assumes that biomass boilers would only be cost-effective for large detached or semi-detached houses (e.g. five or more habitable rooms) that are currently more than 23m off the gas grid and therefore, would not be eligible for a gas grid connection.

4.4. SAP Characteristics

4.4.1. SAP Band

The SAP band (also referred to as the EPC rating) for a property is an indicator of its overall energy efficiency and running costs. As Figure 18 illustrates, SAP bands in Wirral have a normal distribution with nearly half of the stock falling in band D, 45% split evenly between band C and E and the remaining 9% split evenly between bands A-B and F-G.

Compared to larger regional and national trends, Wirral has a lower percentage of properties in the A–C band and a higher percentage in the E band. This is likely because Wirral has more large, old properties with uninsulated, solid walls. If Wirral plans to increase its residential housing stock to a minimum of SAP band C, there will be more properties requiring more significant retrofitting than in an average local authority.

Figure 18 – SAP band of Wirral buildings compared to Northwest and England

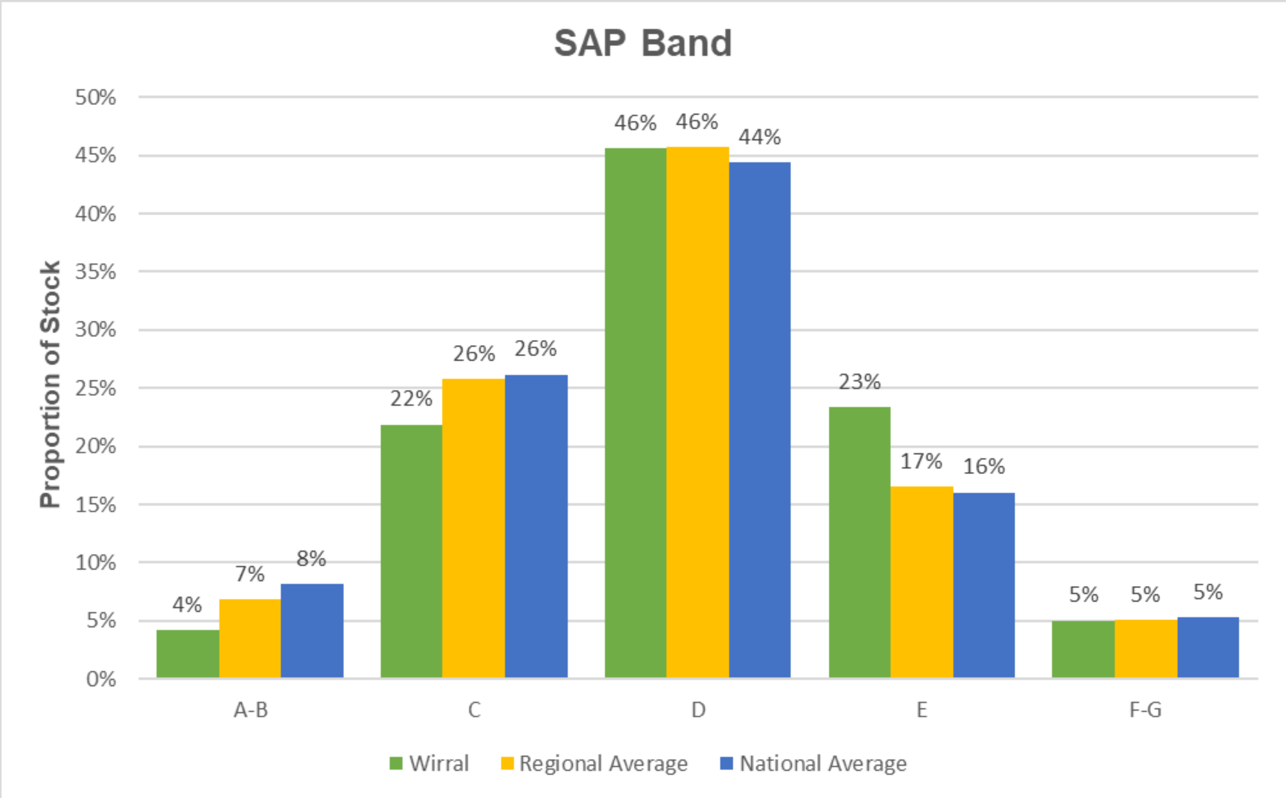


Figure 19 shows the mean SAP score for homes within each LSOA in Wirral. The majority of LSOAs are yellow indicating an average SAP score between 55 and 68 (SAP D), which aligns with the council-level trend in Figure 18. From a targeting perspective, there are 28 LSOAs (orange) that have an average SAP score between 49 and 54 (SAP E) and represent the greatest potential for energy efficiency improvements within Wirral. They are clustered around Wallasey in the north, Bebington in the east and Raby, Thornton and Heswall in the south.

The LSOAs bordering the M53 between Moreton and Bidston have the highest efficiency within Wirral and a relatively low proportion of flats, which suggests they might be better suited for early heat pump adoption rather than further building fabric improvements.

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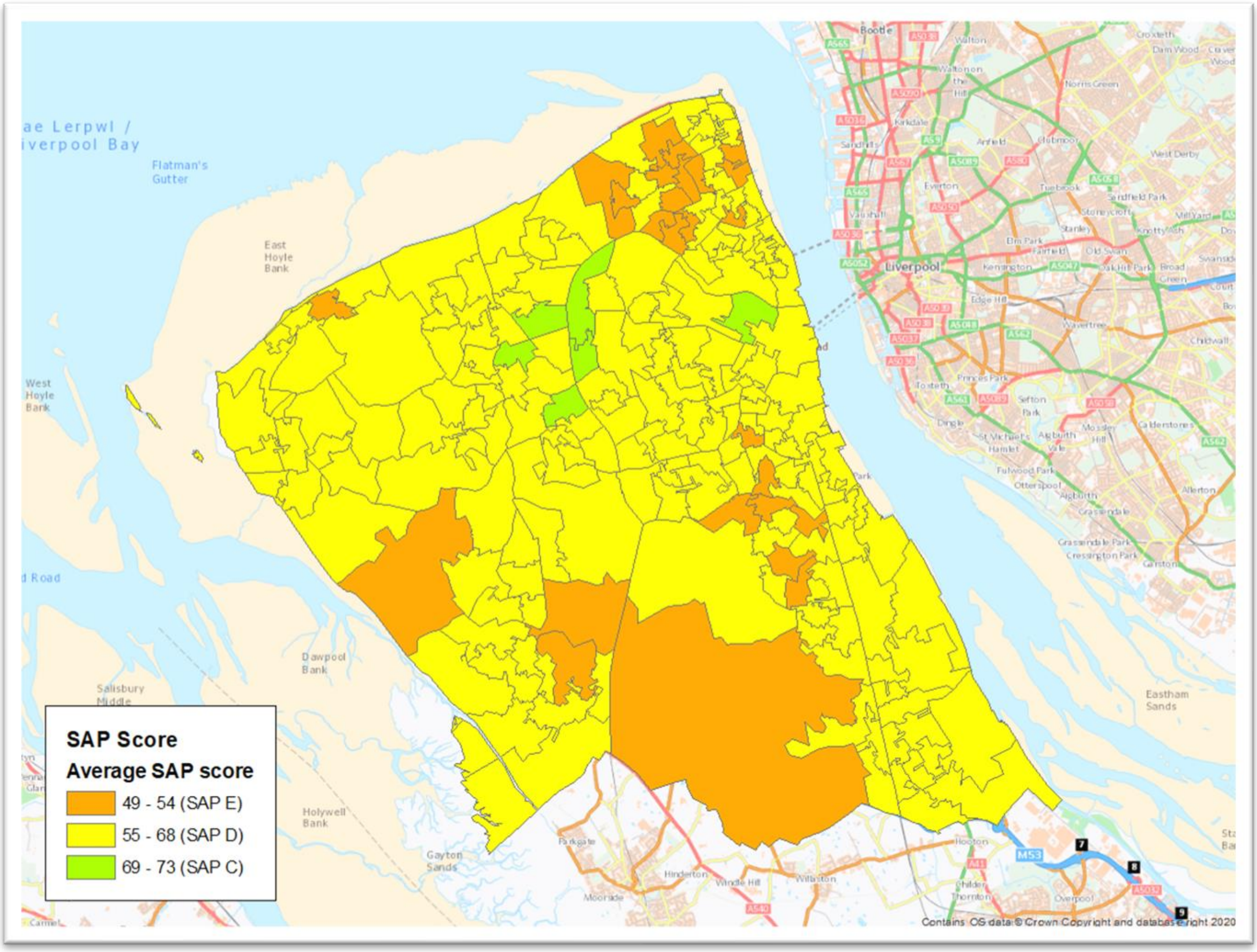
Figure 19 – Average SAP score in Wirral by LSOA

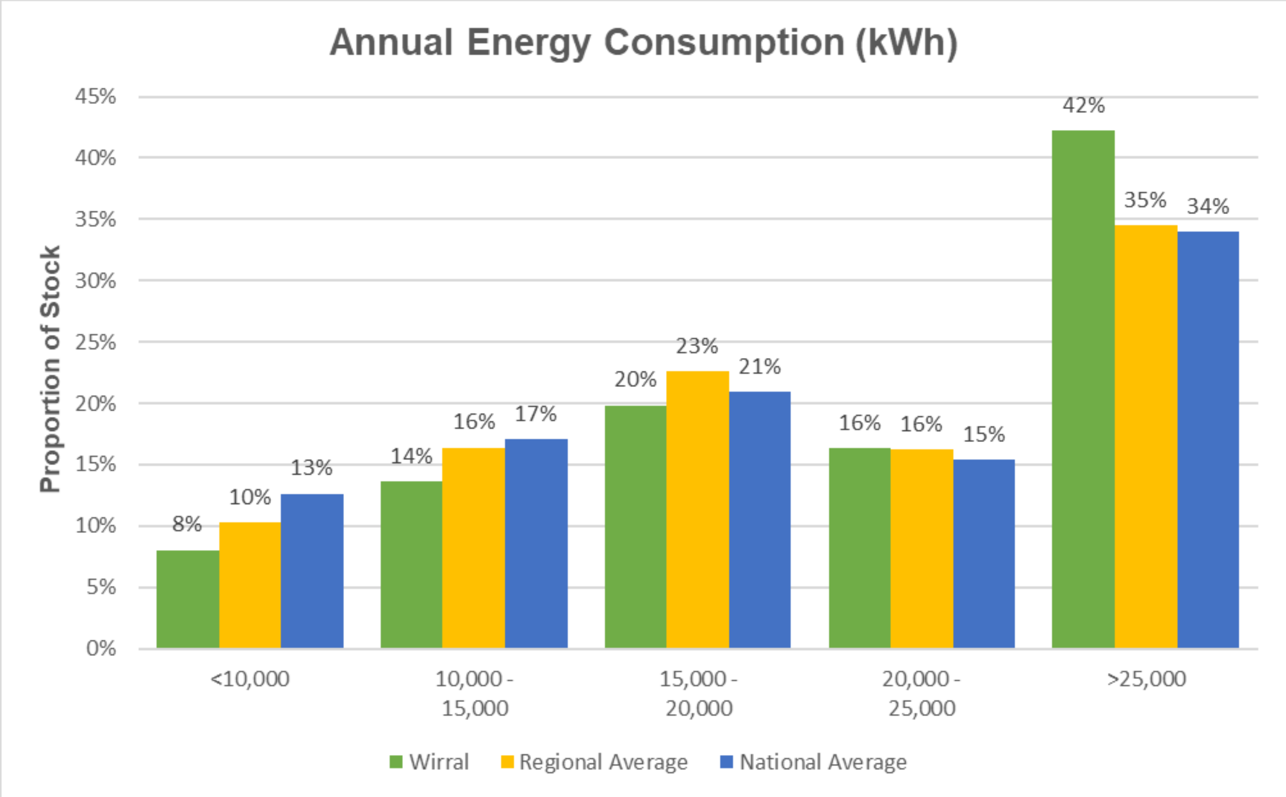


4.4.2. Energy Consumption

Energy demand in Wirral's residential building sector is consistent with the SAP trends observed above. Due to the larger, older, and less efficient nature of the Wirral housing stock, fewer homes fall into the lower bands of consumption and more fall into the higher bands, compared to the regional and national average (Figure 20).

Larger homes have higher space heating demands, so Wirral should have higher average energy consumption. However, implementing upgrades to the building fabric, such as wall, loft, and floor insulation, will help reduce the amount of heat lost and should subsequently, reduce the amount of energy required to heat the home at a comfortable temperature.

