Teignbridge, North & Mid Devon: Pathways Report

version 1.1
7th December 2021

ABOUT PARITY PROJECTS

Parity is an award-winning provider of environmental and energy solutions to the residential building sector. We help our customers identify the most effective ways to reduce the energy impact of their properties.

Our core services, Pathways and Portfolio, use our proprietary software to identify the most appropriate measures for properties based on building physics, market costs, and the clients' carbon and fuel poverty objectives.

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DOCUMENT HISTORY

This is version 1.0

Version	Author	Date	Notes
1.0	**CJN**	**25/11/21**	**Draft Report**
1.1	**CJN**	**06/12/21**	**Minor amends**

Distribution (all versions):

- Devon County Council
- Regen
- West of England CA
- Parity (internal)

REPORT AUTHORS

chris.newman@parityprojects.com

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Glossary

ASHP	Air Source Heat Pump
EPC	Energy Performance Certificate
EI	Environmental Impact
FGHRS	Flue Gas Heat Recovery System
GSHP	Ground Source Heat Pump
LSOA	Lower Super Output Area
PCDF	Product Characteristics Data File (boiler database)
RdSAP	Reduced Data Standard Assessment Procedure
PV	Photovoltaic array
SAP	Standard Assessment Procedure
SAP Score	Energy Efficiency Rating (0-100 or G to A)
TRV	Thermostatic Radiator Valve

Disclaimer

The conclusions in this report are based on the data available. To be able to conduct the analysis, data may have had to be partially interpolated to fill gaps.

Section 10.3 'Data' has comments about the quality of the data on which the analysis is based, and we believe we have used best practice in the collation and analysis of this data. However, as the datasets are incomplete and not entirely verified, data collection will often reveal our estimates, including estimates of SAP rating, to be incorrect in some degree when compared with up to date and complete data collected through detailed property inspections. We believe that the approach taken by Parity has matched our briefing and has been pragmatic and appropriate given the current state of the housing data available. Throughout this report the results of our analysis should be seen as estimates.

As housing analysts we would suggest that even a complete and recent housing dataset, if large, cannot be guaranteed to be free from errors.

The report reflects Parity Projects modelling and results and do not in any way indicate any agreement by or acceptance from Regen, Devon County Council or West of England Combined Authority.

1 Executive Summary

1.1.1 Report Aims

We have been commissioned by West of England Combined Authority (WECA) to provide some analysis for Devon County Council (Devon) on the housing stock across Teignbridge, North Devon and Mid Devon (the 3 Districts) and the potential retrofit Pathways to reach Net Zero by 2050.

The following project aims have been addressed by this report:

- Energy profiling of the housing stock in the 3 Districts across various metrics including SAP (or EPC) score, Environmental Impact (EI), fuel bills and CO_2 emissions. (*Sections 3.1 to 3.3*)
- Profiling the key characteristics of the housing stock in the 3 Districts. (*Sections 3.4 to 3.9)*
- Analysis of the measures that would be required, and associated costs to meet two Net Zero investment scenario targets – with and without disruptive measures. (*Sections 4.1 to 4.2.7* & *4.4.1 to 4.4.8*)
- Analysis of the properties that will be difficult to reach the investment scenario targets. (*Section 4*)
- Analysis of the supply chain requirements to reach the investment scenario targets. (*Sections 4.3* & *4.5*)

It is designed to be a summary of the information provided through the subscription as opposed to a consultancy document. As such you will find that the report is mostly fact based rather than expressing opinions or recommendations.

1.1.2 Pathways Subscription

As above, this report summarises the investment scenario analysis provided to WECA and focuses on presenting the answers to the initial questions posed.

The detail of the data held within the Pathways system allows for ongoing interrogation of the analysis and results to answer follow up questions that this initial work raises. Training will be provided to relevant Local Authority staff to allow them to do this over the software licence period.

1.2 REPORT STRUCTURE

We present a summary of the RdSAP dataset we have produced for all domestic properties. This complete dataset allows us to report on the baseline characteristics of the housing stock ("Baseline Analytics"). It is then used to model and analyse investment Pathways that will achieve Net Zero without and with disruptive measures. We also provide insights into the potential employment opportunities the investment scenarios provide.

The structure of this report is organised into four sections. The first two focus on the current position of the 3 Districts' housing stock (see Section 1.3 for a summary) and the second two on the analysis for the two Pathways (see Section 1.4 for a summary).

- **Baseline Analytics**: Provide an estimate of various common characteristics e.g. inter alia, CO_2, estimated fuel bills, SAP score *(section 3 pages 12-27)*
- **Opportunity Mapping**: Map a number of key opportunities by Lower Super Output Area *(section 3.9 pages 28-36)*
- **Pathways**: Present an analysis of the most cost-effective application of these Measures to meet two scenarios (*section* 4 *pages 37-45*)
- **Trades Analysis**: For each of the Pathways, present information on the potential trades that would be required to carry out the measures identified. (*section* 4.3 *pages* 48-53 and *section* 4.5 *pages 63-65*)

Throughout the report we provide charts and graphs to display results.

1.3 BASELINE SUMMARY

This section sets out the average performance of all the 3 Districts' properties. The reality is that there is a wide range, and this is explored in more detail in *section 3 pages 12-27.*

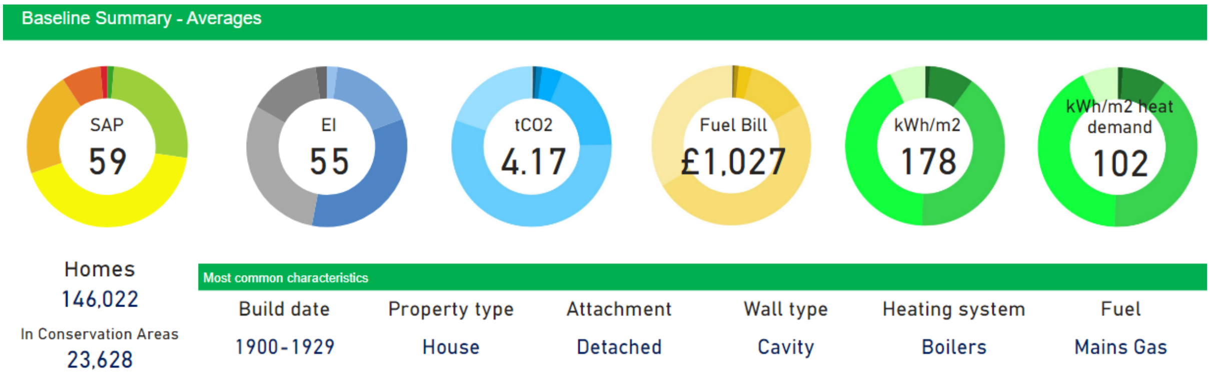


Figure 1

1.3.1 SAP (and EI) baseline

We estimate the average SAP score in 2020 is **59.16** (EPC Band D) and the EI score is **54.63** (Band D). The EI score is the CO_2 equivalent of the SAP score which is based on fuel bill.

1.3.2 CO_2 baseline

We estimate the mean CO_2 emissions per property for primary energy use is **4.17tCO_2** using figures for 2019. In section 3.1.1 we show what this baseline figure would be expected to be using BEIS projections of the grid intensity in future years.

1.3.3 Fuel Bill baseline

We estimate that the mean annual fuel bill is **£1,027**. Throughout the report our fuel bills, as well as all other figures, are for regulated energy use i.e. this excludes appliances and cooking. Please see Section 9 for a note on regulated and unregulated energy.

1.4 PATHWAYS SUMMARY

Our Pathways test all relevant measures in combination for every property to find the most cost-effective route to our clients' targets. In this instance we have modelled two different routes to Net Zero.
We outline the rationale behind the two modelled Pathways, how they have been set up, and detailed results in Section 44.2 pp.37-60. Below we present the headline findings.

1.4.1 Net Zero without disruptive fabric measures

We have modelled the cost and impact of aiming for Net Zero for every rural[1] property in the 3 Districts excluding disruptive measures i.e. internal and external solid wall insulation, and floor insulation. The following give some headline figures from the analysis.

Total Cost (labour & materials):	£1.3 Billion
Median Average cost per residential property affected:	£17,200
Mean tonnes of CO_2 (2038) per property following investment:	0.18 tonnes

Trades Analysis: Average of 320 Full Time Equivalent jobs per year (2022-2050)

1.4.2 Net Zero with disruptive fabric measures

We have modelled the cost and impact of aiming for Net Zero for every rural in the 3 Districts including disruptive measures for consideration. The following give some headline figures from the analysis.

Total Cost (labour & materials):	£1.8 Billion
Average cost per residential property affected:	£21,300
Mean tonnes of CO_2 (2038) per property following investment:	0.15 tonnes

Trades Analysis: Average of 676 Full Time Equivalent jobs per year (2022-2050)

[1] We have used DEFRA's definitions https://www.gov.uk/government/collections/rural-urban-classification

2 Introduction

This report is a brief overview of the analysis conducted of domestic housing in the 3 Districts. Parity has used *Pathways* to model the energy use and CO_2 emissions of the housing stock.

The report is broken down into the following sections:

- **Baseline Analytics:**
  Present the key metrics for housing
  We have used a combination of multiple data sources and interpolation to generate baseline data on every property.
  This is presented in section 3 pp.12-27

- **Opportunity Mapping:**
  Identify, map and evaluate potential for energy, SAP and CO_2 savings, together with fuel poverty and flood risks, to identify target areas.
  This is presented in section 3.9 pp.28-36

- **Pathways**:
  Present an analysis of the most cost-effective measures that aim for a) Net Zero without disruptive measures and b) Net Zero with disruptive measures for each property using BEIS CO_2 grid intensity figures predicted by 2038.
  This is presented in section 4 pp.37-60

- **Trades Analysis**: For each of the Pathways, present information on the potential trades that would be required to carry out the measures identified.
  This is presented in section 4.3 pp.49-53 & section 4.4 pp.63-65

  Pathways generates a range of charts and maps to help identify and communicate patterns in the data.

The detail behind the report from the property level up can be investigated at pathways.parityprojects.com and is available for the duration of the ongoing Pathways licence procured for the 3 Districts as part of this work – contact chris.newman@parityprojects.com for more information.

3 Baseline Analytics

We use the term Baseline to refer to the current state of the housing stock. This section provides kits of information about the current performance – SAP, CO_2, fuel bills etc – as well as details about the characteristics of the housing stock across the 3 Districts – fabric and heating systems, tenure, maps etc.

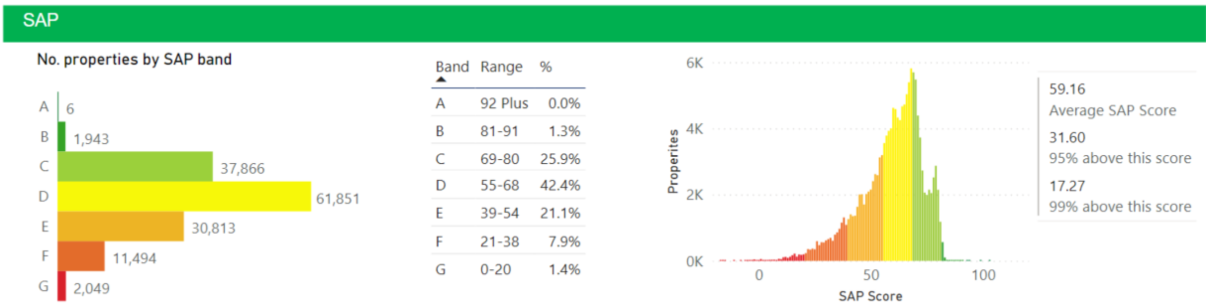
Below we present this through a variety of charts and graphs to highlight the characteristics and performance of the housing stock across all the districts, as well as some commentary of points to note.

The Pathways analysis has been conducted on all 146,022 properties in the 3 Districts.

3.1 SAP AND EI

3.1.1 SAP Score & Profiling

The SAP score (or EPC score) is a standard measure for housing in the UK and reflects the primary fuel bills proportional to the floor area.



Band	Range	%
A	92 Plus	0.0%
B	81-91	1.3%
C	69-80	25.9%
D	55-68	42.4%
E	39-54	21.1%
F	21-38	7.9%
G	0-20	1.4%

Figure 2

We estimate that an average SAP score for domestic housing in the 3 Districts is **59.16** (EPC D). This is based on our calculated SAP scores for every property; around 57% of properties have had some lodged EPC information provided from the Open EPC data and the remaining have required some cloning. See Section 10 page 82 for more information.

The long tail is typical of SAP profile charts.

The figures show that under 2% are EPC B or above. We expect this to be a slight underestimate as from the data available it is hard to model very high rated properties as these require, for example, exact information about makes and models of heating systems, which is not available. However, by the nature of these properties being very efficient they are not of great concern in the modelling of the Pathways.

For a few of the key property characteristics throughout the report we break out the figures by tenure. In Table 1 we have done this for SAP score to show that social housing is the best performing.

Table 1 Average SAP Score by Tenure

Socially Rented (5%)	Privately Rented (8%)	Owner Occupied (30%)	Unknown (57%)
66.05 (Band D)	58.52 (D)	58.41 (D)	59.16 (D)

3.1.2 EI Score & Profiling

The Environmental Index is like the SAP score but reflects CO_2 emissions proportional to floor area. It is an underused metric, with people preferring to measure absolute CO_2 emissions. However, we believe it is a metric that has many benefits over absolute CO_2 as it takes property size into account.

For mains gas heated properties, the EI score closely mirrors the SAP score. For other fuels they may vary – biomass will tend to have higher SAP scores compared to EI scores for instance. LPG has the opposite relationship i.e. a lower SAP compared to EI score.

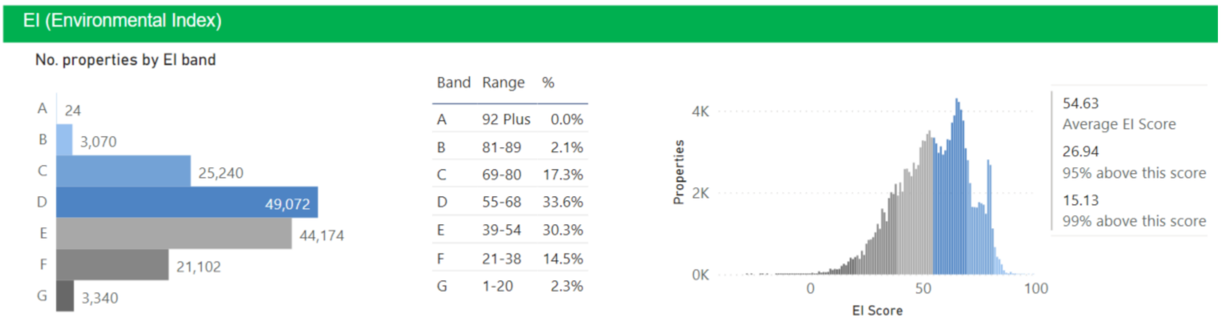


Figure 3

We estimate an average EI score for domestic housing to be **54.63**.

3.1.3 SAP & EI score by Property Type

Although the SAP and EI scores take the relative size of a property into account, both scores still vary by property type due to the relative amounts of fabric proportions e.g. many flats will not have roofs unless they are top floor. The chart below shows the average SAP and EI scores by property type.

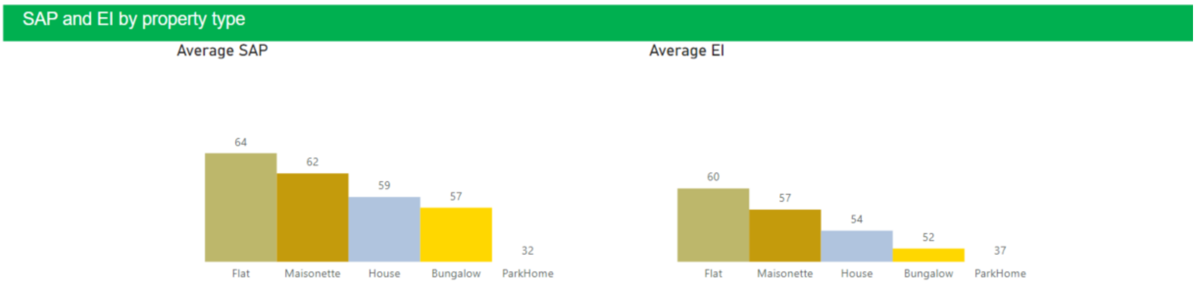


Figure 4

Excluding the Park Homes, bungalows are the lowest performing and flats are the highest – all other things being equal this reflects their ratio of heat loss surfaces to volume.

3.2 CO_2

3.2.1 CO_2 Baseline

Our standard measure of CO_2 uses the carbon factors for SAP10 which is based on 2019 figures. Unless stated otherwise this is used in our charts. The chart on the right below shows how the grid intensity (i.e. electricity) is predicted by BEIS to decrease over time. The reduction from SAP 2012 to SAP 10 is partially due to the reduction in coal for electricity and the increase in large scale renewables.

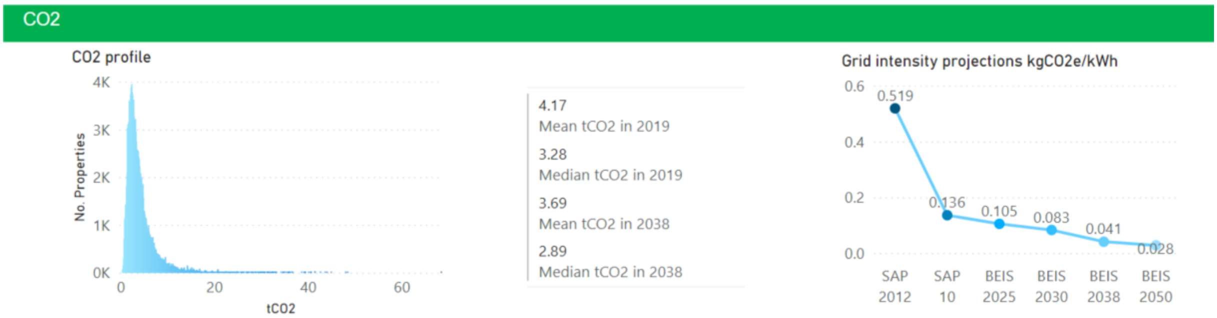


Figure 5

We estimate the mean tCO_2 per property to currently be 4.17 tonnes, and if nothing were to change other than the grid decarbonising, this would reduce to 3.69 tonnes by 2038.

Table 2 breaks out the CO_2 figures by tenure and shows that Owner Occupied tend to have the highest emissions and Socially Rented the lowest. This will be a combination of their efficiency (see Table 1) and their size. The bottom figure for each shows the highest amount after the top 5% outliers are removed and shows that Owner Occupied have the highest spread. These figures allow you to state, for example, that the average Owner Occupied house produces around 4.43 tonnes of CO_2 and very few produce more than 8 tonnes.

Table 2 $C0_2$ Per Property by Tenure

Socially Rented (5%)	Privately Rented (8%)	Owner Occupied (30%)	Unknown (57%)
2.18 Mean tCO2 in 2019	3.34 Mean tCO2 in 2019	4.43 Mean tCO2 in 2019	4.34 Mean tCO2 in 2019
2.05 Median tCO2 in 2019	2.69 Median tCO2 in 2019	3.58 Median tCO2 in 2019	3.39 Median tCO2 in 2019
1.66 Mean tCO2 in 2038	2.77 Mean tCO2 in 2038	3.99 Mean tCO2 in 2038	3.85 Mean tCO2 in 2038
1.71 Median tCO2 in 2038	2.23 Median tCO2 in 2038	3.25 Median tCO2 in 2038	2.97 Median tCO2 in 2038

3.2.2 CO_2 Segmentation

Here we show how CO_2 varies by characteristics in terms of total number of properties and average carbon emissions for the characteristic.

Figure 6

Some key observations:

- Average house emissions are more than double flats, and make up the vast majority of total emissions;
- Detached houses have the by far the highest average CO_2 emissions;
- Properties built before 1930 tend to have around double the emissions of those built after 1983;

3.3 OTHER KEY METRICS

3.3.1 Fuel Bills & kWh/m2

Some other useful statistics relate to fuel bills and kWh/m^2, and a subset that is kWh/m2 heat demand. kWh/m^2 heat demand is agnostic to the CO_2 intensity and price of the current heating source and so is a good measure of the efficiency of the building fabric.

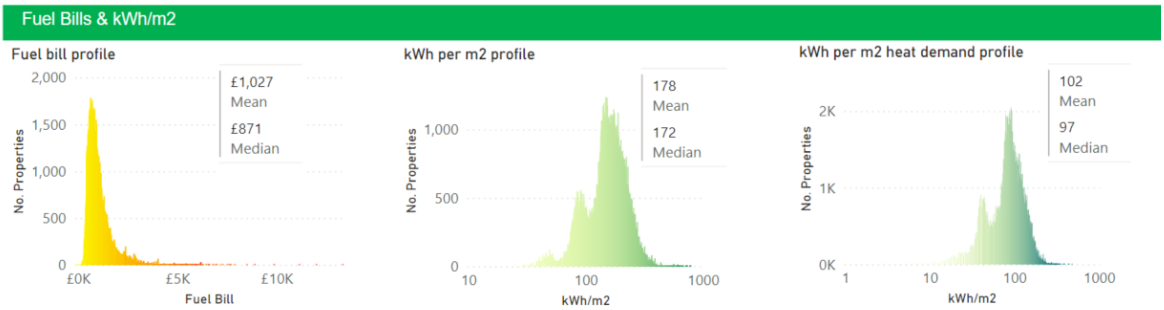


Figure 7

3.4 HOUSING PROFILING - FABRIC

3.4.1 Property Age & Tenure

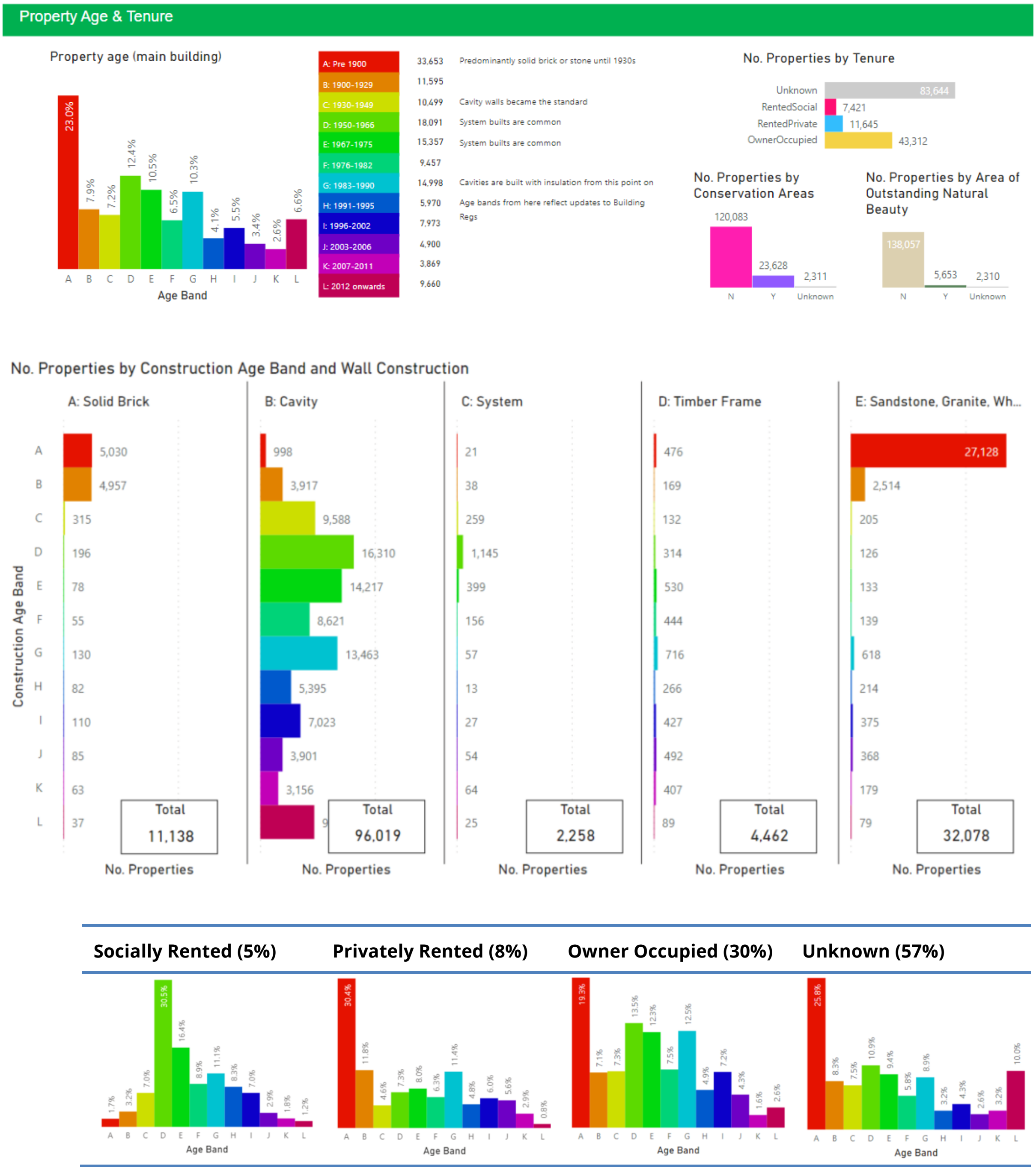


Figure 8

The most common construction period is prior to 1900 when around 23% of properties were built. 50% of properties were built before 1966.

3.4.2 Tenure

We are reliant on the tenure field from the Open EPC dataset for an indication of tenure. This data covers under 60% of properties. It further relies on the EPC surveyor completing it accurately and that nothing has changed since the EPC was produced.

We have decided not to clone out the tenure, as although social housing is often concentrated in estates this is far from always being the situation. This means that for properties where there is no indication of tenure we have marked them as 'Unknown' with regard to tenure. The various charts, as well as logic, indicates that Unknown has a higher degree of Owner Occupied as they will usually have only required EPCs if the property has changed hands, but there will also be some longer term socially rented and longer term privately rented properties.

Based on the above we believe that our ability to model tenure is still useful for understanding general differences but comes with caveats.

3.4.3 Conservation Areas

We have used Conservation Area maps to determine whether a property address is within or outside of a Conservation Area. There may be additional constraints in some areas if a property is close to but outside of a Conservation Area but visible from it. In our analysis these are marked as not being in a Conservation Area.

Conservation Areas will pose additional constraints regarding external wall insulation, photovoltaics (PV), solar thermal, air source heat pumps and windows, without some changes to many planning constraints.