Figure 20 – Energy consumption of Wirral buildings compared to Northwest and England

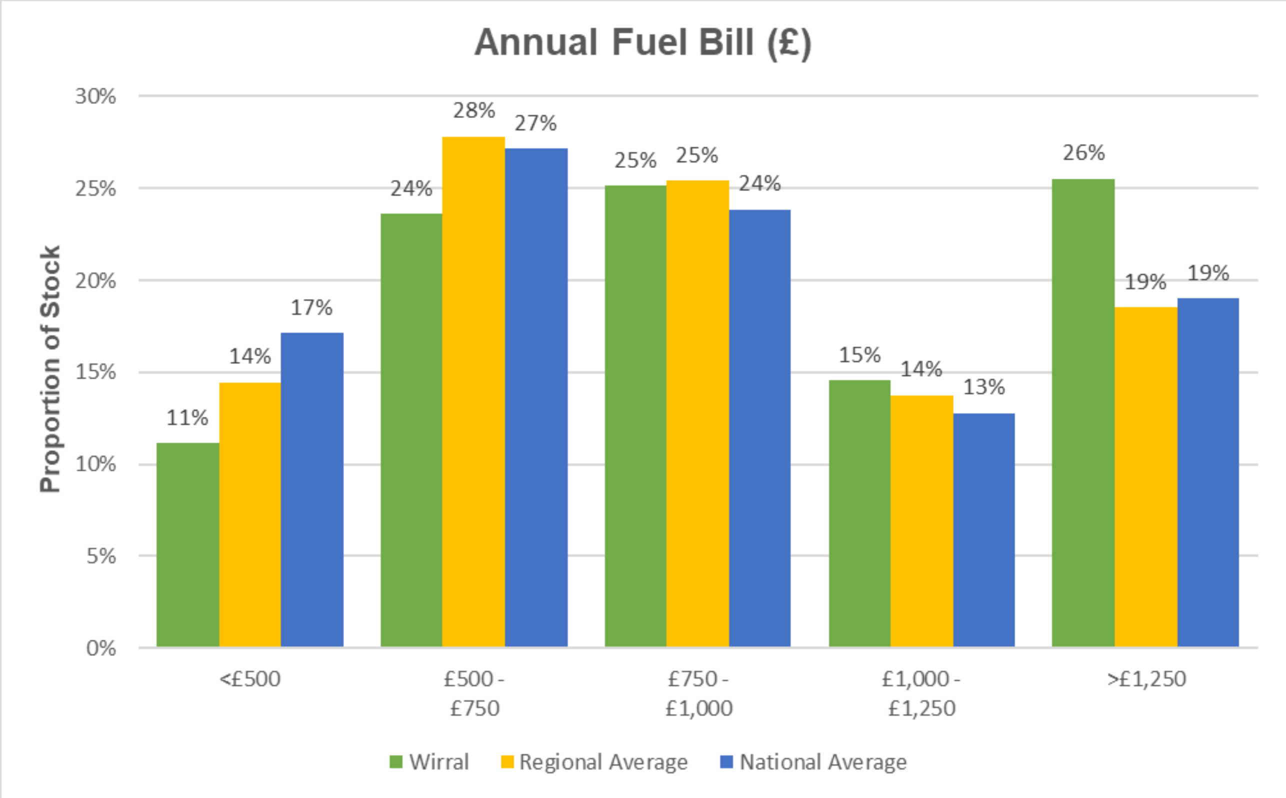


4.4.3. Fuel Bill

Much like energy consumption, there are relatively more residential properties in Wirral with fuel bills in the higher bands (>£1,000/yr) compared to the lower ones (£0-1,000/yr). This comes as no surprise as a property's fuel bill is highly correlated to its energy demand.

It is important to note that the fuel bill figures reported in Figure 21 represent the RdSAP fuel bill (i.e. the theoretical cost of heating the property based on its physical features and SAP assumptions). The actual fuel bill can vary quite substantially from these estimates, depending on occupancy levels, the behaviour of the householders or tenants, as well as their ability to pay (e.g. fuel poverty).

Figure 21 – Fuel bill of Wirral buildings compared to Northwest and England



4.4.4. CO_2 Emissions

As Figure 22 shows, CO_2 emissions in Wirral are slightly higher than the regional and national averages. 52% of homes emit over 4 tonnes of CO_2/yr compared to just 44% in the Northwest and 43% nationally. A higher energy demand in Wirral, is likely the primary driver behind this trend, with the fuel type mix playing a secondary role. Natural gas has recently fallen behind grid supplied electricity as the fuel with the lowest carbon intensity in the UK. Since Wirral has a higher proportion of properties using mains gas, its CO_2 emissions are higher.

Figure 23 illustrates the spatial distribution of CO_2 emissions by LSOA. The areas in the northern, southern and western most parts of Wirral have the highest annual emissions (>6 tonnes CO_2/yr). Many of these LSOAs correspond to the areas with the lowest levels of energy efficiency in Figure 19. Similarly, the areas in green, which emit less than 3 tonnes of CO2/yr, align with the areas in Wirral which have the highest average SAP scores. This reinforces the integral role home energy efficiency improvements play in reducing emissions and achieving reduction targets.

Figure 22 – CO_2 emissions of Wirral buildings compared to Northwest and England

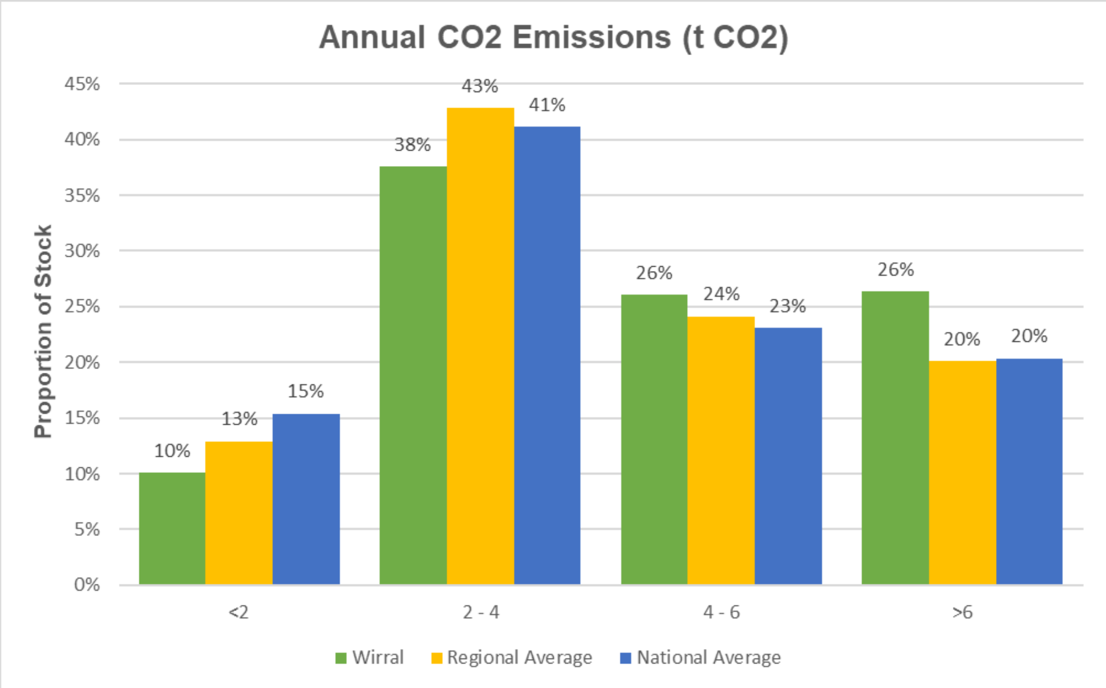
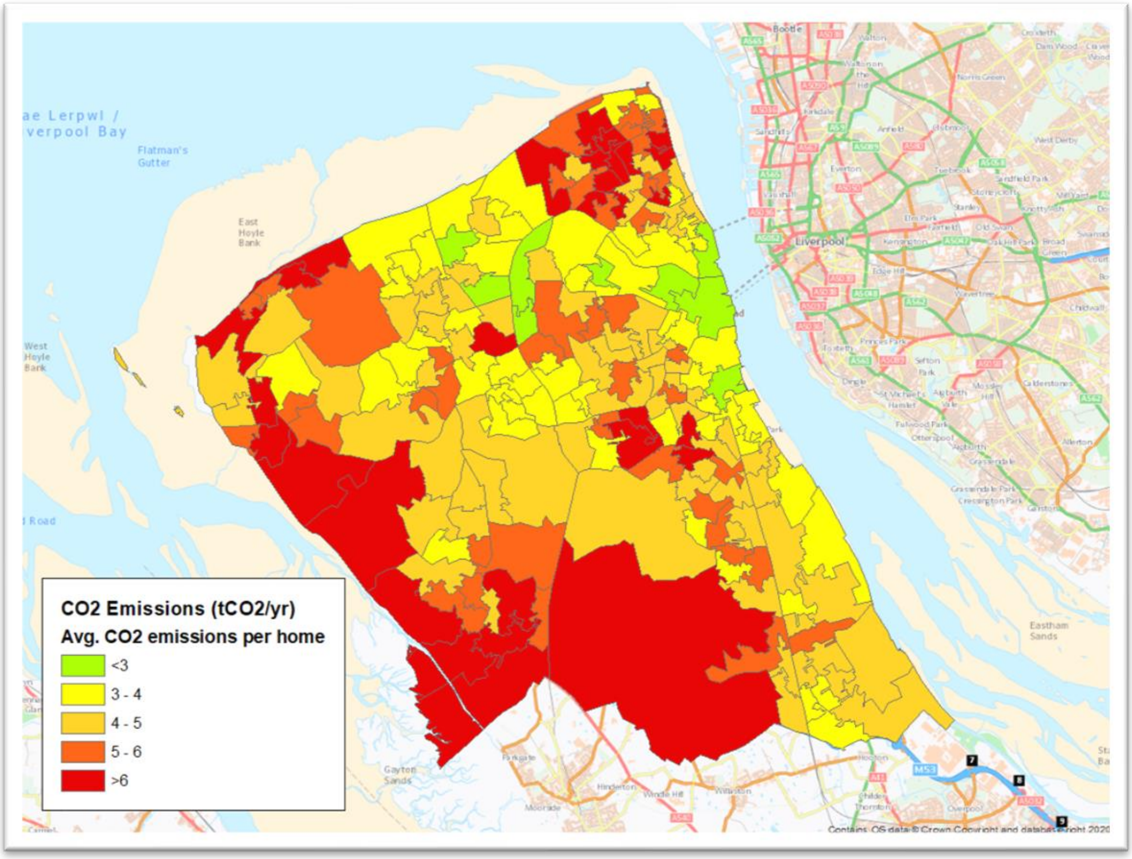


Figure 23 –Average annual CO2 emissions in Wirral by LSOA



5. Retrofit Analysis

This section of the report summarises the results of each PEAT scenario across four key areas of interest: [1] recommended measures, [2] installation costs, [3] SAP score improvement, and [4] savings (e.g. energy, fuel bill, CO_2 emissions). Differences between each scenario are presented and discussed for the whole stock.

5.1. PEAT Scenarios

To model the potential for reducing CO_2 emissions, energy consumption and fuel bills in Wirral, EST performed three scenario analyses using PEAT. Each scenario is summarised with a description and list of assumptions in Table 5 below.

Table 5– Summary of PEAT scenarios

Scenario	Description	Assumptions
Regulatory Standards	Minimum retrofit work required to improve properties to SAP band C.	• Properties below SAP band C are improved up to C (where possible) • Recommended measures based on cost-effectiveness • Homes at/above SAP C are ignored
High Ambition	Measures required for properties to achieve their maximum energy efficiency.	• Considers all homes • No SAP score target • Recommended measures based on cost-effectiveness
Fuel Switching	Measures required for properties to achieve maximum thermal efficiency, accounting for fuel switching.	• Considers all homes • No SAP score target • Fabric measures based on cost-effectiveness • Heat pumps included where feasible (excludes flats)

The first scenario (Regulatory Standards) focused on the properties in Wirral currently below SAP 69 (band C). For these properties, PEAT modelled the minimum retrofit work required to raise their SAP score up to band C.