3.4.4 Property Type

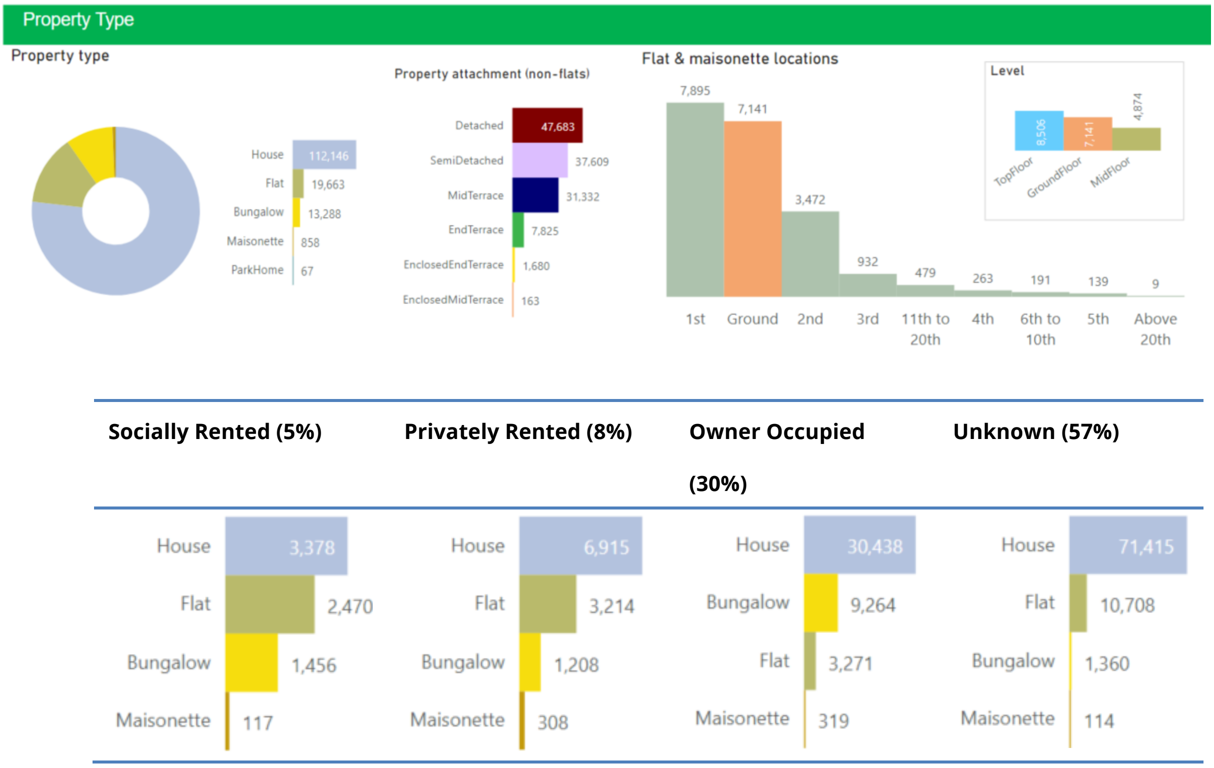
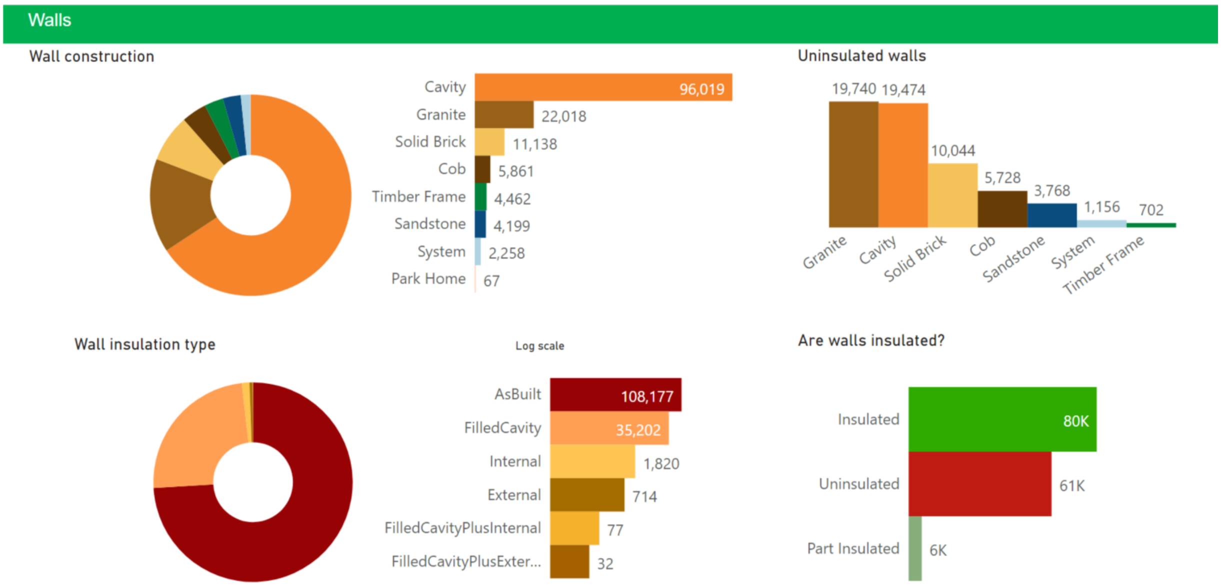


Figure 9

Houses dominate and make up roughly 75% of properties. There are similar numbers of semi-detached, detached and terraced houses. Most flats are in low rise blocks or converted houses. There are slightly more flats on first floors than ground floor as many premises have commercial units, plant rooms or communal space on the ground floor.

3.4.5 Walls



The top most chart shows that cavity walls really dominate, and the top right indicates that most are expected to be insulated. Most of the Granite and Cob walls are showing as uninsulated.

Cavity walls are dominant in all tenures especially in socially rented reflected the construction age bands of that tenure compared to the other tenures.

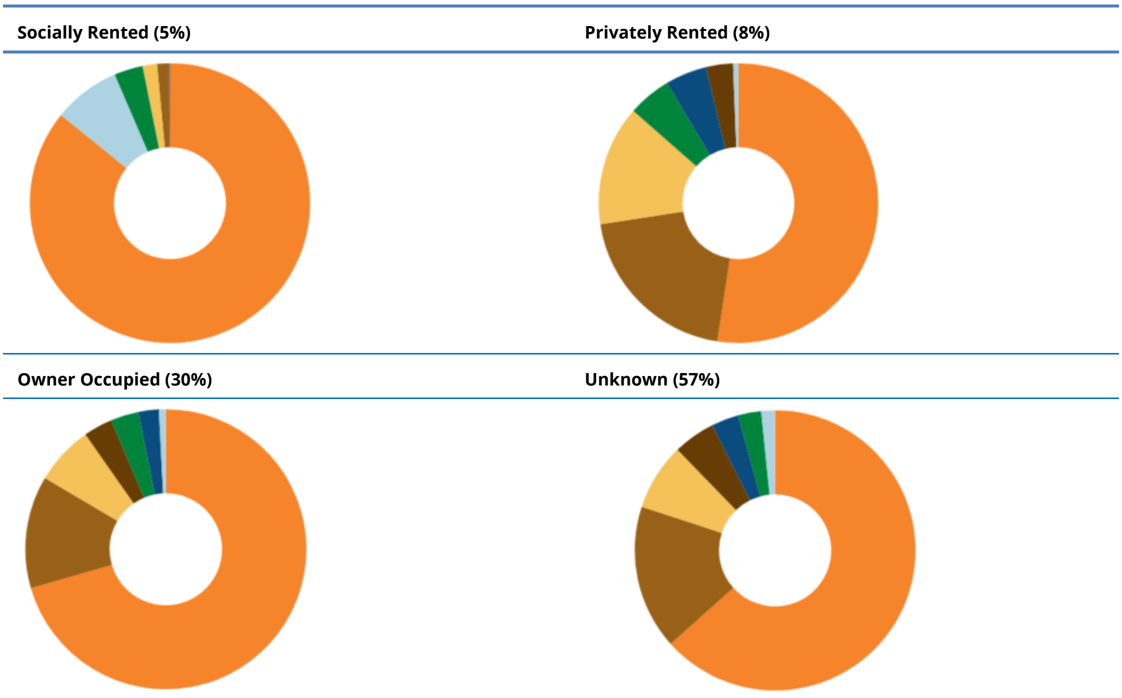


Figure 10

3.4.6 Roofs

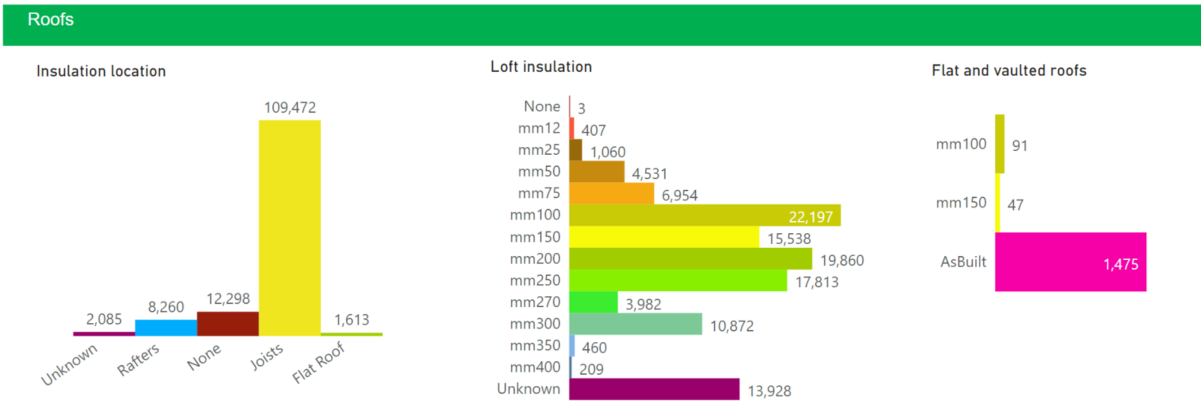


Figure 11

Pitched roofs dominate and there is a large range of expected insulation thicknesses. At least 270mm is the recommended level. Often the data available for secondary roofs is not available so the number of flat roofs is likely understated.

3.4.7 Floors

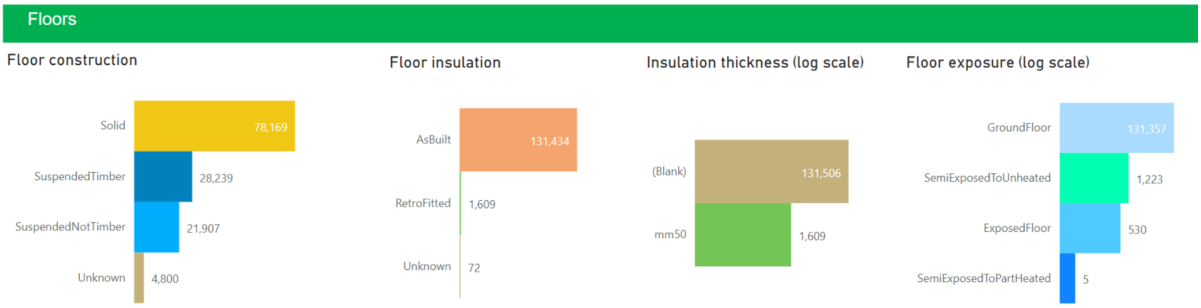


Figure 12

Floors are difficult to treat, especially solid floors, and so based on the age profile of the stock, it is expected that very few will be insulated. Those built after the mid-1980s should have some insulation from when they were constructed.

3.4.8 Windows

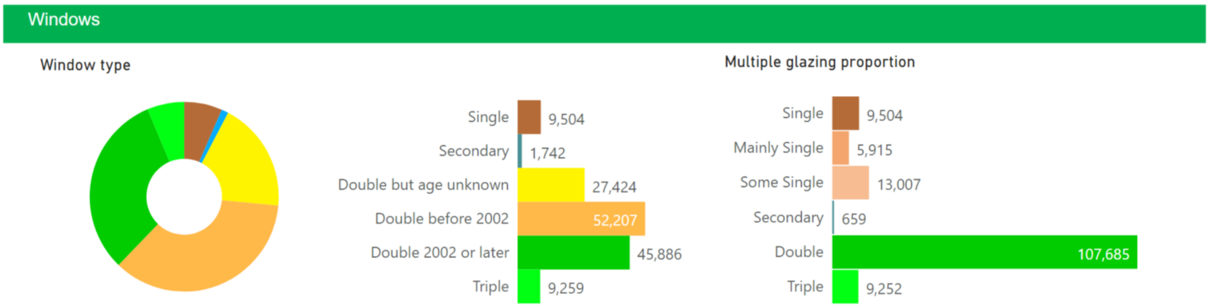


Figure 13

Most of the windows are double glazed with around 9,500 expected to still be fully or mostly single glazed ~ 6.5% of all properties.

3.4.9 Doors & Draughtproofing

SAP methodology is reasonably weak on ventilation and infiltration. It considers draughts to some degree, from windows, doors and open chimneys. SAP also makes some assumptions based on building age, some fabric elements and location. From a practical point of view, a ventilation strategy should be considered whenever works are carried out on a building, especially when significant work that will affect infiltration are undertaken.

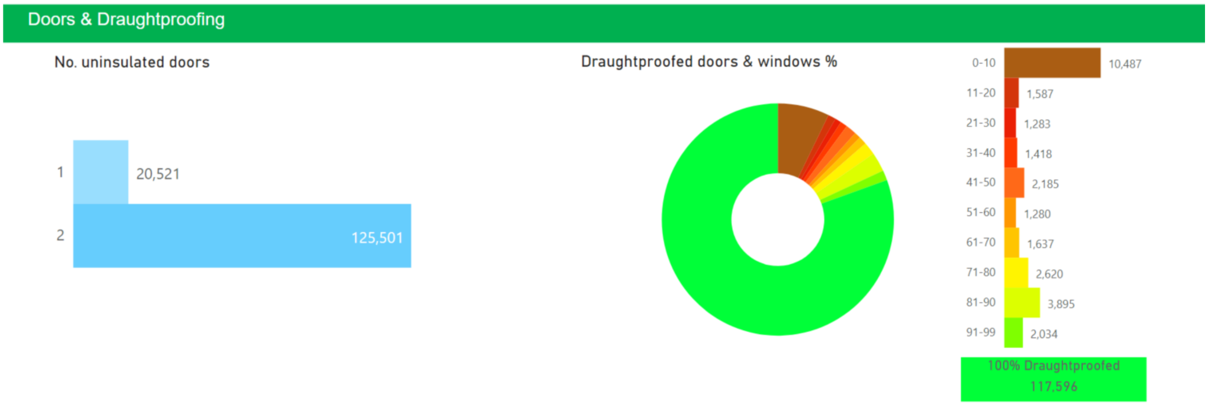


Figure 14

Doors and draughtproofing generally offer much more limited energy and carbon saving opportunities than other elements.

3.5 HOUSING PROFILING – HEATING & HOT WATER

3.5.1 Heating Systems

The heating system often has a major impact on the energy use and CO_2 emissions of a property, and can also be a relatively easy, if expensive, way to improve a property.

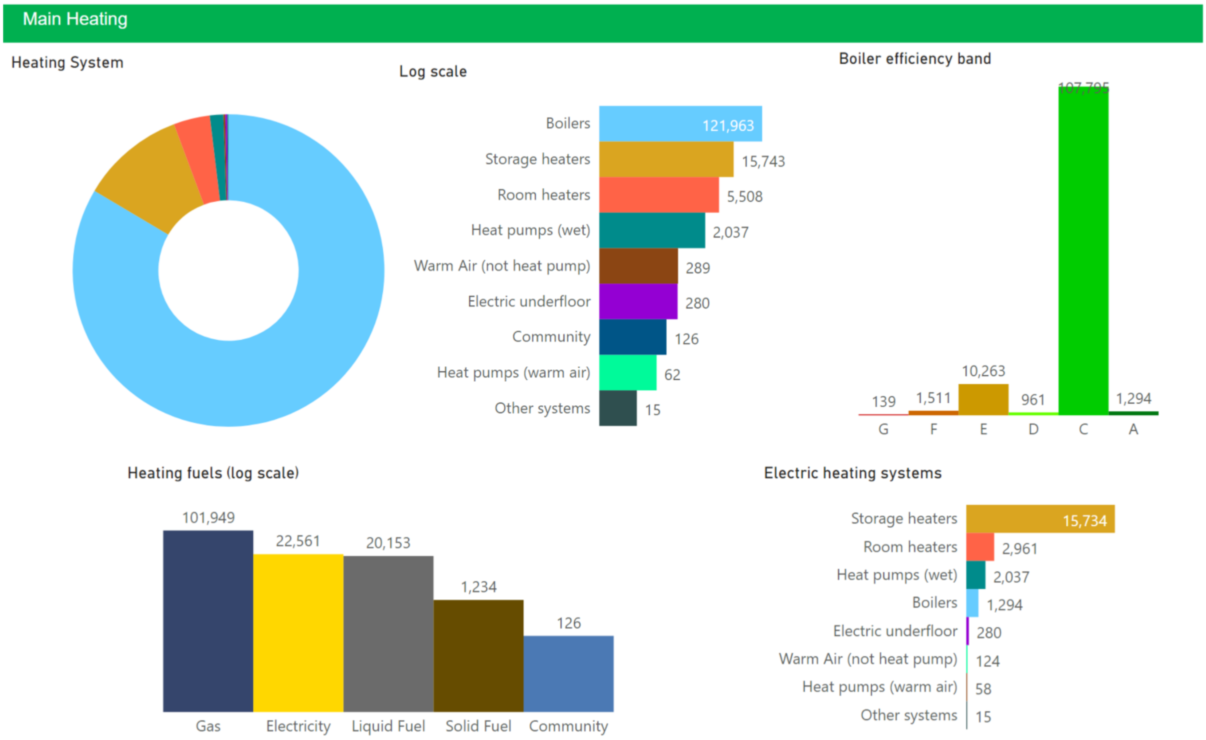


Figure 15

Mains gas with reasonable to good boilers dominate and generate significant carbon emissions. We expect there are more A and B rated boilers than the figures show but for a high rated boiler to be assigned we need the boiler make and model.

Electric storage heaters and Liquid Fuel boilers are a distant second and third most common heating types. The electric, liquid and solid fuel heating systems are more likely to be in rural locations.

3.5.2 Secondary Heating

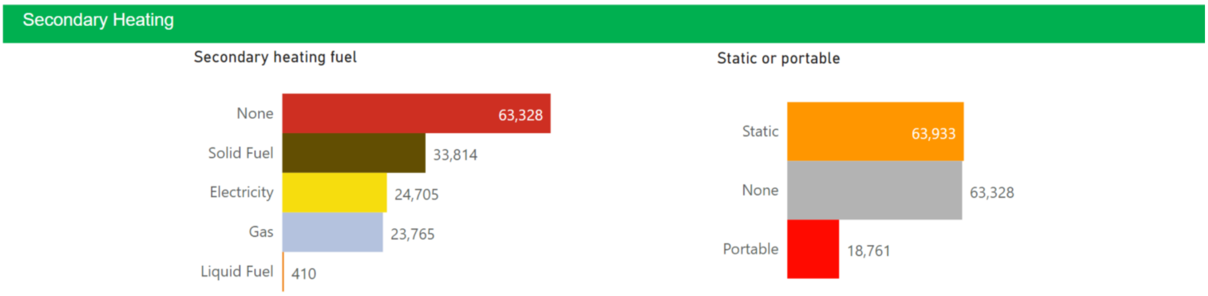


Figure 16

In many circumstances where there is a central heating system, secondary heaters are more of a lifestyle choice rather than a necessity.

3.5.3 Hot Water

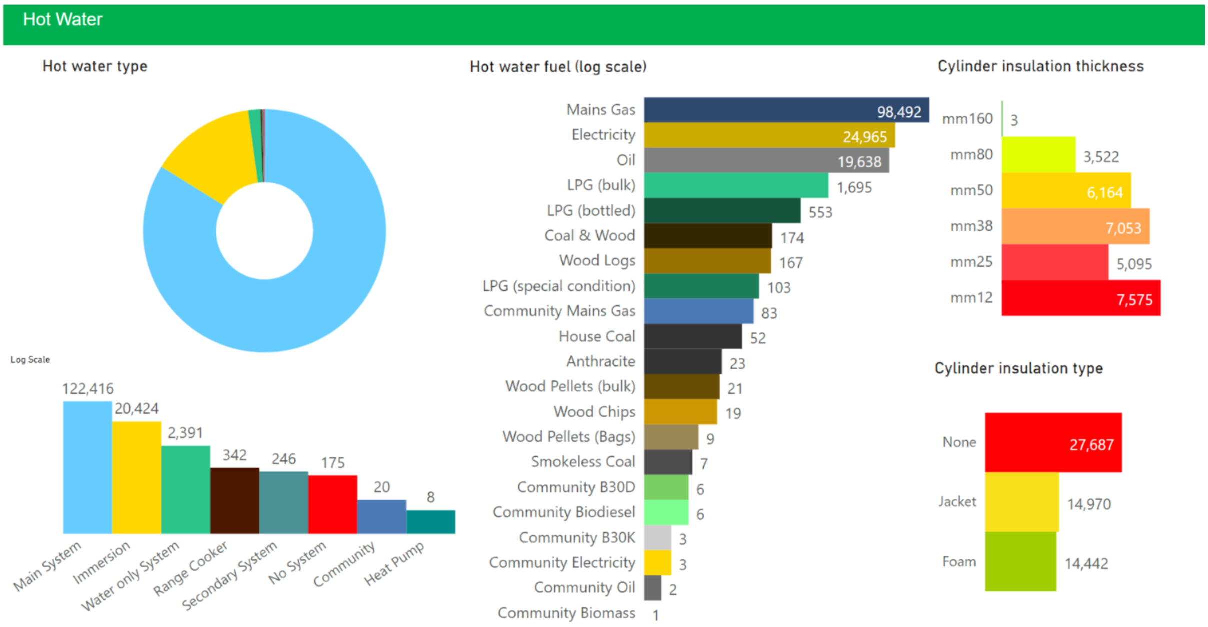


Figure 17

The same gas boilers providing the heating also dominate the provision of hot water. In other circumstances electric immersions tend to be the solution.

For hot water cylinders, foam insulation is better than a jacket, but greater than 50mm of either is considered to be adequate.

3.6 RENEWABLES

3.6.1 Photovoltaics (PV)

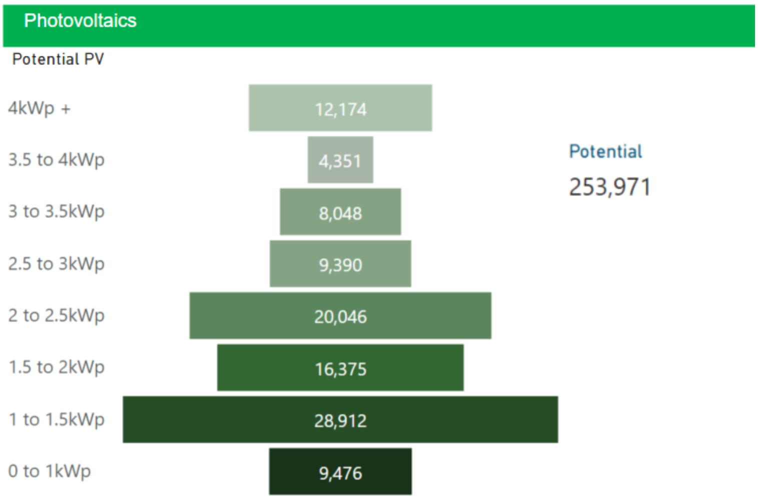


Figure 18

This chart shows our analysis of the potential if all suitable roofs were utilised. A 10-panel system would be around 2.5kWp to 3kWp. 30MWh (13%) of the 254MWh of identified PV potential is in Conservation Areas.

3.7 FLOOD RISK

We have incorporated Open Government data to show how many properties are within given Flood Risk bands and their location. These categories represent current flood risk rather than future flood risk due to climate change e.g. sea level rise. For this reason they tend to be along river systems and coastal areas.

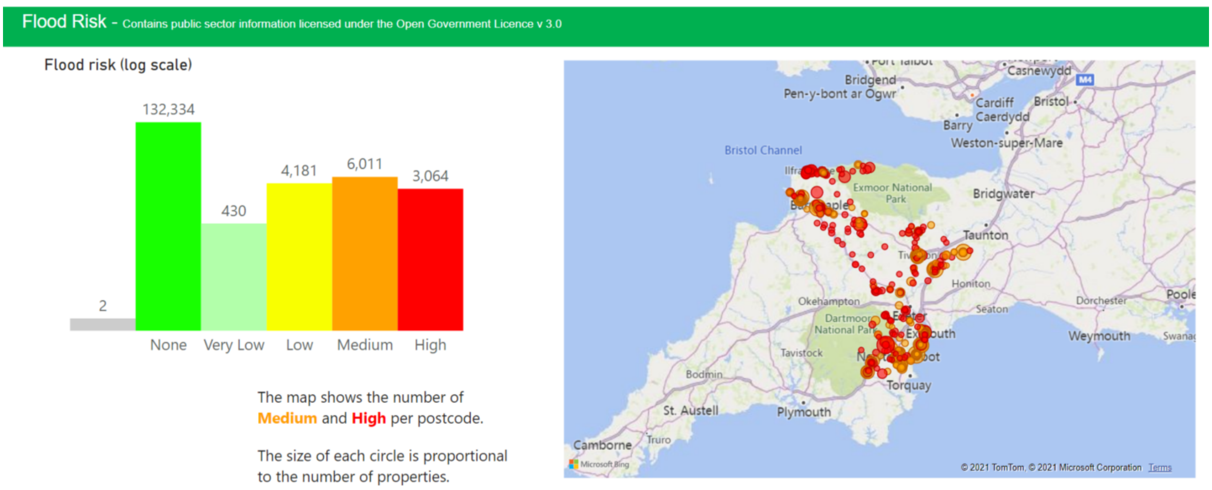


Figure 19

The figures indicate that only 3,064 properties are in high-risk postcodes and 6,011 in medium-risk. The map shows just the medium and high risk postcodes.

3.8 FUEL POVERTY

Fuel poverty is extremely difficult to assess as it is both a factor of the energy efficiency of the property, as well as the income of the household. We do not have any information about the household incomes and so we show how many of the properties are in LSOAs with expected fuel poverty percentage rates – drawn from Government published data on the likelihood of fuel poverty in each LSOA based on national data from the English Housing Survey. This means that, for example, 15-20% of the 19,054 properties in LSOA with a fuel poverty band of "15% to 20%" would be in fuel poverty or between 2,858 and 3,801 households. This results in 15,121 households being estimated to be in fuel poverty across the 3 Districts. There are no LSOAs with greater than 20% incidence of fuel poverty reflecting the relative affluence of the 3 Districts as a whole.