The second scenario (High Ambition) considered all properties and did not impose any SAP score targets. This means that all cost-effective measures that a property was eligible for were recommended. It is important to note that in this scenario solar PV, solar thermal, ASHPs and GSHPs were not viewed as cost-effective vis-à-vis a modern condensing boiler. Since more than 90% of Wirral's residential stock is on mains gas, these technologies were only considered by PEAT for a small proportion of off-gas properties.

The third scenario (Fuel Switching) prioritised carbon emission reductions over short-term cost-effectiveness and considered the effect of installing heat pumps across Wirral. This scenario had two variants.

The first variant is characteristic of what a 'realistic' approach to heat pump installation might look like in Wirral. It assumed that heat pumps would only be installed in suitable off-gas properties or on-gas properties with a current SAP score of band C or higher (i.e. efficient enough that electrifying heat should not adversely impact fuel bills).

The second variant represented a more theoretical 'upper bound' estimate on emission reductions by forcing PEAT to recommend an ASHP or GSHP for all buildings that are currently suitable to have one installed (on top of any other recommended insulation measures). In both variants, blocks of flats were deemed unsuitable for heat pumps and instead used default heating system assumptions (e.g. upgrades to gas condensing boilers).

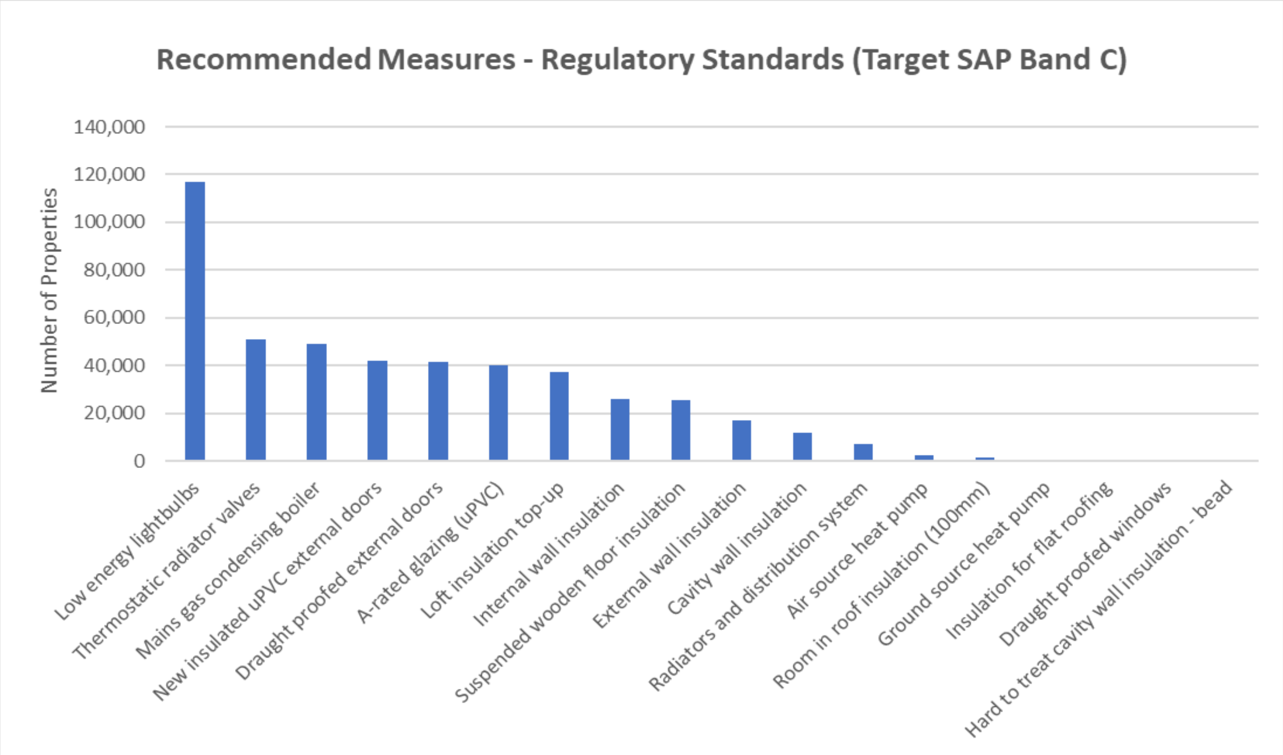
5.2. Recommend Measures

5.2.1. Regulatory Standards

Figure 24 shows the measures PEAT recommended under the Regulatory Standards scenario. Since most properties below SAP band C were within 10 or 15 points of reaching SAP 69, the measures recommended under this scenario are generally lower cost and less intrusive to install. Home Analytics does not contain information on lighting, so by default PEAT assumed that all properties could have 50% of their lighting outlets upgraded to low energy lightbulbs. Condensing boilers and thermostatic radiator valves were the next most common measures (~50,000 properties), followed by new insulated uPVC doors, draught proofed external doors, and A-rated uPVC glazing (~40,000 homes).

The next tier of measures included more costly insulation measures. Loft insulation top-ups were recommended in over 37,000 properties, followed by internal wall insulation and suspended wooden floor insulation (~26,000 properties), external wall insulation (~17,000 properties) and cavity wall insulation (~12,000 properties). Under this scenario, only about 3,000 properties had ASHPs or GSHPs recommended. This is because they are typically the most expensive measure to install and are only considered for off-gas properties, which accounts for a very small proportion of the total properties with a starting SAP score below band C.

Figure 24 – Recommended measures under Regulatory Standards scenario



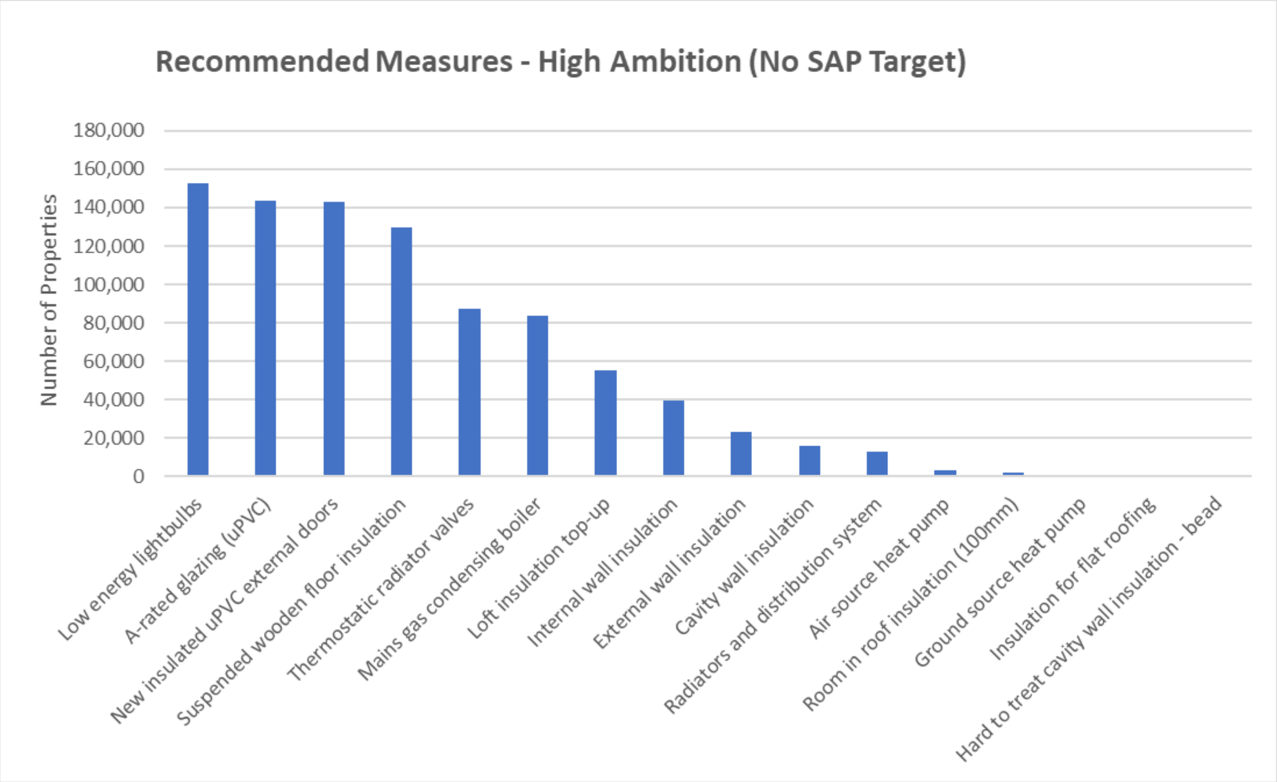
5.2.2. High Ambition

Figure 25 shows the measures PEAT recommended under the High Ambition scenario. Since this scenario considered all properties (even those already above SAP band C) and all cost-effective measures, there were more total measures recommended under this scenario. Like the Regulatory Standards scenario, low energy lighting, A-rated glazing and new insulated uPVC external doors were at the top of the list, with these upgrades recommended in nearly all properties.

Interestingly, the number of recommendations for suspended wooden floor insulation increased by a factor of 5 from the first scenario to nearly 130,000 properties. This corresponds with the observations from Section 4, which identified floor insulation as a large potential opportunity for improving energy efficiency across the Wirral stock. After condensing boilers and thermostatic radiator valves (~85,000 properties), the remaining insulation measures were recommended in 16,000–55,000 properties.

Under this scenario, approximately 300 more properties were recommended to have heat pumps beyond those identified in the Regulatory Standards scenario. This count is marginally higher because the SAP target imposed in the Regulatory Standards scenario was removed, enabling a handful of properties to consider extra measures.

Figure 25 – Recommended measures under High Ambition scenario



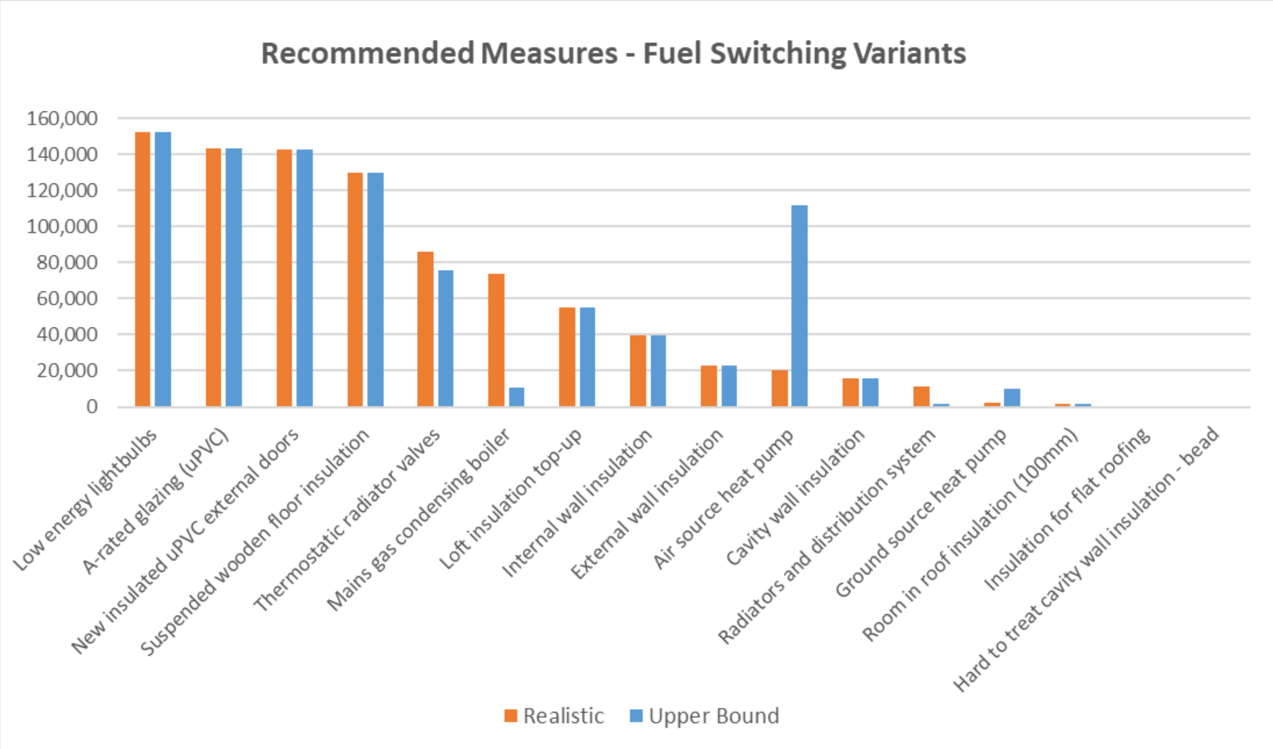
5.2.3. Fuel Switching

Figure 26 shows the measures PEAT recommended under the Fuel Switching scenario. Since the premise of this scenario was to prioritise carbon reductions over efficiency improvements or cost-effectiveness, both variants (realistic, upper bound) resulted in fewer gas boiler upgrades and more heat pump installations than the High Ambition scenario.