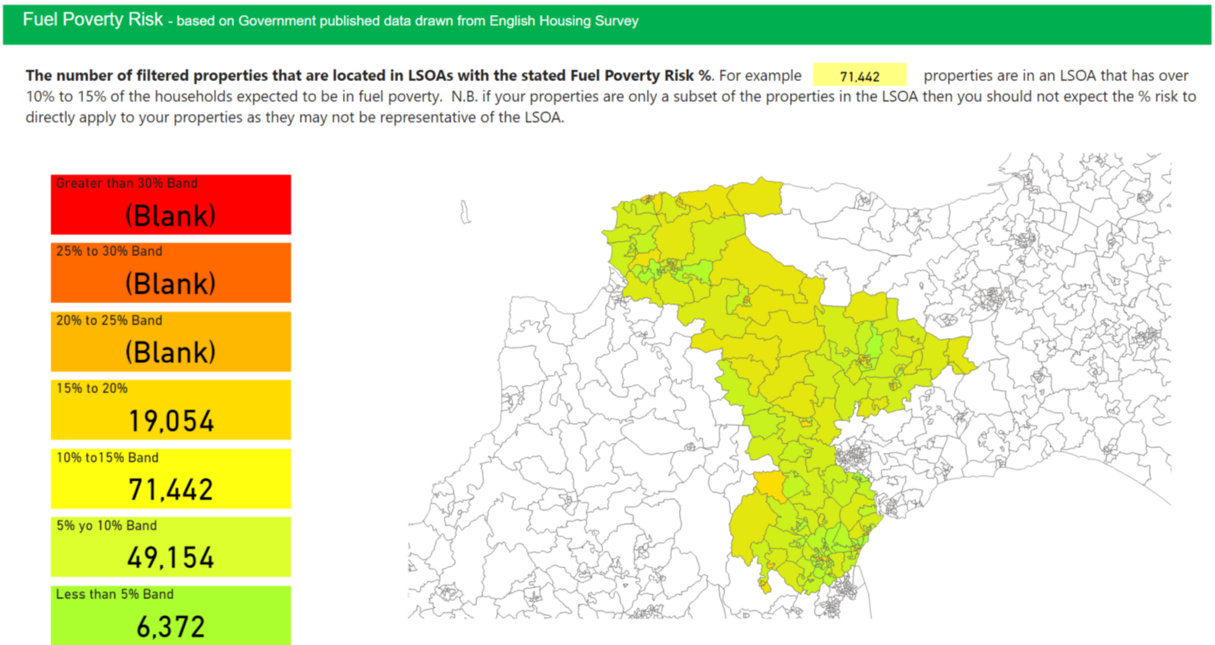


Figure 20

3.9 MAPS

An LSOA is a census area with a minimum population of 1,000 and maximum of 3,000, minimum number of households of 400 and maximum of 1,200.

The numbers in the key below each map give the numbers per LSOA e.g. maximum F&G rated properties in one of the LSOAs, minimum average CO_2 per property in an LSOA etc.

3.9.1 EPC F&G rated properties by LSOA

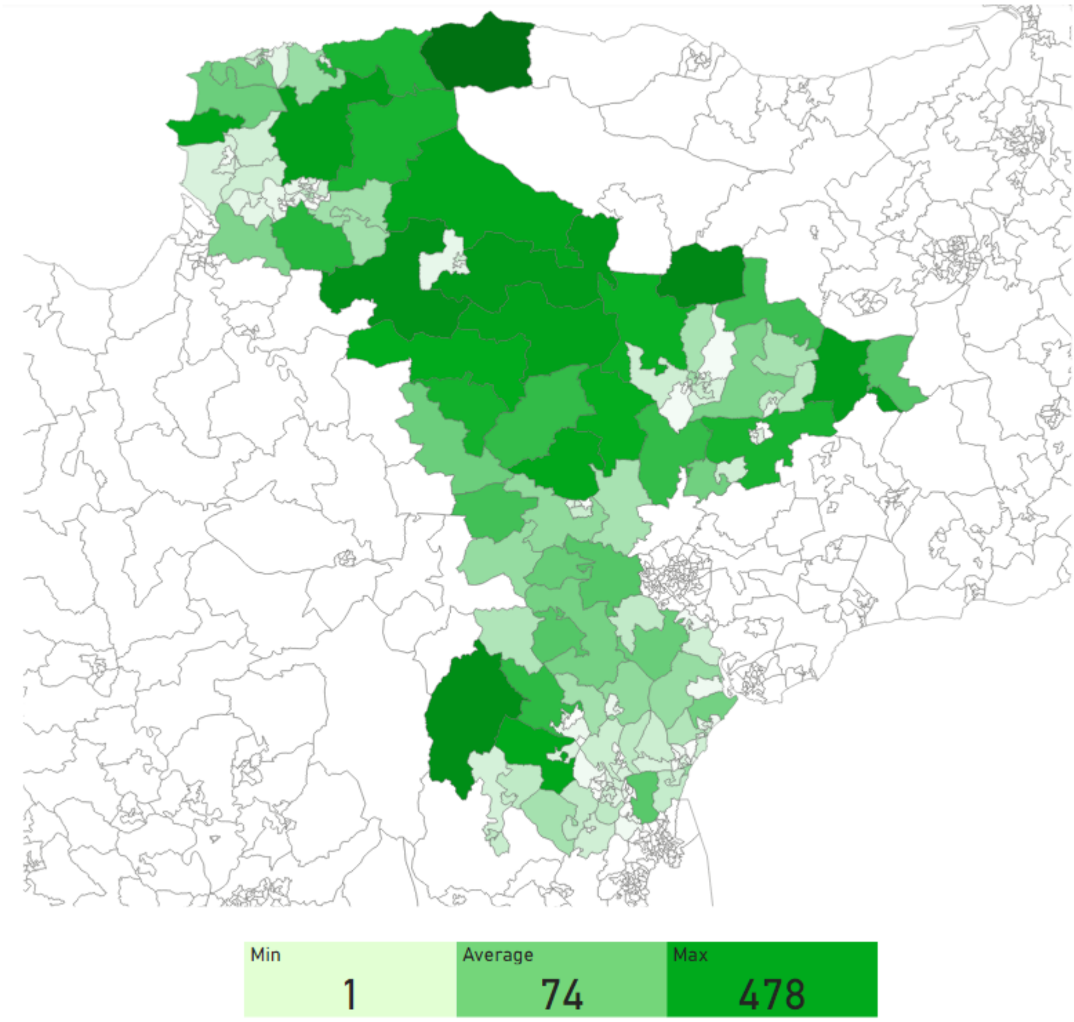


Figure 21

Higher numbers of F&G properties per LSOA are in darker green and tend to be in more remote locations away from the mains gas network.

3.9.2 Average SAP by LSOA

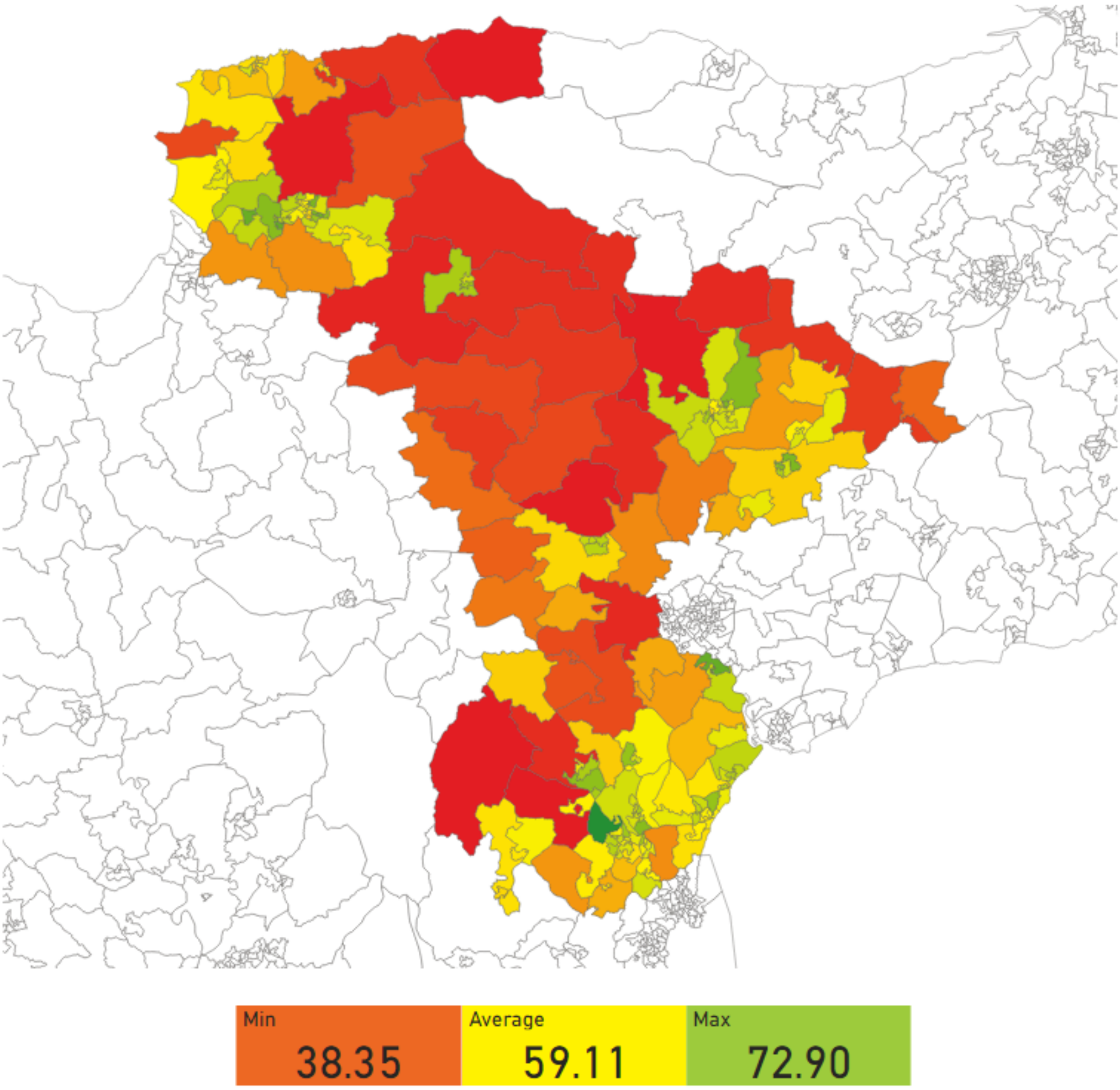


Figure 22

More remote areas tend to have lower average SAP scores as they are likely to be on higher cost heating fuels. The dark green LSOAs may have higher numbers of new build estates.

3.9.3 Average CO_2 by LSOA

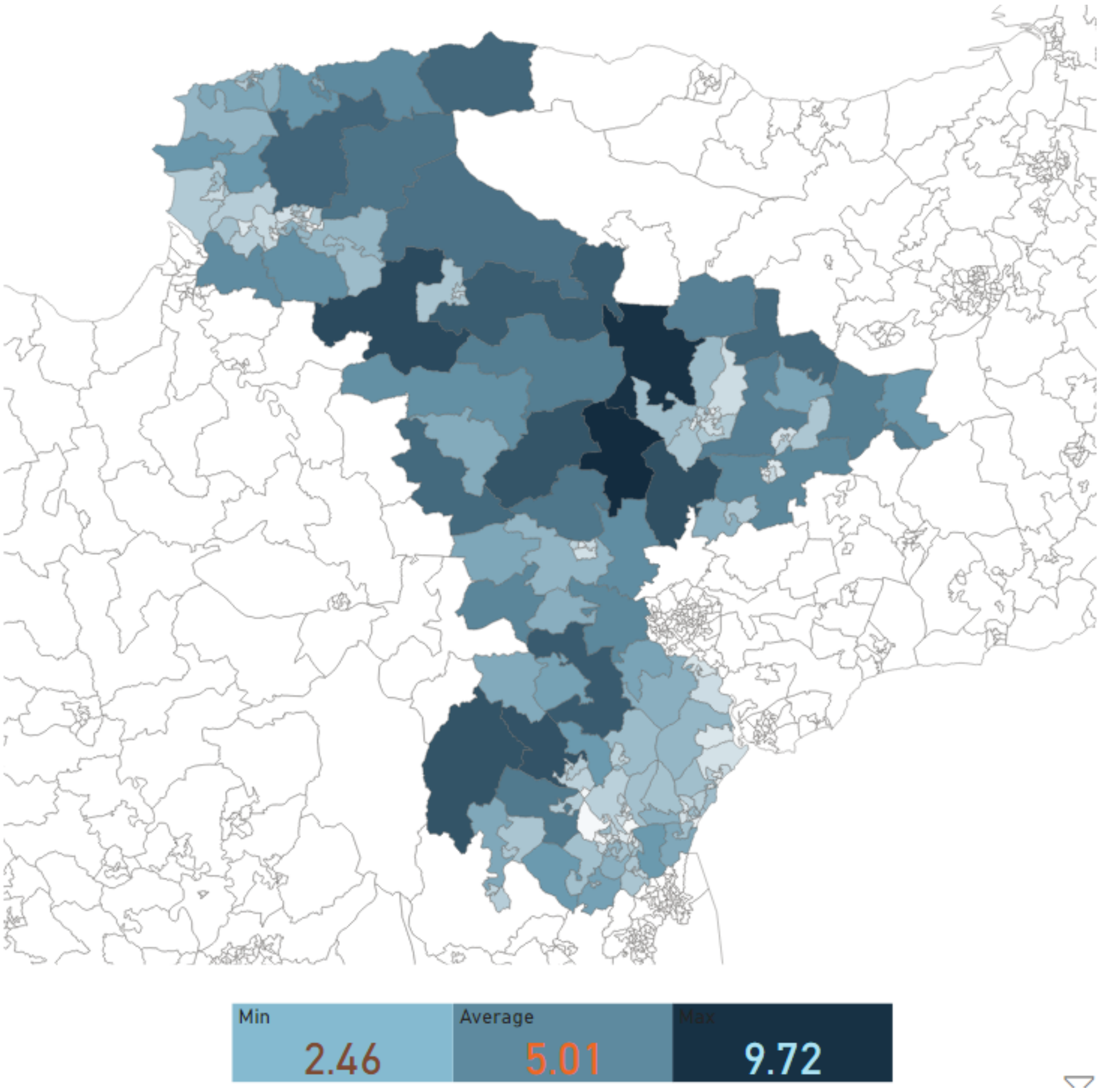


Figure 23

Higher absolute CO_2 will be found in LSOAs with older and larger properties.

3.9.4 Average Fuel Bill by LSOA

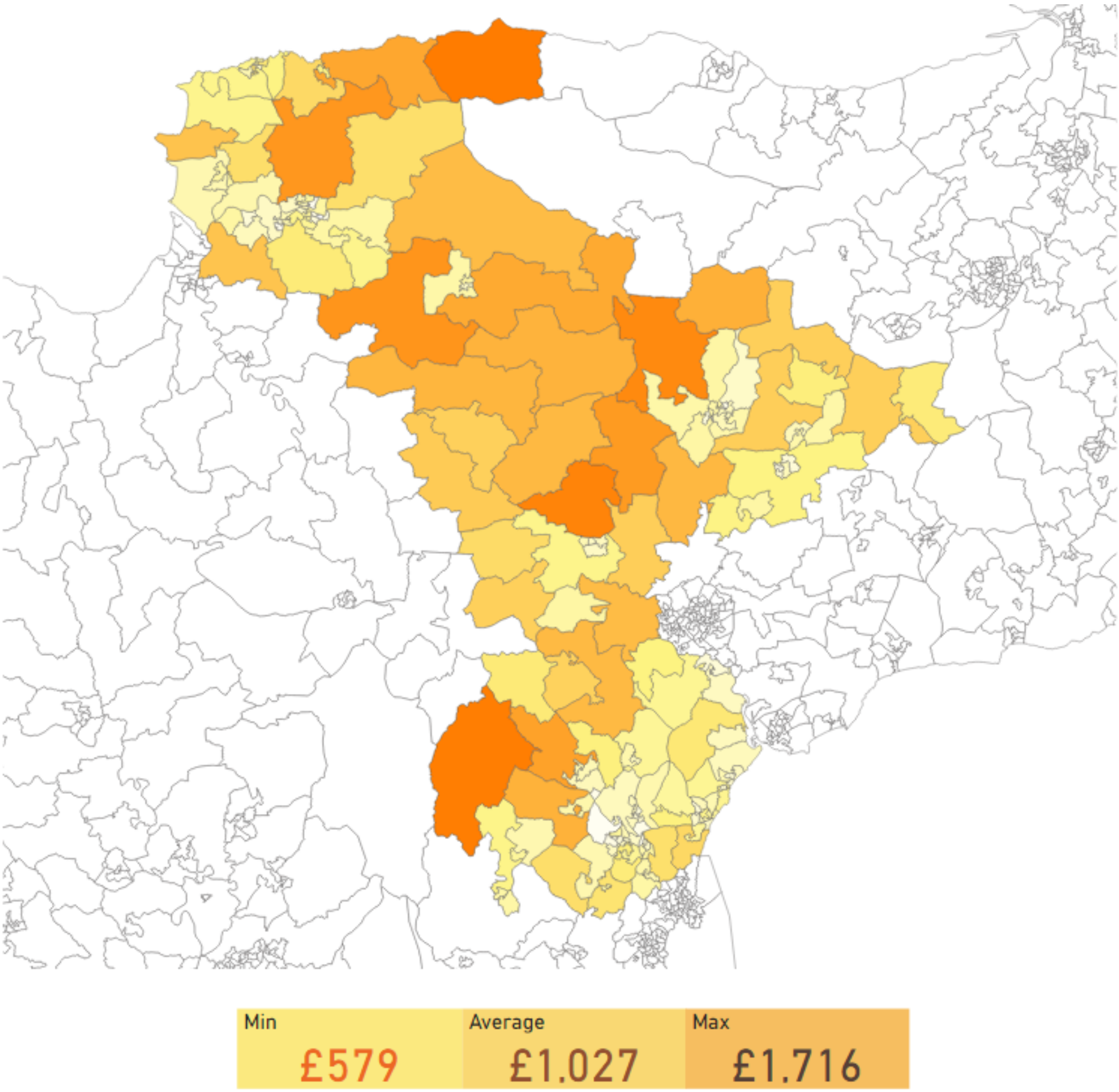


Figure 24

Fuel bills have a similar pattern to the CO_2 map.

3.9.5 Average kWh/m² by LSOA

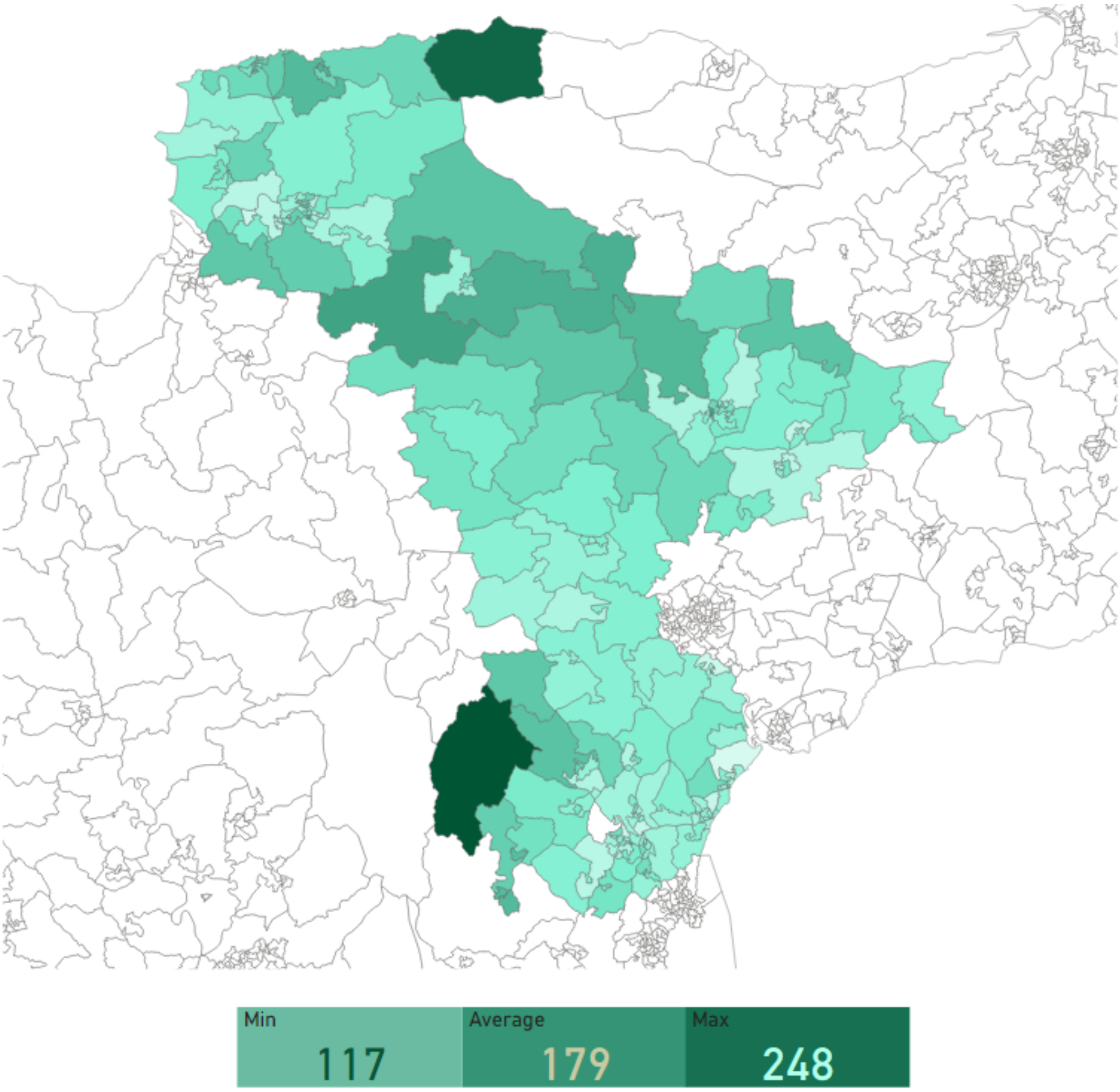


Figure 25

Slightly counterintuitively, kWh/m2 decreases with property size, all other things being equal.

3.9.6 Empty Cavities by LSOA

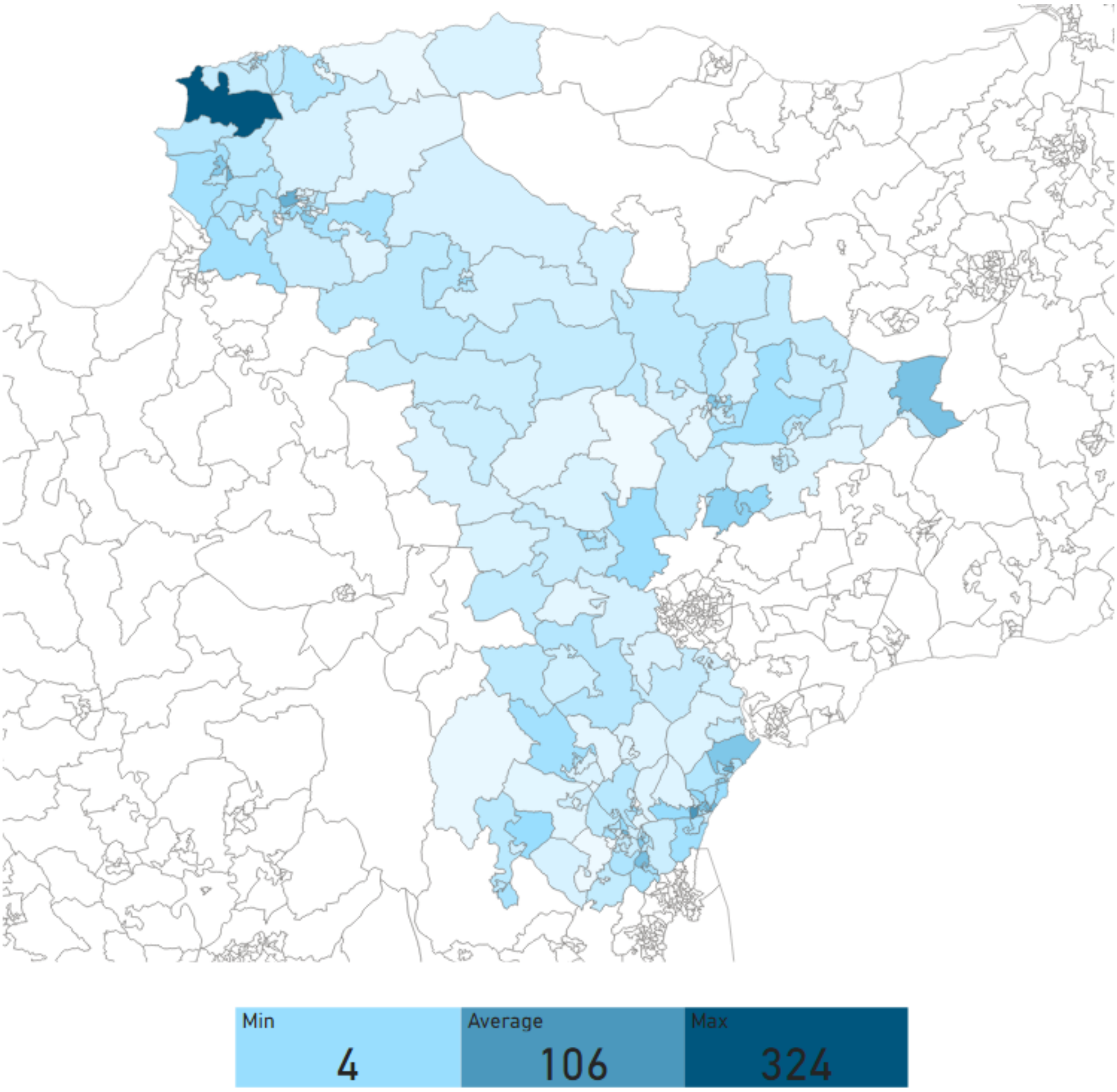


Figure 26

Empty cavities will reflect the location of properties built between the 1930s and 1983.

3.9.7 Uninsulated Solid Walls by LSOA

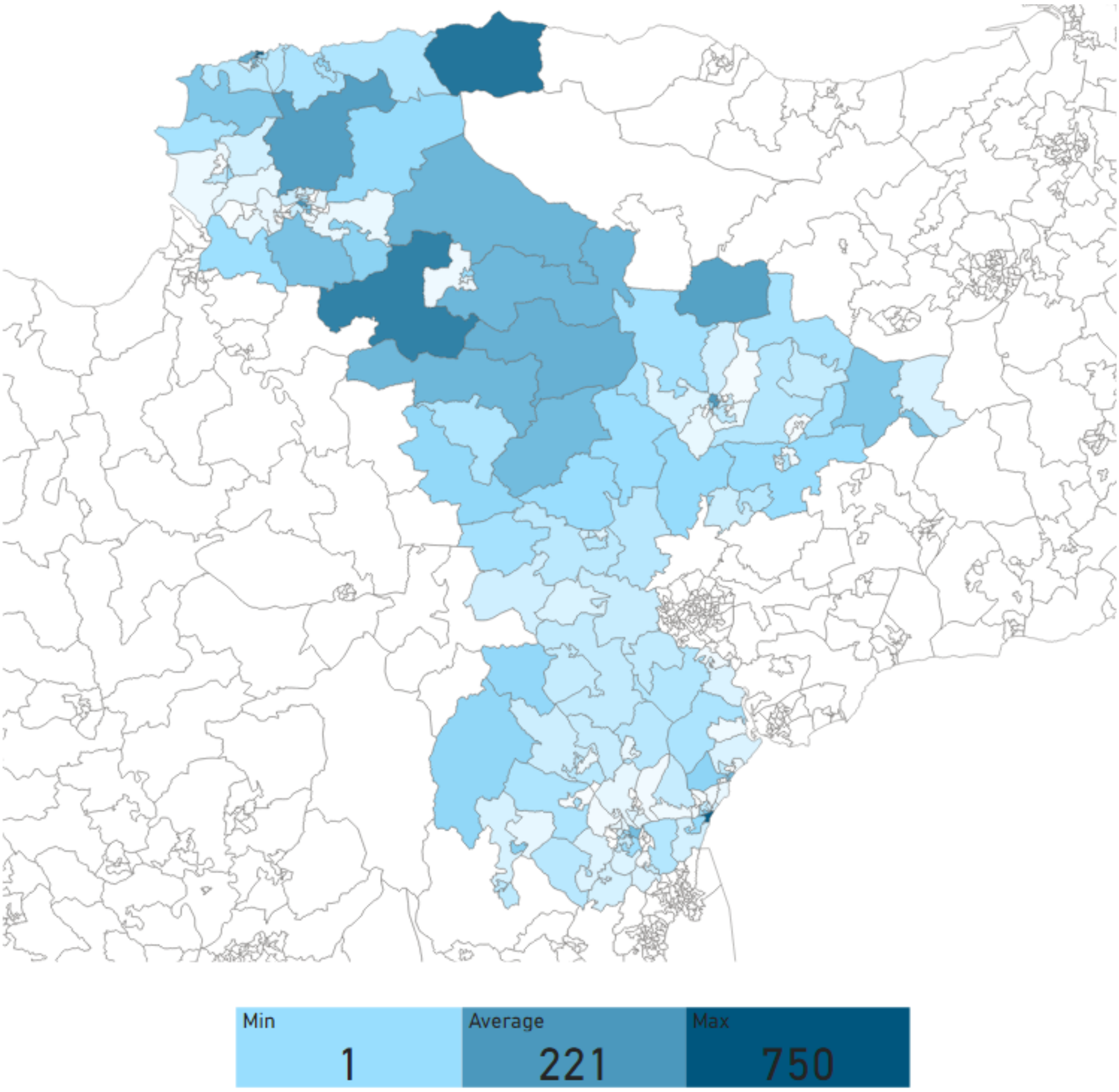


Figure 27

The figures include solid brick, granite, sandstone and any cob walled properties.

3.9.8 Substandard Loft Insulation by LSOA

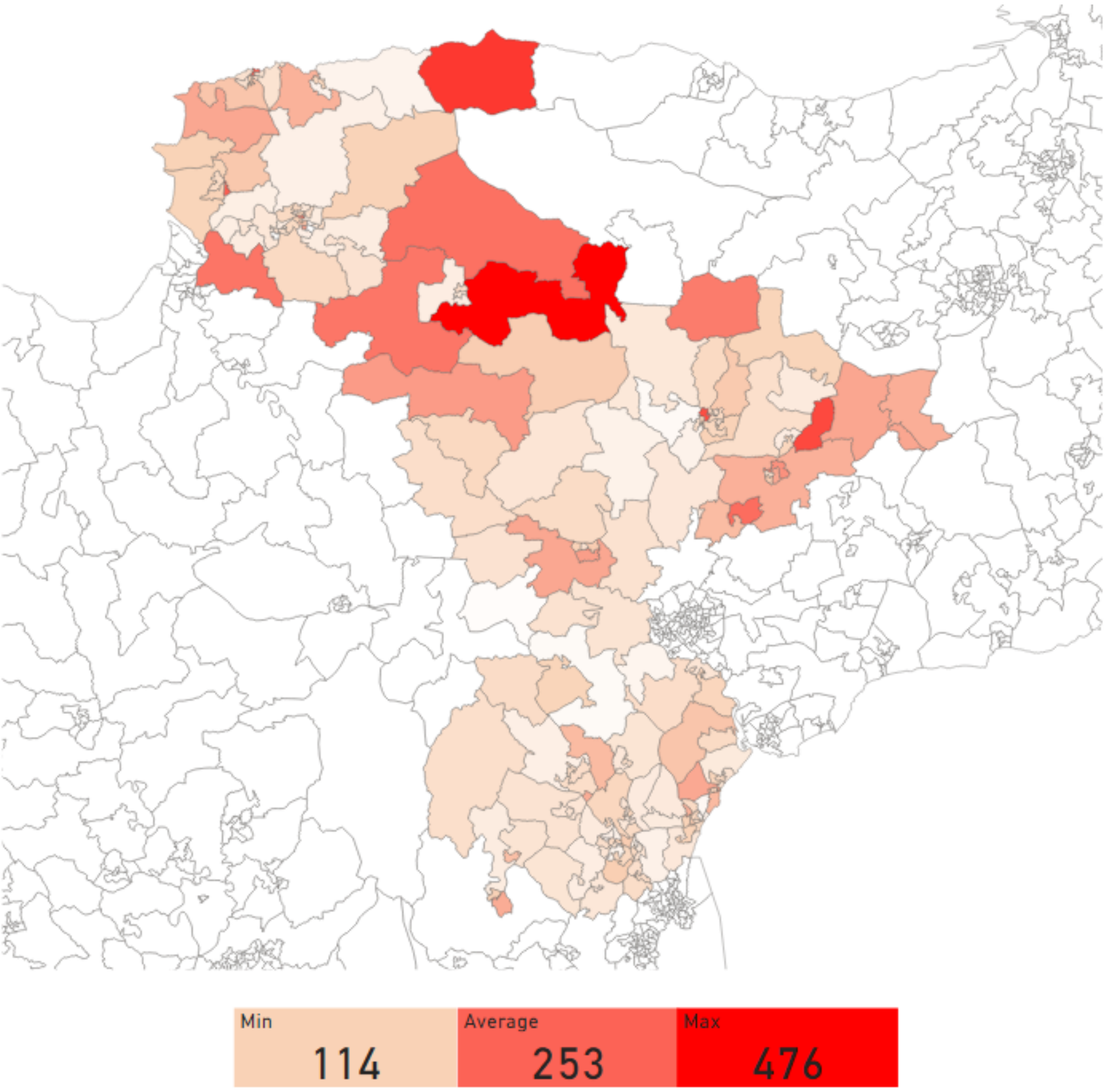


Figure 28

The map shows loft insulation marked as 100mm or below, none or unknown.

3.9.9 Off Gas Properties by LSOA

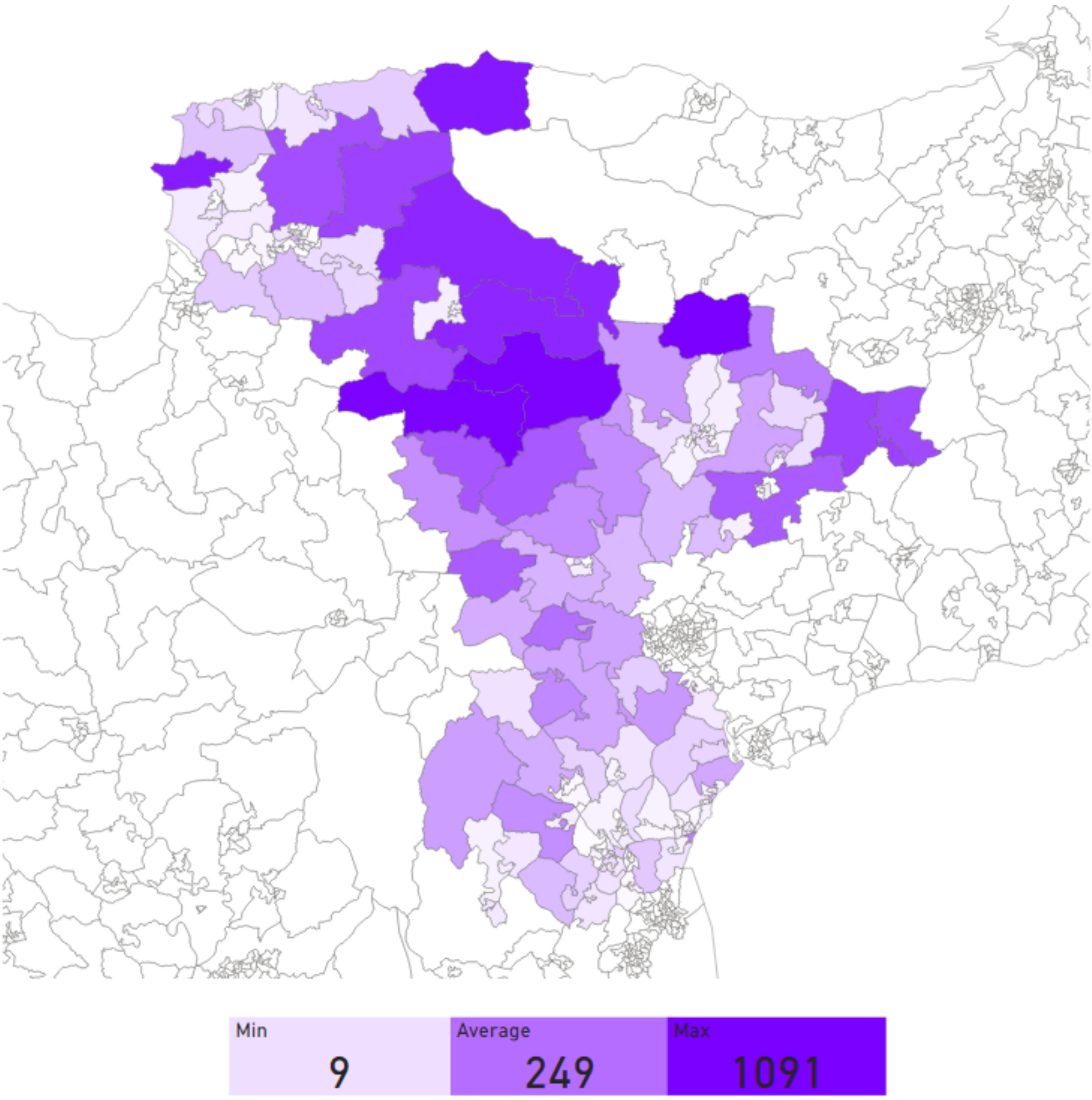


Figure 29

The figures exclude mains gas or community heated properties. Off gas properties are concentrated in more remote areas.

4 Pathways

4.1 PATHWAYS SUMMARY

A Pathway is our term for a modelled investment scenario. This section provides summary results of the Pathways that we have modelled across all 3 Districts – costs and impacts and maps of the Pathways as well as measures and trades required to fulfil the scenarios.

The modelling involves specifying several variables which are then applied to each property to determine a cost-effective list of measures aiming for a chosen target. The results can be viewed from the property level through various portfolios (e.g. filtered by property type, characteristic, age or area), up to the whole stock level. For this report we have considered two Pathways: 'Net Zero without disruptive measures' & 'Net Zero with disruptive measures'.

4.1.1 Grid Carbon intensity for 2038

BEIS produces figures for the expected CO_2 intensity of the grid for various dates into the future. Our modelling can use any of these projected grid intensities to determine which measures are most cost effective in terms of investment per $kgCO_2$ saved. The further into the future, the more the grid is expected to be decarbonised – with the effect that some measures become relatively more cost effective at reducing CO_2 (e.g. Heat Pumps) and others less so (e.g. PV). In discussion with the project team, we decided not to use current grid intensities, as the results would almost immediately be out of date. We also decided not to use 2050 figures; as the grid is expected to be largely decarbonised, the modelling starts prioritising on-peak electric heating and no fabric measures - an approach that will not be sensible until near 2050.

We have therefore chosen the figures for 2038, as they take account of significant further decarbonization of the grid, but not so much as to make the measures selected irrational. Furthermore, we also chose this over 2030, as this will mean the modelled results will still be sensible for many years following the initial target date.

4.1.2 Rationale for Pathway 1: Net Zero without disruptive measures

This Pathway has been primarily designed to meet the objective of getting the housing stock to Net Zero by 2050 with the minimum disruption. It can be seen as the minimum approach although the reasons for going further are outlined in Section 5.

The first and third step are designed to both model sensible cost-effective measures to mitigate from fuel bills rising.

4.1.3 Pathway 1: Setup

Pathway 1: Net Zero without disruptive measures

Steps	Target	Measures Considered	Measures Excluded
1	SAP B	Fabric measures Lighting measures With a cost effect less than £2,000 per SAP point	External wall insulation Internal wall insulation Solid floor insulation Suspended floor insulation Exposed floor insulation
2	Zero CO_2 using 2038 grid intensities	Heat pumps, Community heat pumps, High heat retention storage heaters for currently electrically heated flats	Fossil fuel heating measures
3	SAP A	PV where identified using LIDAR	PV where identified using LIDAR in a Conservation Area

4.1.4 Rationale for Pathway 2: Net Zero with disruptive measures

This Pathway has been primarily designed to meet the objective of getting the housing stock to Net Zero by 2050 allowing for more disruptive measures. This Pathways should lead to more properties having greater reductions on their energy bills, and fewer having increased energy bills.

The first and third step are again designed to both model sensible cost-effective measures to mitigate from fuel bills rising.

4.1.5 Pathway 2: Setup

Pathway 2: Net Zero with disruptive measures

Step	Target	Measures Considered	Measures Excluded
1	SAP B	Fabric measures Lighting measures With a cost effect less than £2,000 per SAP point	
2	Zero CO_2 using 2038 grid intensities	Heat pumps, Community heat pumps, High heat retention storage heaters for currently electrically heated flats	Fossil fuel heating measures
3	SAP A	PV where identified using LIDAR	PV where identified using LIDAR in a Conservation Area

4.1.6 Impacts of the Pathways

Below we compare the relative impacts of the two Pathways with each other. The total investment and average investment per property is just under twice as large for the scenario that includes disruptive measures.

Both Pathways get significant SAP improvements and CO2 reductions – i.e. both result in CO_2 emissions below 125kg per annum in 2038 once the grid has further decarbonised.

Pathway 1: Net Zero without disruptive measures

Pathway 2: Net Zero with disruptive measures

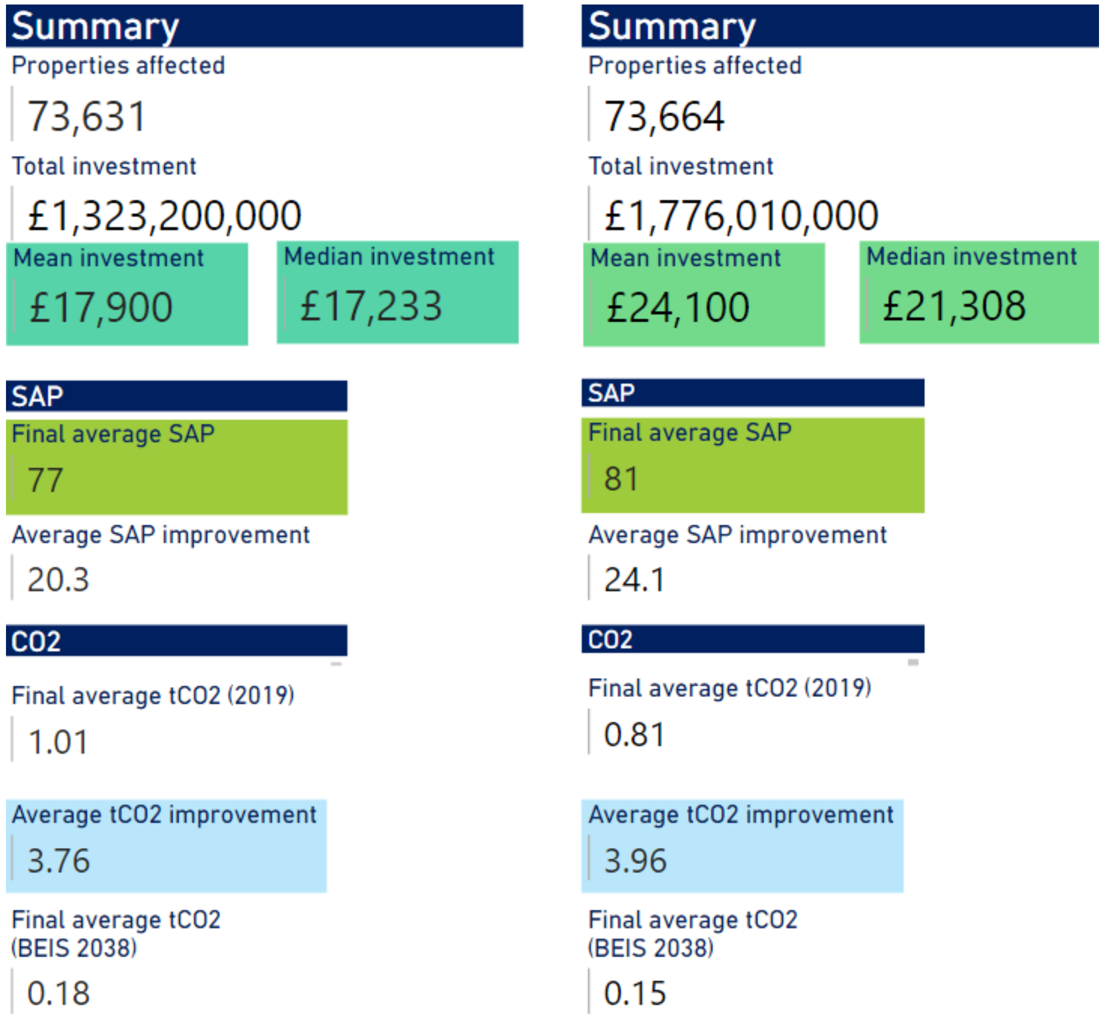


Figure 30

4.2 NET ZERO WITHOUT DISRUPTIVE FABRIC MEASURES: PATHWAY HIGHLIGHTS

In this section we show the key impacts of the Net Zero without disruptive fabric measures Pathway. It is worth highlighting that the final figure for tCO_2 is around 120kg per property using figures for the grid intensity in 2038. The reason it is not actually zero is because all properties will require some heating, which even if electric, will not be carbon neutral, and it is not possible to provide this electricity through on-site renewables. In addition, the figure also actually takes into account some offsetting between increased PV generation in the summer months against heating needs in the winter.

4.2.1 Pathway Summary

The Pathway has been run on all properties in the 3 Districts but the results below are for the subset that are in rural locations.

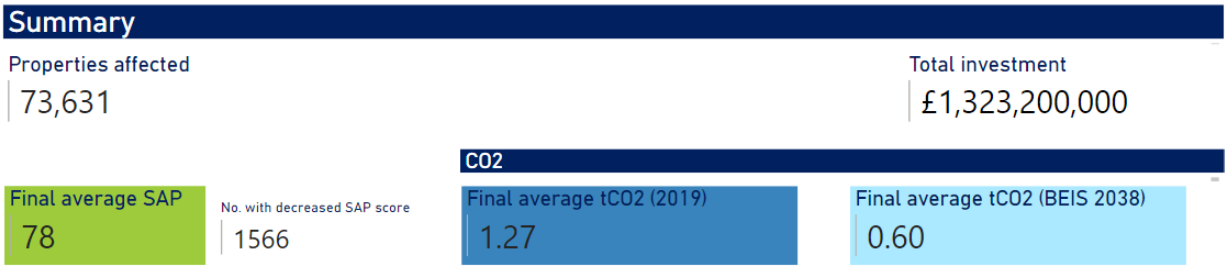


Figure 31

The final average SAP is a high C.

4.2.2 Investment

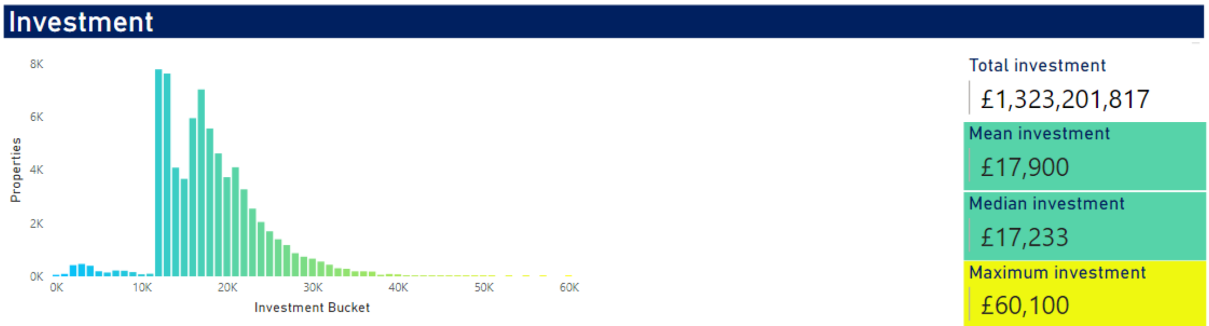


Figure 32

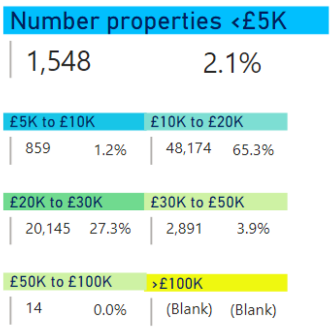


Figure 33

Figure 32 shows the number of properties in each investment group of £1,000 intervals. Figure 33 groups the number of properties by larger investment intervals.

Table 3 shows the results for each District ranked by final SAP score.

Multiple factors relating to the makeup of the housing stock in an area will impact both the average investment and final EPC score and CO_2 emissions. Some of these are discussed in Section 4.4.7.

Table 3 Net Zero without disruptive measures district comparisons

District	Total Investment (Billions)	Median Average Investment	Average Investment Rank (1 is lowest)	Final Average EPC Score	Final tCO_2 (2038)	No. with >£25 increased fuel bills
North Devon	£0.383	£17,850	3	76.5 (C)	0.18	2,076
Teignmouth	£0.460	£16,570	1	76.4 (B)	0.18	2,371
Mid Devon	£0.480	£17,430	2	77.2 ©	0.18	2,621

4.2.3 Investment by LSOA

The map below shows the rural LSOAs that will require higher levels of investment. Some of this will be driven by absolute numbers of properties. The darker green indicates a higher investment is required.

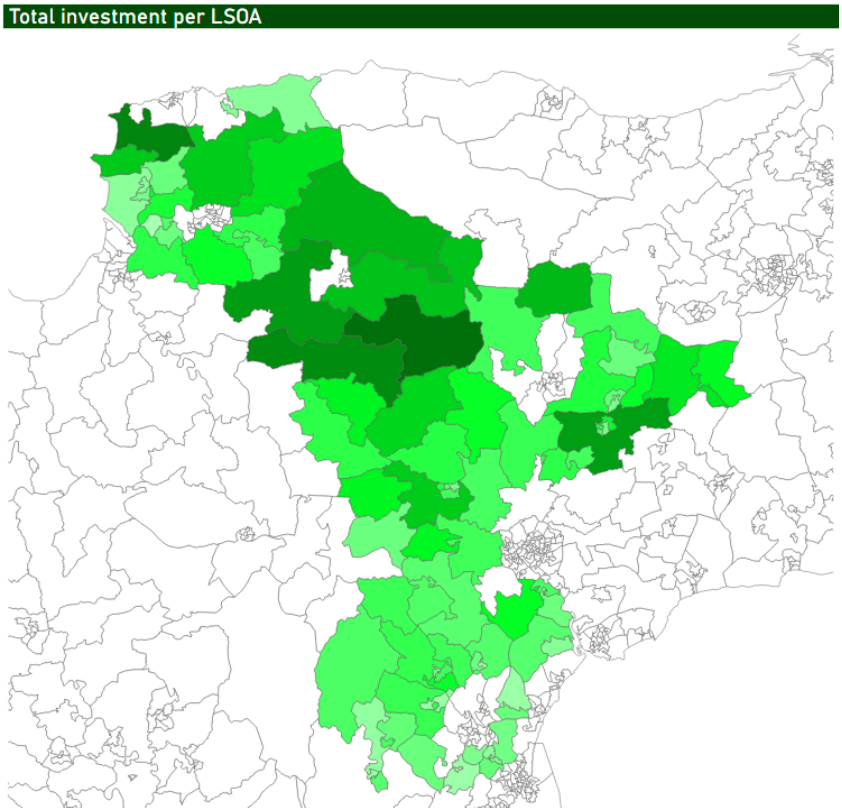


Figure 34

4.2.4 SAP Score

Figure 35 shows how the SAP profile changes from the current shape to one where all the measures identified in the Net Zero without disruptive measures scenario. The shape is reasonably similar but shifted to the right by around 19 points, and has two peaks rather than one. The two peaks may be a reflection of those properties that can have PV and those that can't.