In the realistic variant, ASHPs and GSHPs were recommended in over 22,000 homes (14.6% of the stock). In the upper bound variant, this number grew to ~122,000 homes (80% of the stock). The only homes deemed unsuitable for heat pumps in this variant were blocks of flats, which account for 20% of the stock in Wirral. Due to the higher cost and additional space requirements of GSHPs, 90% of all recommended heat pump installations were for ASHPs.

With fewer heat pumps recommended, the realistic variant had significantly more recommendations for condensing boilers (~63,000), thermostatic radiator valves (~10,000) and radiators/distribution systems (~10,000) compared to the upper bound variant.

Figure 26 – Recommended measures under Fuel Switching scenario



5.3. Costs and Savings

5.3.1. Installation Costs

Under the Regulatory Standards scenario, an investment of approximately £806 million would be required to fund all ~470,000 recommended measures. On average each property would have about four measures installed, with a cumulative installation cost of £6,895.

Under the High Ambition scenario, there were ~892,000 measures recommended (+89%) which would require an investment of £1.8 billion (+123%) to install. On average each property would have nearly six measures installed, with a cumulative installation cost of £11,800 (+71%).

The total investment cost in each scenario is dependent on the number of properties considered in the model, the number of measures recommended and each measure's relative installation cost. The total investment under the High Ambition scenario is significantly higher in comparison to the Regulatory Standards scenario because it:

- Includes an additional ~35,000 properties with starting SAP bands of C or higher
- Assumes nearly 2 more measures per property
- Considers more high-cost measures, such as floor and wall insulation

Under the realistic variant of the Fuel Switching scenario, there were ~900,000 measures recommended, with a total investment of £1.9 billion. Interestingly, the cost of this variant is only £100 million (5%) higher than the High Ambition scenario, despite PEAT recommending about six times as many heat pumps. This is because instead of investing in many lower cost boiler upgrades, this scenario recommended Wirral invest in a few, higher priced heat pump upgrades, due to their carbon reduction potential. Consequently, the percentage of homes with a boiler upgrade recommended was 6.4% lower in this scenario.

Under the upper bound variant of the Fuel Switching scenario, there were ~915,000 measures recommended, requiring an investment of £2.4 billion to install. This cost is nearly 30% higher than both the High Ambition scenario and the realistic variant because heat pump uptake is 80% (compared to just 14.6% and 2.2%) and the average heat pump cost (£6,615) is nearly 3 times as high as the average boiler upgrade (£2,040). With boiler upgrades in the High Ambition scenario replaced by heat pumps in the Fuel Switching scenario, each property still had approximately six measures installed.

Table 6 – Summary of measure counts and investment costs by scenario

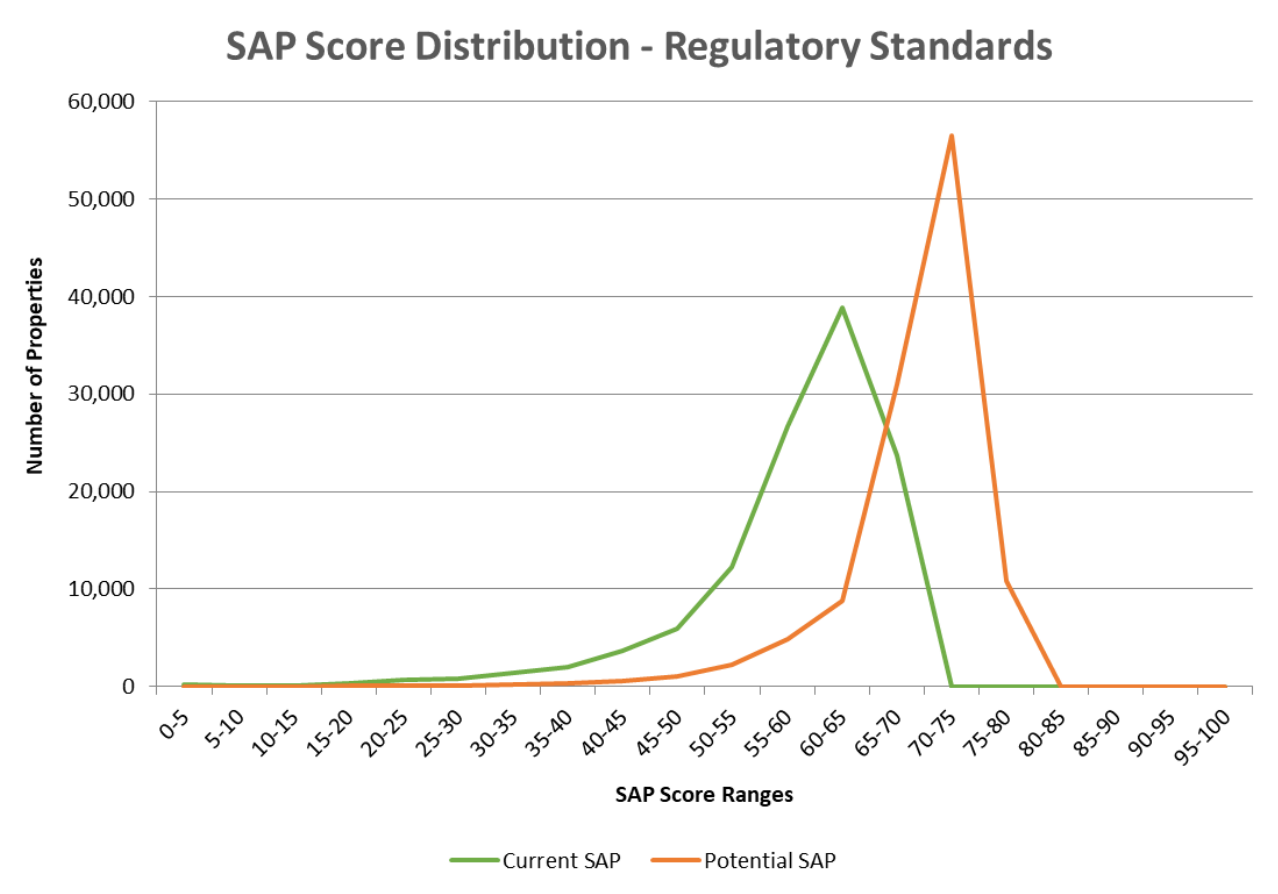
Scenario Statistic	Regulatory Standards	High Ambition	Fuel Switching	
			Realistic	Upper
Total recommended measures	470,575	892,061	898,076	914,855
Recommended measures per home	4.0	5.9	5.9	5.9
Total investment	£0.8 billion	£1.8 billion	£1.9 billion	£2.4 billion
Investment per home	£6,894	£11,799	£12,458	£15,760
Boiler upgrades (% of stock)	32.2%	54.9%	48.5%	0.0%
Heat pump uptake (% of stock)	2.0%	2.2%	14.6%	80.0%

5.3.2. SAP Score Improvement

Under the Regulatory Standards scenario, the average starting SAP score of properties below SAP band C was 58. If all recommended measures were installed, the average SAP score would increase to 69. Figure 27 shows how the distribution of the SAP scores within the stock would change with these measures implemented.

While the majority of properties could be improved to meet a minimum standard of SAP band C, there were ~25,000 properties (16% of the total stock) that would struggle to achieve this level of efficiency in a cost-effective way. Given the total costs detailed in Table 6, the overall SAP improvement achieved under this scenario translates into a cost of £627 per SAP point increase.

Figure 27 – SAP score improvement for Regulatory Standards scenario



Under the High Ambition scenario, the average starting SAP score of all residential properties in Wirral was 62. This is higher than the Regulatory Standards scenario because it included the whole stock (i.e. properties below and above SAP band C). If all recommended measures were implemented, the average SAP score would increase to 73. Figure 28 illustrates how the distribution of the SAP scores would change from the baseline, with these measures implemented. The overall SAP improvement achieved under this scenario translates into a cost of £1,086 per SAP point.

Under the Fuel Switching scenario, the SAP score would increase to 72.4 in the realistic variant and 70.5 in the upper bound. The reason the SAP scores are lower than the High Ambition scenario is because electricity is a higher cost fuel than gas and, given current heat pump efficiencies, is more expensive to run. Since the SAP score is a function of energy efficiency and running costs, it is not surprising that expanding heat pump adoption into homes in which they are not currently cost-effective, results in a minor reduction in SAP score. In the future, we would expect to see this trend reverse as the difference between the gas and electricity price shrinks and heat pump efficiencies improve.

Figure 29 illustrates the impact of the two Fuel Switching variants on SAP score. Under the realistic variant, the cost per SAP point improvement is £1,164 compared to £1,771 in the upper bound variant.

Figure 28 – SAP score improvement for High Ambition scenario

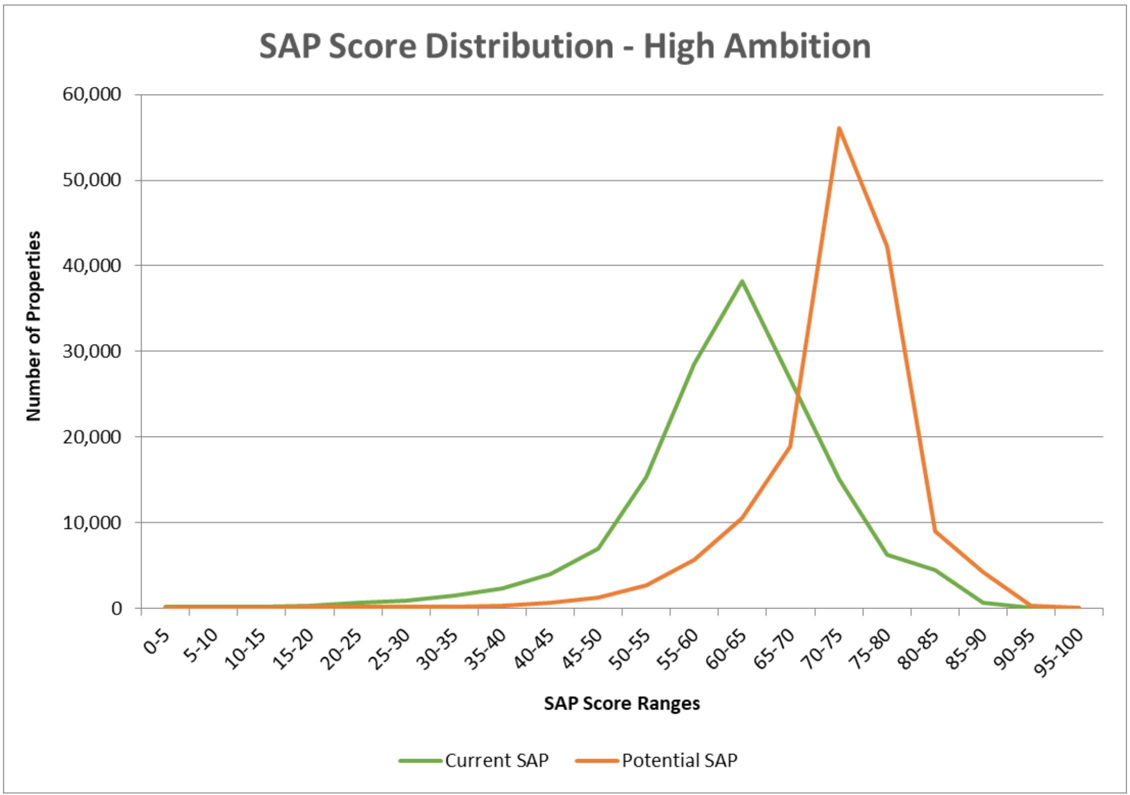
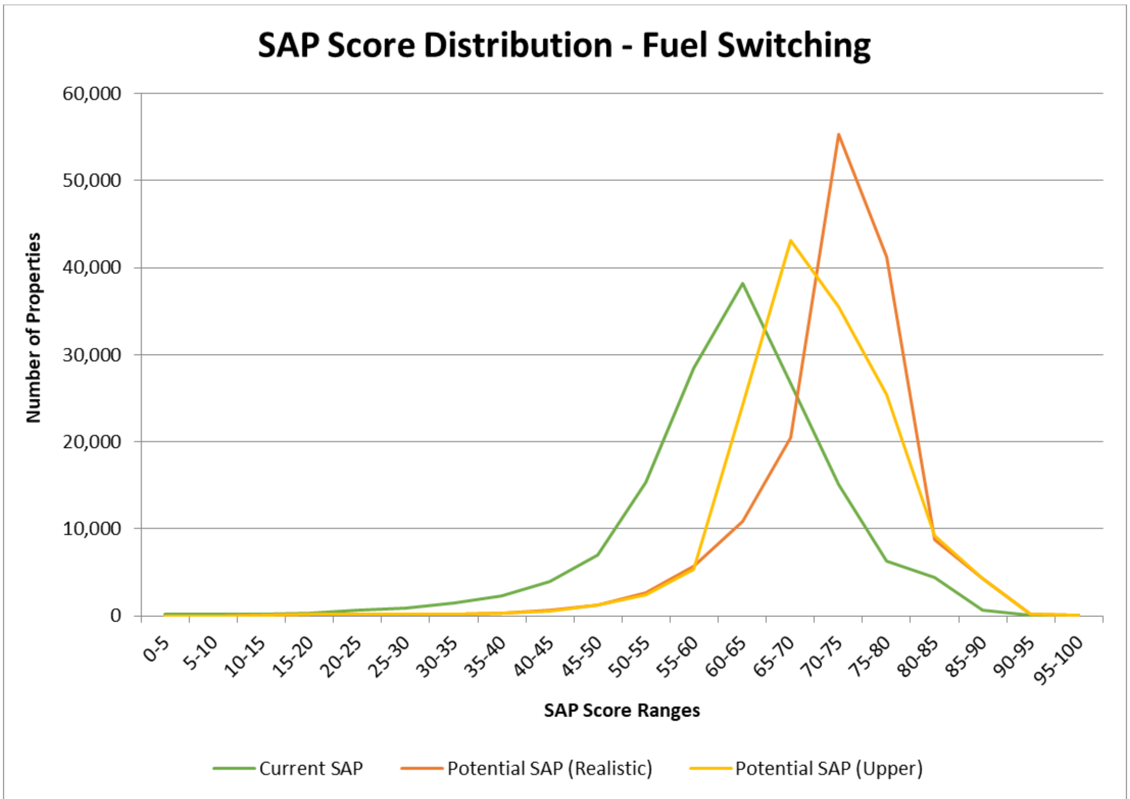


Figure 29 – SAP score improvement for Fuel Switching scenario



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5.3.3. Energy and Fuel Bill Reductions

Under the Regulatory Standards scenario, annual energy consumption in Wirral would decline by 13% or 523 GWh/yr. On average, this would equate to a saving of 4,478 kWh per SAP D-G building. As a result of these recommended measures, average annual fuel bills would decline by £287/yr (29% saving).

Under the High Ambition scenario, energy demand would decline by 19% or 754 GWh. On average, this would equate to a saving of 4,952 kWh per building in Wirral. The average fuel bill would decline by £307/yr (31% saving). The savings are marginally higher in the High Ambition scenario compared to the Regulatory Standards scenario because although deeper reductions are achieved in less efficient homes, the effect of these improvements is spread out over more properties, with the SAP A-C properties starting at a lower energy consumption and fuel bill level.

Under the realistic Fuel Switching scenario, energy demand would also decline by 20% (793 GWh/yr). In the upper bound variant, the saving increases to 30% or 1.2 TWh/yr. On average, this would equate to home-level savings of 5,204 kWh/yr and 7,810 kWh/yr. The average fuel bill would decrease by £280/yr (realistic) and £227/yr (upper bound) respectively. The fuel bill savings are lower in the Fuel Switching scenario compared to the High Ambition scenario because heat pumps increase electricity consumption, which is a higher cost fuel than gas, thereby resulting in higher fuel bills.

5.3.4. CO_2 Emission Reductions

Under the Regulatory Standards scenario, annual CO_2 emissions in Wirral would decline by 14% or ~100,000 tCO_2/yr. On average, this would equate to a saving of 0.86 tCO_2/yr per SAP D-G building. Under the High Ambition scenario, annual CO_2 emissions in Wirral would decline by 20% or ~140,000 tCO_2/yr. On average, this would equate to a saving of 0.9 tCO_2/yr per property.

These emission reductions represent the potential savings that can be achieved through standard energy efficiency measures such as lighting, glazing, draughtproofing, boiler upgrades, and insulation. Outside of the 8% of homes that are currently off the gas grid in Wirral (which were considered for ASHP and GSHP systems), the remaining 92% of the stock has assumed no switching from gas boilers to heat pumps or solar PV/thermal systems. This is because PEAT prioritises cost-effectiveness over emission reductions.

Under the realistic Fuel Switching scenario, annual CO_2 emissions in Wirral would decline by an additional 0.5% compared to the High Ambition scenario (~144,000 tCO_2/yr). Under the upper bound variant, annual CO_2 emissions in Wirral would decline further (26% or ~184,000 t CO_2/yr), resulting in a saving of 1.2 t CO_2/yr per home. In both cases, dwellings that were not suitable for heat pumps (e.g. flats) were considered for boiler upgrades instead.

The reason that the Fuel Switching scenarios provide only modest carbon savings beyond the High Ambition scenario is that the carbon factor used for grid supplied electricity in PEAT is set at 308 tCO2e/kWh (based on DEFRA's 2019 Greenhouse Gas emissions factors). BEIS modelling predicts that this will drop to 130 tCO2e/kWh in 2030, 41 tCO2e/kWh in 2040 and 28 tCO2e/kWh by 2050. Based on these projections, the carbon savings reported by PEAT should be viewed as a lower bound estimate. As the carbon intensity of the electricity supply mix declines over time, the carbon savings delivered by heat pumps and other insulation measures will increase. In order to approach net zero emissions by 2050, Wirral will need to transition its residential buildings from gas to a mix of electrically-powered heat pumps, solar thermal systems, as well as district heating networks. In the short run, some of these technologies will not be cost-effective, but this will change as the carbon intensity drops and prices start to fall.

6. Green Homes Grant Targeting

Using Home Analytics, EST has developed several indicators of eligibility for the Green Homes Grant fund. By combining these indicators with other property attributes stored in the database, EST has produced a series of maps which identify potential hotspots for eligibility that the Council may wish to focus on in the short-term, while funding is available.

6.1. Scheme Details

In October 2020, the UK government launched the Green Homes Grant (GHG) fund – a national scheme in England and Wales which allows homeowners or residential landlords to apply for a voucher to cover the cost of installing energy efficient improvements in their home. As Table 7 shows, eligible measures include insulation, low carbon heating, windows, doors, and heating controls, split across two types of measures: primary and secondary.

Table 7– Summary of Green Homes Grant eligible measures

Type	Category	Eligible Measures
Primary	Insulation	• Solid wall insulation (internal or external) • Cavity wall insulation • Under-floor insulation (solid floor, suspended floor) • Loft insulation • Flat roof insulation • Pitched roof insulation • Room in roof insulation • Insulating a park home
	Low carbon heating	• Air source heat pump • Ground source heat pump • Solar thermal • Biomass boiler • Hybrid heat pump
Secondary	Windows & doors	• Draught proofing • Double or triple glazing • Secondary glazing (in addition to single glazing) • Energy efficient replacement doors
	Heating controls & insulation	• Hot water tank thermostat • Hot water tank insulation • Heating controls (e.g. appliance thermostats, smart heating/zone controls, intelligent delayed start thermostat, thermostatic radiator valves)

A GHG voucher must be used to install at least one eligible primary measure in a household. If a primary measure is installed, then part of the voucher may also be used to install eligible secondary measures. For most households, the voucher will cover two-thirds of the cost of eligible improvements, up to a maximum contribution of £5,000. For households in receipt of specific benefits, the voucher may be eligible to cover the full cost of the improvements, up to £10,000.

6.2. Modelling GHG Eligibility

When modelling GHG eligibility, EST focused on identifying primary measures, as these are a dependency for a household to qualify for funding. For each property in Wirral, Home Analytics holds information on wall type and insulation, floor type and insulation, loft insulation, as well as suitability for the low carbon heating technologies. This enabled EST to estimate GHG eligibility for each property as a binary flag (e.g. 'Eligible', 'Not eligible') and as a count of eligible primary measures. To avoid double counting measures, all low carbon heating measures were treated as a single measure (i.e. if a home was eligible for an ASHP and GSHP, its measure count would be 1).

Figure 30 – Percentage of GHG eligible homes in LSOA

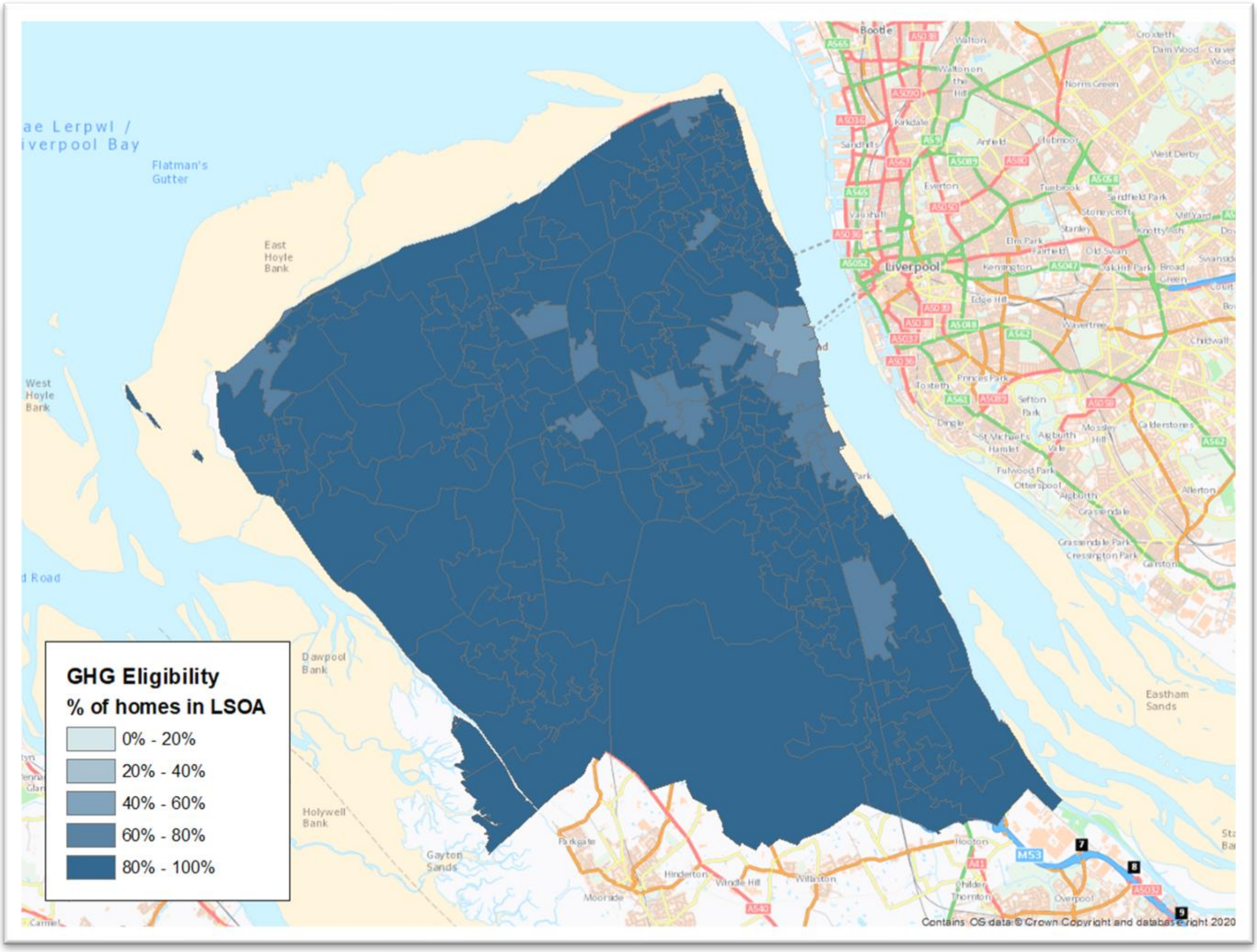
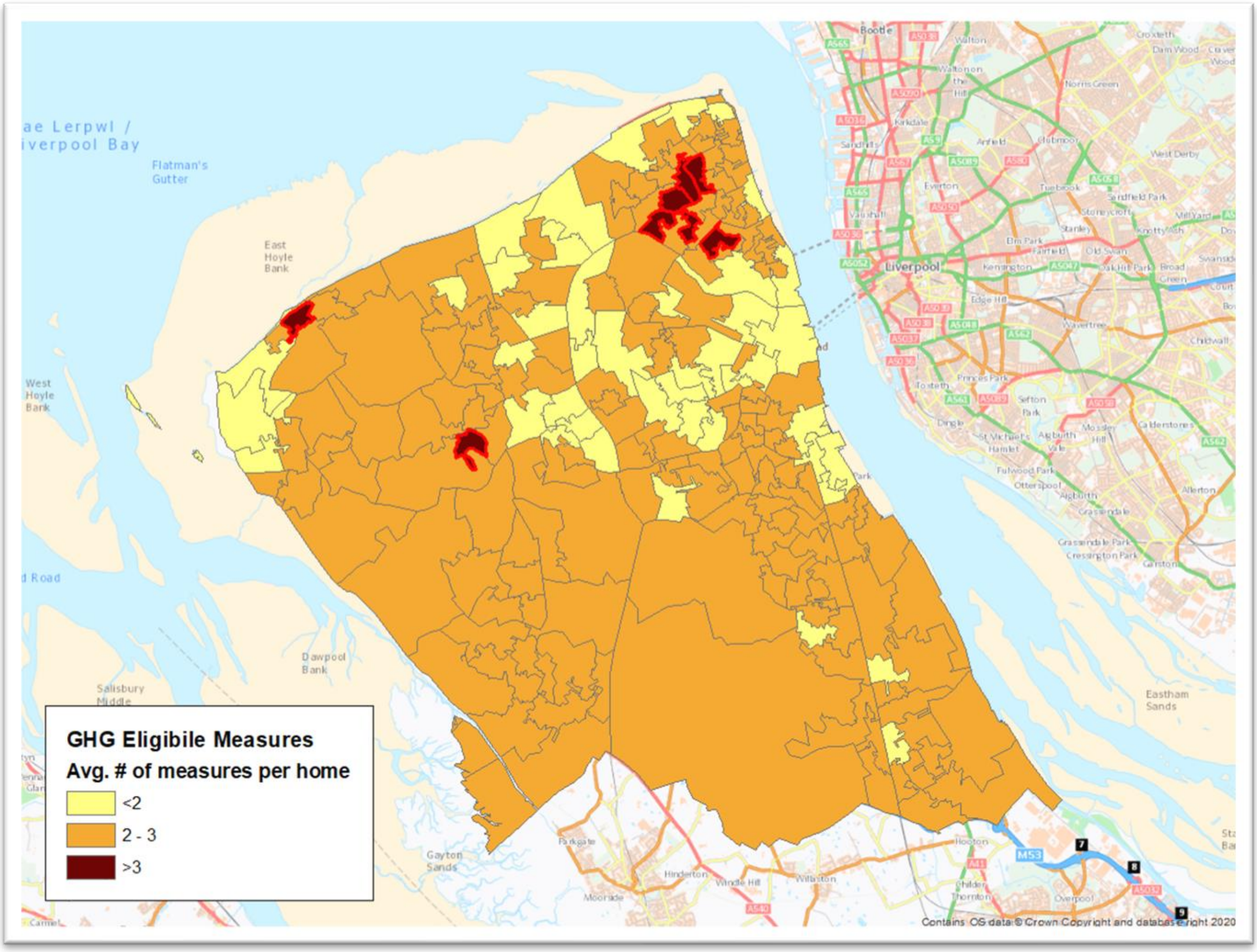