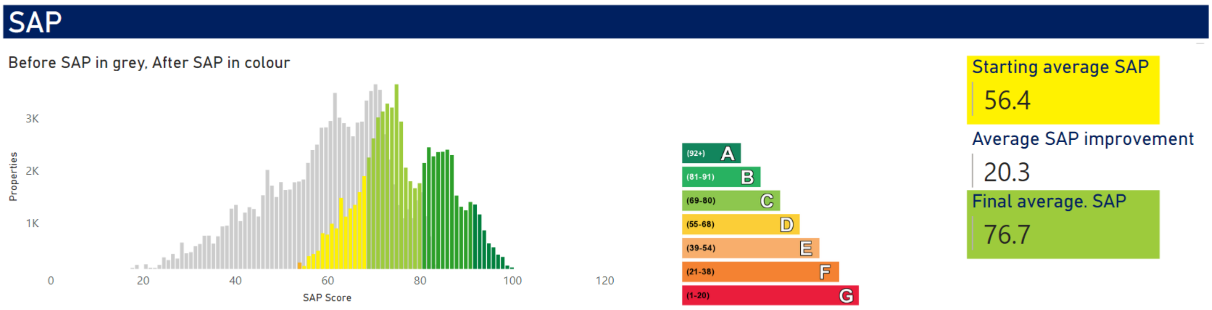


Figure 35

Table 4 Resulting Property Numbers by EPC Band after modelled measures are installed

Resulting EPC Band	Number of properties	% of stock
A	5,957	8%
B	21,755	29%
C	31,382	43%
D	13,573	18%
E	885	<0.015%
F	208	<0.003%
G	42	<0.0006%

4.2.5 CO_2 & Other KPIs

In Figure 36 we show the resulting CO_2 profile chart using the grid intensity predicated for 2019 and in Figure 37 using figures for 2038. Figure 38 provides some other interesting KPIs related to the performance of the buildings and impact on fuel bill cost.

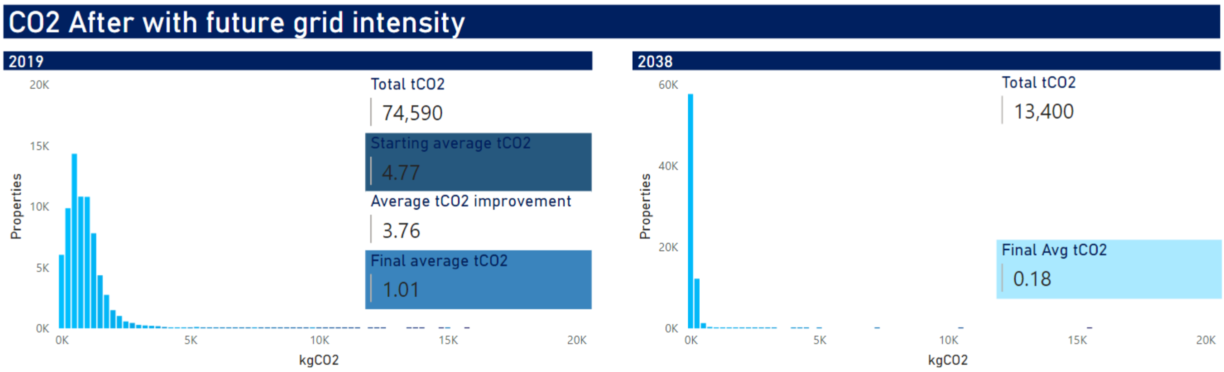


Figure 36

4.2.6 CO_2 Future Grid Intensities

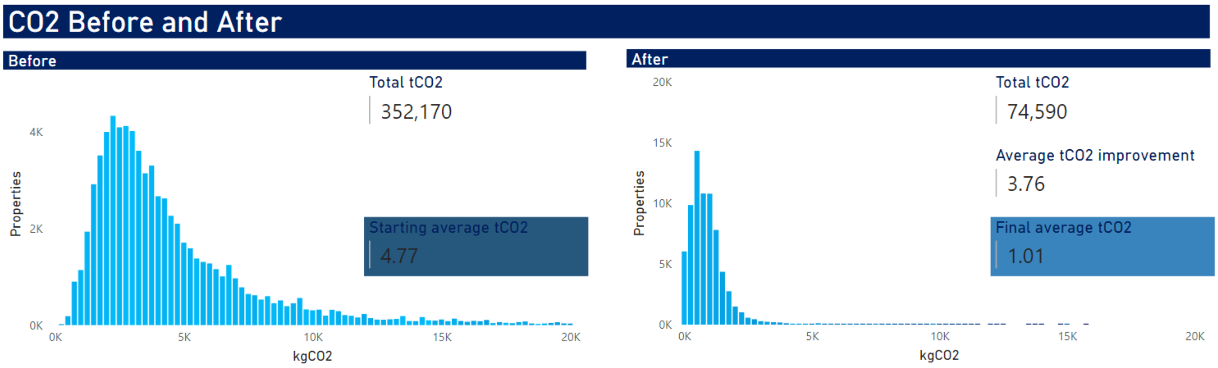


Figure 37


Heating Costs
Starting average heating £
£1,052
Final average heating £
£697
Average heating £ improvement
£355
Maximum heating £
£8,550
No. with higher heating £
2571
No. with >£25 higher heating £
947
Fuel Bills
Starting average fuel £
£1,132
Final average fuel £
£763
Average fuel £ improvement
£368
Maximum fuel £
£10,390
No. with higher fuel £
9203
No. with >£25 higher fuel £
7068
Environmental Index
Starting average EI
52.03
Final average EI
78.8
Average EI improvement
26.8
kWh & kWh/m2
Starting average kWh
20,500
Final average kWh
4,344
Average kWh improvement
16,151
Total kWh
320,625,000
Starting average kWh/m2
181
Final average kWh/m2
40
Average kWh/m2 improvement
141
Highest kWh/m2
475
kWh/m2 heat demand
Starting average kWh/m2 heat demand
106
Final average kWh/m2 heat demand
110
Average kWh improvement
-4

Figure 38

4.2.7 Measures summary

Our method of applying the Pathway criteria to each property produces an ordered list of the most cost-effective measures for every property. A hypothetical example is shown below.

Address	Measure Applied Order	Measure Outcome	Calculated Measure Cost	Cumulative Cost	Resulting SAP Score	Resulting kWh/m2 heat demand	Resulting Fuel Bill	Resulting kgCO2 (2038)
9 Acacia Avenue, BR1 1XX	1	300mm loft insulation	£706	£706	55.48 (D)	85.00	£932.19	3,789
9 Acacia Avenue, BR1 1XX	2	External wall insulation	£9,835	£10,541	66.76 (D)	24.05	£704.57	2,684
9 Acacia Avenue, BR1 1XX	3	Air source heat pump	£12,000	£22,541	68.19 (D)	43.24	£724.46	371
9 Acacia Avenue, BR1 1XX	4	Solar hot water	£4,725	£27,266	75.74 ©	44.75	£528.80	267
9 Acacia Avenue, BR1 1XX	5	Photovoltaic array	£4,174	£31,440	85.55 (B)	44.75	£350.91	131

Figure 39

We can use these individual property results to total the number and cost of each of the measures grouped at various levels e.g. cavity wall insulation has been found for 19,632 properties at a cost of £29 million. This is included in the total Fabric measures of 102,713 at a total cost of just over £138million. The table below gives the high-level summary and the following tables provide more detail on the measures and their costs (materials and labour). These tables are necessarily very detailed and may require zooming in to be more visible if on a smaller screen.

Table 5 Breakdown of the Pathway measures results by high level category

	Value (£ millions)	No. measures (thousands)
Fabric	138 (10%)	103 (38%)
Heating & Hot Water	990 (75%)	73 (27%)
Photovoltaics	191 (14%)	36 (13%)
Lighting	3.7 (0.3%)	58 (21%)

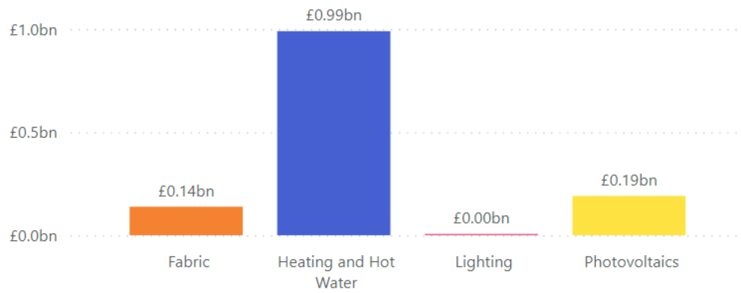


Table 6 Detailed breakdown of the Pathway results fabric measures

.	Total Investment	No. Measures	Average Cost	Av. SAP Change	Av. Fuel £ Saving	Av. Heating £ Saving	Av. kgCO2 Saving 2019	Av. kgCO2 Saving 2038	Av. kgCO2 Saving 2050
⊞ Heating and Hot Water	£990,277,916	73271	£13,515	9.68	£256.35	£254.87	2,932	3549	3591
⊞ Photovoltaics	£190,805,669	35566	£5,365	12.65	£386.91	£0.00	682	120	82
⊟ Fabric	**£138,461,100**	**102713**	**£1,348**	**2.79**	**£76.69**	**£76.54**	**361**	**322**	**319**
⊟ Glazing	**£69,651,123**	**15966**	**£4,362**	**3.39**	**£82.28**	**£81.88**	**336**	**268**	**264**
⊞ Triple	**£430,124**	**60**	**£7,169**	**3.06**	**£59.47**	**£58.35**	**173**	**65**	**57**
⊞ Double	**£60,355,728**	**9387**	**£6,430**	**5.10**	**£128.57**	**£127.90**	**537**	**443**	**436**
⊞ Doors	**£8,444,640**	**6166**	**£1,370**	**0.91**	**£15.35**	**£15.35**	**46**	**16**	**14**
⊞ Secondary glazing	**£420,631**	**353**	**£1,192**	**1.34**	**£24.17**	**£24.44**	**100**	**72**	**70**
⊟ Walls	**£29,215,781**	**19632**	**£1,488**	**4.66**	**£118.40**	**£118.40**	**592**	**539**	**535**
⊞ Cavity	**£29,215,781**	**19632**	**£1,488**	**4.66**	**£118.40**	**£118.40**	**592**	**539**	**535**
⊟ Ventilation	**£343,200**	**286**	**£1,200**	**5.34**	**£154.30**	**£122.17**	**360**	**151**	**137**
⊞ Remove MV	**£343,200**	**286**	**£1,200**	**5.34**	**£154.30**	**£122.17**	**360**	**151**	**137**
⊟ Roofs	**£31,310,572**	**41077**	**£762**	**2.82**	**£85.81**	**£85.81**	**410**	**375**	**372**
⊞ Flat Roof	**£3,698,818**	**545**	**£6,787**	**9.64**	**£241.87**	**£241.87**	**1,182**	**1066**	**1058**
⊞ Rafter or Ceiling	**£136,763**	**63**	**£2,171**	**2.13**	**£52.23**	**£52.23**	**263**	**235**	**233**
⊟ Loft	**£27,474,991**	**40469**	**£679**	**2.73**	**£83.76**	**£83.76**	**400**	**365**	**363**
⊞ Unknown	£47,410	55	£862	7.24	£238.46	£238.46	1,014	925	919
⊞ Virgin	£4,954,234	5831	£850	10.76	£369.91	£369.91	1,767	1631	1621
⊞ Top Up	£22,473,347	34583	£650	1.36	£35.27	£35.27	169	151	150
⊟ Draughts	**£7,940,424**	**25752**	**£308**	**0.92**	**£26.02**	**£26.02**	**121**	**108**	**107**
⊞ Chimneys	**£4,092,060**	**11995**	**£341**	**1.06**	**£26.45**	**£26.45**	**126**	**114**	**113**
⊞ Doors & Windows	**£3,848,364**	**13757**	**£280**	**0.80**	**£25.64**	**£25.64**	**116**	**103**	**103**
⊞ Lighting	£3,657,132	57619	£63	0.92	£25.86	-£6.39	26	-18	-21
Total	£1,323,201,817	269169	£4,916	5.57	£155.71	£97.22	1,031	1101	1106

Table 7 Detailed breakdown of the Pathway results heating. lighting and PV measures

.	Total Investment	No. Measures	Average Cost	Av. SAP Change	Av. Fuel £ Saving	Av. Heating £ Saving	Av. kgCO2 Saving 2019	Av. kgCO2 Saving 2038	Av. kgCO2 Saving 2050
⊟ **Heating and Hot Water**	**£990,277,916**	**73271**	**£13,515**	**9.68**	**£256.35**	**£254.87**	**2,932**	**3549**	**3591**
⊟ **Individual Heating and Hot Water**	**£989,551,916**	**73205**	**£13,518**	**9.69**	**£256.49**	**£255.00**	**2,933**	**3551**	**3593**
⊟ **Heating System**	**£989,551,916**	**73205**	**£13,518**	**9.69**	**£256.49**	**£255.00**	**2,933**	**3551**	**3593**
⊟ **Heat Pump System**	**£984,750,316**	**70985**	**£13,873**	**9.72**	**£259.96**	**£258.43**	**3,018**	**3661**	**3704**
GSHP	£6,229,996	330	£18,879	16.05	£551.44	£551.91	1,712	1268	1238
ASHP	£978,520,320	70655	£13,849	9.69	£258.60	£257.06	3,024	3672	3716
⊟ **Electric Storage**	**£4,801,600**	**2220**	**£2,163**	**8.59**	**£145.53**	**£145.42**	**193**	**44**	**34**
Electric - Not Wet	£4,801,600	2220	£2,163	8.59	£145.53	£145.42	193	44	34
⊞ **Community Heating**	**£726,000**	**66**	**£11,000**	**5.26**	**£103.89**	**£103.89**	**1,946**	**1554**	**1548**
⊟ **Photovoltaics**	£190,805,669	35566	£5,365	12.65	£386.91	£0.00	682	120	82
⊞ **Identified PV system**	**£190,805,669**	**35566**	**£5,365**	**12.65**	**£386.91**	**£0.00**	**682**	**120**	**82**
⊞ Fabric	£138,461,100	102713	£1,348	2.79	£76.69	£76.54	361	322	319
⊞ **Lighting**	**£3,657,132**	**57619**	**£63**	**0.92**	**£25.86**	**-£6.39**	**26**	**-18**	**-21**
Total	£1,323,201,817	269169	£4,916	5.57	£155.71	£97.22	1,031	1101	1106

4.3 NET ZERO WITHOUT DISRUPTIVE MEASURES EMPLOYMENT ANALYSIS

4.3.1 Existing sector

The number of people employed in the existing refurbishment sector is hard to determine as ONS statistics and figures are categorised differently from what is needed e.g. they give total numbers of plasterers in all construction which will cover commercial, public sector and new build, or the value is split into public and private but not new build or refurbishment. We have therefore triangulated various numbers from the Office of National Statistics (ONS) and we estimate it currently stands at 12% of the entire UK construction industry by headcount. For the trades working in retrofit, we assume current work is 30% of the UK's construction workload by value. From this we estimate the recent make-up of the UK domestic refurbishment industry in terms of employees as shown below:

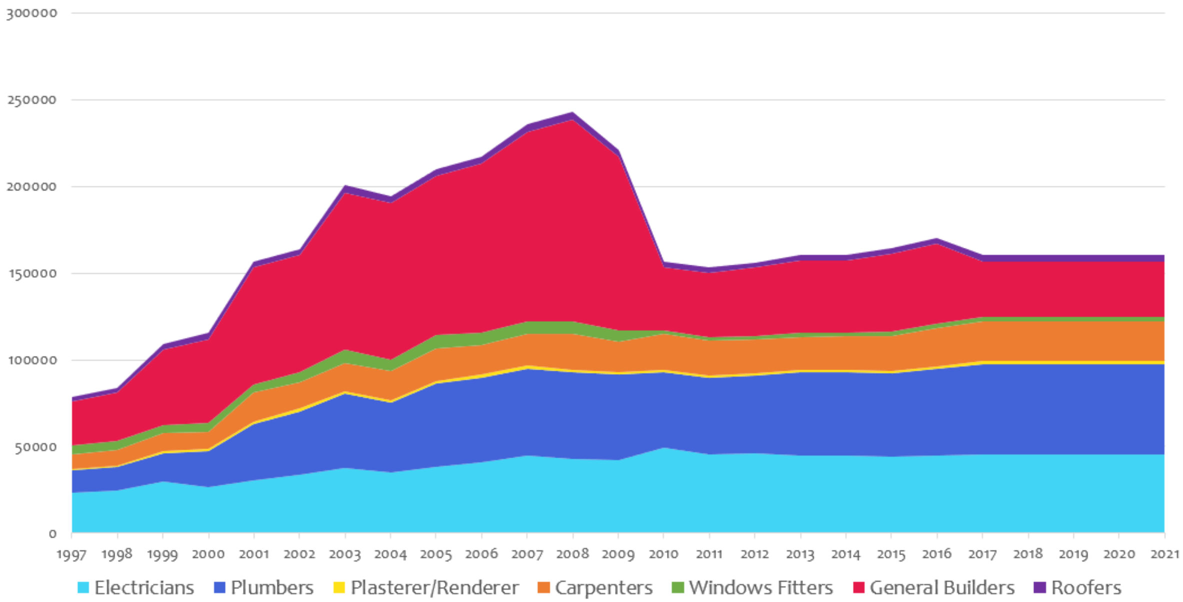


Figure 40 Estimated Trades in the UK

In 2008 there were 242,800 trades in ROOFING, INSTALLATION OF ELECTRICAL WIRING AND FITTING, PLUMBING, AND HEAT AND AIR CONDITIONING INSTALLATION, PLASTERING/RENDERER, JOINERY INSTALLATION, GLAZING, OTHER CONSTRUCTION WORK AND BUILDING INSTALLATION AND COMPLETION. There was then a large overall drop-off in 2008 that has never been recovered. It disproportionately affected general builders, but joiners, electricians and heating engineers have been reasonably steady across most of the later part of the period. We do have an underlying crisis in this sector and that is a lack of new entrants to it; a rapidly ageing workforce threatens our ability to maintain the current levels of work. For instance, the average age of a Gas Safe heating engineer is 56 and that is the age they start thinking about retirement.

4.3.2 Methodology

4.3.2.1 Current Trades

We have taken the data above for national existing trades and adjusted this proportionately to the number of properties in the 3 Districts. Admittedly this is quite a crude approach but inevitable in the absence of considerable primary research. The results of the two Pathways' trades analysis should be viewed the context of these existing trade estimates.

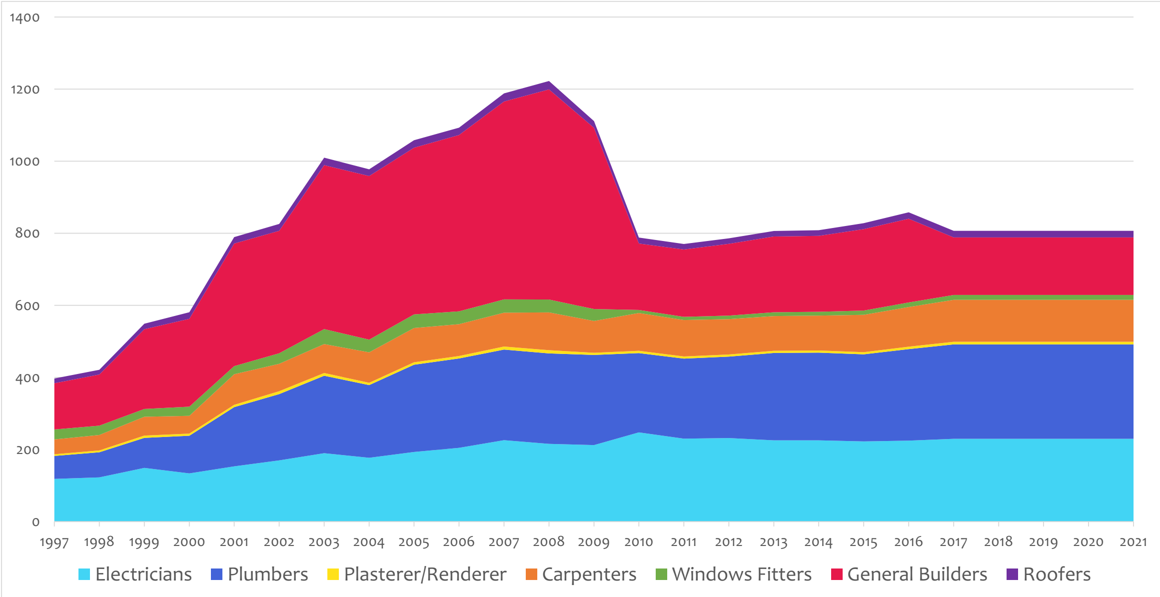


Figure 41 Estimated Current Trades in the 3 Districts including Rural and Urban areas

4.3.2.2 Required Trades

We have determined estimated figures for trade requirements for each measure applied in our two Pathways – see example below. These are totalled and then spread over the time period to 2050 using different implementation profiles outlined below in Sections 4.3.3 & 4.5.2.

<u>Example</u>

Measure: "Flat Roof Insulation to existing pre 1976 to 1982 flat roofs"

Assumed Trade Days required per job:

- Insulation Specialist – 2 days
- Carpenter – 2 days
- General Builder – 2 days

No. Jobs identified: 867

4.3.2.3 Retrofit Coordinators

This new professional role is critical to ensure a smooth flow of work and quality assurance at a time when ramping up volume risks the introduction of inexperienced people and poor practices. The Retrofit Coordinator will oversee the process for each householder from first introduction to sign-off of the work. We have made assumptions for Retrofit Coordinator hours for each measure type.

4.3.2.4 Average Trade Days for a 28-year programme (to 2050)

Figure 42 shows the number of different trades that would be required each year to deliver the 'Net Zero without disruptive measures' Pathway over 28 years. In total this programme would require 319 full time employees each year – standard building trades dominate. The charts also show how these are split across trades.

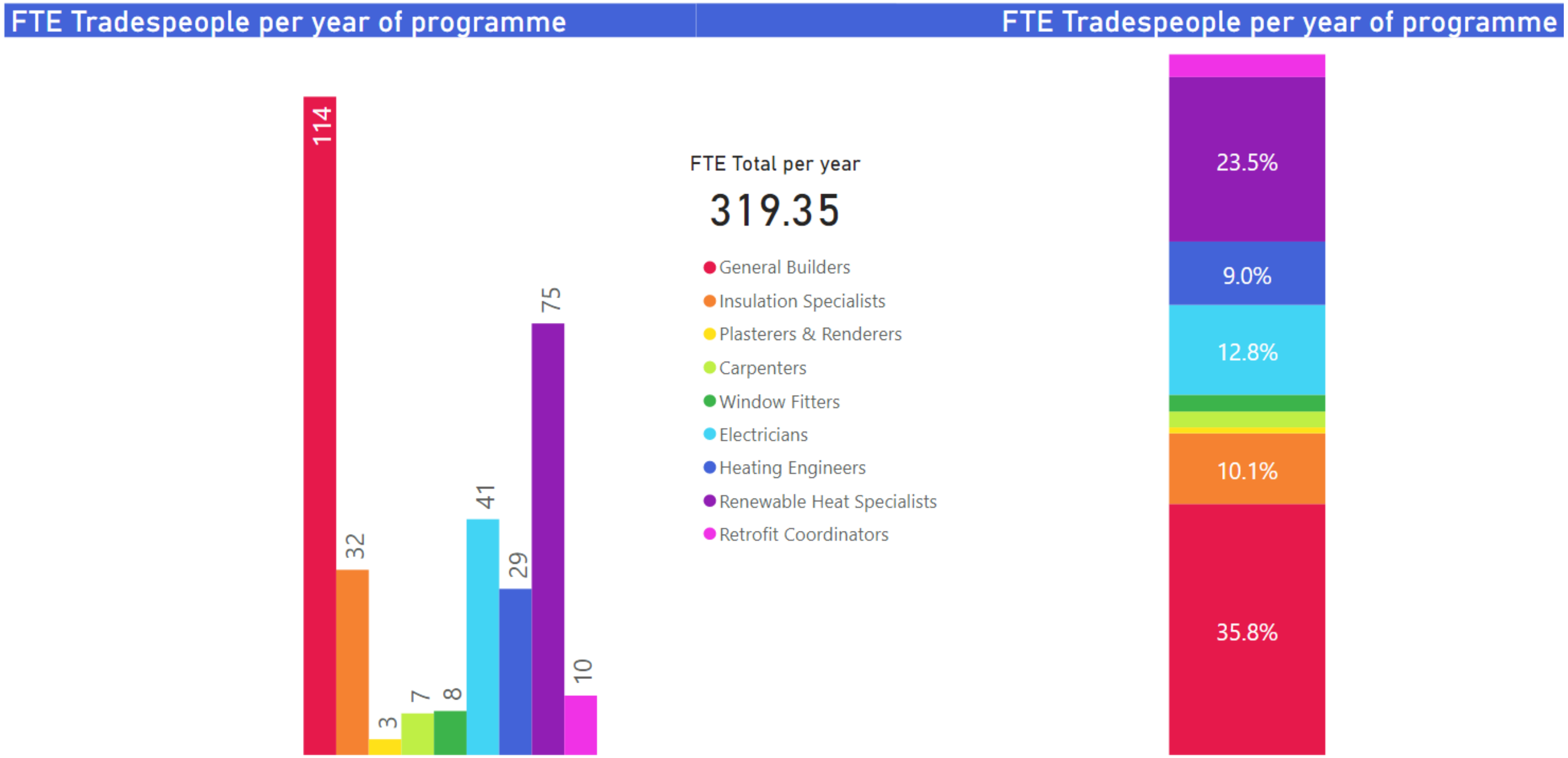


Figure 42

Alternatively, in Figure 43 we present the programme delivery in terms of individual trade days and total trade years.