Figure 30 shows the percentage of homes in each LSOA that Home Analytics deemed eligible for GHG funding. Since over 90% of homes in Wirral have uninsulated floors, most homes in the council qualified for the GHG scheme on this basis alone. Figure 31 provides a more useful picture of eligibility by showing the average number of eligible measures per home. The darker LSOAs (outlined in red), identify areas where properties are likely to qualify for three or more measures and therefore, have more potential for targeting. This includes the following eight LSOAs: Wirral 0140, Wirral 004A, Wirral 007A, Wirral 004B, Wirral 023A, Wirral 007E, Wirral 004E and Wirral 004F.

Figure 31 – Average number of GHG eligible measures in home by LSOA



Households in receipt of specific benefits are eligible for a higher maximum voucher value, therefore it was important to group these households separately. Although household-level benefits data is not publicly available due to its sensitive nature, the Department for Work and Pensions (DWP) publishes counts of recipients of all relevant benefits programmes at the COA level. By analysing this data, EST identified all COAs with a benefit claimant count in the top quartile nationally. All GHG-eligible households in these COAs, were assumed to be eligible for the low-income voucher amount.

Figure 32 – Percentage of low-income GHG eligible homes in LSOA

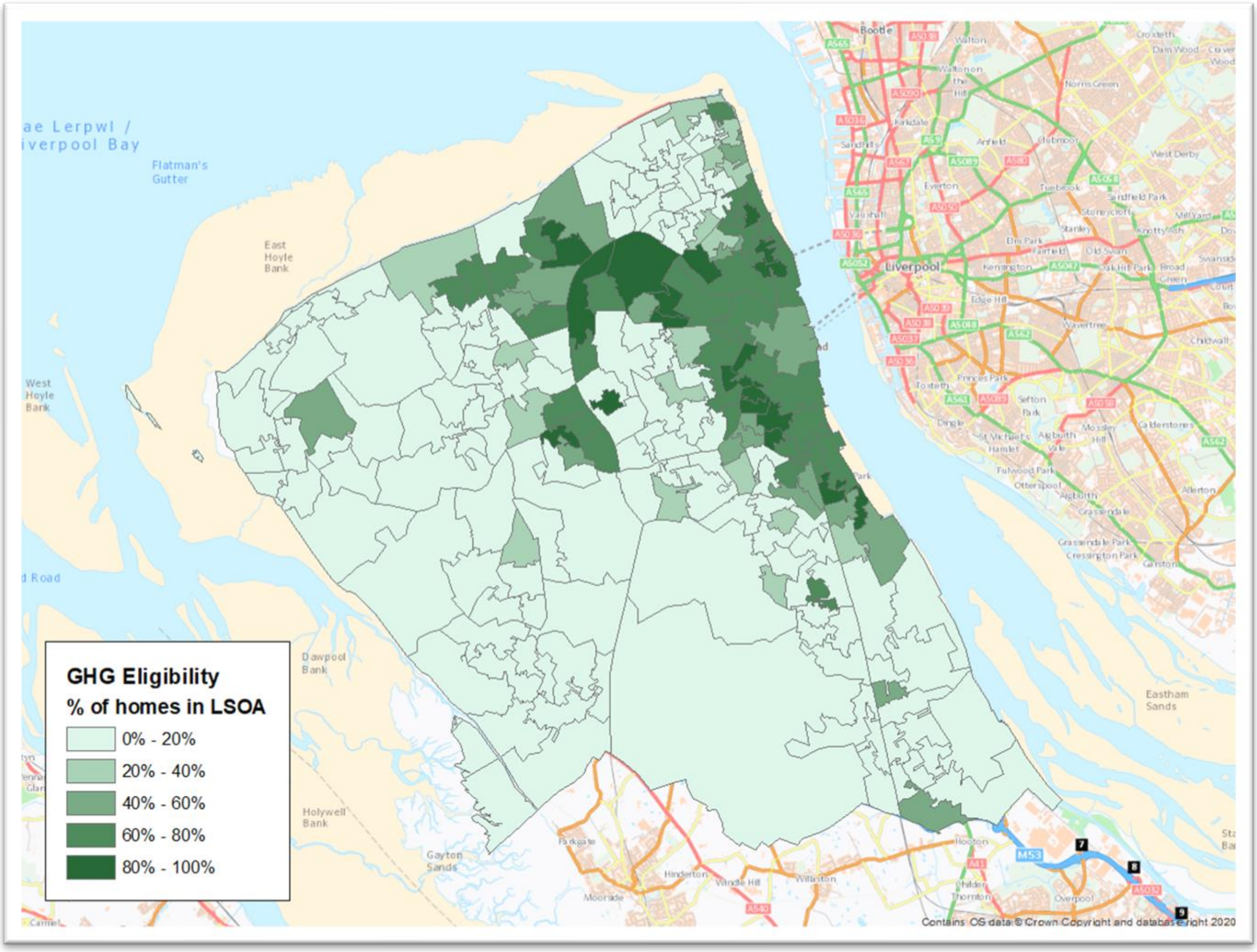


Figure 32 shows the percentage of low-income eligible home by LSOA. Interestingly, many of the areas with high proportions of eligible low-income homes overlap with the areas that have the fewest eligible measures in Figure 31. The likely explanation for this trend is that households in receipt of benefits are more likely to be living in social housing, which typically has higher energy efficiency standards and therefore, fewer opportunities for improvement. The spatial distribution of social housing units shown in Figure 33 and the distribution of SAP bands by tenure type (Figure 34) support this hypothesis.

Figure 33 – Percentage of homes in social housing by LSOA

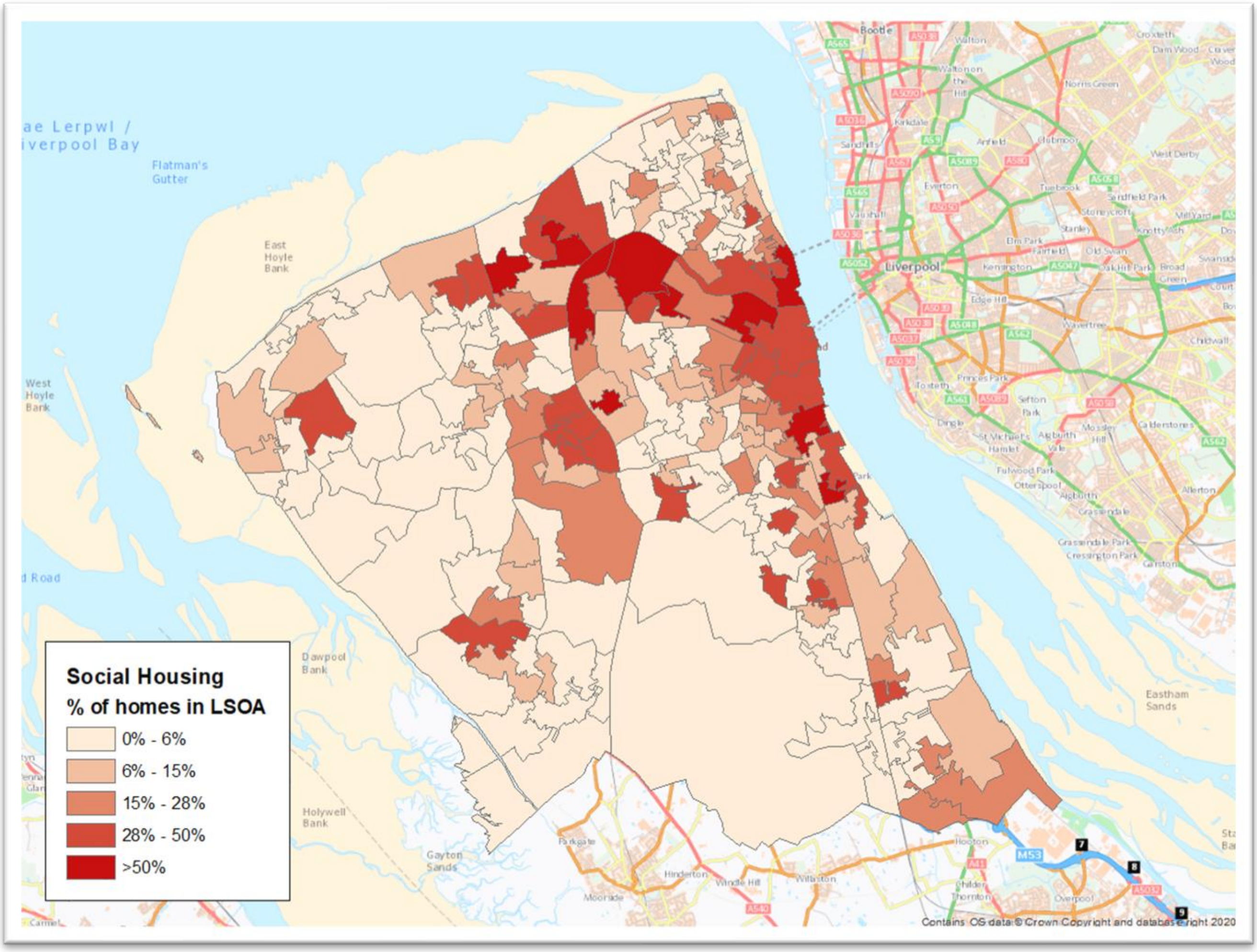
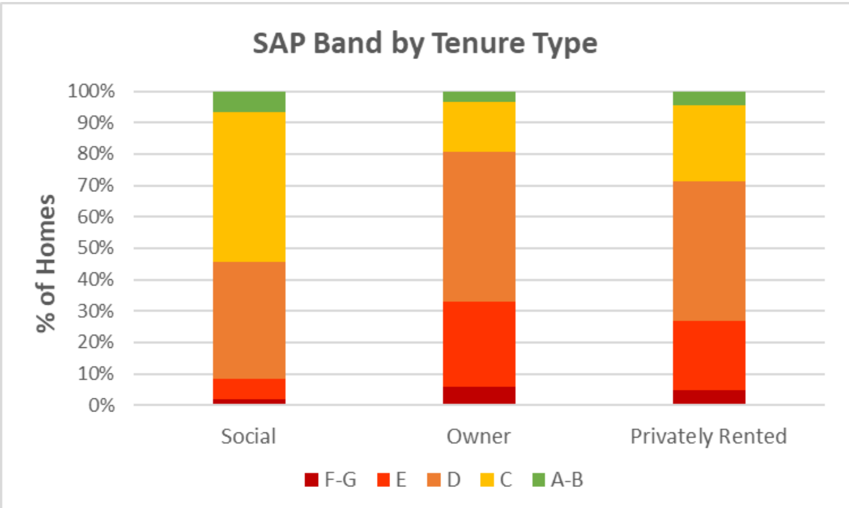


Figure 34 – Distribution of Wirral SAP bands by tenure type



6.3. Able-to-Pay Households

Although a home could be eligible for primary measure funding, there may be other constraints preventing the household from undertaking the improvement. The first factor is cost. While the GHG fund covers two-thirds of the cost of the home improvement (up to £5,000), households that are not in receipt of benefits, still need to cover the remaining one-third. Given the relatively high cost of solid wall insulation, floor insulation, heat pumps and solar systems, it is possible that the household may not be in a financial position to cover the remaining expense.

The second factor is ownership, specifically regarding rental properties. Although a property may qualify for GHG funding based on its physical attributes, it is possible that the landlord may not wish to invest in eligible upgrades because they are not living in the property and therefore, will not receive the benefit of lower fuel bills. Similarly, the tenant will not want to invest in a property that they do not own. This is commonly referred to as the split-incentive problem and is one of the main hurdles to energy efficient improvements in the private rented sector.

The third factor is property type. This relates directly to the logistical challenges and costs associated with installing primary measures in a home. For example, it is more complex and costly to install external wall insulation in a block of flats compared to a detached home, due to the larger surface area of the wall and the number of units and householders affected by the work.

The fourth factor is the current efficiency of the home. If a property has already had significant upgrades installed, then the incremental fuel bill savings achieved through additional improvements may be smaller and therefore, less attractive as an investment to the homeowner. It is also in the council's interest to encourage uptake in homes where the biggest impact can be made. Taking these factors into account, homes that have already achieved a SAP band of C or higher are less likely to participate in the GHG scheme and should be de-prioritised in targeting.

To help Wirral identify areas where able-to-pay homes are most likely to participate in the GHG scheme and in greatest need of improvement, EST began with the GHG eligibility indicator derived from Home Analytics. Due to the high cost of low carbon heating technologies, uncertainty around Wirral's long-term approach to fuel switching, as well as the difficulty of assessing heating system suitability without conducting site assessments, EST created a second GHG eligibility flag based only on primary insulation measures.

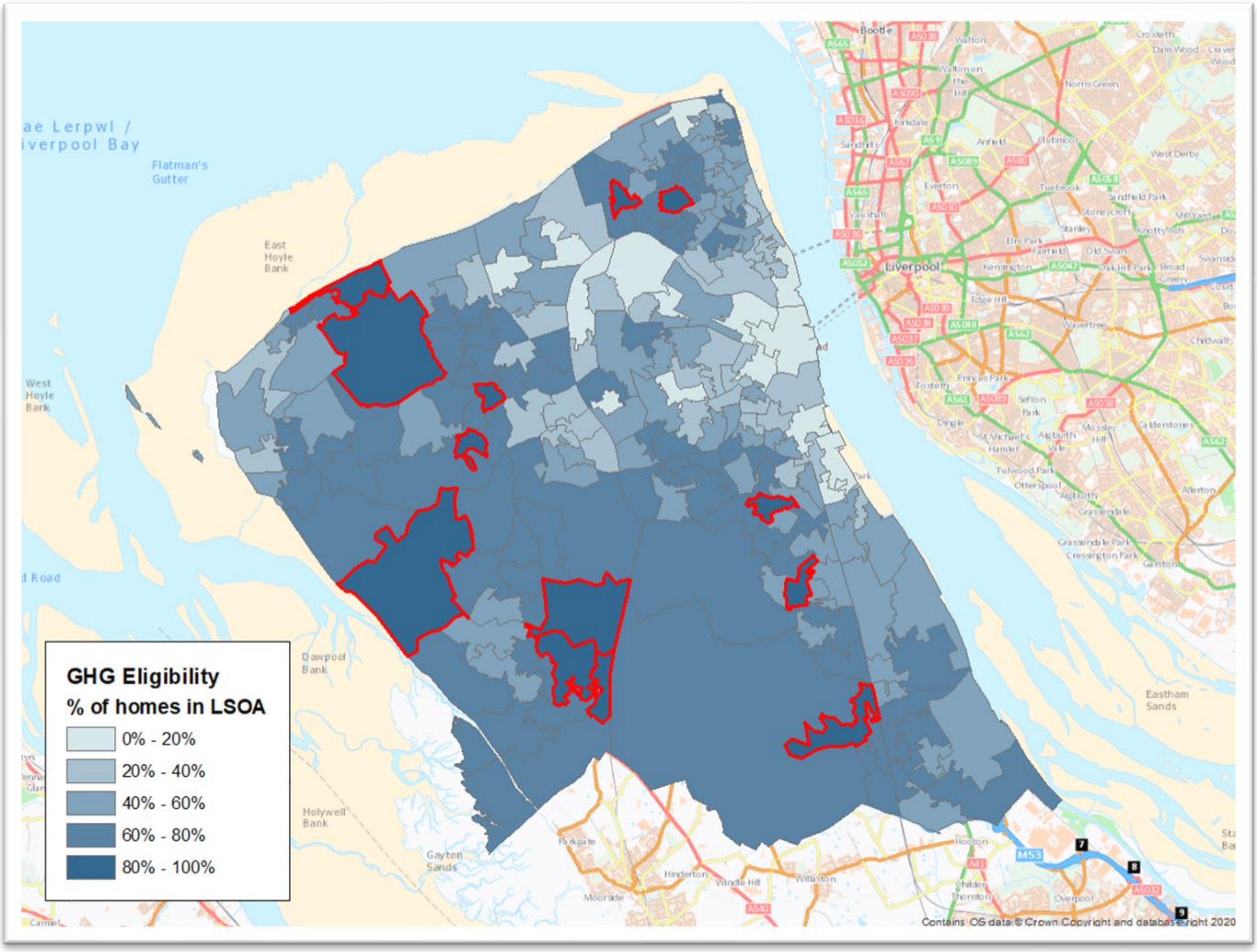
Since eligibility for these measures is known from EPCs, modelled more accurately, and more likely to be the target of the grant funding (due to lower average installation costs and support for a fabric-first approach to retrofits), the insulation-only indicator represents a more realistic indicator of GHG eligibility within the council. EST then applied three additional address-level criteria to further refine the analysis:

- Property tenure = Owner occupied
- Property type = Detached, semi-detached, mid-terraced or end-terraced house
- Current SAP band = D-G

The map presented in Figure 35 illustrates the spatial pattern of the above targeting, when aggregated at the LSOA level. By focusing on the able-to-pay homes that are most likely to participate in the GHG scheme, we see a considerably more refined picture of eligibility, compared to the map in Figure 30.

Not surprisingly, the area with the highest number of benefit claimants and low-income eligibility (identified in Figure 32), also has the lowest level of eligibility amongst able-to-pay households in Wirral. While the property constraints have reduced eligibility across the city, there are still 13 LSOAs (outlined in red) where at least 80% of dwellings are eligible for GHG funding. This includes the following LSOAs: Wirral 032A, Wirral 038E, Wirral 035D, Wirral 034A, Wirral 040A, Wirral 040C, Wirral 013A, Wirral 013B, Wirral 023A, Wirral 017C, Wirral 033B, Wirral 003E and Wirral 004F. These areas represent the best opportunities for targeting GHG eligibility among the able-to-pay segment of households.

Figure 35 – Targeted GHG eligibility (able-to-pay segment)

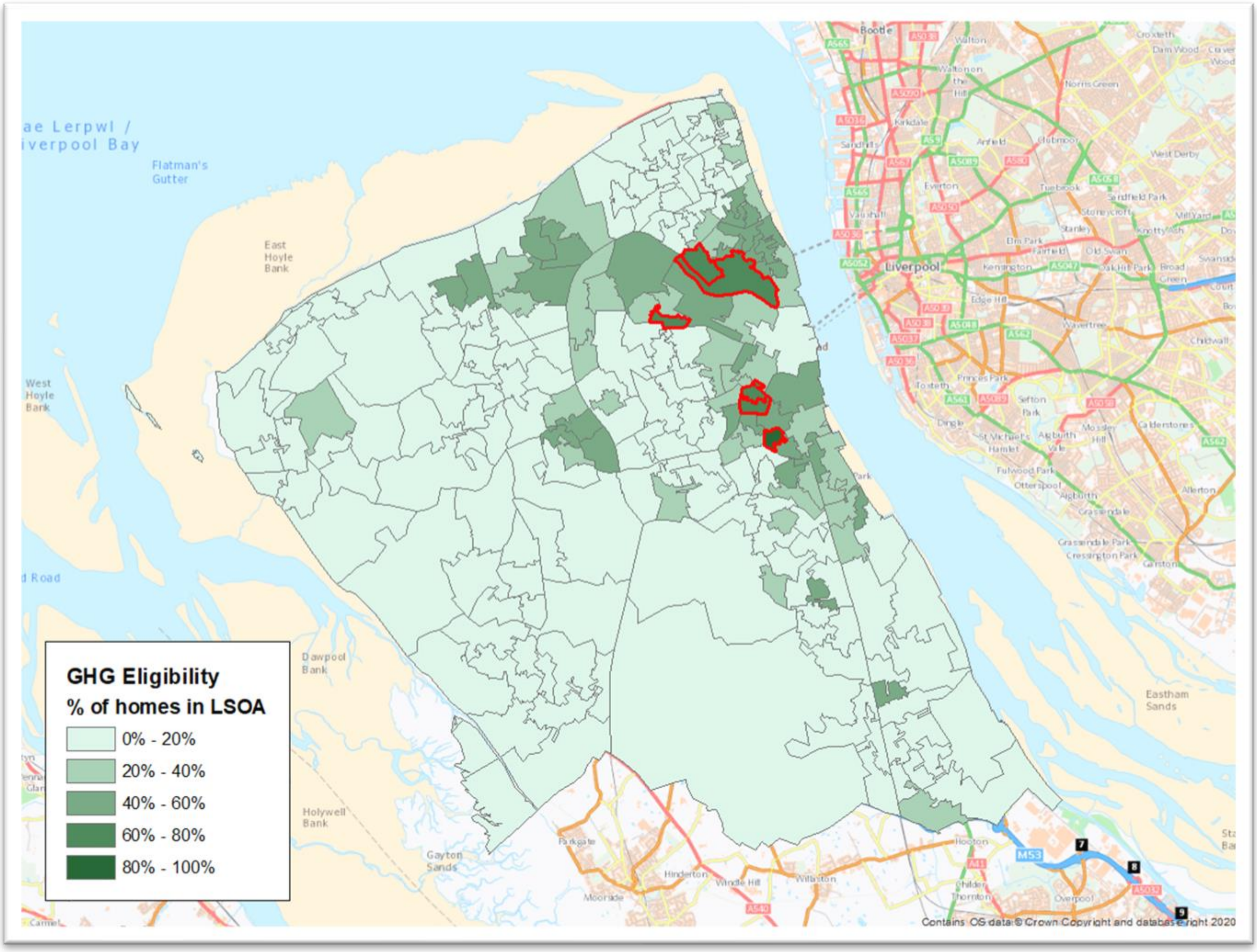


6.4. Low-income Households

The low-income GHG eligibility measure presented in Figure 36 provides a reasonable first-pass overview of potential low-income eligibility in Wirral. To present a more nuanced picture of GHG eligibility for benefit recipients, EST applied two extra address-level filters:

- Property type = Detached, semi-detached, mid-terraced or end-terraced house
- Current SAP band = D-G

Figure 36 – Targeted GHG eligibility (low-income segment)



The map in Figure 32 shows a similar pattern of eligibility compared to the low-income eligibility map in Figure 36. By applying additional filters to the data, the total number of eligible dwellings per LSOA is generally lower. There are however, six LSOAs outlined in red (Wirral 015A, Wirral 021A, Wirral 021B, Wirral 010C, Wirral 010D, Wirral 021F) that still have at least 60% of their dwellings predicted to be eligible for the maximum GHG voucher value (£10,000). These likely represent the best opportunities for targeting eligible low-income households in Wirral.