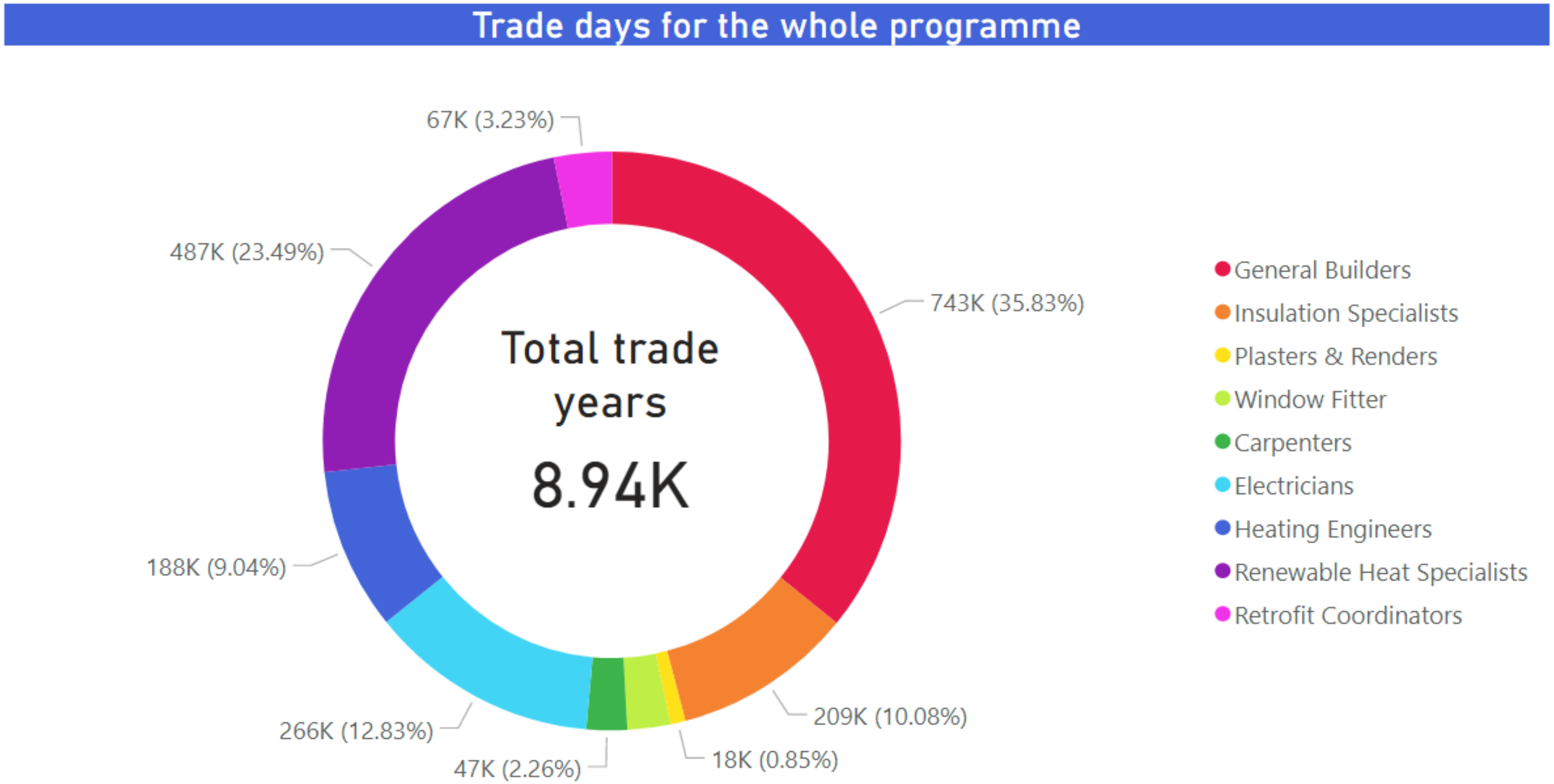


Figure 43

4.3.3 2050 Completion Target

The ambition of the 3 Districts is to reach Net Zero by 2050 – from little more than a standing start. Below we have shown the trades required to meet the target with an implementation trajectory that ramps up to a peak at 2030 and completed by 2050. After 2030 there will be ongoing maintenance roles and so it is envisaged that this would not result in an employment cliff edge.

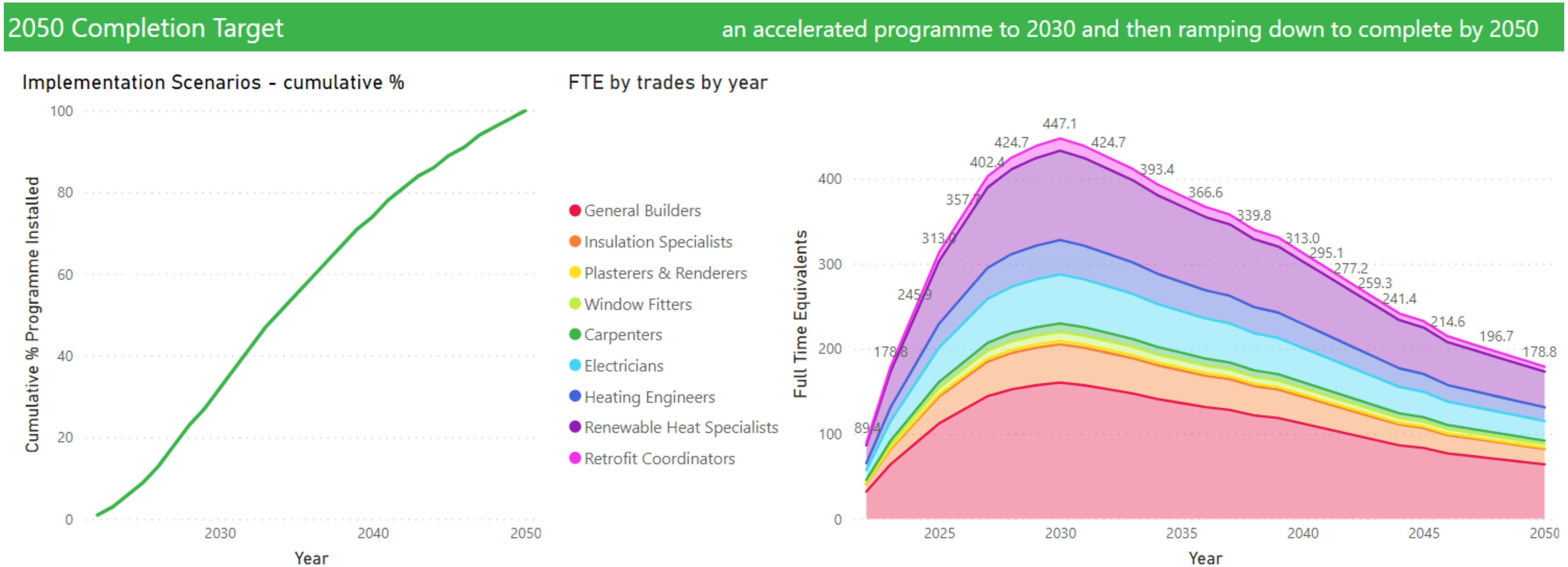


Figure 44

Table 8

	General Builders	Insulation Specialists	Plasters & Renderers	Window Fitters	Carpenters	Electricians	Heating Engineers	Renewable Heat Specialists	Retrofit Coordinators
No. FTE in 2030	160	45	4	11	10	57	40	105	14

4.4 NET ZERO WITH DISRUPTIVE FABRIC MEASURES: PATHWAY HIGHLIGHTS

In this section we show the key impacts of the Net Zero without disruptive fabric measures Pathway. It is worth highlighting that the final figure for tCO_2 is around 100kg per property using figures for the grid intensity in 2038. The reason it is not actually zero is because all properties will require some heating, which even if electric, will not be carbon neutral, and it is not possible to provide this electricity through on-site renewables. In addition, the figure also actually takes into account some offsetting between increased PV generation in the summer months against heating needs in the winter.

4.4.1 Pathway Summary

The Pathway has been run on all properties in the 3 Districts but the results below are for the subset that are in rural locations.

Summary

Properties affected
73,664

Total investment
£1,776,010,000

CO2

Final average SAP
81

No. with decreased SAP score
458

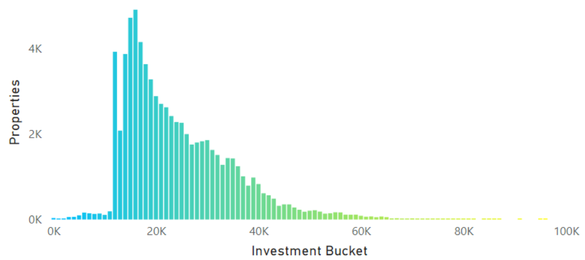
Final average tCO2 (2019)
0.81

Final average tCO2 (BEIS 2038)
0.15

Figure 45

4.4.2 Investment

Investment



Total investment
£1,776,005,586

Mean investment
£24,100

Median investment
£21,308

Maximum investment
£95,800

Figure 46

Number properties <£5K	237	0.3%
£5K to £10K	679	0.9%
£10K to £20K	32,154	43.6%
£20K to £30K	22,059	29.9%
£30K to £50K	16,407	22.2%
£50K to £100K	2,128	2.9%
>£100K	(Blank)	(Blank)

Figure 47

Figure 46 shows the number of properties in each investment group of £1,000 intervals. Figure 47 groups the number of properties by larger investment intervals. If a maximum investment were to be set then these could be used to determine the numbers of properties that definitely miss the target.

Table 9 shows the results for each District ranked by final SAP score.

Table 9 District Net Zero Target Results

District	Total Investment (Billions)	Median Average Investment	Average Investment Rank (1 is lowest)	Final Average EPC Score	Final tCO_2 (2038)	No. with >£25 increased fuel bills
North Devon	£0.53	£23,020	3	81.1 (B)	0.14	754
Teignbridge	£0.60	£19,870	1	79.9 (C)	0.15	1,074
Mid Devon	£0.64	£21,620	2	80.7 (B)	0.14	1,128

4.4.3 Investment by LSOA

The map below shows the rural LSOAs that will require higher levels of investment. Some of this will be driven by absolute numbers of properties. The darker green indicates a higher investment is required.

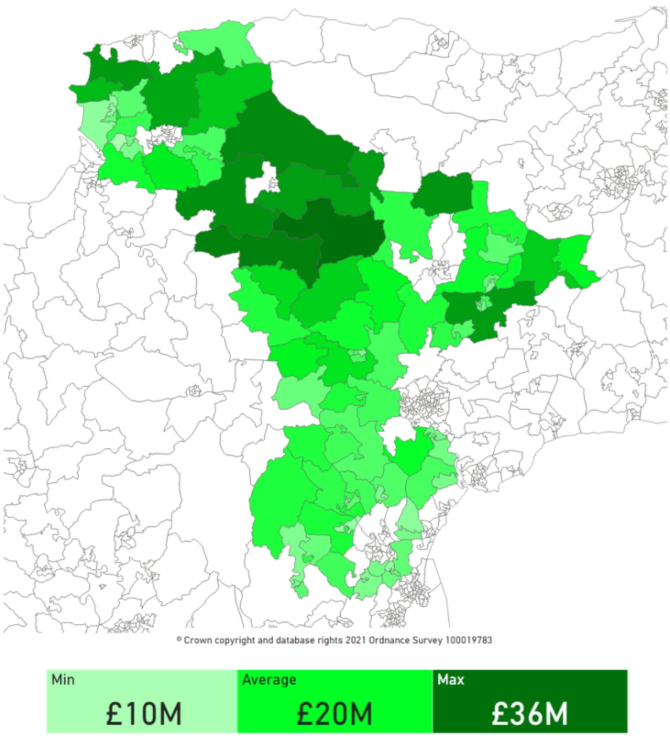


Figure 48

4.4.4 SAP Score

Figure 49 shows how the SAP profile changes from the current shape to one where all the measures identified in the Net Zero with disruptive measures scenario. The shape is reasonably similar but shifted to the right by around 2 points, and has two peaks rather than one. The two peak may be a reflection of those properties that can have PV and those that can't.

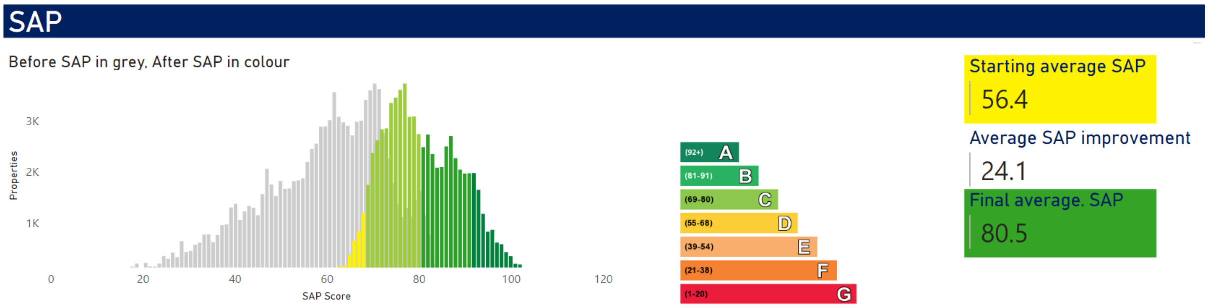


Figure 49

Table 10 Resulting Property Numbers by EPC Band

Resulting EPC Band	Number of properties	% of stock
A	9,132	12%
B	25,201	34%
C	35,502	48%
D	3,627	5%
E	202	<0.003%
F	97	<0.002%
G	41	<0.001%

4.4.5 CO_2 & Other KPIs

Below we also show the resulting CO_2 profile chart using the grid intensity predicted for 2038. Figure 52 provides some other interesting KPIs related to the performance of the buildings and impact on fuel bill cost.

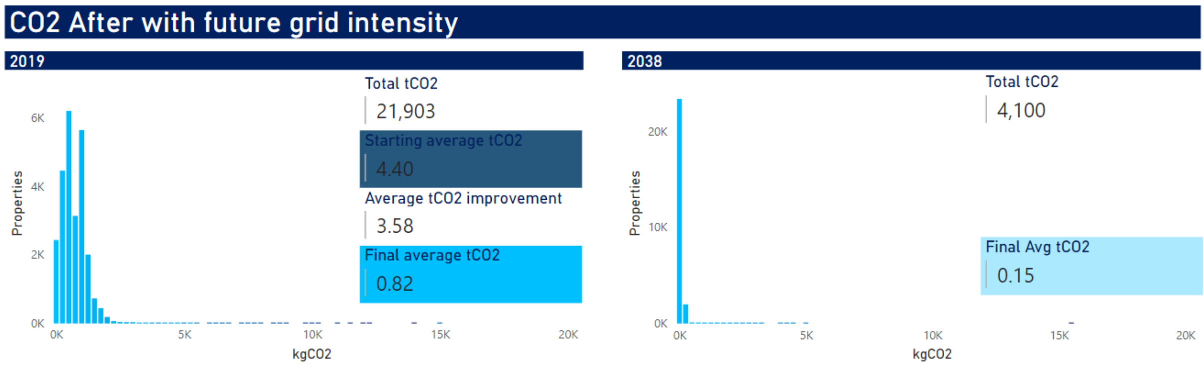


Figure 50

4.4.6 CO_2 Future Grid Intensities

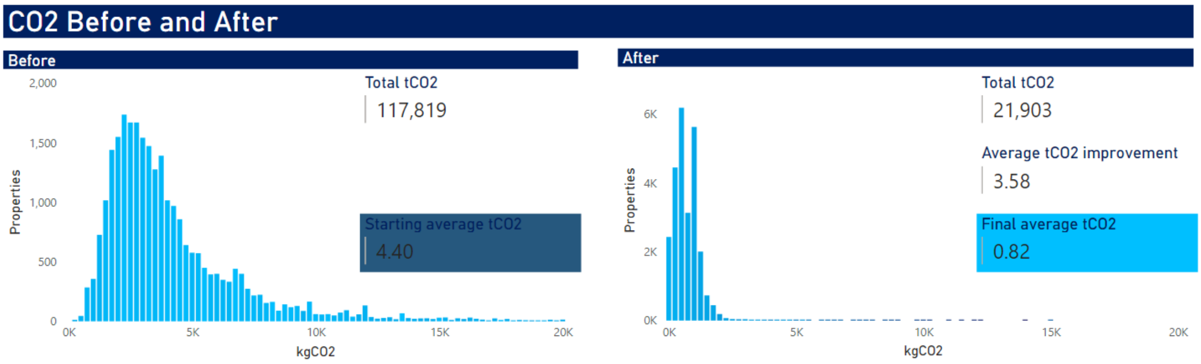


Figure 51

Heating Costs

Starting average heating £: £965

Final average heating £: £581

Average heating £ improvement: £384

Maximum heating £: £8,350

No. with higher heating £: 499

No. with >£25 higher heating £: 163

Fuel Bills

Starting average fuel £: £1,072

Final average fuel £: £626

Average fuel £ improvement: £446

Maximum fuel £: £9,500

No. with higher fuel £: 1504

No. with >£25 higher fuel £: 1074

Environmental Index

Starting average EI: 53.86

Final average EI: 81.8

Average EI improvement: 28.0

kWh & kWh/m2

Starting average kWh: 19,700

Final average kWh: 3,519

Average kWh improvement: 16,172

Total kWh: 94,210,000

Starting average kWh/m2: 181

Final average kWh/m2: 34

Average kWh/m2 improvement: 147

Highest kWh/m2: 475

kWh/m2 heat demand

Starting average kWh/m2 heat demand: 105

Final average kWh/m2 heat demand: 78

Average kWh improvement: 27

Figure 52

4.4.7 Trends by Total Investment

We have also looked at some key properties details for properties that fall into each of three total investment groups – those requiring below £15,000 investment, those between £15,000 and £35,000 and those over £35,000. In addition, we have looked in more detail at properties that may result in higher fuel bills under the 'Pathway without disruptive measures' Pathway. These are shown in the table below with some commentary for each.

Table 11 Comparisons of different characteristics by required investment grouping

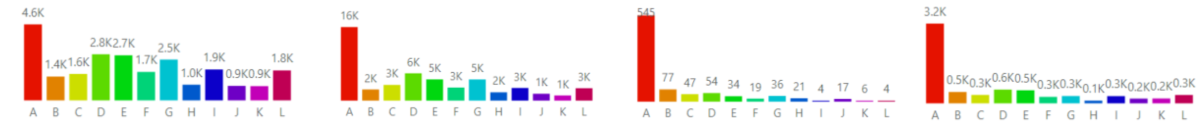
EPC Band

As you would expect, properties with lower baseline EPC scores will require more investment to bring to Net Zero.

Total Investment: Less then £15,000	£15,000 to £35,000	£35,000+	Higher resulting fuel bills (>£25)
No. Properties: 23,862 ~32%	49,076 ~66%	864 ~1.1%	6,809 ~9.2%

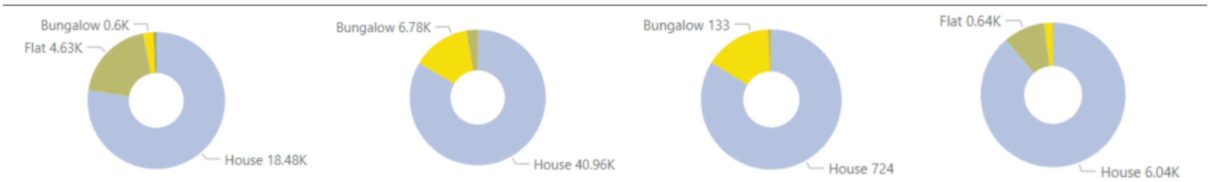
Property Age Band

Older properties tend to require more investment.



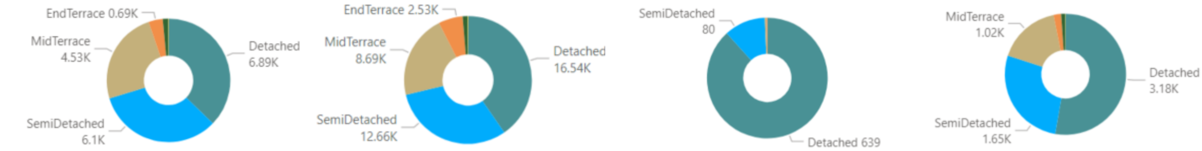
Property Type

Houses become much more dominant for the highest investment groups which will reflect the larger size and more surface area.



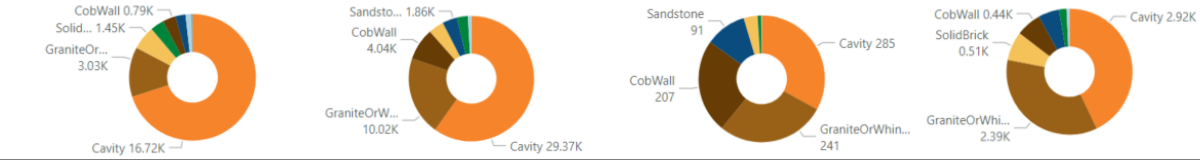
Detachment (Houses only)

For houses, the more detached the property, the higher the investment required. This will be driven by the property size and external wall area.



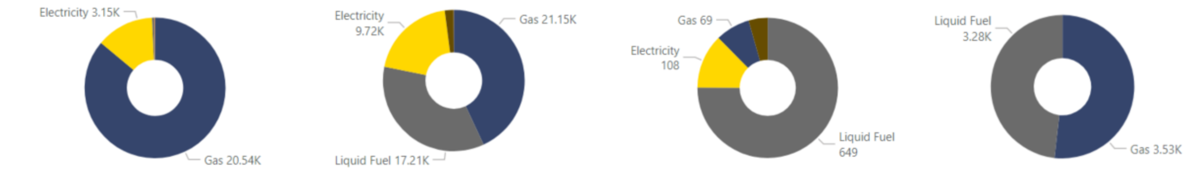
Wall Construction

There are minor changes to the makeup of the wall types with cavity walls be less representative in both the properties that require greater capital investment and those that may experience higher fuel bills.



Main Heating Fuel

Properties that are currently electrically heated are absent from the cohort that may experience higher fuel bills as they won't experience a fuel switch.



4.4.8 Measures summary

The table below gives the high-level summary of measures employed in this scenario, and the following pages provide more detail on the measures and their costs (materials and labour).

Table 12 Breakdown of the Pathway measures results by high level category

	Value (£ millions)	No. measures (thousands)
Fabric	591 (33%)	183 (52%)
Heating & Hot Water	990 (56%)	73 (21%)
Photovoltaics	1901 (11%)	36 (10%)
Lighting	3.7 (<1%)	58 (17%)

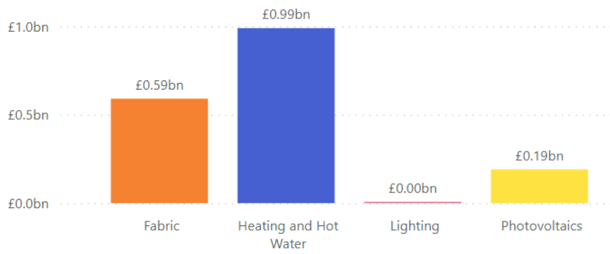


Table 13 Detailed breakdown of the Pathway results fabric measures

.	Total Investment	No. Measures	Average Cost	Av. SAP Change	Av. Fuel £ Saving	Av. Heating £ Saving	Av. kgCO2 Saving 2019	Av. kgCO2 Saving 2038	Av. kgCO2 Saving 2050
Heating and Hot Water	£990,252,356	73269	£13,515	6.65	£179.09	£177.61	2,299	2851	2888
Photovoltaics	£190,805,669	35566	£5,365	12.65	£386.91	£0.00	682	120	82
Fabric	**£591,290,429**	**183192**	**£3,228**	**4.32**	**£117.80**	**£117.68**	**537**	**475**	**470**
Walls	**£329,777,705**	**42853**	**£7,696**	**10.25**	**£295.61**	**£295.61**	**1,355**	**1214**	**1204**
Stone or Cob	**£236,354,281**	**15998**	**£14,774**	**18.09**	**£565.16**	**£565.16**	**2,555**	**2316**	**2300**
External	£234,206,655	15775	£14,847	18.24	£570.86	£570.86	2,582	2343	2326
Internal	£2,147,626	223	£9,631	8.08	£161.52	£161.52	624	428	415
Timber	**£3,698,492**	**310**	**£11,931**	**13.05**	**£283.65**	**£283.65**	**1,162**	**878**	**859**
Solid brick	**£30,971,723**	**2702**	**£11,463**	**12.42**	**£298.09**	**£298.09**	**1,382**	**1190**	**1177**
External	£19,350,572	1579	£12,255	13.75	£356.92	£356.92	1,665	1477	1464
Internal	£11,621,151	1123	£10,348	10.54	£215.38	£215.38	983	787	773
System	**£4,664,505**	**439**	**£10,625**	**14.46**	**£318.91**	**£318.91**	**1,396**	**1139**	**1122**
Cavity	**£53,932,324**	**22287**	**£2,420**	**4.68**	**£115.39**	**£115.39**	**556**	**490**	**485**
External	£21,991,880	2356	£9,334	5.02	£98.22	£98.21	308	138	126
Internal	£2,904,864	508	£5,718	2.50	£35.50	£35.50	117	32	26
Cavity Insulation	£27,109,880	17589	£1,541	5.12	£130.78	£130.78	657	600	596
Insulate Party Wall	£1,925,700	1834	£1,050	0.68	£12.01	£12.01	33	11	9
Other	**£156,380**	**1117**	**£140**	**1.17**	**£19.26**	**£19.26**	**82**	**57**	**56**
Glazing	**£117,040,960**	**24673**	**£4,744**	**4.02**	**£85.50**	**£84.96**	**333**	**245**	**239**
Triple	**£430,124**	**60**	**£7,169**	**3.54**	**£63.36**	**£62.24**	**186**	**67**	**59**
Double	**£107,882,829**	**18217**	**£5,922**	**5.08**	**£109.75**	**£109.03**	**432**	**324**	**317**
Doors	**£8,387,880**	**6101**	**£1,375**	**0.99**	**£16.19**	**£16.18**	**48**	**17**	**15**
Secondary glazing	**£340,127**	**295**	**£1,153**	**1.53**	**£25.75**	**£25.95**	**100**	**64**	**62**
Floors	**£104,886,266**	**48567**	**£2,160**	**2.28**	**£52.49**	**£52.49**	**247**	**218**	**216**
Ventilation	**£343,200**	**286**	**£1,200**	**5.34**	**£154.31**	**£122.17**	**360**	**151**	**137**
Remove MV	**£343,200**	**286**	**£1,200**	**5.34**	**£154.31**	**£122.17**	**360**	**151**	**137**
Roofs	**£31,303,173**	**41064**	**£762**	**2.84**	**£86.16**	**£86.15**	**412**	**376**	**374**
Flat Roof	**£3,698,818**	**545**	**£6,787**	**9.83**	**£245.54**	**£245.54**	**1,201**	**1084**	**1076**
Rafter or Ceiling	**£136,763**	**63**	**£2,171**	**2.32**	**£54.96**	**£54.96**	**277**	**248**	**246**
Loft	**£27,467,592**	**40456**	**£679**	**2.75**	**£84.06**	**£84.06**	**401**	**367**	**364**
Unknown	£47,410	55	£862	7.24	£238.46	£238.46	1,014	925	919
Virgin	£4,954,234	5831	£850	10.76	£369.92	£369.92	1,767	1631	1621
Top Up	£22,465,948	34570	£650	1.39	£35.59	£35.59	170	153	151
Draughts	**£7,939,125**	**25749**	**£308**	**0.93**	**£26.08**	**£26.08**	**121**	**109**	**108**
Chimneys	**£4,092,060**	**11995**	**£341**	**1.06**	**£26.45**	**£26.45**	**126**	**114**	**113**
Doors & Windows	**£3,847,065**	**13754**	**£280**	**0.81**	**£25.75**	**£25.75**	**116**	**104**	**103**
Lighting	£3,657,132	57619	£63	0.92	£25.86	-£6.39	26	-18	-21
Total	£1,776,005,586	349646	£5,079	5.09	£142.87	£97.82	837	855	856

Table 14 Detailed breakdown of the Pathway results heating. lighting and PV measures

.	Total Investment	No. Measures	Average Cost	Av. SAP Change	Av. Fuel £ Saving	Av. Heating £ Saving	Av. kgCO2 Saving 2019	Av. kgCO2 Saving 2038	Av. kgCO2 Saving 2050
⊟ **Heating and Hot Water**	**£990,252,356**	**73269**	**£13,515**	**6.65**	**£179.09**	**£177.61**	**2,299**	**2851**	**2888**
⊟ **Individual Heating and Hot Water**	**£989,526,356**	**73203**	**£13,518**	**6.65**	**£179.16**	**£177.67**	**2,299**	**2852**	**2889**
⊟ **Heating System**	**£989,526,356**	**73203**	**£13,518**	**6.65**	**£179.16**	**£177.67**	**2,299**	**2852**	**2889**
⊟ **Heat Pump System**	**£984,724,756**	**70983**	**£13,873**	**6.69**	**£182.08**	**£180.55**	**2,368**	**2940**	**2979**
GSHP	£6,229,996	330	£18,879	10.15	£376.18	£376.65	1,097	734	710
ASHP	£978,494,760	70653	£13,849	6.68	£181.17	£179.63	2,374	2951	2990
⊟ **Electric Storage**	**£4,801,600**	**2220**	**£2,163**	**5.21**	**£85.93**	**£85.80**	**110**	**25**	**19**
Electric - Not Wet	£4,801,600	2220	£2,163	5.21	£85.93	£85.80	110	25	19
⊞ **Community Heating**	**£726,000**	**66**	**£11,000**	**5.16**	**£102.37**	**£102.37**	**1,780**	**1377**	**1370**
⊟ **Photovoltaics**	£190,805,669	35566	£5,365	12.65	£386.91	£0.00	682	120	82
⊞ **Identified PV system**	**£190,805,669**	**35566**	**£5,365**	**12.65**	**£386.91**	**£0.00**	**682**	**120**	**82**
⊞ Fabric	£591,290,429	183192	£3,228	4.32	£117.80	£117.68	537	475	470
⊞ **Lighting**	**£3,657,132**	**57619**	**£63**	**0.92**	**£25.86**	**-£6.39**	**26**	**-18**	**-21**
Total	£1,776,005,586	349646	£5,079	5.09	£142.87	£97.82	837	855	856

4.5 NET ZERO WITH DISRUPTIVE MEASURES EMPLOYMENT ANALYSIS

4.5.1 Existing Sector and Methodology

Please refer to Sections 4.3.1 and 4.3.2 for information about the current sector employment figures and our trades analysis methodology.