7. Conclusions

In this section of the report, EST identifies existing opportunities and challenges for retrofitting the Wirral housing stock. Based on these findings, a series of recommendations are provided to inform the Council's decarbonisation planning.

7.1. Opportunities in Wirral

EST's analysis of the Home Analytics data and PEAT scenarios has highlighted six key retrofit opportunities in Wirral.

1. **Solid wall and floor insulation** – 88% of solid walls and 92% of floors are currently uninsulated within Wirral. While these types of insulation have been neglected in the past due to their high costs, they are both eligible for GHG funding, which can significantly reduce the financial burden on the homeowner. With 96% of properties in Wirral suitable for one of these two measures, encouraging uptake will not require a high degree of targeting and represents the biggest potential for energy efficiency improvements in the council.

2. **Loft insulation** – over one-third of homes have less than 150mm of loft insulation and can benefit from a top-up of at least 100mm. Despite smaller potential than wall or floor insulation, loft insulation is considerably cheaper to install and is also an eligible primary measure under the GHG, which can further reduce the upfront cost.

3. **Heat pumps** – 8% of homes in Wirral are currently using a fuel type other than gas as their primary heating source. Installing heat pumps in these homes can provide a cost-effective alternative to high priced, carbon-intensive fuels. Electrifying heat in off-gas neighbourhoods will allow these neighbourhoods to leapfrog gas and avoid additional retrofits in the future.

4. **Large homes** – Wirral has a higher-than-average concentration of old, large houses. As a result, its average energy and carbon footprint is higher too. The good news is that these types of properties are much easier to retrofit than blocks of flats and, with the right upgrades, can realise greater relative savings. For example, under the High Ambition and Fuel Switching scenarios, semi-detached and terraced houses had more than 2 extra measures recommended compared to flats.

5. **Green Homes Grant** – the government has extended the GHG to the end of March 2022, giving homeowners and landlords more time to access vouchers for home improvements. This report has identified several hot spots of able-to-pay and low-income households in Wirral.

6. **New builds** – while outside the scope of this report, new builds represent an opportunity for Wirral to phase out traditional gas heating by requiring developers to adopt low carbon heating systems in their plans. Wirral is already taking steps to do this with the phased plan for district heating in the Wirral Waters and Birkenhead developments.

7.2. Challenges in Wirral

In addition to the above opportunities, there are six challenges that Wirral will need to mitigate in order to achieve its short, medium and long-term carbon reduction goals in a strategic, cost-effective way.

1. **Reliance on gas** – the residential building stock in England is highly dependent on mains gas for heating. With less than half the number of off-gas dwellings (8%) as the national average (20%), Wirral's ability to encourage cost-effective electrification is limited. Electrifying heat demand is expected to be the biggest impediment to achieving net zero emissions from residential buildings by 2050.

2. **Council housing** – nearly all social housing in Wirral is owned and operated by housing associations. This means that the Council does not have direct control over the housing stock, limiting its ability to implement retrofit measures.

3. **Technological uncertainty** – recent energy and climate policy documents released by the UK Government and Committee on Climate Change (CCC) have set goals and objectives for several different types of low carbon heating fuels and enabling technologies (e.g. heat pumps, hydrogen, batteries). The uncertainty of knowing which systems will be supported through future policy and funding grants can limit investment, stunt growth, and lead to hesitancy or inaction.

4. **Balancing priorities** – the retrofit pathway that achieves the greatest carbon emission reductions (i.e. electrification) is also the pathway with the highest upfront cost. Based on current fuel prices, heat pump efficiencies and carbon factors, installing heat pumps is not cost-effective, outside of off-gas homes. Long-term carbon reduction goals will need to be pursued in a strategic and measured way that avoids unanticipated consequences, such as increased fuel bills and higher rates of fuel poverty.

5. **Supply chain bottlenecks** – this challenge is not unique to Wirral. To meet the targets proposed by national government and CCC, annual heat pump installations in England will need to ramp up from ~30,000 in 2020 to more than 600,000 by 2028. This will require a significant investment to expand and train the supply chain and create a local network of trusted installers.

6. **Blocks of flats** – 20% of residential dwellings in Wirral are located within blocks of flats. This is problematic because flats pose a unique set of logistical hurdles that must be overcome to get energy efficiency upgrades (e.g. wall insulation) approved and installed. Flats are also quite difficult to retrofit with low carbon heating systems, like heat pumps and solar, making fuel switching more difficult. While not an immediate concern, Wirral will need a tailored plan to address flats, specifically those which are privately owned or rented (70% of all flats).

7.3. Recommendations

Based on the opportunities and challenges described above, EST has produced a set of recommendations that Wirral can use to guide its decarbonisation efforts.

1. **Adopt a fabric-first approach to retrofits**. The best way to prepare the housing stock for an electrically heated future is to follow the energy hierarchy and reduce heat demand through behaviour change and energy efficiency. By promoting insulation upgrades, Wirral can reduce heating requirements in existing homes, which will help lower running costs and improve the short-term economics of heat pumps.

   The average lifetime of a boiler is 15 years, so although installing a boiler may be more cost-effective today, it will either lock the house into gas consumption for the foreseeable future or will need to be replaced sooner to comply with future regulations. By promoting insulation measures over condensing boilers installations, homeowners can avoid unnecessary costs and Wirral can accelerate the transition to electric heating.

   Homes that are currently below a SAP band of C should be the focus of this retrofit work as they represent the largest potential for improvement. Homes with a SAP band of E-G are significantly more likely to be in fuel poverty, so targeting these areas can create additional benefits in terms of fuel poverty mitigation.

2. **Prioritise owner occupied homes**. In England, social housing providers are required to achieve a minimum SAP band of C by 2030. Consequently, housing associations in Wirral have already taken steps towards this standard and hold a higher average SAP score (68.3) compared to privately rented (60.9) and owner-occupied homes (58.4). While not as stringent, privately rented homes are also required to achieve a minimum SAP band of E, which forces landlords to engage with energy efficiency and make some required improvements. It is likely that both these standards will continue to rise in the future, spurring further action.

   Approximately three quarters of the residential housing stock in Wirral is owner occupied, yet there are no comparable standards or regulations governing the energy efficiency of these buildings. This segment of the housing stock has the largest carbon footprint, most recommended measures, greatest potential for improvement and should be addressed appropriately.

   In the short-term, Wirral should aim to raise awareness about GHG funding by planning targeted maildrops in areas with the highest proportion of owner-occupied homes and GHG eligibility. Areas with a high concentration of flats should be avoided as these will be more difficult to retrofit and will likely need a separate approach. The Council should also consider working with local installers and delivery partners to share insight about where eligible homes are located, reducing the search cost for installers, and helping to connect eligible households with trusted professionals.

In the long-term, Wirral should strive for collaboration with other departments and organisations in the council such as emergency services, personal care workers and tradespeople, so that when workers visit a home, they can inform the householder of the benefits of energy efficiency, heat pumps, available grant funding, etc. By leveraging these touchpoints, Wirral can help extend its reach in the community and lay the groundwork for a referral program.

While owner occupied homes should be the focus, Wirral can still help housing associations and private landlords by facilitating the required improvements. There is considerable overlap between areas with a high percentage of benefit recipients and social housing, which could translate into higher GHG voucher values and further upgrades. Wirral should work with local housing providers to make sure they are aware of this and help them tap into it, where possible.

3. **Support the adoption of heat pumps**. The CCC and UK Government have bold goals for ramping up heat pump adoption over the next 10 years. Nationally, the supply chain is limited in terms of installers with the knowledge required to properly install and maintain heat pumps. Building a network of local installers today will help fill an existing gap in the market and put Wirral in a stronger position to deliver on ambitious local and national reduction targets.

   Many people are not familiar with heat pump technology, so education and outreach are also crucial steps. Making people aware of the benefits and facilitating early adoption of heat pumps will help spread the word and move Wirral along the adoption curve at a quicker rate. To this end, off-gas homes represent a great opportunity for encouraging early adoption. Heat pumps are already a cost-effective alternative for homes that are currently using coal, oil, LPG, or electricity as their main fuel source. They can deliver on environmental, social, and economic objectives while avoiding the financial and carbon impact of extending the gas grid.

   Comparing the total costs of the High Ambition scenario to the Fuel Switching (realistic) scenario shows that with a 5% increase in investment, an additional 12.2% of the stock can be converted to heat pumps (Table 6). If Wirral was to meet the targets set out by the central government and CCC for heat pump penetration, then the heat pump uptake rate in the realistic Fuel Switching scenario (14.6%) would likely be achieved between 2029 and 2032. Between now and then, it is likely that the price of gas will rise (as the cost of carbon is internalised in the price) and the material and labour costs of heat pumps will drop due to economies of scale, further improving the business case for a mass rollout of heat pumps.

   In the long run, the carbon factor of grid-supplied electricity will continue to fall as fossil fuels are phased out and new renewable generation comes online. Therefore, from a carbon reduction perspective, heat pumps will become increasingly attractive over time. Since it will take time for production and installation to ramp up, Wirral should start aggressively promoting heat pumps now. By the time uptake rates increase to a material level, the economics should have improved to the point where heat pumps are a cost-effective choice, even in properties connected to the gas grid

4. **Capitalise on the extension to the GHG scheme.** The GHG fund is perfectly tailored to the insulation and low carbon measures that are most needed within Wirral (e.g. wall, loft, floor insulation and heat pumps). Funding has been extended until March 2022, so Wirral should use Home Analytics and the maps provided in this report to target the segments of the stock that have the highest likelihood of eligibility and greatest potential for improvement.

   The GHG provides an important call to action and a great incentive for the Council to work together with local installers and supply chain members to coordinate a targeted marketing campaign. GHG vouchers will help reduce the cost of measures that have been historically, too expensive for owners to pursue and should be maximized while they are still available.

5. **De-prioritise blocks of flats**. Flats pose a unique set of constraints, which makes a traditional fabric-first approach as well as the adoption of low-carbon heating a challenge. Most retrofit measures are more costly and difficult to install within flats. The savings are also relatively lower, as flats have smaller average floor areas and therefore, lower energy demands and carbon footprints. The most cost-effective approach is to exclude them from short-term retrofit plans and instead, focus on more feasible, high-return segments. This will buy more time for Wirral to develop an appropriate solution for overcoming this 'problem' segment.

6. **Do not wait for new technologies to act**. The potential of hydrogen and battery storage technology is currently uncertain. They will likely play a role in the low carbon heating landscape of the future, but their scale and scope are currently unknown. Given the half-life of carbon dioxide in the atmosphere and the rate at which it is accumulating, every year matters. It would be a mistake to delay action, hoping for more clarity on potential technological fixes. It is crucial that Wirral support the technologies that are available today (e.g. heat pumps, district heating, solar) to take firm steps towards a net zero future.

   Wirral has already started to do this by working with BEIS to conduct site identification and planning studies for a phased heat network development in the Wirral Waters / Birkenhead area. While not considered in this analysis, district heating has the potential for replacing gas connections in new developments. In the future, there could be potential for establishing additional heat networks in Wirral. To that end, EST is currently modelling non-domestic buildings in Wirral, which may help identify buildings that could serve as anchor loads for heat networks in the future.