4.5.1.1 Average Trade Days for a 28 year programme to 2050

Figure 53 shows the number of different trades that would be required each year to deliver the 'Net Zero with disruptive measures' Pathway 28 years. In total this programme would require 676 full time employees each year – standard building trades dominate. The charts also show how these are split across trades.

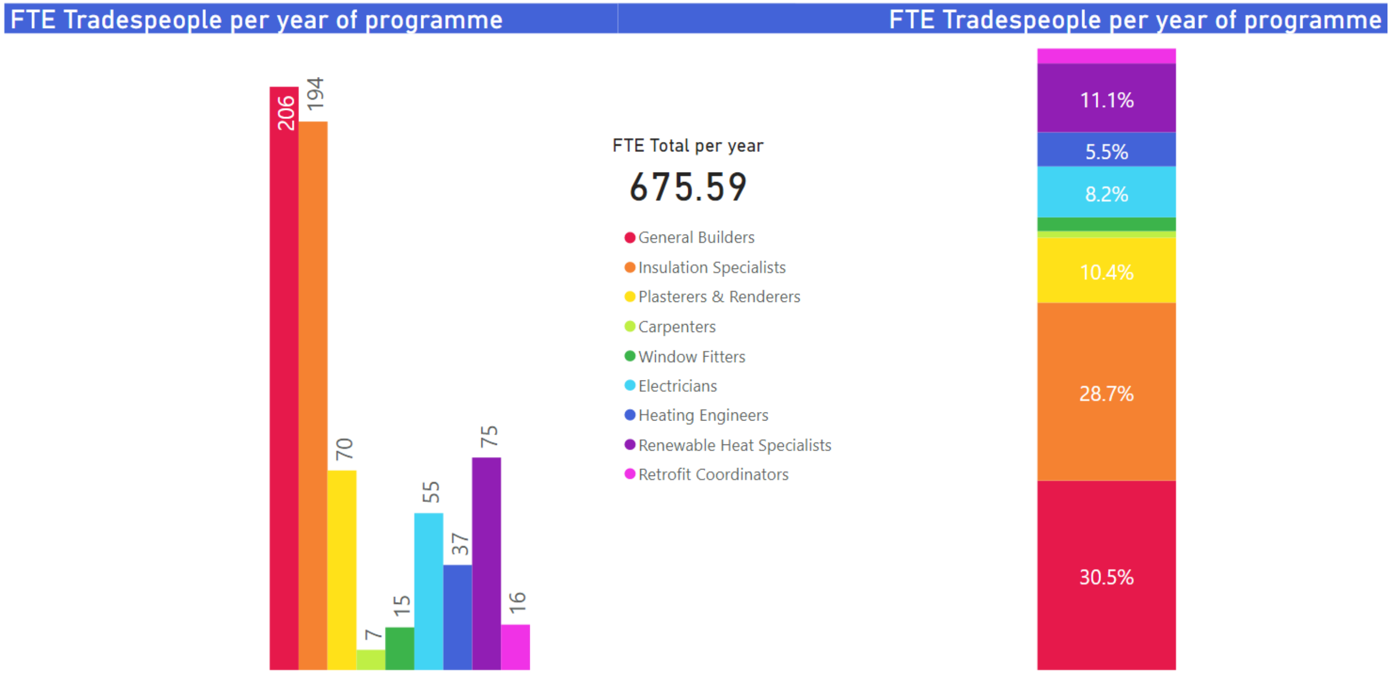


Figure 53

In Figure 54 we present the programme delivery in terms of individual trade days and total trade years.

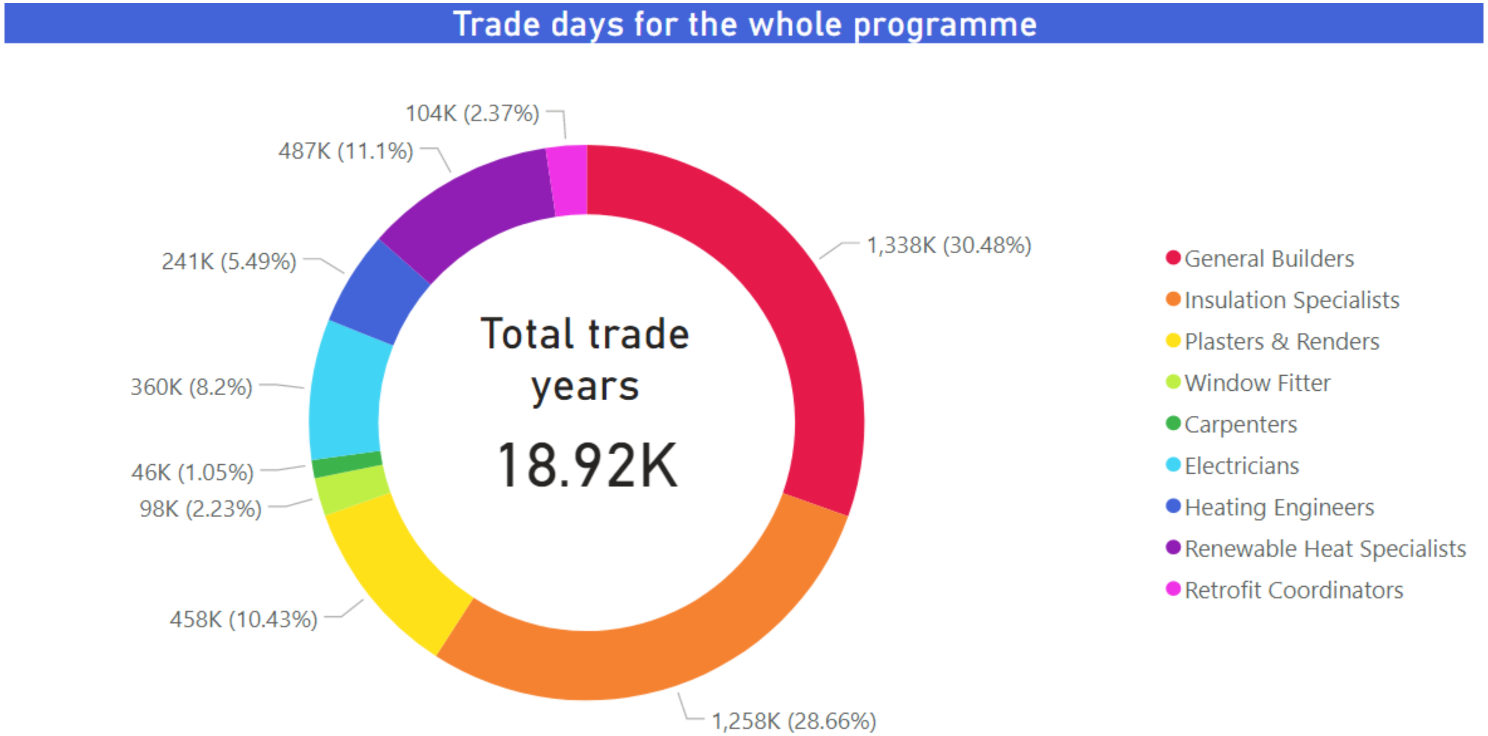


Figure 54

4.5.2 2050 Completion Target

Here we show a potential installation profile for reaching Net Zero by 2050 for the 'Net Zero with disruptive measures' Pathway.

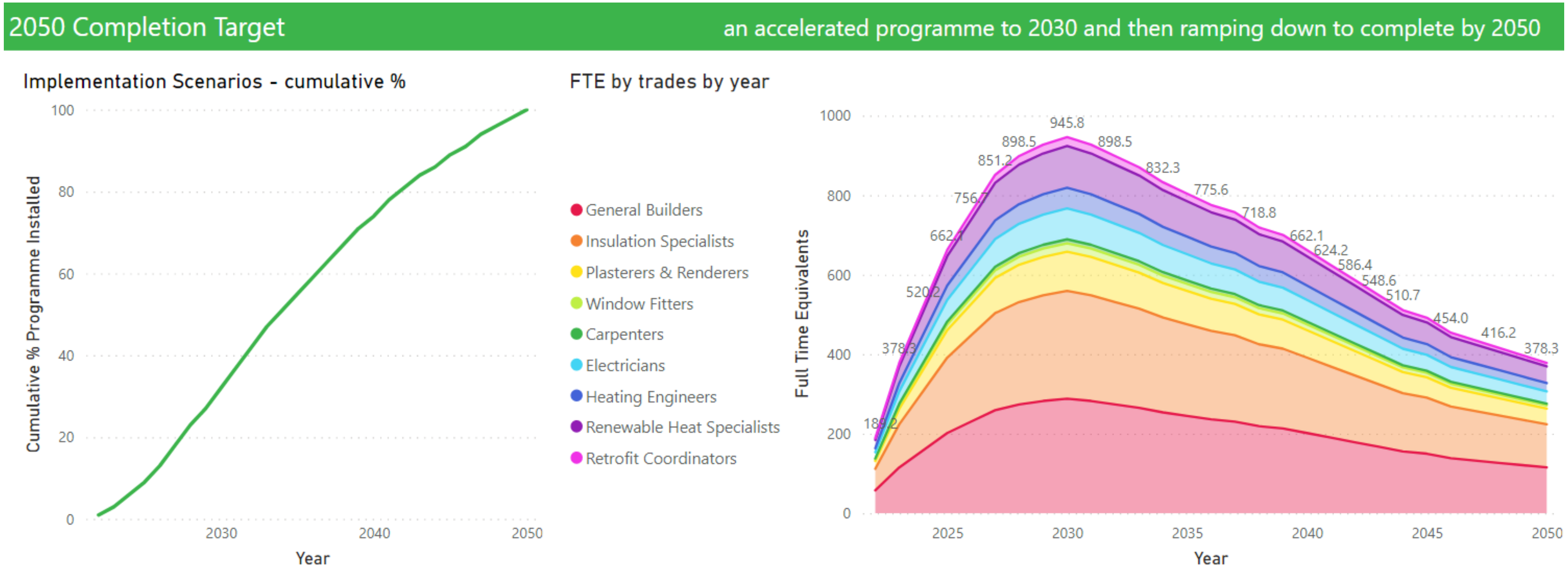


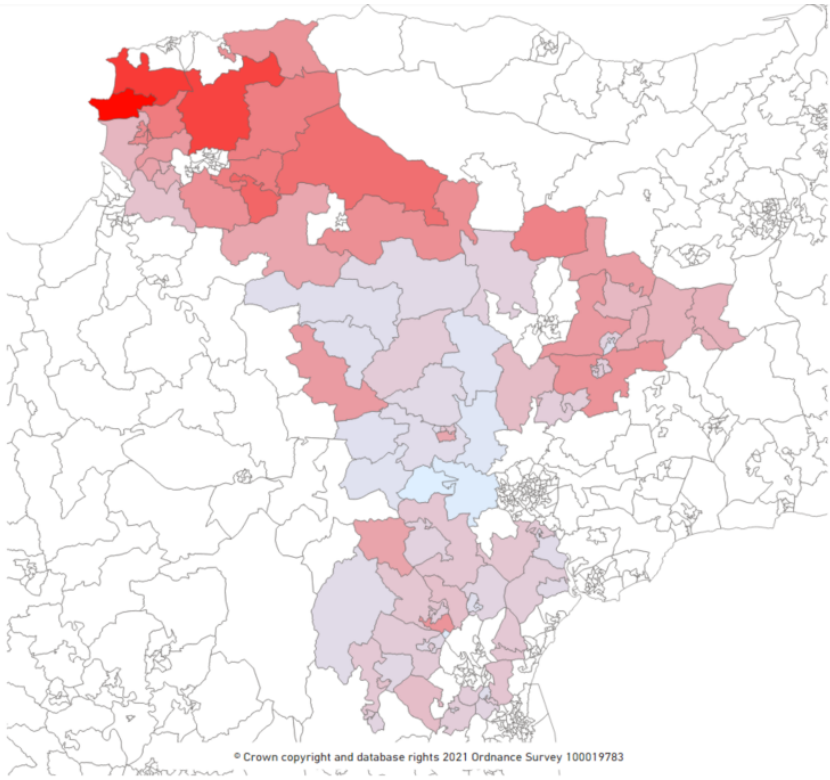
Figure 55

Table 15

	General Builders	Insulation Specialists	Plasters & Renderers	Window Fitters	Carpenters	Electricians	Heating Engineers	Renewable Heat Specialists	Retrofit Coordinators
No. FTE at the peak	288	271	99	21	10	78	52	105	22

4.6 HYBRID PATHWAY ANALYSIS

A final bit of analysis involved excluding the properties that resulted in increased fuel bills greater than £25 per annum from the 'without disruptive measures' Pathway, and only applying the 'with disruptive measures' to those properties. There were 6,809 of these properties – 9% of the properties in the 3 Districts. Figure 56 shows that they are concentrated on the outside of towns.



Min	Average	Max
2	209	905

Figure 56

Figure 57 highlight is that these properties, whilst performing slightly better when having disruptive measures considered, some still struggle to improve significantly – 1,074 still have fuel bills increased by greater than £25 per annum.

Net Zero without disruptive measures[2]   Net Zero with disruptive measures[3]

Figure 57

[2] Excluding 6,809 properties which have been modelled to have >£25 higher fuel bills under this scenario
[3] Only for the 6,809 properties

Focusing in on the actual expected fuel bill changes for just the 6,809 properties that could be expected to have greater than £25 increase fuel bills under the 'without disruptive measures' for each Pathways shows in Figure 58 & Figure 59 that there is a marked decrease in the average negative impact under the second scenario.

Figure 58 Fuel bill changes without disruptive measures for the 6,809 properties

Figure 59 Fuel bill changes with disruptive measures for the 6,809 properties

We conclude that this cohort of properties fall into the category of hard to treat with regard to reducing fuel bills with heat pumps.

5 Archetyping

5.1 BASELINE

5.1.1 Archetyping Process

A quantitative and qualitative approach was undertaken to identify up to 12 archetypes that covered a substantial proportion of the rural housing stock.

Without the qualitative aspect then since cavity wall properties make up 66% percent of the properties, it would have resulted in 8 of the 12 archetypes relating to subsets of this wall type.

Table 16 outlines the most common resulting archetypes from this process across the 3 Districts. Table 17 contains maps that show the geographic spread across all of the rural areas of Devon and concentrations of the archetypes by LSOA.

Without the Pathways software, the 12 archetypes have been set up as 'AddressGroups', which means any baseline or scenario analysis can be filtered to these groups.

5.1.2 Archetyping Results

Table 16

No.	Criteria	Typical sub-archetype	No. with EPCs (across Devon)	% of 'rural stock with EPCs'
1	Houses & Bungalow Cavity walls Mains gas heating	Mid-century detached cavity houses on mains gas	40,785	36.6%
2	Houses & Bungalow Cavity walls Electric heating	Mid-century detached cavity houses on electric	10,808	9.7%
3	Houses & Bungalow Cavity walls Other heating	Mid-century detached cavity houses on oil	14,642	13.1%
4	Houses & Bungalow Granite walls Not mains gas heating	Victorian granite detached houses off gas	12,465	11.2%

5	Flats & Maisonettes Cavity walls Any heating fuel	Late mid-century cavity flats	7,208	6.5%
6	Houses & Bungalow Granite walls Mains gas heating	Victorian granite detached houses on mains gas	5,176	4.6%
7	Houses & Bungalow Timber frame walls Any heating fuel	Mid-century semi or detached timber frame houses	2,868	2.6%
8	Houses & Bungalow Cob walls Any heating fuel	Victorian cob detached houses	4,590	4.1%
9	Houses & Bungalow Uninsulated solid walls Mains gas heating	Late Victorian/Edwardian terraces on mains gas	1,656	1.5%
10	Flats & Maisonettes Granite walls Any heating fuel	Victorian granite converted houses	2,002	1.8%
11	Flats & Marionettes Uninsulated solid walls Any heating fuel	Late Victorian/Edwardian converted terraces	818	0.7%
12	Houses & Bungalow Uninsulated solid walls Not mains gas heating	Late Victorian/Edwardian houses off gas	1,368	1.2%
			104,386	93.7%

Focusing on the relative numbers of properties in each of the 12 archetypes in the 3 Districts gives the distribution shown in the top chart of Figure 60 and then broken down by wall construction type in the bottom charts. You can clearly see that cavity walls dominate, with granite making up the bulk of what remains.

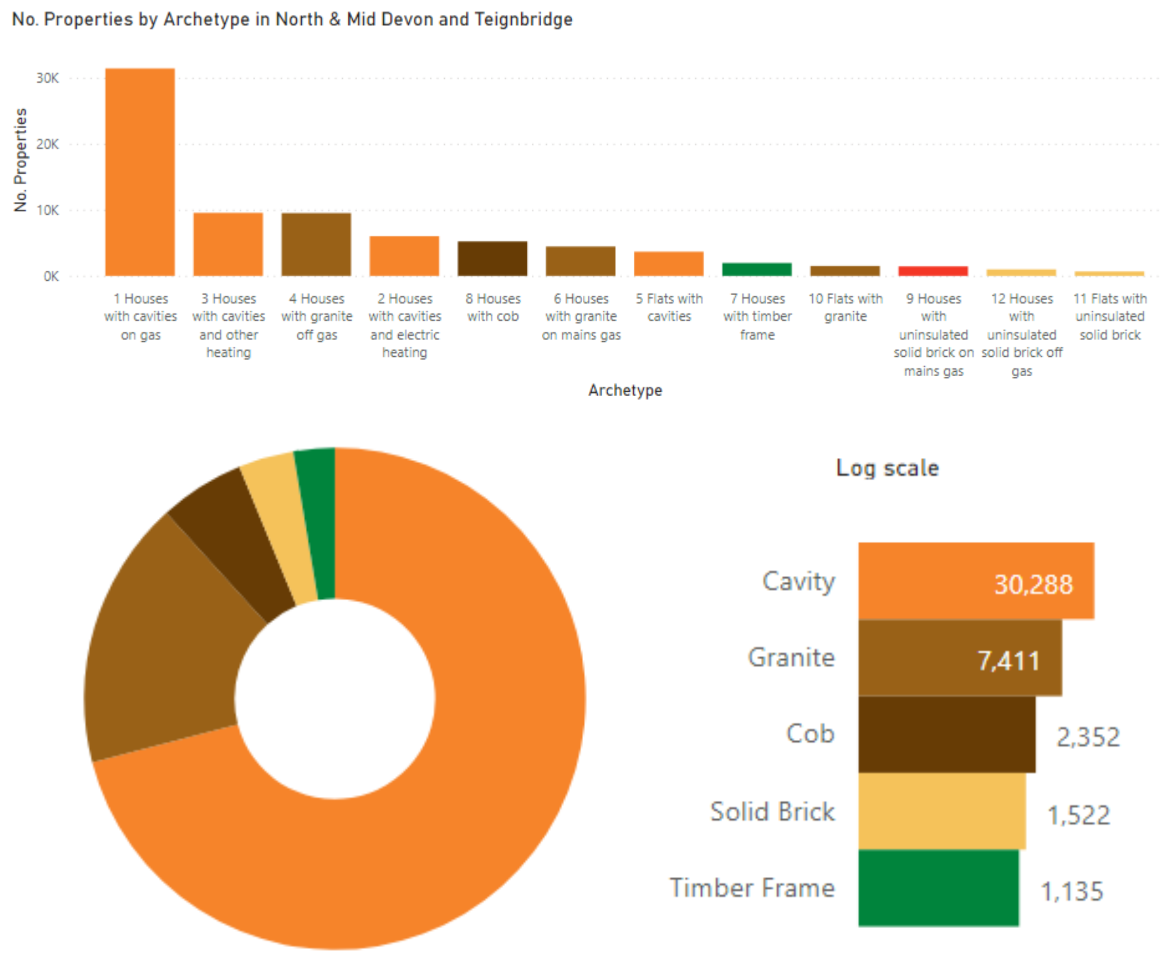
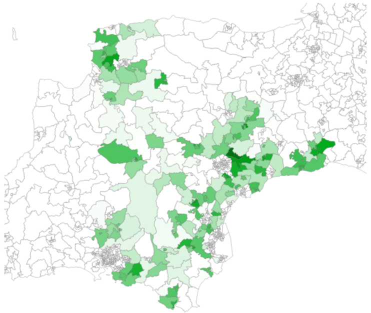


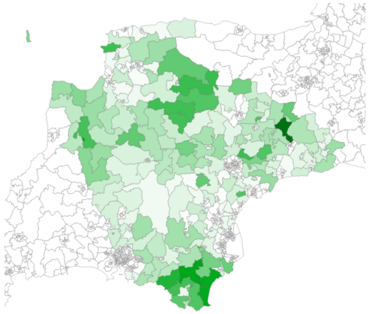
Figure 60

Table 17

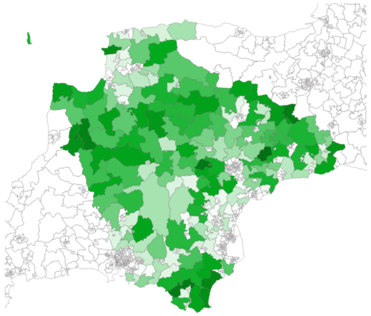
1 – Houses, Cavity, Gas



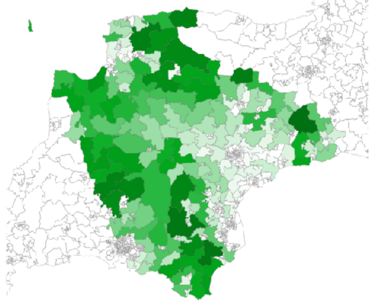
2 - Houses, Cavity, Electric



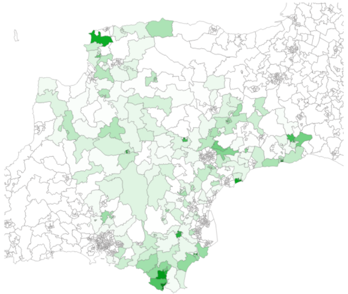
3 - Houses, Cavity, Other



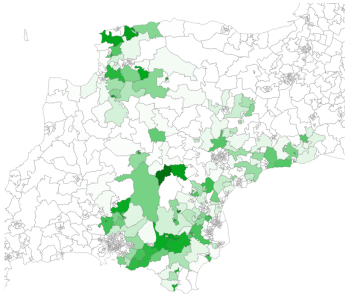
4 – Houses, Granite, Not Gas



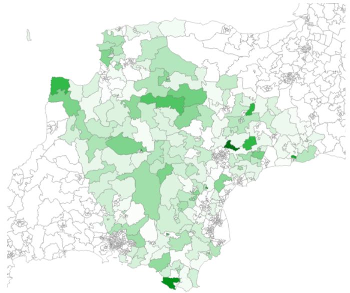
5 - Flats, Cavity



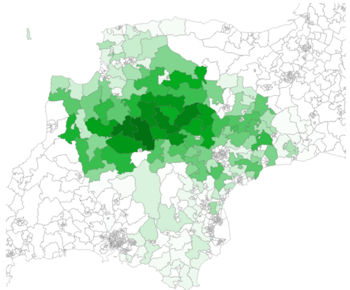
6 – Houses, Granite, Gas



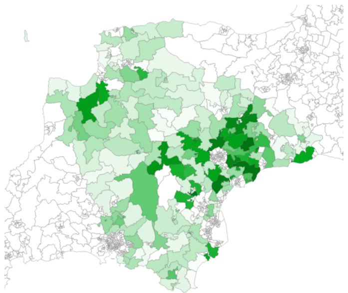
7 – Houses, Timber Frame



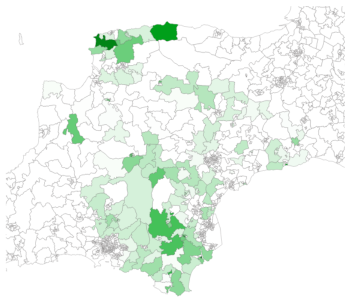
8 – Houses, Cob



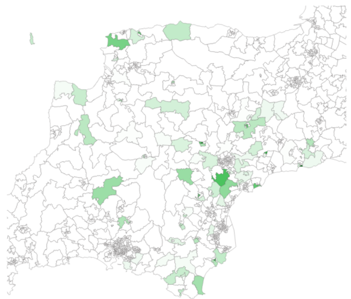
9 - Houses, Uninsulated solid brick, Gas



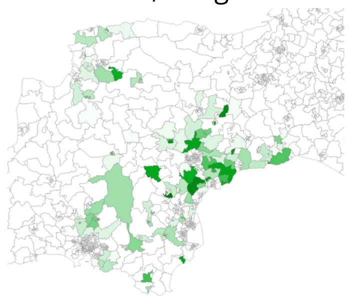
10 - Flats, Granite



11 – Flats, Uninsulated solid brick



12 - Houses, Uninsulated solid brick, not gas

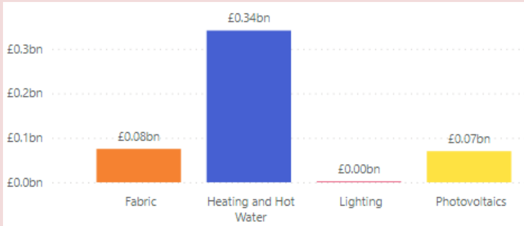


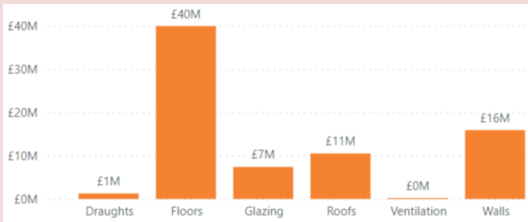
5.2 PATHWAYS

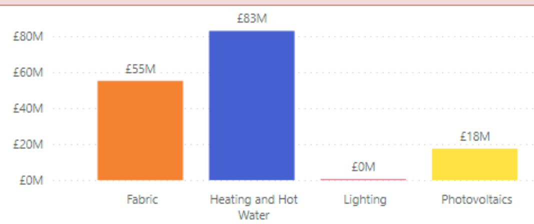
5.2.1 Archetyping Pathway Results

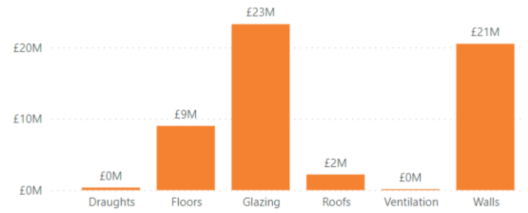
In Table 18 we have shown some key results for Pathway 2: Net Zero with Disruptive Measures to show the relative capital spend, the median average capital spend and the relative mix of measures for each of the 12 archetypes.

Table 18

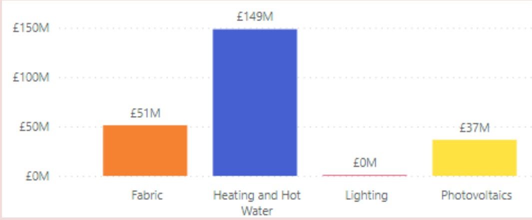
<table>
<tr><th>No.</th><th>Criteria</th><th>Total Capital Spend (Millions):</th><th>Median Spend per property (ranking : 1 highest)</th><th>Measures Mix</th></tr>
<tr><td>1</td><td>Houses & Bungalow
Cavity walls
Mains gas heating</td><td>£488</td><td>£16,425 (11)</td><td>


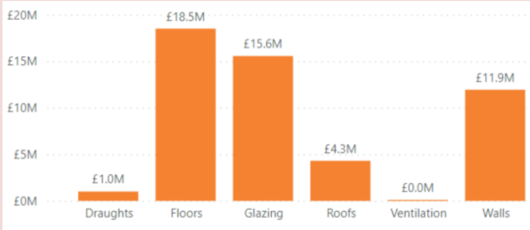
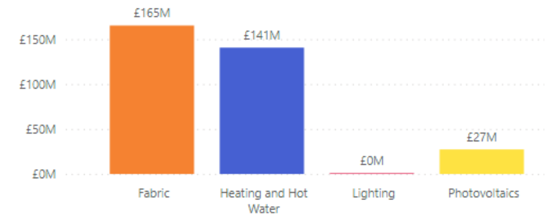
Fabric measure breakdown:


</td></tr>
<tr><td>2</td><td>Houses & Bungalow
Cavity walls
Electric heating</td><td>£156</td><td>£27,375
(5)</td><td>


Fabric measure breakdown:


</td></tr>
</table>

<table>
<tr><td>3</td><td>Houses & Bungalow
Cavity walls
Other heating</td><td>£237</td><td>£25,610
(7)</td><td>

Fabric measure breakdown:

</td></tr>
<tr><td>4</td><td>Houses & Bungalow
Granite walls
Not mains gas
heating</td><td>£334</td><td>£37,780
(1)</td><td>

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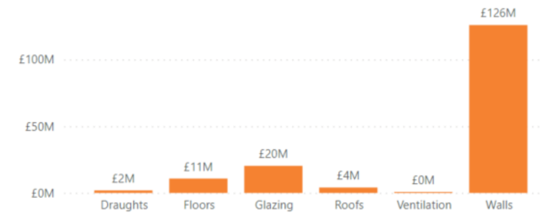
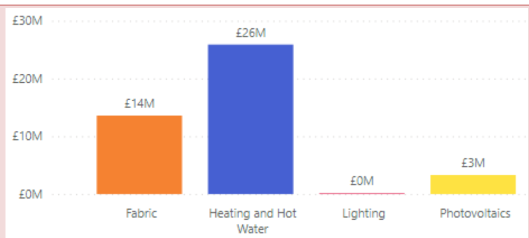

</td></tr>
<tr><td>5</td><td>Flats & Maisonettes
Cavity walls
Any heating fuel</td><td>£43</td><td>£12,890 (12)</td><td>

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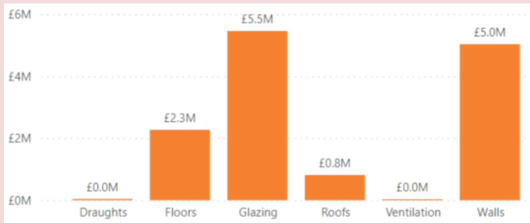
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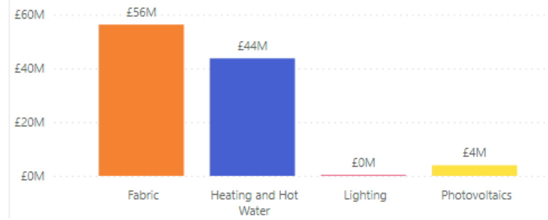
<table>
<tr><td>6</td><td>Houses & Bungalow
Granite walls
Mains gas heating</td><td>£104</td><td>£28,020
(4)</td><td>

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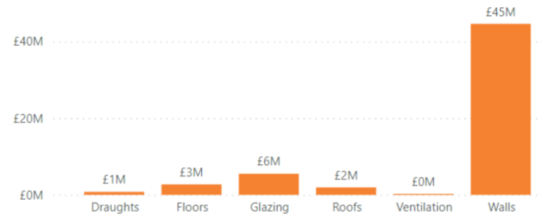
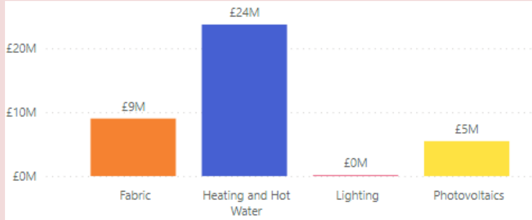

</td></tr>
<tr><td>7</td><td>Houses & Bungalow
Timber frame walls
Any heating fuel</td><td>£38</td><td>£19,880 (10)</td><td>

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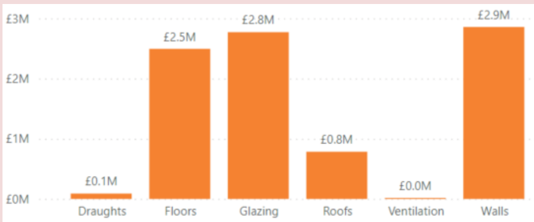
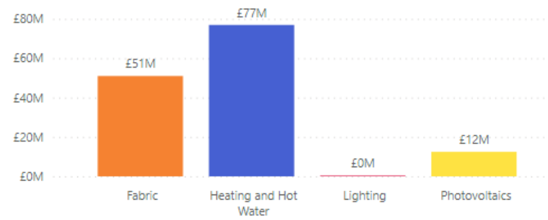

</td></tr>
<tr><td>8</td><td>Houses & Bungalow
Cob walls
Any heating fuel</td><td>£141</td><td>£29,860
(3)</td><td>

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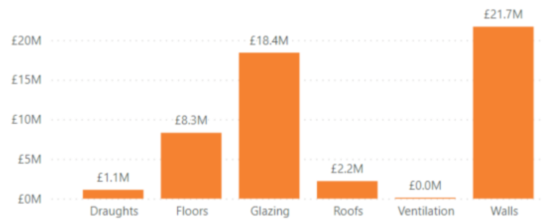
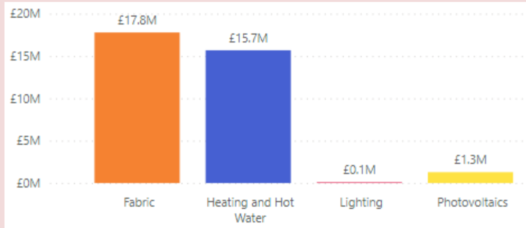
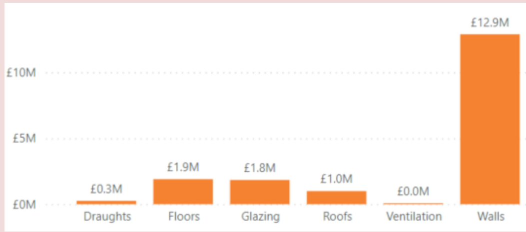
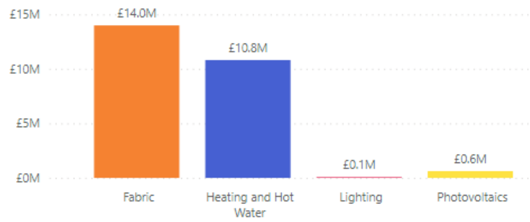
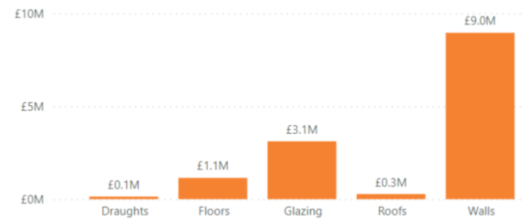
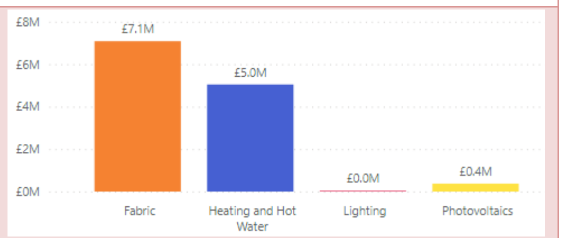
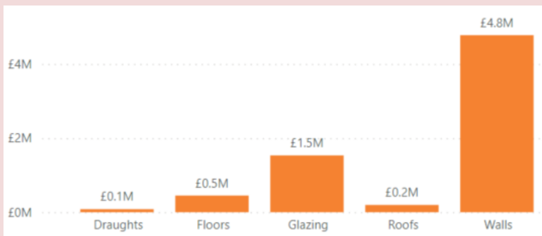
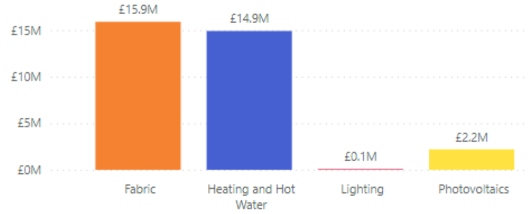
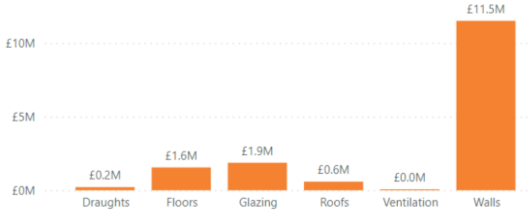

</td></tr>
</table>

9	Houses & Bungalow Uninsulated solid walls Mains gas heating	£35	£26,160 (6)	 Fabric measure breakdown: 
10	Flats & Maisonettes Granite walls Any heating fuel	£25	£21,530 (9)	 Fabric measure breakdown: 
11	Flats & Marionettes Uninsulated solid walls Any heating fuel	£13	£22,560 (8)	 Fabric measure breakdown: 

12	Houses & Bungalow Uninsulated solid walls Not mains gas heating	£33	£34,790 (2)	 Fabric measure breakdown: 

6 Energy efficiency's importance with a decarbonising grid

A key concept to understand is that the carbon intensity of the electricity grid is constantly changing. There are intra-day fluctuations due to the impact of demand variations (e.g. early evening peaks) as well as production variations (e.g. still days affecting wind and night-time affecting solar). Related to this is that in the case where there is an excess of available supply, then to a large extent the makeup of the supply can be concentrated on sources with the lowest CO_2 intensity i.e. if demand is reduced, in a crude sense, the grid responds by turning off coal rather than stopping wind turbines.

Since around 50% of the grid is close to zero carbon, it follows, at least at an approximation, that a 50% decease in demand could therefore theoretically remove all the high carbon sources from the mix, and result in a near zero carbon intensity grid. Even a 20% demand reduction could reduce the carbon intensity by close to 50%. This is illustrated by Figure 62 below.

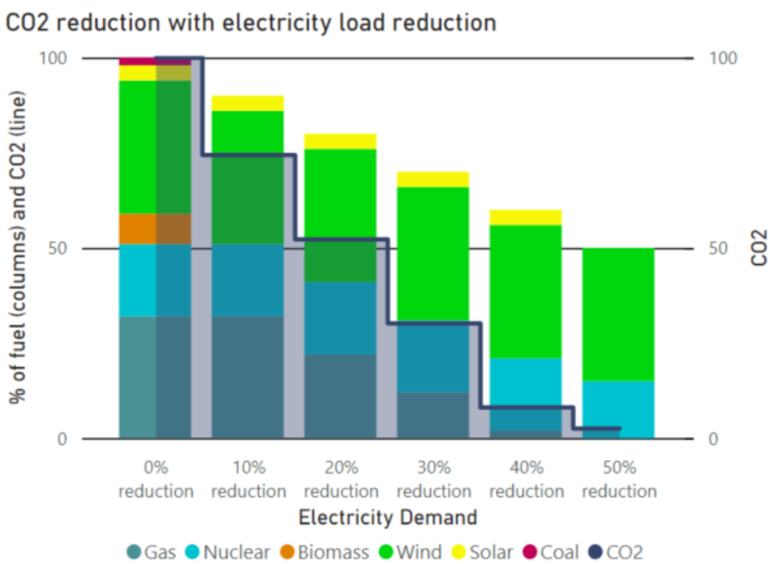


Figure 61

This means that whilst an individual homeowners impact on the overall grid carbon intensity is negligible and they usually more focused on energy bills as per the modelled scenarios, at a macro level, taking energy efficiency beyond just having a neutral impact on energy bills has a role to play in meeting the UK's decarbonisation targets.

A secondary consideration relates to the longer term trends towards decarbonisation as higher intensity sources e.g. coal are replaced with lower e.g. wind. The key here is longer term, so any reduced demand earlier in that timeframe will be saving carbon whilst the grid is still not fully decarbonised.

7 Hydrogen as an alternative

We are increasingly being asked about the potential impact of Hydrogen as a heating fuel as an alternative to Heat Pumps. We remain unconvinced because we would expect that as the grid decarbonises the ideal solutions will increasingly be heat pumps and community systems, with storage heaters and then electric boilers being the alternatives in the situations where heat pumps remain difficult.

The basis of our thoughts is a comparison of the resultant heat delivery proportions once losses have been taken into account. This is illustrated in Figure 62 below. Whilst the total amount of Green Electricity is limited, a heat pump solution will enable in excess of four times the delivered heat, or put another way, heat pump solutions require less than a quarter the green electricity capacity compared to a Hydrogen solution.

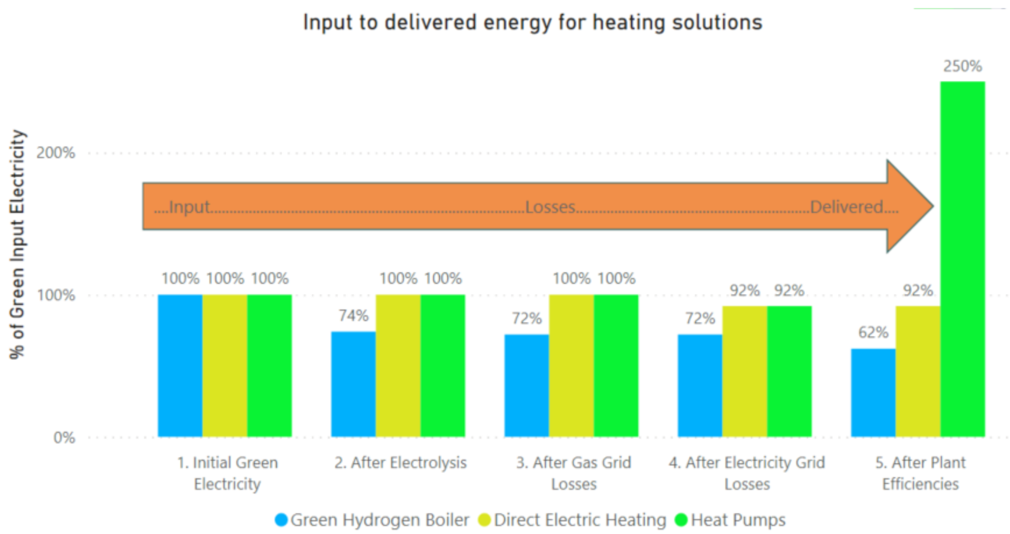


Figure 62

We do believe that Hydrogen will play a role in a low carbon future economy where electrification remains problematic e.g. some industrial uses and some transport.

Various Hydrogen 'colours' often get mentioned and below is a quick summary of the differences.

Green Hydrogen – hydrogen made using renewables or nuclear for electrolysis of water.
Yellow Hydrogen – a subset of Green hydrogen but using electricity from solar sources exclusively.
Pink Hydrogen – another subset of Green Hydrogen using nuclear energy specifically for electrolysis.

Blue Hydrogen – hydrogen made from natural gas but incorporating Carbon Capture and Storage (CCS) for the CO2 biproduct. Currently advocated by mains gas production and supply companies as a transition fuel.

Grey Hydrogen – similar to Blue Hydrogen but without any CCS. This effectively makes it a high CO_2 fuel.

Brown and Black hydrogen – electrolysis using coal or lignite so effectively very high CO_2 hydrogen.

Turquoise Hydrogen – using methane pyrolysis rather than electrolysis. Unproven technology at scale and would require low carbon electricity to be considered within Green Hydrogen

White Hydrogen - is a naturally-occurring geological hydrogen found in underground deposits and created through fracking. There is no commercial way to exploit this at present.

8 Ventilation note

All buildings require a certain amount of fresh air to maintain indoor air quality. In many circumstances, especially for older buildings, this is provided through infiltration and so also causes unnecessary heat loss.

Terminology:
Infiltration – uncontrolled air ingress or loss e.g. window and door draughts, fabric holes, open chimneys, passive vents
Ventilation – controlled air movement e.g. removal of moist air from wet rooms through extractor fans, trickle vents, humidity controlled passive vents

All buildings require a certain amount of fresh air to maintain indoor air quality. In many circumstances, especially for older buildings, this is provided through infiltration and so also causes unnecessary heat loss.

Many fabric measures applied to existing buildings will by design reduce the infiltration rate. In order to maintain indoor air quality it is often therefore necessary to introduce additional controlled ventilation. There are many solutions available, and the appropriate solution should be determined for each building. Most solutions will not be excessively expensive.

It should be noted that most ventilation solutions will cause a slight increase in CO_2 emissions either through heat losses or increased electricity use and as such will not be selected as part of our automated solutions. Therefore, in reality there may be some additional measures and costs required for some of the properties to provide adequate background ventilation.

The small amount of ventilation measures identified in our automated Pathways modelling is where the software has identified energy intensive systems such as positive pressure systems whose removal would decrease the modelled CO_2 of the property.

9 Regulated and unregulated energy note

Regulated energy relates to use from fixed building services and fittings only i.e. heating and hot water, fans and pumps, ventilation and lighting. Unregulated energy relates to uncontrolled systems such as refrigeration, washing machines, computing, cooking and entertainment devices.

Our analysis is only concerned with, and only takes account of regulated energy. There will therefore be additional CO_2 associated with unregulated energy that is not included in the analysis. As the vast majority will be electricity these will necessarily reduce in emissions as the grid continues to decarbonise.

10 Methodology

10.1 OVERVIEW

The work has consisted largely of:

- Producing a dataset for each property based on the data sources listed below.
- Analysis and computer modelling of the housing in the 3 Districts based on the data available.

The accuracy of the findings of this report is directly related to the accuracy and level of completeness of the data available.

10.2 PATHWAYS MODEL

The Pathways model uses data about building characteristics and resident behaviour to derive an accurate estimate of the annual energy and carbon usage of dwellings. It then applies an algorithm to derive the cost, savings and payback of a very wide variety of possible carbon saving measures tailored specifically based on their applicability to the individual dwelling and to the preferences and requirements of the client. Costs can be based on dwelling characteristics (e.g. wall insulation can be based on the sum of a flat rate and a per m^2 wall area) and so are realistically applied to each building in turn. The cost rates are derived from our experience of carrying out the work, but can be revised for any situation, for instance where a framework contract is in place for installation of measures.

In addition, the model and accompanying analysis allows custom initiatives to be applied: this functionality allows any realistic change to a building to be modelled, and affords a great deal of flexibility in allowing for future scenarios such as extensions or emerging innovative measures. The calculations used by the model are based on RdSAP 2012 which is the current version in operation for generating EPCs.

Where details are unknown (e.g. loft insulation, heating type) assumptions are made based on expected proportions of houses with a particular characteristic. Where possible, this is done based on known statistics from the similar and/or surrounding stock. Where this is not possible assumptions can be made using other data sources, or based on sensible estimates. The assumptions made for this analysis are stated in the report.

Pathways produces estimated current fuel use for every dwelling considered in an area, in parallel with estimated fuel use and typical installation cost for every energy/CO_2 saving measure that can be applied to each dwelling. These model outputs can be used to derive cost savings, carbon savings, paybacks, and so on. It should be understood that where the model outputs are based on assumptions, they should be used primarily as a strategic tool as outputs for individual dwellings may have limited applicability.

10.3 DATA

In order to complete the analysis, we have populated a full RdSAP data set for each property in the County, along with a few additional fields that allow for more granular application of measures e.g. window type.

The data sources and there uses and relative coverage are given in the table below:

Table 19 Data sources used in the analysis

Source	Key fields	Coverage	Comments
Open EPC data	Subset of RdSAP fields including Building Age, total floor area, key fabric types and efficiencies, summary level heating type and efficiencies	~59%	The complete underlying RdSAP dataset it's not available, but we have built a process to reverse engineer what is available to populate the potential options for the vast majority of RdSAP data fields.
Postcode Address File	Postal address	100%	
Conservation Areas	Shape files of Conservations areas	100%	Used alongside OS AddressBase to determine whether a property is in a Conservation Area.
OS Mastermap	Footprint of each property to inform floor area and property type and attachment.	100% of standalone properties	Also used to select nearby properties for cloning.
OS Addressbase	Location of each property	100%	
LIDAR	Provides a 3D representation of an area at reasonable resolution	100% of standalone properties	Informs storey height, roof area, roof type, roof pitch and PV suitability.
LSOA Defaults	Age, wall type, wall finish, window type, house storeys, flat type	100% at LSOA level	Informs which of the options determined from the Open EPC data to select if they are included in the options.

Once a RdSAP dataset has been completed for each property with Open EPC data, the options determined for each field are iterated five times and the corresponding SAP score compared to the one known from the Open EPC data. The combination of options that is closest to the Open EPC SAP score is then selected.

10.3.1 Data Confidence

Our methodology records a subjective confidence for each data point for each property. These can be viewed with Pathways. Because of the nature of the methods used to populate the data, properties in Pathways generally fall into two categories of confidence – those for which there was underlying EPC data and those where there is no underlying EPC data.

10.4 OVERVIEW AND EXPLANATION OF REPORT CONCEPTS / TERMINOLOGY

This section provides a brief introduction to some of the methods, concepts and terminology used in this report, and in the underlying analysis.

10.4.1 SAP

SAP stands for Standard Assessment Process. It is a method for assessing the energy performance of houses using a standard methodology specified by the UK government. The current version of SAP is SAP 2012, and it calculates a 'SAP rating' as well as an estimate of energy bills and CO_2 emissions associated with the estimated energy use.

The SAP calculations are based on building dimensions, construction (and therefore energy performance) of building elements such as walls and windows, details of the heating and hot water systems and controls, and any installed renewable technologies including solar PV panels. The number and percentage of low energy light fittings is noted, but the calculations do not take note of other electrical appliances and actual occupancy and heating usage (temperatures, heating hours, hot water usage etc.), or actual fuel tariffs (standard typical energy prices are used).

A SAP survey is a relatively time consuming process (perhaps 2 hours work), and is usually only required for new build housing etc.

10.4.2 RdSAP

RdSAP is the method used to produce Energy Performance Certificates (EPCs). RD stands for Reduced Data, and the method is designed to allow surveys to be completed more quickly and therefore more cheaply than a full SAP survey at some cost of accuracy. The reduced data survey is extrapolated up to full SAP level data using a standard set of rules before SAP calculations can be conducted. The current version of RDSAP is 9.93.

10.4.3 Link between SAP score and fuel bills

The SAP score is a number, nominally between 1 and 100, which is calculated using a slightly abstruse algorithm which takes as inputs the floor area and estimated fuel bills. The SAP score is divided into rating bands which are used in EPCs. A higher SAP score is better than a lower SAP score, and a typical Registered Provider currently has a SAP score around 70. [Note: it is theoretically possible to have a SAP score above 100 if energy bills are negative (e.g. if exported energy fees exceed bills for energy used.)]

10.4.4 General Approach

Throughout our analysis we have used RdSAP as the basis for our calculations of SAP score, CO_2 emissions and fuel bills.

10.5 COPYRIGHT STATEMENTS & SOURCE DATA ACKNOWLEDGMENTS

Parity Projects use various data sources to produce or enhance the analysis presented in this report. These are attributed on individual pages where relevant, and we have also listed the appropriate attributions below:

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projects

Ashden
Award
winner
2012